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GARDENS' BULLETIN

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Vol. XXVII, Part I 15th February, 1974

Boletus and Phylloporus in Malaysia: further notes and descriptions

by

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New taxa:— *Boletus* subgen. *Boletus, B. hibiscus* sp. nov. (Sarawak), *B. rubroglutinosus* sp. nov. (Sarawak); subgen. *Leccinum, B. peronatus* sp. nov. (Sarawak), *B. squarrosipes* sp. nov. (Malaya); subgen. *Punctispora* subgen. nov., *B. punctisporus* sp. nov. (Sarawak); subgen. *Tylopilus, B. longipes* Mass. var. *albus* var. nov. (Sarawak), *B. tristior* sp. nov. (Sarawak); subgen. *Xerocomus, B. albipurpureus* sp. nov. (Sarawak), *B. setigerus* sp. nov. (Java). — *Phylloporus squamosus* sp. nov. (Sarawak), *P. stenoporus* sp. nov. (Java).

In the week of 21 August 1917 C. F. Baker and N. Patouillard had the luck to encounter a run of boleti in the Gardens' Jungle in Singapore. They described 16 new species but, as many of these had already been collected by H. N. Ridley and described by Massee, merely five of their names have survived (Corner 1972). During the week 20–27 August 1972 I had the luck to encounter a similar run of boleti in Sarawak about the neighbourhood of Kuching, especially in Bako National Park. I record 20 species of which six appear to be new. These and a few others from Malaya and Java are here described. So it is that every region of south-east Asia adds to our knowledge of boleti.

The weather in Malaysia had been exceptionally dry from May or June 1972 until the beginning of August; in places there had been water-rationing. Heavy showers then induced this first crop of agarics which began around Kuching on 19 August with boleti and *Cantharellus* and passed on to *Amanita, Russula* and *Entoloma*. In early September I had to leave on my homeward journey via Ceylon where a similar dry period had extended until about 12 September. The monsoon broke at this date when I was in Polunarawa. Unfortunately I could not delay, but I wondered what fungi would come up in the extensive, if mainly secondary, forests that are around this ancient town; the region is unexplored mycologically. Many trees at Polunarawa had already begun to develop new leaves in anticipation, as it were, of the rains which had ceased in the middle of March; the parched scene was set for the mycologist, and it struck me as a good occasion for gasteromycetes.

In Sarawak I was particularly interested in the fungi of Bako National Park because it consists largely of the xerophilous *kerangas* forest on sandstone with a few small valleys of typical lowland dipterocarp forest. Yet I could find no marked difference between the fungous floras of these very different kinds of forest. The species of *Boletus* and *Amanita* seemed to occur indiscriminately. Many were widely distributed species of lowland West Malaysia and Singapore which are without *kerangas* forest.

I draw attention to *Boletus hibiscus* as a massive ally of *B.* (*Phaeogyroporus*) *portentosus* which has not been reported from Malaysia, to *B. punctisporus* as an ally of the North American *B. betula,* to *B. setigerus* as yet another small species with thick-walled cystidia, and to the two new species which I assign to subgen. *Leccinum* for they relate with *B. borneensis* which I have described from Kinabalu (Corner 1972).

BOLETUS Fr.

subgen. *Austroboletus* Corner

B. dictyotus (Boedijn) Corner

var. *morchellipes* Corner (1972) p. 85.

Pileus 7–17 cm wide, conical then convex to more or less plane, fawn ochraceous felted, dry, becoming cracked; margin at first extensively appendiculate and in unopened fruit-bodies concrescent with the upper ridges of the stem-reticulum, but sometimes detaching from the pileus as a more or less broken ring. Stem 8–15 cm × 7–25 mm (excluding the reticulum), subcylindric, white, coarsely alveolate-reticulate downwards, the meshes towards the base of the stem 5–15 mm deep. Tubes 12–20 mm long, white then vinaceous pink, soft; pores 0.5–2 mm wide, white then vinaceous pink. Flesh 20–35 mm thick in the centre of the pileus, white, unchanging, but yellowish at the base of the stem with age. Spores 12–15.5 × 5–6μ (spore-body), with small warts 0.5–1μ high, both ends of the spore smooth.

Sarawak, Bako National Park, scattered in the humus, rarely two together, in *kerangas* and lowland dipterocarp forest, Corner P–147, 25 Aug. 1972.—Malaya, Pahang, Fraser's Hill, Corner s.n., 6 Sept. 1972.

This with its massive spongy stem is one of the more striking species of Malaysia. It was common at Bako and the fruit-bodies were eaten by squirrels.

B. malaccensis (Pat. et Baker) Corner (1972) p. 85.

Pileus without marginal veil. Stem –9 cm high, attenuate upwards from the fusiform base, in the lower third with shallow, very elongate meshes –25 × 4 mm and 1–1.5 mm deep, wholly minutely yellowish pruinose. Spores 10.5–13(–14) × 4.7–5.5μ. Basidia 27–34 × 10–11μ; sterigmata 4, 6–8μ long. Tube-trama becoming sloppy-gelatinous in alcohol-formalin.

Sarawak, Bako National Park, solitary in humus, Corner P–158, 26 Aug. 1972.

This collection agreed closely with those from Singapore.

B. mucosus Corner (1972) p. 77.

Sarawak, Bako National Park, common in all inland parts whether in *kerangas* forest or not.

The young fruit-bodies had the margin of the pileus extended into a flange, as in *B. longicollis,* and disrupting to make a broken annulus on the reticulate stem.

B. rubiicolor Corner (1972) p. 86.

Pileus –6 cm wide, minutely rufous madder or purple madder squamulose; margin appendiculate –15 mm long, disrupting into fragments or collapsing on to the stem. Stem 13–15 cm × 7–8 mm at the apex, 10–15 mm at the subclavate base, white, finely reticulate at the apex, coarsely and rather shallowly costato-reticulate downwards with elongate meshes 10–17 × 2–4 mm, 1–3.5 mm deep, most pronounced about the middle of the stem. Tubes –20 mm long; pores 1–1.3 mm wide. Flesh –13 mm thick in the centre of the pileus, soft, sappy, easily putrescent, unchanging.

Except for the much larger fruit-bodies with pronounced marginal flange to the pileus and rather strongly lacunoso-reticulate stem, the collections agreed with previous ones from Singapore. This appears to be one of the very early species to fructify at the beginning of a fungous season.

Sarawak, Kuching, Semanggoh Forest, Corner P–91, 19 Aug. 1972; Bako National Park s.n., 26 Aug. 1972, in *kerangas*-humus; solitary, scattered.

subgen. *Boletellus* Murr.

B. ananas Curtis

Sarawak, Bako National Park, in *kerangas*-humus, s.n. 26 Aug. 1972.

B. longicollis Ces.

Sarawak, Bako National Park, in *kerangas*-humus and that of lowland dipterocarp forest, frequent, solitary, 26 Aug. 1972.

subgen. *Boletus*

Boletus hibiscus sp. nov.

Pileus 9–26 cm latus, convexus dein planus et concavus, laevis, siccus, laete cervino-luteus dein (? de sporis depositis) cinnamomeo-ferrugineus; margine flavido, primo ut membrana 3–4 mm lata tubulos excedenti. Stipes 7–12 cm × 16–45 mm, cylindricus, firmus dein subcompressus intusque spongiosus, cortice dura, luteus dein e basi fusco-brunnescens, ex integro minute pruinoso-furfuraceus, haud reticulatus; mycelio albo. Tubi 9–12 mm longi, sinuato-ventricosi, pallide cervino-cinnamomei dein cinnamomeo-ferruginei; poris 0.8–1.5 mm latis, angulatis, rugulis longitudinalibus subcompositis, marginem pilei versus saepe radiato-elongatis, concoloribus. Caro in centro pilei 16–35 mm crassa, firma dein spongiosa, flavo-alba, basim stipitis versus dura et intense ochraceo-lutea, sub superficie pilei flava, fractu vix flavescens vel in stipite subbrunnescens, nec cyanescens nec rubescens. Odor subacidus. Sporae 8–9.5 × 6.3–7μ, in cumulo laete ferrugineae (nec olivaceae nec incarnatae), ovoideae, laeves, inamyloideae, 1-guttatae, tunica in KOH subincrassata, apiculo 0.2μ longo.

Ad terram arenosam maritimam in *Hibisceto tiliaceo,* gregaria, saepe in circulis latis. Sarawak, Bako National Park, Telok Pandan et Telok Bako, 28–29 Sept. 1972, leg. E. J. H. Corner P–181 (typus, CGE).

Pileus bright brownish yellow, becoming cinnamon-ferruginous from the spores; margin exceeding the tubes as a flange 3–4 mm wide. Stem yellow, then fuscous brown from the base upwards, minutely pruinose, firm then somewhat baggy with spongy interior and firm rind. Tubes sinuate, pale brownish cinnamon then ferruginous; pores angular, becoming subcompound with internal longitudinal ridges, concolorous with the tubes. Flesh thick, yellowish especially in the stem, unchanging.

Spores bright ferruginous in the mass. Basidia 30–42 × 8.5–10μ, 4-spored. Cheilocystidia 30–45 × 4–8μ, more or less narrowly ventricose, often with prolonged or bifurcate obtuse apex 2–3μ wide, thin-walled, colourless, as a sterile edge to the pores. Pleurocystidia not seen. Surface of pileus consisting of a disrupted and flattened pile of hyphal ends –100μ long, with submoniliform clamped cells 20–40 × 7–15μ, not encrusted, the end-cells subclavate. Surface of the stem covered by a more or less disrupted and (?) mainly sterile hymenium of immature basidia and cystidia as the cheilocystidia. Tube-trama phylloporoid with long-celled mucilaginous hyphae 4–11μ wide, clamped, becoming rather toughly gelatinous in alcohol-formalin. Hyphae *clamped*, inflating, with scattered oleaginous hyphae in the stem and pileus; in the stem mainly longitudinal with the cells 70–400 × 5–35μ, cylindric or fusiform, thin-walled, with some uninflated interweaving hyphae as laterals of the inflated longitudinal hyphae, but with narrower and more compact hyphae in the firmer cortex; without chlamydospores at the base of the stem.

This striking species is recognised from its large size, bright brownish yellow colour, unchanging flesh, copious ferruginous spore-deposit, and habitat. With clamped hyphae it comes near to *B. portentosus* which differs in the olivaceous fruit-body and spores. The ferruginous spores place the species in *Gyrodon* which, however, has decurrent tubes. *Phaeogyroporus* with olivaceous brown spores has the sinuate-ventricose tubes. To both genera a boletoid tube-trama is ascribed; that of *B. hibiscus* is phylloporoid. According to a collection that I have from Brazil, *Phaeogyroporus tropicus* (Rick) Singer has yellow-brown (not olivaceous) spores, phylloporoid trama, and adnexed or tapered-adnate tubes. Therefore, while the distinction of these imperfectly characterised genera (including *Phlebopus*) is so uncertain, I retain the species in *Boletus* near to *B. portentosus* and *B. tropicalis.*

I found about 150 fruit-bodies of *B. hibiscus* in two forested bays of Bako National Park. They grew in more or less complete circles up to 5 m in diameter in thickets of *Hibiscus tiliaceus, Dillenia suffruticosa, Planchonella* and *Pandanus odoratissimus,* not directly on the sea-front but where this vegetation borders the outlets of mangrove-streams. It was impossible to associate these circles with any particular tree or, indeed, to trace the mycelium beyond the lowest level of the humus where it mixed with the sand. The fungus did not grow with *Rhizophora, Bruguiera* or *Sonneratia* or in the muddy ground of the palms *Oncosperma* and *Salacca.*

B. hibiscus comes in the artificial key to Malaysian boleti (Corner 1972, p. 49), next to B. *chlamydosporus.*

B. rubroglutinosus sp. nov.

Pileus 4.5–6 cm latus, sanguineo-ruber, glutinosus. Stipes 6–7 cm × 9 mm, cylindricus, concolor, rubro-pruinosus, ad basim mycelio ochraceo-aureo vestitus. Tubi 5 mm longi, sinuato-adnati, flavi; poris minutis, sanguineo- vel aurantiaco-rubris, dein sordide aurantiaco-incarnatis. Caro –9 mm crassa, flava, intense cyanescens ut tubi porique. Sporae 9.5–12 × 3.7–4.5μ, in cumulo fusco-purpureae, leniter olivaceotinctae, laeves.

Ad terram in silva. Sarawak, Bako National Park, Corner P–145 (typus, CGE), P–145a, 25–26 Aug. 1972.

Pileus 4.5–6 cm wide, convex (immature), evenly blood-red, smeary-viscid pelliculose. Stem 6–7 cm × 9 mm, cylindric, dry, blood-red, minutely red scurfy-pruinose, not reticulate, base slightly tapered and thinly villous with the ochraceous golden-yellow mycelium. Tubes 5 mm long, adnate then sinuate, yellow; pores minute, blood-red or orange-red, then dull orange-pink. Flesh –9 mm thick in the centre of the pileus, yellow, quickly and intensely cyanescent on bruising or cutting as the tubes and pores. Smell none.

Spores in the mass fuscous purplish tinged olivaceous. Basidia 25–32 × 9–10μ; sterigmata 4. Cheilocystidia 20–40 × 8–14μ, clavate to subventricose or subfusoid, thin-walled, as a sterile edge to the pores. Pleurocystidia –75 × 14μ, ventricose, thin-walled, with a short appendage 2μ wide, sparse. Surface of the pileus composed of appressed, narrow, colourless mucilage-hyphae 2–3.5μ wide, with cylindric ends, neither as a pile nor as a palisade, without clamps. Surface of the stem with a disrupted and mainly sterile hymenium of clavate sterile basidia, subglobose cells 14–21μ wide, and more or less ventricose cystidia, some with an appendage –60 × 2–3μ; stem-hyphae 5–16μ wide, without clamps, many secondarily septate. Tube-trama boletoid, swelling and firmly gelatinous in alcohol-formalin, with a narrow medulla of narrow hyphae 3–5μ wide and a cortex of gradually divergent hyphae –9μ wide with strongly mucilaginous walls.

This species is distinguished by the glutinous red pileus, the dry red furfuraceous stem, the minute red pores, the yellow cyanescent flesh, and the yellow mycelium. With boletoid trama and viscid pileus it should go into *Suillus* of modern authors but, among Malaysian boleti, it seems to me related with *B. subreticulatus* and *B. lubricus,* neither of which have cyanescent flesh. It may be rare for I found but two specimens. In the artificial key to Malaysian *Boletus* (Corner 1972, p. 41) it should be entered in Group C after *Heimiella mandarina.*

B. rufo-aureus Mass.

Sarawak, Bako National Park, in *kerangas*-humus, Corner P–182, 28 Aug. 1972.—Malaya, Pahang, Fraser's Hill, Corner s.n., 6 Sept. 1972.

Though large, with the pileus 8–12 cm wide and the stem 11 cm × 27 mm, the specimens were immature; it is the wont of this species to mature late in development. The few spores that I found were smaller than usual and 9.5–11 × 3.5–4.2μ; cystidia, most basidia, and the hyphal ends on the pileus had not reached their adult size and shape.

B. sinapicolor Corner (1972) p. 124.

Pileus –8 cm wide. Stem poroid-reticulate at the apex, the reticulations elongate and deeper downwards, –0.5 mm deep, but absent from the lower third of the stem. Tubes 7–8 mm long, sinuate; pores 0.5 mm wide. Flesh hard and firm in the stem.

Spores 10.5–12.7 × 4–4.5μ. Basidia 30–37 × 9–10μ; sterigmata (2–3–) 4. Pleurocystidia –65 × 9–14μ, ventricose with narrow apex, thin-walled, inconspicuous, sparse. Cheilocystidia similar, sparse. Surface of pileus with cells 40–80 × 7–14μ in the hyphae of the pile, the end-cells clavate or ventricoso-attenuate. Stem-surface with a disrupted sterile hymenium, along the ridges with excrescent 2–3-septate hyphae –170 × 7–9μ. Stem-hyphae with the cells –170 × 7–16μ. Tube-trama subboletoid with slight medulla of narrow hyphae, the cortical hyphae 5–13μ wide, becoming somewhat swollen but firm in alcohol-formalin.

Malaya, Pahang, Fraser's Hill, Corner P–201, 6 Sept. 1972, in humus in *Trigonobalanus*-forest.

This collection, from the same valley where I first found the species forty years ago, has enabled me to add some details to the description. The spores were slightly longer than I had previously found.

Recently *B. auripes* Pk. has been recorded from Japan by Hongo (1970) whose description of the species, as it occurs in Japan, reads extremely like that of *B. sinapicolor*. He describes the yellow tomentose base of the stem but the yellow colour of the fruit-body does not seem to be the uniform and striking mustard-yellow of *B. sinapicolor*. In contrast, for North American specimens of *B. auripes*, the mycelium at the base of the stem is given as white (Snell and Dick 1970) and it is not figured or described as yellow by Coker and Beers (1943). But these authors describe, and Hongo finds in the Japanese material, the immature pores as stuffed and covered, as it were, by a membrane. This is the nature of the young pores in *B. phaeocephalus* to which I considered *B. sinapicolor* to be allied (Corner 1972, p. 125), but I have not seen this membrane in *B. sinapicolor*, though I have had young specimens. Here is evidently a close alliance in which the Japanese *B. auripes* approaches *B. sinapicolor*.

B. thibetanus Pat.

Pileus –8 cm wide. Stem –10 cm high. Pores 0.5 mm wide, golden citrine. Spores 10.5–13(–14) × 4.5–5.5μ, olive brown turning dark fuscous brown in potash.

Sarawak, Bako National Park, solitary in humus, Corner P–157, 26 Aug. 1972.

This characteristic species was recognised at once in the forest but microscopic examination of the dried material some months later revealed a point which may be peculiar or, hitherto, overlooked. The spores of the Sarawak collection, which were slightly larger than the Malayan, turned rather dark fuscous brown in potash. Dried spores of the Malayan material (now thirty years old) are very pale in potash.

B. xylophilus Petch

Malaya, Kuala Lumpur, Lake Garden, on earth in the centre of an isolated clump of the palm *Oncosperma*, Corner s.n. 3 Sept. 1972.

subgen. *Leccinum* S. F. Gray

B. peronatus sp. nov. — Figure 1c.

Pileus 6–9 cm, siccus, obscure brunneus villoso-subtomentosus, dein ochraceo-brunneus. Stipes 7–8.5 cm × 9–12 mm, subcylindricus v. subfusiformis, basim versus attenuatus, albidus dein subochraceus, annulis floccosis in squamulis 1–2 mm projicientibus fuscescentibus irregulariter peronatus, haud reticulatus; mycelio albo. Tubi 6–9 mm longi, adnexi, subliberi, cremeo-albi dein olivaceo-virides; poris minutis, tubis concoloribus, aetate brunnescentibus. Caro 10–16 mm crassa, albida dein subflavida, aetate vel fractu tarde ochraceo-brunnescens, haud cyanescens. Odor subacidus. Sporae 8.5–11 (12) × 3.7–4.7μ, in cumulo olivaceae, laeves.

Ad humum in silva, solitarius v. caespitosus. Sarawak, Bako National Park, Corner P–142 (typus, CGE) P–144, 25 Aug. 1972.

Pileus 6–9 cm wide, convex then plane, dry, at first dark fawn brown and villoso-subtomentose, then brownish ochraceous with fuscous brown centre, paler to the margin, tomentose, becoming minutely cracked, especially in the centre; without veil. Stem 7–8.5 cm × 9–12 mm, subcylindric or subfusiform –15 mm wide in the middle, usually attenuate at the base, whitish then pallid ochraceous buff, irregularly peronate with more or less interrupted, divergent, floccose bands projecting 1–2 mm in the middle of the stem and often appearing as connate squamules, the bands becoming fuscous brownish, stem-apex smooth, not reticulate; mycelium white, fibrillose. Tubes 6–9 mm long, adnexed, nearly free, subventricose, pale cream-white then pale greenish olivaceous; pores minute, concolorous with the tubes then brownish with age. Flesh 10–16 mm thick in the centre of the pileus, white then pale yellowish white, becoming pale brownish subochraceous in the stem and pale brownish or pinkish brown with age or on exposure in the pileus, not cyanescent or truly rufescent. Smell slightly sour.

Spores olive in the mass. Basidia 26–30 × 9–10μ; sterigmata 4, 4–5μ long. Cystidia not seen; pore-edges more or less gelatinised without cellular structure. Surface of the pileus composed of more or less divergent (–70μ) or appressed, laxly interwoven, uninflated hyphae 3–6μ wide with slightly thickened walls, not encrusted, not as a pile. Surface of the stem sterile except the stem-apex, composed of narrow longitudinal hyphae 3–6μ wide divergent in massive array to form the peronate scales or annuli; hyphal ends in the scales uninflated or as small clavate end-cells –40 × 12μ, as vesicular cells –16μ wide, or subfusiform but not set in a regular layer; internal hyphae of the stem –14μ wide, longitudinal, without clamps, often secondarily septate, at the base of the stem 3–8μ wide with slightly thickened walls, very compact, without chlamydospores. Tube-trama phylloporoid, composed of longitudinal hyphae 4–8μ wide, gradually divergent, rather firmly gelatinous and somewhat swollen in alcohol-formalin.

This species is distinguished by the peronate scales of the stem. In the collection P–144 it seemed that they are formed by the cracking of the stem-surface, but in P–142 they were firm as massive outgrowths of hyphae though evidently spaced peronately by the elongation of the stem. In this respect the species resembles *B. borneensis* Corner (1972, p. 106), which differs in the richer colour, cyanescent flesh, longer spores and boletoid tube-trama. Possibly *B. peronatus* is related with *B. graveolens* Corner. On stem-character the species belongs in subgen. *Leccinum*. It will go in the artificial key to Malasian boleti in Group G (Corner 1972, p. 50) after *B. sylvestris*. Compare the following species with yet shorter spores.

B. squarrosipes sp. nov. — Figure 1d.

Pileus 7 cm, viscidus, pallide cervino-brunneus. Stipes 6 cm × 12 mm, siccus, concolor, squamulis brunneolis furfuraceo-squarrosus; mycelio albo. Tubi 6 mm longi, sinuati, pallide flavo-virides; poris 0.5–0.8 mm, tubis concoloribus. Caro alba immutabilis. Sporae 6–7.5 (–8) × 5–6μ, in cumulo olivaceo-brunneae, laeves.

Ad humum sub arboribus. Malaya, Selangor, Kepong, Corner P–191 (CGE) 1 Sept. 1972.

Pileus 7 cm wide, plane, smeary-viscid, pale fawn brown. Stem 6 cm × 12 mm, rather stout, fibrous, dry, pale fawn brown, in the upper two-thirds coarsely squarroso-furfuraceous with pale brown particles or squamules; mycelium white. Tubes –6 mm long, sinuate, pale greenish yellow; pores 0.5–0.8 mm, pale greenish yellow. Flesh white, yellowish above the tubes, in the stem brownish, unchanging.

Spores olive brown in the mass, 1-guttate, smooth. Basidia 25–30 × 9.5–11μ, 4-spored. Cystidia –46 × 7–11μ, fusiform subventricose with the apex 3–4μ wide, thin-walled, sparse on the pore-edges and on the tube-surfaces. Surface of the pileus composed of appressed hyphae 3–8μ wide with mucilaginous walls and brown sap, with scattered larger hyphal ends 9–18μ wide (as if relics of a pile of hyphal ends). Surface of the stem with the squarrose particles consisting of the narrow superficial hyphae of the stem divergent in tufts and bearing a dense patch of sterile hymenium composed of clavate cells and subventricose cystidia –55 × 11μ, rarely with fertile basidia, and with occasional larger and shortly septate hyphal ends with the cells 20–45 × 9–13μ (as the larger hyphal ends on the pileus). Hyphae of the stem –18μ wide, longitudinal, without clamps. Tube-trama subboletoid, rather soft and sloppy in alcohol-formalin, with longitudinal hyphae –9μ wide.

This fungus, like the preceding, recalls *B. borneensis*. Compare, however, *B. lubricus* with viscid umber pileus, merely pruinose stem, and larger spores. *B. squarrosipes* will go in Group C of the artificial key to Malaysian boleti (Corner 1972, p. 42) next to *B. lubricus*.

subgen. *Punctispora* subgen. nov.

Statu ut in subgen. *Boletello*. Sporae in cumulo olivaceo-brunneae, elongato-ellipsoideae, verrucis v. echinulis in exosporio hyalino praeditae. Tubi adnexi ventricosi v. subliberi, olivacei v. flavidi dein olivacei; trama plus minus phylloporoidea. Stipes reticulatus v. sublacunoso-reticulatus. Hyphae sine fibulis. Typus, *B. punctisporus* sp. nov.

This subgenus may be described as *Boletellus* with internally verrucose, not striate, spores. It is based on the following species *B. punctisporus* from Sarawak, which turns out to be an unexpected ally of the North American *Boletus betula* Schw. The fruit-bodies of *B. punctisporus* combine the characters of several sub-genera or genera. They have the long, red, reticulate stems of *Heimiella,* the marginal flange or veil of the pileus so conspicuous in subgen. *Austroboletus* and *Boletellus,* and the yellow to olivaceous tubes with olive-brown spores of *Heimiella, Boletellus* and *Boletus* s. str.

Microscopically the spores have distinctive markings, caused by internal papillae in the exospore, such as have been described for *B. betula* by Singer (1945), Snell and Dick (1970), and Grand and Moore (1971). The same markings occur in subgen. *Austroboletus* but its spores are purple-brown or vinaceous and its tubes, which lack the yellow and olive colours, have the mucilaginous boletoid trama.

For *B. betula,* now usually referred to *Boletellus,* there is already the special section *Allospori* Singer. The discovery of *B. punctisporus* shows that the two species are part of an alliance equivalent to *Boletellus* (striate spores) or *Austroboletus,* within which sect. *Allospori* is distinguished by the viscid pileus without marginal veil. Two other species may belong. *Boletellus purpurascens* Heinem. of the Congo and *B. schichianus* (Teng et Ling) Teng of China have verrucose spores. The illustration of the spore of *Porphyrellus subflavidus* (Murr.) Singer, given by Grand and Moore (1971), is like that of *B. betula* but the end of the spore is smooth as in subgen. *Austroboletus,* and the tubes and spores of this species evidently lack the olive colour; hence I retained it in subgen. *Austroboletus* where it fits closely (Corner 1972).

B. punctisporus sp. nov. — Figure 1b.

Pileus –6 cm latus, convexus, siccus, villosus, fusco-brunneus, dein in squamulis cuti-fractus; margine primo ut membrana floccosa –10 mm lata tubos excedenti, dein e pileo exscisso et ad stipitem annuliformi collapso. Stipes –11.5 cm × 12 mm, ad basim 7 mm latum attenuatus v. basi subdiscoideo, plerumque elongato-reticulatus, furfuraceus, purpureo-ruber, basim albovillosum versum laevis brunneus. Tubi –17 mm longi, adnexi, ventricosi, olivacei; poris 0.5–0.8 mm, olivaceis. Caro 9–10 mm crassa, flavidula, sub superficie pilei stipitisque rubra, supra tubos subcyanescens. Sporae 14–19 × 7–8μ, in cumulo olivaceo-brunneae, membrana hyalina punctata inclusae, ad apicem porosae, endosporio 0.7μ crasso colorato, nec alatae nec striatae, apiculo 0.5μ longo.

Sarawak, Bako National Park, leg. E. J. H. Corner P–154, 25 Aug. 1972, P–154A (typus CGE) 28 Aug. 1972.

Pileus –6 cm wide, convex, dry, villous, snuff-brown or fuscous brown, then cracked into small squamules; margin exceeding the tubes as a floccoso-membranous flange –10 mm wide, splitting from the pileus and collapsing as a ring on the stem. Stem –11.5 cm × 12 mm, attenuate to the base 7 mm wide or the base slightly dilated and subdiscoid, rather dull purplish red, with a concolorous reticulum of shallow and narrow, elongate meshes, rough with scurfy purple-red flecks scattered on the reticulum, smooth and brownish near the white villous base; mycelium white. Tubes –17 mm long, adnexed, ventricose, dull olive; pores 0.5–0.8 mm wide, dull olive. Flesh 9–10 mm thick in the centre of the pileus, pale yellow, over the tubes deeper yellow and slightly cyanescent on exposure, dull red below the surface of the stem and pileus, not otherwise cyanescent or rufescent.

Spores olive-brown in the mass, ellipsoid, obtuse, the hyaline exospore surrounding the brown ovoid endospore (11–15 × 6–7μ) and pierced by fine processes appearing as hyaline dots on the surface of the exospore, the endospore-wall 0.7μ thick, 1–2-guttate, apiculus 0.5μ. Basidia 14–16μ wide, pyriform clavate; sterigmata 4. Cystidia ? lanceolate-ventricose, as the caulocystidia, but sparse. Surface of the pileus with a thick pile –200μ high, eventually disrupted into squamules, composed of more or less moniliform hyphae with cells 25–75 × 8–19μ, the end-cells subclavate or subventricose. Stem with a more or less disrupted hymenium of fertile and, mostly, sterile basidia, with scattered projecting, lanceolate or subventricose, thin-walled cystidia –60 × 7–10μ. Hyphae of the stem –15μ wide, secondarily septate, without clamps. Tube-trama more or less phylloporoid.

In the forest this species may be mistaken for *Heimiella retispora* or *H. subretispora*, which lack the marginal flange or veil of the pileus. In the collection P–145A the base of the stem was subdiscoid as in various species of *Boletellus*.

subgen. *Tylopilus* Karst.

B. ballouii Pk. var. *fuscatus* Corner (1972) p. 194.

Sarawak, Bako National Park, Corner P–173, 27 Aug. 1972.

B. coccineinanus Corner (1972) p. 152.

Java, Sukabumi district, Tjiletuh, Corner J–21, 29 April 1972, scattered singly along an earth-bank at the edge of the forest, but not infrequent.

These specimens differed from the Malaysian merely in the red-brown, rather than crimson, pileus, the wider stem (1.5–2 mm), the slightly redder pores (crimson when young, fading on expansion), and the yellow (not orange-yellow) mycelium. The spores under the microscope were pale ochraceous without olive tint. The tubes were white, then pink, without a yellow or olive tint.

B. longipes Mass.; Corner (1972) p. 165.

Sarawak, Bako National Park, Corner P–143, P–143A, P–143B, P–143C, 25–28 Aug. 1972.

This was a common species, either solitary or occasionally in small troops, both in the dipterocarp forest and in the *kerangas*-forest of the plateau. The spores had in all the collections the characteristic blood-red colour in the mass, and the blackening with potash, but there were differences in size; in P–143B the spores were typical, 11.5–16 × 4.5–5.3μ; in P–143A and P–143C they were 12–14 × 4.5–5.7μ; in P–143 they were 10–13 × 4.5–5.2μ. I did not find var. *latisporus*.

The reticulations of the stem become more pronounced in older specimens. On most the longer ventricose caulocystidia become slightly but distinctly thick-walled at the base.

var. *alba* var. nov.

Receptacula alba; tubis porisque maturis pallide olivaceis, dein subroseis. Sporae 12.5–16 × 4.2–4.5μ, in cumulo purpureo-vinaceae, in KOH nigrescentes.

Sarawak, Bako National Park, Corner P–184 (CGE) 28 Aug. 1972, ad humum in silva *kerangas*.

Pileus 6–9.5 cm. Stem 4–6.5 cm × 7–10 mm above, 12–16 mm at the base, wholly shallowly and irregularly reticulate, the meshes elongate in the lower part of the stem. Tubes 7–12 mm long; pores 1–1.5 mm wide.

About 30 fruit-bodies were found scattered in one patch of the *kerangas* forest. They differed from typical *B. longipes* only in being pure white, except for the maturing tubes and pores. The tube-trama was boletoid with narrow, compact, medullary hyphae 2.5–5μ wide, and more mucilaginous cortical hyphae 4–8μ wide. The trama remained firmly gelatinous in alcohol-formalin.

B. nanus Mass.; Corner (1972) p. 150.

Sarawak, Bako National Park, scattered in small groups in *kerangas* humus, 26 Aug. 1972.

B. tristior sp. nov.

Pileus 5–8 cm latus, convexus dein planus v. concavus, siccus, fuligineo-umbrinus dein sordide brunneo-umbrinus, minute pruinoso-velutinatus et cutifractus. Stipes 3–5 cm × 10–15 mm, subventricosus, subconcolor, ex integro minute fuscobrunneo-pruinosus, ad basim mycelio albo villosus, haud reticulatus. Tubi –11 mm longi, adnexi, ventricosi, fere liberi, pallide griseo-rosei; poris 0.5–0.8 mm latis, pallide roseis. Caro 8–10 mm crassa, alba firma immutabilis. Odor subnullus. Sporae 9.5–12.5 (–16) × 3.5–4.2μ, in cumulo pallide roseae, laeves.

Ad humum, solitarius, sparsus. Sarawak, Bako National Park, Corner P–156, 26 Aug. 1972.

Basidia 28–33 × 9–10μ; sterigmata 4. Cystidia 40–85 × 6–18μ, more or less ventricose, obtuse, not distinctly appendaged, thin-walled, multiguttulate, not red-brown in potash, frequent on the tube-surface and pore-edges. Surface of the pileus with a very short and compact pile 45–65μ high, composed of 1–3-septate hyphae 4–12μ wide, the cells 7–33μ long, with brown walls, cylindric or submoniliform. Stem-surface with an interrupted and more or less sterile hymenium of clavate cells 16–28 × 4.5–12μ and subventricose cystidia –60 × 7–10μ. Hyphae of the stem –12μ wide, secondarily septate, without clamps; at the surface of the stem 2.5–5μ wide, very compact, with slightly thickened walls. Tube-trama sub-boletoid, with a medulla of narrow hyphae, the larger hyphae –10μ wide and scarcely divergent, little swollen and rather firm in alcohol-formalin.

This species strongly recalls *B. albo-ater* Schw. but the tubes are strongly ventricose and the tissue is not rufescent-nigrescent. It comes near to *B. funerarius* Mass. which has a rich brown pileus and stem, shorter spores, and a strong smell; both have the firm flesh, particularly at the surface of the stem. In the key to *Tylopilus* for Malaysian boleti (Corner 1972, p. 147) the species comes after *B. cervicolor*.

B. viridis (Heinem. et Gooss.) Corner (1972) p. 197.

Pileus with small, pale olivaceous grey squamules under the gluten, crowded over the centre. Stem 3–4 cm × 5–7 mm above, 5 mm at the base, cylindric or attenuate downwards, at first white and pale fuscous olivaceous pruinose, then viscid; mycelium white. Tubes 6–8 mm long, sinuate-adnate, pale pinkish ochraceous; pores pale pinkish ochraceous. Spores 11.5–15 (–17) 4–4.7μ, –5.5μ wide in P–153B, in the mass fuscous ferruginous or tinted chocholate, golden brown under the microscope. Cystidia not seen. Trama boletoid.

Sarawak, Bako National Park, solitary in humus, Corner P–153, 26 Aug. 1972, and P–153A, 28 Aug. 1972. — Malaya, Pahang, Fraser's Hill, Corner P–153B, 6 Sept. 1972.

There are slight differences from previous Malayan collections, such as the squamules under the viscid layer of the pileus, the stem at first pruinose then viscid (as in *B. thibetanus*), and the colour of the tubes and pores. The species has some similarity with *B. nanus* Mass.

subgen. *Xerocomus* (Quél.) Konrad

B. albipurpureus sp. nov.

Pileus 7 cm latus, convexus (vix maturus), siccus, minute villoso-subtomentosus, purpureo-brunneus. Stipes –11 cm × 15 mm, subcylindricus, in parte superiori longitudinaliter rugulosus, haud reticulatus, ex integro minute furfuraceo-pruinosus, concolor vel basim versus fuscobrunneus; mycelio albo. Tubi –10 mm longi, sinuato-adnati, pallide olivacei; poris 0.5–1 mm latis, pallide flavido-olivaceis. Caro alba, sub superficie pilei purpureo-brunnea, immutabilis. Sporae 14–20 × 5.5–6μ, in cumulo olivaceo-brunneae, boletoideae, laeves, (an laevissime striatae ?).

Ad humum in silva, solitarius. Sarawak, Bako National Park, Corner P–155, 26 Aug. 1972 (CGE).

Basidia 32–43 × 11–12.5μ; sterigmata 4. Pleurocystidia 67–105 × 16–25μ, ventricose with a rather short and obtuse or subcapitate appendage –25 × 7–10μ, thin-walled, copious. Surface of the pileus with a more or less interrupted pile of cylindric or submoniliform hyphal ends –270μ long, the cells 20–90 × 5–11μ, with slightly thickened and thinly encrusted walls. Surface of the stem with a disrupted hymenium of fertile and sterile basidia, scattered ventricose cystidia often larger than the pleurocystidia with the apex –18μ wide, and numerous filiform hyphal ends –80 × 3–5μ with the tips 2μ wide. Hyphae of the stem –16μ wide, often secondarily septate, without clamps. Tube-trama subboletoid with a narrow medulla of narrow hyphae, the wider hyphae (–12μ wide) scarcely divergent, little swollen and rather firm in alcohol-formalin.

This species comes in the close affinity of *B. ferruginospora* Corner, *B. raphanolens* Corner and *B. variisporus* Corner. It differs in the larger fruit-body with purple-brown pileus and stem, the rugulose stem, and the stout pleurocystidia. The spores agree best with those of *B. raphanolens* which has yellowish flesh and mycelium and rugulose-reticulate pileus. It keys out in Group G (Corner 1972, p. 49) with *B. variisporus*.

B. destitutus Corner (1972) p. 227.

The following collection of a single specimen I refer to this species for convenience. It keys out to *B. destitutus* but the wider spores and richer colouring of the pileus, though not the small fruit-body, suggest *B. satisfactus*. In the study of these small species it is difficult to know, as yet, what are the more critical points, whether the size of the fruit-body, the length or width of the spores, or the cyanescence of the flesh are the more reliable characters than, say, colour or attachment of the tubes. It may be that this collection is a new species with small, richly coloured fruit-body and short wide spores.

Malaya, Penang Hill, 300 m alt., Corner P–68, 29 July 1972, solitary on a bank in the forest. — Pileus 22 mm wide, convex, villous to minutely scurfy velutinate, ferruginous fawn or fulvous cinnamon. Stem 12 × 3.5 mm, attenuate downwards, pale brownish, apex slightly yellowish, minutely pruinose; mycelium white. Tubes sinuato-adnate, pale dingy olivaceous buff; pores small concolorous. Flesh 3 mm thick in the centre of the pileus, pale yellowish white; no part cyanescent.

Spores 6.7–8 (–9) × 5.5–6.2 (–6.7)μ, fuscous olivaceous under the microscope, ovoid, smooth, 1-guttate. Basidia c. 30 × 10–11μ, 4-spored. Cheilocystidia as sterile basidia. Pleurocystidia ? (not seen). Surface of the pileus with a pile of submoniliform hyphal ends –250μ long, some –400μ long, with the cells 18–60 × 8–18μ, the end-cells obtuse and subclavate. Surface of the stem with a disrupted sterile hymenium of clavate cells 20–34 × 7–12μ, with scattered narrow excrescent hyphal ends 3–5μ wide. Hyphae –23μ wide in the stem, without clamps. Trama phylloporoid, with hyphae 3–14μ wide.

B. nugatorius Corner (1972) p. 224.

I refer here with doubt the following Javanese collection. It has the spores and wide superficial hyphae of the pileus of *B. junghuhnii* but lacks the red colour in the stem and the cyanescence of the pores. In shape and colour of the fruit-body, but neither in its size or viscid pileus, it recalls *B. thibetanus.*

Java, Tjibodas, Corner J–6, 11 April 1972, solitary on the ground in the forest. — Pileus 3 cm wide, convexo-plane, dry, finely tomentoso-villous, purplish brown, then minutely cracked with the yellow flesh showing. Stem 4 cm × 4 mm, attenuate upwards, pale brownish yellowish, minutely yellowish scurfy; mycelium white. Tubes adnexed, olive-yellow; pores 0.3–0.5 mm wide, angular, unequal, yellow to olive. Flesh pale yellow, no part cyanescent.

Spores 10.5–12 × 4.5–5μ, pale ochraceous under the microscope. Cystidia ventricose, not appendaged, 11–20μ wide, thin-walled, scattered in the tubes. Surface of the pileus with a pile –180μ high, composed of moniliform hyphal ends with cells 20–50 × 12–30μ, the end-cells subclavate and obtuse. Surface of the stem with a disrupted sterile hymenium, no ventricose cystidia seen. Tube-trama phylloporoid.

B. setigerus sp. nov. — Figure 1a.

Pileus 15 mm latus, siccus, tomentosus, livido-ochraceus. Stipes 15 × 2 mm, fibrillosus, haud reticulatus, pallide ochraceus; mycelio albo. Tubi 3 mm longi, sinuati, albi dein flavidi; poris 0.5 mm latis, flavidis. Caro 4 mm crassa, alba immutabilis. Sporae 6.8–8.3 × 4.5–5μ, ochraceo-incarnatae s.m., laeves. Pleurocystidia –110 × 11–25μ, ventricosa, obtusa, crassitunicata. Superficies pilei ex hyphis angustis appressis instructa.

Ad ripam juxta silvam, solitarius. Java, Sukabumi distr., Tjiletuh, Corner J–29 (CGE), 30 April 1972.

Pileus convex, dry, opaque, thinly subtomentose, pale livid ochraceous. Stem slightly thickened to the base 3.5 mm wide, pallid ochraceous buff, then pale fuscous from the base upwards. Flesh slightly yellowish in the stem.

Spores pale pinkish subochraceous under the microscope, ellipsoid obtuse, even subreniform, smooth, 1–2-guttate, slightly darker in Melzer's iodine. Basidia 33–42 × 9.5–11μ, 4-spored. Cheilocystidia 40–65 × 7–12μ, fusiform to subventricose with obtuse, not prolonged, apex 3–6μ wide, the walls 0.5–1.5μ thick in the free part of the cystidium but not at the apex. Pleurocystidia –110 × 11–25μ, ventricose with obtuse, not prolonged, apex 6–9μ wide, varying subfusiform but

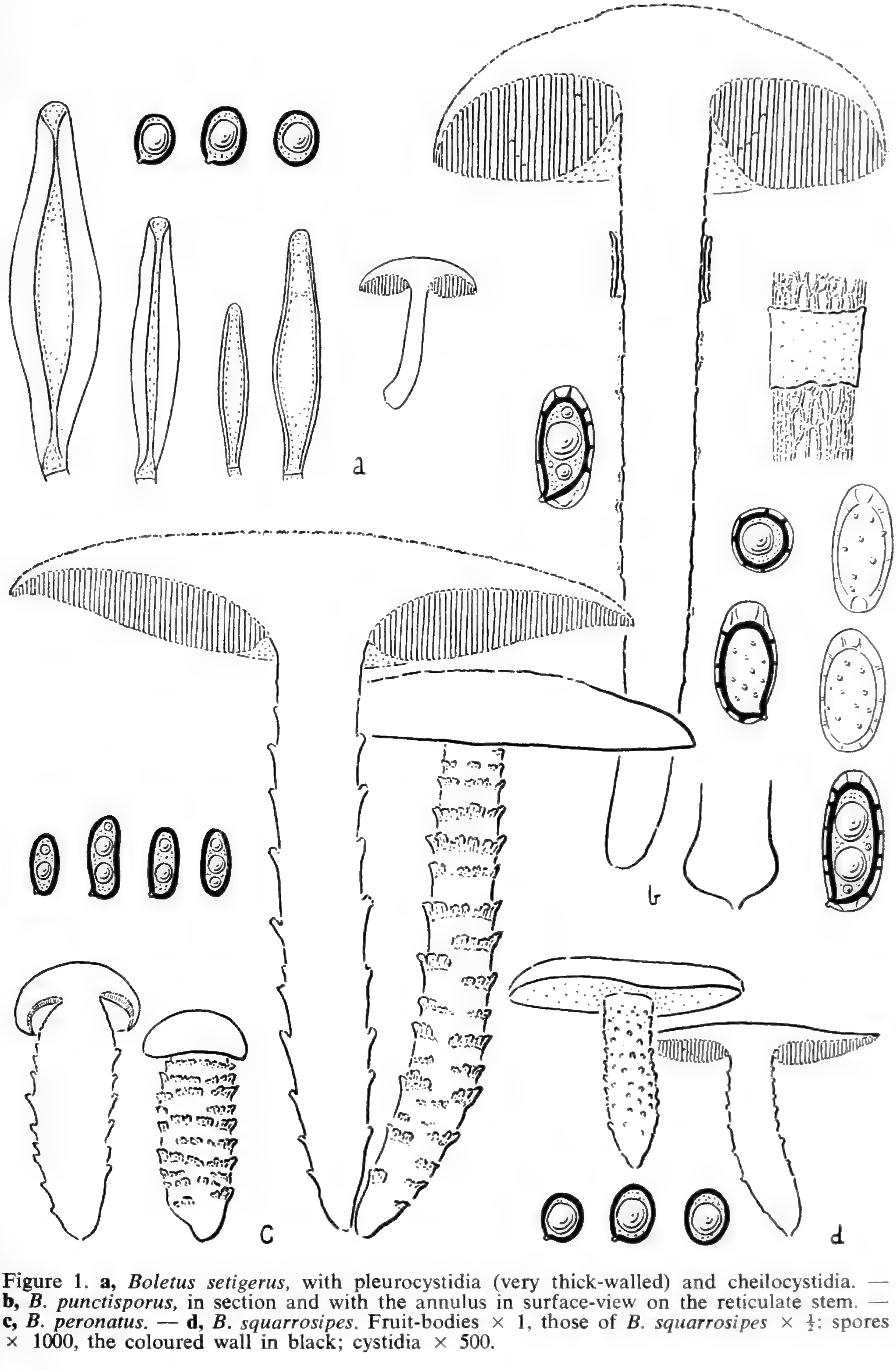

Figure 1. **a,** *Boletus setigerus,* with pleurocystidia (very thick-walled) and cheilocystidia. — **b,** *B. punctisporus,* in section and with the annulus in surface-view on the reticulate stem. — **c,** *B. peronatus.* — **d,** *B. squarrosipes.* Fruit-bodies × 1, those of *B. squarrosipes* × ½; spores × 1000, the coloured wall in black; cystidia × 500.

always obtuse, the wall very strongly thickened, the lumen narrow, projecting, the subhymenial base 5–7μ wide and thin-walled but not dilated, with transitions to the cheilocystidia near the pore-edges. Surface of the pileus composed of appressed, interwoven, uninflated hyphae 3–6μ wide, without a pile of hyphal ends. Tube-trama with rather toughly mucilaginous longitudinal hyphae –12μ wide. Hyphae without clamps.

This small species of pallid colour seems near to *B. aculifer* Corner and *B. hastulifer* Corner, and to the much larger *B. olivaceiluteus* Corner (with acute cystidia), but all these have a conspicuous pile of hyphal ends on the pileus. The colour of the spores suggest that *B. setigerus* may belong in subgen. *Tylopilus*. With these doubts, the species comes at the end of the key to Group I of Malaysian boleti (Corner 1972, p. 52).

GYROPORUS Quél.

G. castaneus (Fr.) Quél.

Java, Sukabumi district, Lengkong, Corner s.n. 29 April 1972, solitary in the forest.

HEIMIELLA Boedijn

H. retispora (Pat. et Baker) Boedijn

Pileus rose-red, then paler and brownish red on expansion. Flesh lurid yellow, orange-yellow in the stem, not cyanescent.

In humus of dipterocarp forest, gregarious in compact troops. Sarawak, Bako National Park, Corner P–160, 26 Aug. 1972, and P–160A, 28 Aug. 1972.

These specimens were typical except for the lack of cyanescence. I think that *H. japonica* is at most a variety. One has to be careful now not to mistake this in the forest for *Boletus punctisporus* with marginal flange to the pileus and pale yellow flesh.

PHYLLOPORUS Quél.

P. squamosus sp. nov.

Pileus 6–8 cm, convexo-planus, siccus, tomentosus, purpureo-brunneus dein fusco-cervinus et squamulis fibrilloso-fasciculatus. Stipes 5–6 cm × 7–9 mm, subcylindricus, cervino-brunneus, ex integro brunneo-pruinosus; mycelio albo. Lamellae alte decurrentes, confertae, alte et late poroideo-anastomosae, albidae dein pallide brunneae. Caro 6–8 mm crassa, albida dein flavidula, in stipite brunneola, immutabilis. Sporae 8.3–10.3 × 4.5–5.3μ, in cumulo ochraceo-brunneae, laeves. Cystidia 50–128 × 14–20μ, copiosa, tenuiter tunicata. Hyphae sine fibulis.

Ad humum sub *Quercu*. Sarawak, Bako National Park, Corner P–141 (CGE), 25 Aug. 1972.

Pileus 6–8 cm wide, convex then plane, not umbonate, dry, brown tomentose tinged purple, then fuscous fawn and splitting into fibrilloso-fasciculate squamules larger in the centre and smaller towards the subtomentose margin. Stem 5–6 cm × 7–9 mm, subcylindric or slightly tapered downwards, or flattened –11 mm wide, fawn brown, wholly minutely brown pruinoso-subfurfuraceous, weathering smooth, base thinly white villous. Gills deeply decurrent, rather crowded, 27–30 primaries

6–8 mm wide, 3–4 ranks, not dichotomous, becoming deeply and widely poroid from the stem to the outer part of the limb with transverse and oblique ridges forming meshes 2–4 mm wide radially, the reticulations not reaching the gill-edges, thus persistently lamellate with deeply poroid-reticulate interstices, whitish then rather pale fawn brown. Flesh 6–8 mm thick in the centre of the pileus, spongy, pallid white tinged yellowish, in the stem pale brownish, not changing colour on exposure or bruising.

Spores not darkening in potash. Basidia 34–40 × 9.5–11μ; sterigmata 4, 4.5μ long. Cystidia 50–128 × 14–20μ, cylindric to subventricose, apex obtuse, projecting, thin-walled, abundant on the gill-surface and along the fertile edge. Surface of the pileus with a disrupted pile of hyphal ends –800μ long, forming the fibrillose squamules, composed of subcylindric rows of cells 23–85 × 8–18μ, the end-cells obtuse or more or less attenuate (even subappendaged), with brown contents and thin brown incrustation. Surface of the stem covered with a disrupted sterile hymenium of subclavate and immature basidia and rather scattered cystidia (as on the gills). Hyphae of the flesh 3–18μ wide, without clamps; longitudinal in the stem with the cells 25–120μ long, 3–6μ wide at the surface of the stem, and with somewhat thickened walls in the interior of the stem. Gill-trama with mucilaginous longitudinal hyphae 5–15μ wide.

This species with such deeply alveolate-reticulate gills comes in size of fruit-body between the Malayan *P. ochraceobrunneus* Corner (1970) and the north temperate *P. rhodoxanthus* (Shw.) Bres.; it differs from both in the pallid (not yellow) gills, the squamulose pileus, and the short spores. It may be closer to the Malayan *P. bellus* (Mass.) Corner which has the small spores, also pale under the microscope, a merely villous-subtomentose pileus, and yellow gills reticulate only at the base. The North American *Boletinus squarrosoides* Snell et Dick (Mycologia 28, 1936, 468), referred later to *Phylloporus* and now to *Xerocomus,* may also be related; it differs in the more or less reticulate yellow stem, yellow gills poroid in the outer part of the pileus, and the narrow spores (7–10 × 3.5–4.5μ). Compare, also, *Paxillus squarrosus* McNabb (1969) with dichotomous, not poroid, gills and rufescent flesh.

P. stenosporus sp. nov.

Pileus 4 cm latus, siccus, subtomentosus v. fere laevis, pallide cervino-brunneus, aetate subgriseus. Stipes 22 × 7 mm, basim versus attenuatus, brunneo-albidus, ex integro albido-pruinosus; mycelio albo. Lamellae decurrentes, subdistantes, primariae c. 30, 3–4 mm latae, ordinibus 3–4 instructae, nec reticulatae nec dichotomae, flavidae. Caro crassa, albida, in stipite brunneola, immutabilis, Sporae 9.5–11.5 (–12.5) × 3.7–4.2μ, ochraceae s.m., laeves, 2–3-guttatae. Cystidia 60–120 × 14–20μ, tenuiter tunicata, copiosa.

Ad ripam juxta silvam, solitarius. Java, Sukabumi distr., Tjiletuh, Corner J-23 (CGE), 29 April 1972.

Spores narrowly boletoid, not amyloid, not darkening in potash. Basidia 9–10μ wide, 4-spored. Cystidia 60–120 × 14–20μ, ventricose with slightly prolonged obtuse apex 6–9μ wide, varying clavate or subcylindric, tapered into the narrow subhymenial base, abundant on the gill-surface and edge. Surface of the pileus evidently with a pile of inflated hyphal ends –170μ long when young, but the pile becoming flattened and disorganised with age, the hyphae cylindric or, if short-celled, then submoniliform, the cells 18–120 × 8–17μ, the end-cells obtuse. Stem with a disrupted sterile hymenium. Hyphae 8–20μ wide, without clamps.

The pale narrow spores distinguish this species which seems near to the slender *P. brunneolus* Corner (1970) which has rufescent flesh and slightly cyanescent gills.

STROBILOMYCES Berk.

S. velutipes Cke et Mass.

Pileus with appressed scales. Stem reticulate only at the apex. Flesh slowly turning red then black.

Sarawak, Bako National Park, Corner P–159, 26 Aug. 1972; Semanggoh Forest, Corner s.n., 19 Aug. 1972.

References

Coker, W. C. and Beers, A. H. (1943) — The Boletaceae of North Carolina.

Corner, E. J. H. (1970) — *Phylloporus* Quél. and *Paxillus* Fr. in Malaya and Borneo. Nova Hedwigia 20, 793–822.

———— (1972) — Boletus in Malaysia. Government Printing Office, Singapore.

Grand, L. F. and Moore, R. T. (1971) — Scanning electron microscopy of basidiospores of species of Strobilomycetaceae. Can. J. Bot. 49, 1259–1261.

Hongo, T. (1970) — Notulae mycologicae (9). Mem. Shiga Univ. 20, 49–54.

McNabb, F. R. (1969) — The Paxillaceae of New Zealand. N. Z. J. Bot. 7, 349–362.

Singer, R. (1945) — The Boletineae of Florida, with notes on extralimital species. Farlowia 2, 138.

Snell, W. H. and Dick E. A. (1970) — The Boleti of northeastern North America.

Contribution to the Knowledge of Cecidia of Singapore

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This report is based on the author's thesis for the "Diplome d'Etudes Approfondies" presented before the Faculty of Science, University of Paris, in July 1970. The work was done partly at the Department of Botany of the Singapore University in 1968–69, which is under the direction of Professor A. N. Rao, and partly in Paris in the Laboratory of Tropical Botany in 1969–70 under the direction of Professor R. Schnell.

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INTRODUCTION

I began my study in cecidiology in Singapore where material was collected during the academic year 1968–69, and where subsequently I have had the opportunity to enrich my collection and to make new observations during two study trips in January and April 1970.

Singapore is a small island in the Malesian Region, situated at a latitude of 1° 21′ North. It is exposed, at the same time, to an equatorial climate and a monsoon climate, uniformly hot and humid, nonetheless temperate because of the presence of the sea(Bib. 23; fig. la); the average annual precipitation is over 2.41 m. with seasonal maximums staggered from November to January.

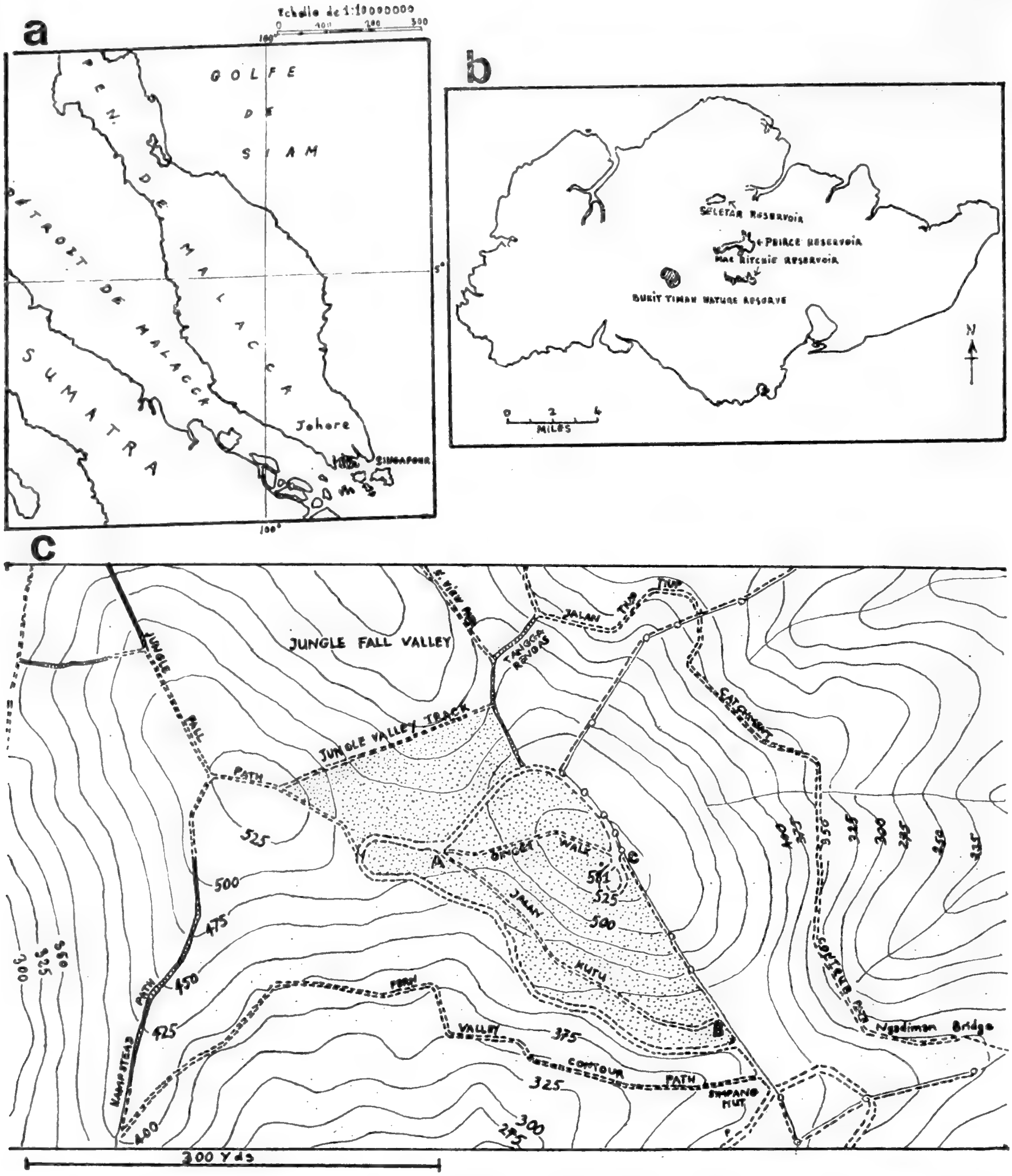

Fig. 1. **a**, location of Singapore adapted after the "Nouvel Atlas Général" (Bordas ed.); **b**, map of Singapore adapted after "Modern Singapore" (1969. Ooi Jin-Bee, Chiang Hai Ding ed., 285 pp.); **c**. part of the Bukit Timah Nature Reserve, adapted after an unnumbered plan. The stippled area represents my field of study. Contour numbers are in ft.

Meanwhile, in the course of "winter" 1968–69 rains were unusually low. This climatic anomaly certainly influenced the flora and its pathology, and therefore must have affected my results. I unfortunately cannot assess the importance, having made my observations over such a short period. Material was collected leisurely during walks in private gardens and along the wayside. A limited area in the Bukit Timah Nature Reserve was chosen for systematic collecting and study (fig. 1, *b* & *c*). This Reserve is according to H. M. Burkill*, a block of 184

* H. M. Burkill: A Survey of Nature Conservation on Singapore Island. The Proceedings of the Ninth Pacific Science Congress, 1957. Vol. 7, 1959.–pp. 34-37, 1 map.

acres of lowland forest clothing Bukit Timah (Malay for "Hill of Tin"). It is granite and without any tin deposits. With its two peaks both slightly over 525 ft the Reserve is the highest ground on Singapore Island. It is one of the first Forest Reserves made after Cantley's report* and has never been exploited for timber.

One should note that a large number of *Shorea curtisii* King** saplings which compose the undergrowth in my field area, is the result of the germination of anemochorous and heliophilic seeds. This testifies to a recent thinning of the forest.

Under "Material and Technique" is a description of the method I have used and perfected for my study. The cecidia that I have collected are listed with notes. This list follows the style of those of Houard (Bib. 28), and of W. and J. Docters van Leeuwen-Reijnvaan (hereafter D. v. L. R.) (Bib. 22), and consists of a succint morphological description of my specimens, illustrated with line drawings and plates. As far as possible, a few morphological and physiological interpretations relative to the process of the cecidiogenesis are given. They are based on the recent works of Strasbourg Laboratory (Bib. 39). Adopting the ideas of Kloft (Bib. 34), Maresquelle and Meyer (Bib. 38), I have included in my list all developmental anomalies of parasitic origin, where the anomaly has bearing on the positive or negative growth, or also on the cellular differentiation.

Historical Review

The only works of importance concerning cecidia in the Malesian Region are those of D. v. L. R. (Bib. 6 to 22), and of Houard (Bib. 28). There are also several previous Indonesian studies generally relevant to the pathology of economic and agricultural plants, unfortunately disseminated in journals of local interest and unavailable even in Singapore. The multiple studies of D. v. L. R. on Indonesian cecidia, complemented by the works of Nalepa (Bib. 40 to 44), on Acarina, and of Karny (Bib. 30 to 32) on the Thysanoptera are of fundamental interest. The systematic list of Houard relevant to the zoocecidia of the whole Malesian Region are of invaluable interest. Nonetheless one must know that the galls of this immense Region fractioned in a pleiad of islands and islets, are far from being well known. No previous cecidiological study in Singapore has been published.

MATERIAL AND TECHNIQUE

Gall Collecting and its Problems

The complete study of each cecidium necessitates much material; several duplicates are required for fixing, making of herbarium specimens, and separately for extricating gall-makers for the purposes of culture and despatch to various specialists for the determination of the host plants and gall-makers.

In the list, gall specimens are numbered in Arabic, identically as the host plant. Where different types of galls are found on the same host, each cecidium is labelled with an additional proper number in Roman.

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*N. Cantley: Report on the Forests of the Straits Settlements. 1883, fide H.M. Burkill.

**All host-plants here published under this name are recently determined, thanks to Dr. K. M. Kochummen, Forest Botanist at the Forest Research Institute in Kepong. They appear under the erroneous name of *Shorea pauciflora* in earlier publications.

In order to make a complete study of a gall, various stages of its development are needed. With some species, these could be found during a single collecting trip, e.g. the mite-galls on *Litsea elliptica* (Bl.) Boerl. and *Actinodaphne* sp. Often, repeated collecting was necessary as is the case of the psyllid-gall on the leaf of *Notaphoebe kingiana* var. *malvescens* Gamble where juvenile stages were found in December-January and late stages only in April. Similarly were the coccid-galls on *Shorea curtisii* King (gall 23I and gall 23IVa) and the wasp-gall (gall 23IVb) on the same host: in December only a few juvenile stages of gall 23I whereas in April a considerable number of young stages were available. On the other hand, in the same interval, juvenile stages of 23IVa and 23IVb were totally absent. The wasp-gall (gall 120) on *Lithocarpus conocarpus* (Oudem.) Rehd. was first collected end March 1969 when it detached itself from the leaf, taking with it the larva in the fall. Despite methodic collecting March-September 1969, and in January 1970, that type of gall was not seen again. Finally in April 1970, I found leaves that bore marks of recent drop of galls. These observations lead me to conclude that galls 120 have a rapid development in February and March.

The observations above seem to confirm those made in temperate climates (Mani — Bib. 36. p. 197) to the effect that the majority of cecidia would develop strictly during a definite moment of vegetative growth of the host plant. Previous publications on the development cycle of galls refer to work in temperate climates (ibid. Chap. X, pp. 196–212) where the seasonal alternation fundamentally influences the vegetative rhythm of the host plant. No study has yet been made in the humid tropics where inspite of the absence of prominant seasons certain galls seem to have their own rhythm of development.

These observations suggest that a statistical correlative study in the tropics would be interesting. It would perhaps be possible to establish a calender of gall development in Singapore in relation to the climate cycles, the internal rhythm of growth of the host plant and the cycle of the development of the gall-makers.

PRESERVATION OF THE COLLECTION

The most complete botanical specimen, carrying flowers and fruit if available, and the one with the least parasites are reserved for determination. Several parts of which the galls are well formed, ripe or already opened, are kept for the herbarium. One important part is put aside for obtaining or rearing the gall-makers. Juvenile or intermediate stages are fixed with F.A.A. for a morphological and anatomical study of the development.

Herbarium. For each type of gall two sets of herbarium sheets were made. One set is now at the Laboratory of Tropical Botany of Paris, the other at the University of Singapore, Botany Department.

The conventional techniques including the drying under pressure used for preservation in the herbarium are not to be recommended in many cases. Certain galls have a characteristic relief and a disposition which are useful to preserve. One can, for this reason, dry out the plant-part carrying the galls in a crystal powder of $CuSO4$ dehydrated by heat before use. However this method presents the inconvenience of crowding and material prepared this way is very fragile.

Fixing in F.A.A. After drying, the fleshy galls shrink and become unrecognisable. It is better to fix them with F.A.A. I intend to make more precise anatomical and morphological study of the development of the galls subsequently. In this study a series of permanent hand-sections were made by using a method taken from Johansen (Bib. 29): (*a*) technique of fixation, sectioning, staining (p. 102); (*b*) schedule of dehydration by T.B.A. (pp. 110–113). From these sections it was possible to make anatomical observations on certain cecidia which are listed.

Using the methods described above, more than one hundred galls were collected and preserved. This collection represents only a fragment of the galls in Singapore. Based on the 1536 numbers of galls of Indonesia, as given by D. v. L. R. (Bib. 22, p. 31), it is anticipated that the present collection will grow considerably in the years to come.

OBTAINING AND NAMING GALL-MAKERS AND INIQUILINES

This study necessitates much time and patience and can only be achieved by a resident worker in the area. Adult gall-makers are difficult to obtain in sufficient numbers to permit a determination. Thus my conclusions are very fragmentary and incomplete. There is no general method for obtaining parasites: the technique to be employed depends largely on the type of the gall-maker.

Mites

With the help of Mr. D. H. Murphy, I have tried out and perfected several methods to obtain mites: —

(*a*) *Showing the gall-mites in situ.* The numerous morphological convergences between mycocecidia and acarocecidia (yellowish or orange swelling of the lamina, hypertrophy of the epidermic cells into hairs, parenchymatous, fleshy growths) had caused some confusion to early cecidiologists. (Mani-Bib. 36, p. 157). A method which can distinguish the presence of acarocecidia from mycocecidia and which stains both mites and fungal mycelium alike (if present) is adapted here from one in use for research on nematodes. So far, fungi are absent in the galls examined. The process is: —

— Section the fresh and dry galls.

— Place them in a test tube and cover with a mixture composed of 5 parts of $H_2 O_2$ (20 vol.) and 1 part of ammonia (880) for 24 hours. This is for decolourization of plant tissues.

— The mixture is discarded and replaced with a solution of Aman's lactophenol mixed with 0.05 gm cotton blue stain.

— After boiling the test tube in a double boiler for 1 hour, leave galls in stain for at least 24 hours.

— The liquid is discarded, specimens are washed with pure lactophenol which is also used as a liquid for preservation.

— Mount specimen in drop of lactophenol.

The cuticle of mites absorb the blue stain but its opacity renders the method unsuitable for specific identifications of acarocecidia. For this the most classic method is one which is perfected by Nalepa (Bib. 40; vol. V; p. 49).

(*b*) *Collecting mites by Nalepa's method.* After driving out the mites from the galls by gradual drying, they should be fixed with heated chloropicric acid. The 70% alcohol stage used by Nalepa is here bypassed because according to Keifer's work cited by Owen Evans, Sheals and Mac Farlane (Bib. 45), alcohol is a bad medium for preserving mites, and these authors preferred to preserve them in the liquid of fixation. With this method a large number of mites can be obtained, but it necessitates much gall-material. On the other hand, I have noticed as did D. v. L. R. (Bib. 22; p. 17), that the success of this experiment depends on the humidity of the air: if the atmosphere is too humid, the gall goes mouldy, and the mites are killed inside.

(*c*) *Collecting mites by soaking methods.* Another technique of obtaining mites, more economical in material and independent of atmospheric conditions, was developed by Keifer as cited by Owen Evans, Sheals and Mac Farlane (Bib. 45; pp. 67–70). Their method of soaking in a solution made of resorcinol (50 g.), diglycolic acid (20 g.), glycerol (25 ml.), iodine water (about 10 c.c.), has been tried without success as I have not been able to needle the mites out of this solution which turned black and thick. That led me to investigate other methods of soaking based on the destruction of cellulose in the plant cell: —

Method I: Soaking in a solution of enzymatic extracts of digestive tubes of a snail; the snail is the only multiple-celled animal capable of digesting cellulose directly.

Method II: Soaking in Schweitzer's solution that dissolves cellulose and not chitin.

INSECTS

I set out to culture gall-midges and wasps, and inquilines but, cecidiological moths and beetles being rarer, did not provide sufficient material for applying the methods described below to culture their larvae: —

(*a*) *Method of D. v. L. R.* (Bib. 22, m. 17). Galls are collected, opened up, and placed with their pupated parasites in a closed tube with a piece of gauze. Many wasps have been obtained by this method. The rearing of Diptera was much more difficult: the pupae of midges were very weak, they dried out and became mouldy. These unpredictable results led me to develop another technique described here.

(*b*) *Placing cages on the gall-bearing plant.* For descriptions and usage of various types of cages see Leach*.

It is necessary to have an opening covered over by a piece of gauze, thereby permitting aeration of the attacked part contained in the cage, and avoiding excess condensation which may cause (1) galls to mould before the opening or (2) the parasites to drown and to decompose rapidly after their exit. This method seems perfectly adapted to the rearing of winged gall-producers. It permits the observer to follow the development of the gall-makers and their cecidea in situ under quasi-natural conditions. The disadvantages are subsequent re-location of cages in the Nature Reserve and risk of destruction of those deposited in public areas. Also, leaves may succumb under the heavy weight of the cage and insects such as wasps and ants tend to cut out the gauze for making nests or to colonise the cages.

Frequently, several different sorts of animals are obtained, e.g. Diptera and Hymenoptera; it is at first sight difficult to discern as to which is the gall-maker, the parasite or the inquiline.

* J. G. Leach: Insect transmission of plant diseases. McGraw-Hill Book Co., Inc. New York and London. 615 pp. 238 figs. 1940.

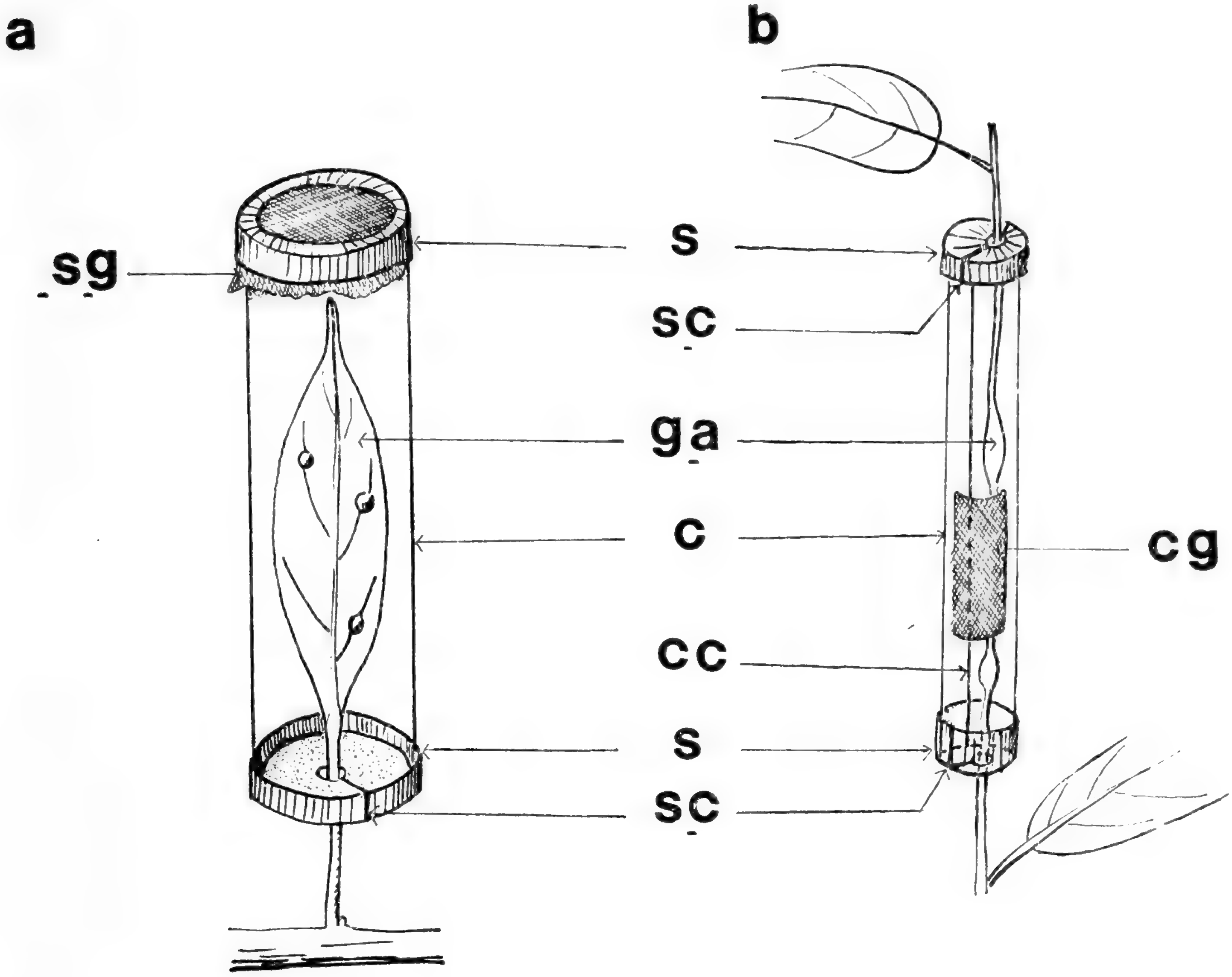

Fig. 2. Cages for rearing gall-makers; **a,** for foliar galls and acrocecidia; **b,** for pleurocecidia. c; transparent plastic cylinder; cc: cylinder cut; cg: gauze glued with chloroform to the cylinder; ga: gall bearing organ; s: perforated plastic stopper; sc: stopper cut; sg: gauze held in position by the stopper.

PROBLEMS ON DISTRIBUTION OF GALLS AND GALL-MAKERS

Range of geographical distribution

Of the hundred galls that are in my collection, only ten have been reported by workers in other parts of Malesia. This applies proportionately also to gall-producers: none of the animal species submitted to specialists for determination has been hitherto described. Thus the list contains many unidentified species. A new genus of Diptera was found on *Calophyllum ferrugineum* Ridl. (gall 68). Another, new genus of Coccidae is *Gallacoccus* with species *G. secundus* (Gall 23 I) and *G. anthonyae* (Gall 23 V) both on *Shorea pauciflora* King described by J. W. Beardsley*.

* J. W. Beardsley: A New Genus of Gall-Inhabiting Eriococcidae from Singapore (Homoptera: Coccoidea). The Proceedings of the Hawaiian Entomological Society, (1971) Vol. 21 (1) 31-39. *N.B.* See footnote on p. 19.

As many as seven different coccid-galls were collected; three occurred on *Shorea curtisii* King (Dipterocarpaceae), one on *Hypserpa cuspidata* (Wall). Miers (Menispermaceae), one on *Calophyllum inophylloide* King (Guttiferae), one on *Xylopia malayana* Hk. f. and Th. (Annonaceae), and one on *Lithocarpus sundaicus* (Bl.) Rehd. (Fagacae). Now, all the works that I have consulted indicate that coccids occupy a minor place among the gall-makers, except in Australia where they attain their maximum development. (Bib. 28, Vol. I, p. 11, Vol. II, p. 590. — Bib. 36, p. 27. — Bib. 22, p. 13). It seems so far that the galls on the flora in Singapore are very special and original; this endemism is certainly linked with the insular character of the region.

On Mount Kinabalu in Borneo, a coccid-gall on a young *Dipterocarpus? gracilis* Bl. was collected by E. J. H. Corner in 1963 (Bib. 2, pp. 339–341). This gall presents many analogies with *Gallacoccus secundus* i.e. gall 23I on *Shorea curtisii* King. The discovery of gall-coccids in Singapore with related representations in Borneo suggests a wider distribution and cecidiologists will perhaps be brought to reconsider the importance of coccids as gall-producers.

Ecological Problems on the distribution of galls

Plants of *Actinodaphne* sp. seemed to me equally spread out on the slope ABC limited by Ginger Walk and Jalan Kutu (fig. 1, c). *Actinodaphne* sp. carries several galls, two of which are caused by midges (gall 24II & 99III, see p. 38). One can find gall II everywhere in this location. In contrast the occurrence of gall III seems strictly limited around point C. Why is the distribution of these two midge-galls not homogeneous? Although a statistic study is necessary to confirm my findings, I can nonetheless, beginning with these observations, show up the problems on the distribution of the gall-makers and their ability to propagate. An ecological study of the habit of these two kinds of Diptera in relation to the variations of the microclimatic factors such as humidity, temparature, sun and others should be also interesting.

Distribution of galls and gall-makers in the different plant families (table 1)

The table here follows the style of D.v.L.R. (Bib. 22, pp. 28–31). It does not claim to embody exhaustive data but the following are noteworthy:

— The plant families of my list carrying the greatest number of different galls are the Dipterocarpaceae, Guttiferae, Myrtaceae, Lauraceae and Euphorbiaceae; the last three correspond to the collections of D.v.L.R. (ibid p. 28).

— Concerning the gall-makers, there are many obscure points. However midges are preponderant among gall-producers and occur in nearly all the regions of the world (Bib. 36, p. 30).

— In Bukit Timah 25 dipterocecidia and 7 acarocecidia were collected. The ratio is comparable to that of 4 : 1 as given by D.v.L.R. (Bib. 22, p. 26) w.r.t. humid forests in S. E. Asia. Future collections will perhaps modify my current results though the present data confirm the assessments of those authors and correspond with data related to forest and climatic types as given by them i.e. to the particularly high humidity of the undergrowth of Bukit Timah forest despite the relative dryness of the November 1968 — January 1969 period.

TABLE 1

Gall-maker	Mite		Midge		Wasp		Moth		Thrips		Psyll		Cocc.		Aphid		Insect		Fungus		?		Total
Plant-families	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a b
Anacardiaceae			2									1											3
Annonaceae		1		2								2		1									6
Apocynaceae																						1	1
Asclepiadiaceae																	1						1
Burseraceae		1		1						1												1	4
Combretaceae	1																						1
Celastraceae																		1					1
Dipterocarpaceae				2		3								3				2					10
Euphorbiaceae				2		1				1		1						1			1	1	8
Fagaceae				1		1		2						1									5
Guttiferae				4				2			1	1	1										9
Lauraceae		3		4						1		2						2					12
Leguminoseae				2						1												1	4
Loganiaceae				1					1														2
Menispermaceae														1									1
Moraceae	1					1			1														3
Myristicaceae										1								1				1	3
Myrsinaceae																		1					1
Myrtaceae						1	1			2	2	4						2			1		13
Rhizophoraceae				1																			1
Rubiaceae				2																		1	3
Sapotaceae				1														1					2
Tiliaceae				1																			1
Verbenaceae		2		1												2			1				6
Vitaceae												1											1
Oleandroideae	1																						1
Total b		7		25																			
Total a+b	10		27		7		5		9		15		7		2		12		1		8		103

b: galls from Bukit Timah Nature Reserve
a: galls from other localities

CONCLUSION

My results show that the gall flora of Singapore is special when compared with those in Malesia hitherto published.

(i) About ten only of the cecidia of my list have been mentioned in previous studies, the other galls appear, for the most part, on host-plants not mentioned in the works of Houard or D.v.L.R.

(ii) Moreover, my coccid-galls appear in the present stage of knowledge as pathological forms particular on the island of Singapore. Also my discoveries of coccids, added to that of Corner in Borneo, commit me to question the dogma generally accepted, i.e. that these Homoptera are hardly important as gall-producers except in Australia.

The list shows that, despite their particularities, my cecidia present certain typical characters of humid tropical regions: abundance in some families such as Lauraceae, Myrtaceae, Euphorbiaceae, and also abundance of gall-midges and thrips.

Certain types of galls, provoked by the same animal genus on the same plant genus are extremely widespread in the tropical world, for example the psyllid-galls on the *Eugenia* genus "distributed from East Africa to the Gambier islands" (Bib. 28, p. 592) are numerous in the Malesian Region (Bib. 28, pp. 593–598; Bib. 22, pp. 407–417), and in particular in Singapore (see list). This poses a phytogeographical problem of distribution and dispersion of the flora with the associated fauna.

Finally, it is noted that, though the action of gall-makers belongs to the same zoological group, galls of identical aspect and structure appear on taxonomically distant plant species. Examples are the ball-shaped, parenchymatous, fleshy midge-galls of my list: gall 168I on *Shorea* sp. (Dipterocarpaceae), gall, 13II on *Grewia blattaefolia* Corner (Tiliaceae), gall 107II on *Calophyllum pulcherrimum* Wall. (Guttiferae). In the formation of a gall two fundamental factors are distinguished: first, the role of the animal and second that of the host-plant. In the cases mentioned above, it would seem that under the influence of certain gall-makers, the same genetic factor of localisation would intervene in the gall morphogenesis.

ANNOTATED LIST OF GALLS

ANACARDIACEAE

Mangifera indica Linn. Gall. 140. Pepis Road (garden).

Midge-gall affecting the two faces of the lamina. Adaxially the cylindrical gall is 1.5 mm to 2.5 mm in diam., and 1 to 1.5 mm in height, often around the gall the lamina is elevated. The distal region of the cylinder has a small lid. Abaxially the gall is cone-shaped: 1.5 to 2 mm high, the diam. of the base 1.5 to 2 mm. Inside is a very small circular larval cavity. The galls on the specimens in Singapore were mostly located along the midrib and side veins.

Distribution: Singapore-Java, Rhio Archipelago, Sebesy Island, Celebes, Malacca. See Bib. 7, p. 107. No. 66, fig. 36–9, p. 187, No. 189.–11, p. 92, No. 12.–15, p. 36, No. 41.–20, p. 303, No. 43.–21, p. 137, No. 53, fig. 28.–22, p. 325, No. 803, fig. 579.–28, p. 467, No. 1719 & ? 1721.

Idem. Gall 82; Singapore, Changi Road, 11½ m.s.

Midge-gall looking like the preceding one but smaller. Adaxially, the cylinder is 1 mm high, and 0.5 mm in diam.; the apex of the cylinder is rounded. That is where the dehiscence by a pore is located. The gall is not surrounded by an elevation of the lamina as in the preceding case. Abaxially, cone of 1 mm high on 1 mm in diam. of base. It seems to correspond to the description of Houard (Bib. 28, p. 467, No. 1721).

Semecarpus sp. Gall 59 & 46. B.T.N.R.

Psyllid-gall. Disc-shaped thickening of the lamina 4 mm in diam. on 1 mm thickness, visible on both faces of the leaf. The exit pore of the gall-maker is abaxial and the tissue around it is slightly elevated.

ANNONACEAE

Artabotrys suaveolens (Bl.) Bl. Gall 22 I, 26 & 127. B.T.N.R. (Pl. 1).*

Midge-gall, attached to one or the other face of the lamina and sometimes to the twig by a large circular base 5 mm in diam. If the leaf is very infected it becomes atrophic. The young gall is horn-shaped, more or less curved, up to 2.5 cm long. In the course of its development, its inferior third part becomes hypertrophic and is 5 mm across; the superior part keeps its conical shape. In the centre of the swollen part is the larval chamber, surrounded by a hard and fibrous shell that digitates into the white parenchyma surrounding it (Pl. 1, e). The gall is covered with a green and glabrous epidermis. In the gall-chamber is only one midge-larva. On maturity the gall cavity is much widened; its wall becomes blackish. The midge makes its way out by piercing a large canal through the wall of the swollen part of the gall (Pl. 1, d, f), and leaves its pupal integument partly inserted in the gall (Pl. 1, b). Very often the gall contains a parasitic moth. There is then deviation of the cecidiogenesis: the swollen part becomes preponderant, reaching 1.4 mm in diam. The superior conical part is reduced to 2 mm in height. The moth larva eats the internal part of the gall and, after metamorphosis leaves the gall through a large circular pore (Pl. 1, c). When the parasite or gall-maker has left, the gall detaches itself easily from the leaf, therefore inducing the formation of an alveole on the lamina (Pl. 1, a, d).

Distribution: Singapore-Java (Bib. 22, p. 185, fig. 285).

Idem. Gall 22 II. B.T.N.R. (Pl. 1, g).

Psyllid-gall, very wide-spread in the Nature Reserve. The lamina is marked by conical elevations, 0.5 mm high, on a base 1 mm in diam., caused by the young psyllids attached abaxially.

Cyathocalyx ramuliflorus (Hk. f. and Th.) Scheff. Gall 100. B.T.N.R. (fig. 15, a).

Mite-gall. Mamiliated pockets that pouch out from the adaxial leaf-surface between the side-veins, 3 to 5 mm high. The interior of the cavity is covered with an erineum that is brown when the gall is adult.

Popovia tomentosa Maingay Gall 70 & 151. B.T.N.R., Jalan Kutu and Jungle Valley. (fig. 13, c; Pl. 11, d).

*Figures 3 to 18 and all plates follow bibliography.

Midge-gall often attacked by wasps. On the stem or leaf-stalk, the gall is ovoid, 2 mm in height and 1 mm at the widest part, fixed by a large base. The opening is apical. On the leaf (Pl. 11, d), the galls are attached laterally along the midrib, usually packed closely in a more or less coalescent row. The isolated gall presents itself adaxially as a protuberance 2 mm in height and 1 mm wide at the base, and abaxially is a less distinct swelling, less than 1 mm in height. The large gall-chamber, containing only one midge-larva, is located at the level of the lamina; around it one finds the nutritive tissue (nt), a protective shell (s), and a tanniferous parenchyma. Finally the gall is covered with a hairy epidermis (fig. 13, c). The opening is apical and adaxial. After the exit of the gall-maker, one notices that the gall-chamber is plastered with a hard and blackish covering.

Xylopia malayana Hk. f. and Th. Gall 154. B.T.N.R., between Ginger Walk and Jalan Kutu. (fig. 12, c).

Pleurocecidium caused by a coccid belonging to the family Lecaniodiaspididae, *Lecaniodiaspis* sp. On the scale-mother periphery, a fusiform wad develops in the direction of the axis of the stem, 1 cm long and up to 6 mm wide. The large opening of the gall cavity is covered by a waxy and resinous scale, 5 mm across, secreted by the mother. The female deposits its eggs beneath this scale. Under the growth of cortical tissues that actively participate in gall morphogenesis, the bark is fissured.

Undetermined ANNONACEAE. Gall 164. B.T.N.R., Jungle Valley.

Psyllid-gall. Conical elevation of the lamina, less than 1 mm in height, provoked by psyllids attached abaxially.

APOCYNACEAE.

Willughbeia coriacea Wall. Gall 28. B.T.N.R.

Cause not determined. Fusiform swelling 1 to 1.5 cm wide, affecting the stem for several cm in length. Under the effect of the growth of internal tissues (xylem, phloem, cortical parenchyma), the bark cracks and breaks up into fragments.

ASCLEPIADIACEAE.

Hoya diversifolia Bl. Gall 90. Dalvey Road.

Insect-gall. Leaf-gall affecting only the upper surface of the lamina. It presents itself as a slight purple protuberance of 5 mm in maximum diam, yellow in its centre.

BURSERACEAE.

Canarium pilosum A. W. Benn. Gall 69 I, 83 & 109. B.T.N.R. (Pl. 5, c).

Gall caused by a mite, *Eriophyes* sp. close to *E. reijnvannae* Nal. fide Dr. Keifer in litt. Hairy clavate finger-gall in 1 cm height by 5 mm width at the maximum, projecting out from the adaxial side of the leaflet, has a small abaxial opening and is covered inside with straight hairs. This type of gall occurs frequently on the genus *Canarium*. For example: *Canarium hispidum* (Bib. 28, P. 422, no 1550.—22, p. 262, no 627, fig. 436.—16, p. 28, no 531, fig. 531); *Canarium* sp. (Bib. 22, no 627 & 629, p. 263, fig. 438).

Idem. Gall 165 II. B.T.N.R.

Thrips-gall. The leaflets become involute.

Idem. Gall 121 III. B.T.N.R., between Jalan Kutu and Main Road.

Midge-gall (Pl. 5, a, b). Ovoid cecidium, 2 mm long, less than 1 mm wide, attached to the veins by a large base and opening by a round apical pore, when mature. Inside is a large gall-chamber containing a midge-larva. The internal wall of the gall is grey or blackish.

Idem. Gall 121 IV. B.T.N.R., between Jalan Kutu and Main Road.

Cause not determined (Pl. 5, d). Under the influence of the parasite, there is inhibition of the vein-growth, which creates the pleating of the lamina of leaflets the edges of which, moreover, tend to become involute.

COMBRETACEAE.

Terminalia catappa L. Gall 145. Campus of the University of Singapore and Angullia Park.

Mite-gall. On the adaxial face of the leaf this yellow, green or red pouch-gall forms a rounded protuberance less than 1 mm high; the ostiole of the gall is abaxially opened and leads to a small chamber.

Distribution: Singapore — Java, Krakatau Island, Sumatra, Salajar Group. (Bib. 15, p. 43, no 64, fig. 64.—16, p. 68; no 674.—17, p. 78, no 18, fig. 18.—28, p. 582, no 2104.—22, p. 404, no 1048, 20, fig. 752). This gall has a large distribution area, following the pantropical character of the host-plant.

CELASTRACEAE.

Salacia korthalsiana Miq. Gall 169. B.T.N.R.

Insect-gall. Fusiform swelling of the midrib, abaxially visible. The main vein can be affected locally and/or along its entire length. In the second case the lamina is contorted towards its abaxial side. The side-veins can also become hypertrophic at their junction with the midrib. The gall manifests itself adaxially by the unusual width of the affected veins. The exit of the gall-makers is abaxial.

DIPTEROCARPACEAE.

Shorea curtisii Dyer ex King Gall 23 I. B.T.N.R.

Gallacoccus secundus Beardsley, new genus and species.

—— Description of an adult gall (Pl. 2, a, b, e): purplish-green pear-shaped gall, 3.5 cm long, 2 cm wide at its maximum. Its irregular surface is covered with bumps each of which has an apical tuft of hairs. It is formed of foliaceous appendages overlapping at their apex, with more or less thickened and fused bases. The two median appendages, larger than the others, separate between them a large ovoid gall-chamber containing many coccids.

—— Location on the host (figs. 3, 4; Pl. 2): it is found in the axil of the leaf or on a leaf vein. Therefore this gall is hard to interprete without precise ontogenical study. The study of the young stages shows that this gall occurs either on one of the internal stipules (fig. 3, a, b; fig. 4, b), or on one of the young leaves of the bud (fig. 4, c, d; Pl. 2, f). Normally the stipules are deciduous but if one of them has parasites, it participates in its totality to the cecidiogenesis without affecting the growth of the rest of the bud (fig. 3, a, b). That is why at the adult stage this gall gives the impression of being in the axil of a leaf: in fact it is in a lateral position since it is a stipule transformed by the cecidiogenesis. An anatomical study would be necessary to pinpoint to what degree the axillary bud of the leaf is affected. At the beginning of the development of the gall, a wad is always formed (fig. 3; 4), then there is the outgrowth of the foliaceous appendages. That leads me to think that after the installation of the gall-maker, there occurs, dedifferentiation, formation of a callus, then of an abnormal bud. One can note the resemblance of the gall 23 I with those figuring in the bibliography: 2, pp. 339–341, fig. 1–2.—22, p. 391, fig. 721.

—— Deviation of the cecidiogenesis due to the presence of secondary hosts in the coccid-gall 23 I on *Shorea curtisii* King (Pl. 2, c, d). For an analogous problem see Bib. 39, Vol. 33, section 3, pp. 143–148, 2 Pl. The galls attacked by parasitic wasps appear almost normal except that they never reach their maximum size. They are more woody and dried out than normal galls. Moreover the parasitic wasps do not leave through the apical canal, but through apertures which they make in the gall-wall. The gall-cavity is very reduced and irregular; coccids are present but in very small numbers. On the other hand, the walls of the gall are hypertrophic and chambered. The parasitic wasps develop themselves in these oval gall-chambers which are 2 mm long and 1.5 mm wide. They protrude inward in the gall-cavity which explains its reduced size and its irregularity.

Idem. Gall 23 II. Wide-spread in B.T.N.R.

By means of cages, wasps and midges were obtained. Fide D.H. Murphy (personal communication), wasps are the gall-makers, and midges are inquilines (fig. 5, d, e; Pl. 4, e). Galls 23 II protrude onto the adaxial leaf-surface, mainly alongside the midrib and sideveins where they form continuous, non-coalescent alignments. At that level the lamina is deformed and has a tendancy to roll up, thus partially covering them (Pl. 4, e). A fully developed gall is column-shaped, 2 mm high and less than 1 mm wide, reddish brown, covered with simple hairs. The gall can be divided into three superimposed parts: a pedicel, a median swollen zone and an apical zone (fig. 5, d). The pedicel is roughly cylindrical and perpendicular to the lamina. The gall swelling corresponds to the rounded larval chamber which appears lateral in position relative to the median gall-axis. The tapering apical zone is more or less curved. The position of the cavity and the apex of the gall distinguish morphologically a longitudinal plane of symmetry, perpendicular to the lamina. An anatomical study confirms this. The gall is covered with a piliferous epidermis. A longisection of the gall, perpendicular to the lamina shows that the epidermic gall-cells are longitudinally hypertrophic being 3.3 times longer than normal epidermic cells, and transversally only slightly higher. Under the gall epidermis one finds a cortical tanniferous parenchyma which reaches its maximum thickness in the apical gall part. Some or all cells of the outer cortical layers are differentiated into sclerenchymatous cells forming more or less a continuous shell. The gall axis consists of a tanniferous medullar parenchyma. Epidermis, cortical and medullar parenchyma are the only three tissues that constitute the apical gall-part. The cells of those tissues are much elongated in the direction of the longitudinal gall-axis. Level with the swollen part one finds the larval cavity surrounded by a spherical mass of nutritive parenchyma the cells of which are polygonal and characterised by a nuclear and nucleolar hypertrophy.

A section cut along the plane of symmetry shows that the nutritive tissue juts out over the gall pedicel and that its protruding part is covered uniquely by epidermic and shell layers; on the internal side the medullar parenchyma runs along the nutritive tissue. A vascular ring of tracheids and associated parenchyma runs the length of the pedicel in between cortical and medullar parenchyma. That vascular tissue in relation with the leaf-veins at the base reaches the nutritive tissue: the vascular bundles that come right up to the nutritive tissue spread and surround it on both sides of the gall plane of symmetry. Those bundles which are diverted from the nutritive tissue joins the latter by running obliquely round the medullar parenchyma. On maturity there is necrosis of the medullar parenchyma and formation of a dehiscing canal in the centre of the gall-pedicel. This canal opens through an abaxial pore.

Idem. Gall 23 III & 77. B.T.N.R. (fig. 5, a, b, c; Pl. 4, f, g).

By means of cages, Diptera and Hymenoptera have been obtained. Diptera: this species belongs to the subfamily Cecidomyiinae, supertribe Asphondyliidi. The genus seems to be underscribed fide Dr. Nijveldt in litt. Hymenoptera: Chalcidae of the family Eulophidae, genus near *Pediobius* fide Kerrich in litt. The midges are the gall-makers, the wasps are parasites. At the height of its development, the gall reaches 2 mm long by 1.5 mm wide. It is mushroom-shaped: pedicel topped by a cap. It stands more often on the abaxial surface of the leaf. The pedicel inserted on a small leaf-vein between the side-veins stands out adaxially as a small bright red protuberance; it is red at its base as well, becoming lighter and turning yellow towards the top. The cap is green-yellow. The gall turns brown and dries out when mature. The young gall is green-yellow, the red pigmentation does not appear until later. The gall-chamber containing one midge-larva is situated under the cap at the apex of the pedicel. This chamber remains open by a small ostiolar canal surrounded by hairs and located in the centre of the cap (fig. 5, c). The gall-cavity is surrounded by a sclerenchymatous shell made of an upper part and a lower part. The latter is covered by a thin nutritive epidermis. The epidermis of the gall is glabrous, level with the pedicel and hairy, level with the cap: on the external cap-side (*e*) these hairs are tufted and relatively short; on the internal side (*i*) they are very long and form a sleeve surrounding the apex of the pedicel. Under the epidermis lies a hypertrophic and tanniferous cortical parenchyma. The centre of the gall is occupied by a medullar parenchyma the cells of which are elongated vertically in the pedicel and radiate round the gall cavity, level with the cap. In the internal part of the parenchyma one finds about 24 vascular bundles disposed in a circle which run up the pedicel parallel to its axis. These bundles enter the cap and reach the ostiolar canal as shown on fig. 5, c. Ontogenically, the hairy cap forms first, the pedicel develops subsequently. The gall cavity, very small at the beginning, becomes enlarged due to the development of nutritive pillars that disjoint the lower and upper parts of the shell. After pupating the midge makes its way through the wall of the cap, leaving its pupal integument partly inserted in the gall. When the gall is attacked by parasitic wasps, its apical part is deformed by a lateral swelling, and the cap of the cecidium is rejected on the side (fig. 5, a).

Idem. Gall 23 IVa. B.T.N.R. (Pl. 3, a, b, c).

Cause: Coccidae, genus *Beesonia,* undescribed species, fide Beardsley in litt. These coccids are very unusual according to this specialist. They provoke a fusiform hypertrophy affecting the stem on a variable length, sometimes for more than

10 cm. The placement of the coccids is marked by a small depression, in the centre of which with the binocular magnifying glass one notices the brown cuticle of the posterior part of the scale mother. When mature the latter has a distended body in the shape of a flat bag, reaching 1 cm long by 8 mm wide, lying between the central cylinder and the cortical parenchyma. Dr. Beardsley comments as follows: "the posterior end of the bag forms a constricted neck which extends through the bark of the twig, and the young coccids probably leave the mother's body and the gall by way of an opening at the tip of this constricted portion". Under the influence of the parasitic coccids, the plant tissues necrotize, become brown, and the whole twig on which the gall occurs dries out (Pl. 3, a). The gall is often attacked by parasitic wasps that make their ovoid larval cavities in the hypertrophic cortical gall-tissue. They leave the gall by piercing the gall-tissues (Pl. 3, b, c).

Idem. Gall 23 IVb, 77, 75, 106. B.T.N.R. (Pl. 3, d, e).

Wasp-gall. The attacked part of the stem becomes hypertrophic, fusiform and covered with hemispheric swellings of approximatively 3 mm in diam. Each of these growths contains several wasp-larvae, lodged in a rounded gall-cavity. The exit of the gall-makers is central and at the distal extremity of the vertical axis.

Idem. Gall 23 V. B.T.N.R., between Jalan Kutu and Main Road. (Pl. 4, a, b, c, d).

Gallacoccus anthonyae Beardsley. Same genus as the gall forming coccid 23 I. (for reference see foot-note on p. 23). The gall, abaxially attached on the basal half of the midrib or the petiole, has the form of a bud, constitutes overlapping foliaceous appendages, the base of which are on two generating lines (distichous disposition). It can reach 6 cm long and 2 cm at the widest part. Light-green and whitish when young, yellowing at maturity, it turns brown and dries out like the leaf that carries it. The young coccids are found in a translucid bag. They are surrounded by their waxy whitish secretion and hold themselves in the axil of the seventh leaf counting from the base.

Idem. Gall 23 VI. B.T.N.R., Ginger Walk.

Insect-gall. Ball-shaped, 1 to 2 mm in diam., yellow, becoming red-brown at maturity. The cecidia located on the veins are visible only on that face of the lamina on which they find themselves. They detach themselves easily.

Idem. Gall 23 VII. B.T.N.R., Ginger Walk.

Wasp-gall. Disc-shaped gall, less than 1 mm in thickness, 4 mm in diam., affecting symmetrically both faces of the lamina. The exit of the gall-makers is abaxial.

Idem. Gall 23 VIII. B.T.N.R., Ginger Walk.

Insect-gall. Adaxially, it is a conical protuberance 1 mm in height, on a base 1 mm in diam., to which corresponds abaxially a similar protuberance. The galls are located along the length of the side-veins, and on the side of the petiole. When they are close together, they fuse at the base, forming alignments that look like cockscombs.

Shorea sp. Gall 168 I. B.T.N.R., Jungle Valley.

Midge-gall. Bright-yellow spheroid gall 3 or 4 mm in diam., attached by a short pedicel to the under-side of the leaf. The point of attachment is marked on the upper-surface of the leaf by a little protuberance surrounded by a depigmented area. This gall resembles the gall 21437 no. 1007 on *Shorea belangeran* Burck. (Bib. 22, p. 391).

EUPHORBIACEAE.

Acalypha wilkesiana Muell. Arg. Gall 161. Coronation Road (garden) Singapore, and Botanic Gardens of Tjibodas, Java.

Cause not determined. It appears as a globulous mass of witches' broom about 6 cm in diam., sprouting from the twigs. This gall is made up of a tangle of filaments radicular in nature, and of twigs carrying reduced leaves.

Aporosa benthamiana Hook. f. and Thom. Gall 98 I. B.T.N.R., Jalan Kutu. (fig. 6; Pl. 11, b).

Thrips-gall. The leaf becomes involute; the leaf-tip is not involved in the cecidiogenous morphogenesis. Abaxially the lamina is punctuated between the side-veins by little pustules 1 mm in diam., with a black point in their centre.

Idem. Gall 98 III. B.T.N.R. Jalan Kutu. (Pl. 11, b, c).

Insect-gall. Petiole or midrib develops roundish or fusiform swellings, 4 to 10 mm long and about 4 mm wide, visible on both faces of the lamina. The ovoid gall-cavity is located in the hypertrophic medullar pith. Exit of the gall-maker is by a large pore.

Idem. Gall 98 IV. B.T.N.R., Jalan Kutu. (Pl. 11, c).

Wasp-gall. Yellowish fleshy mamillated swelling affecting laterally the stem along a few cm. A longisection of the gall shows that the cortical parenchyma is the only stem-tissue to be hyper-developed under the influence of the numerous wasp-larvae that it contains; pith and vascular bundles are not modified by the gall-makers. That explains why the stem-growth is not affected by the gall. On maturity the wasps leave the gall through a large pore.

Baccaurea ? griffithii. Gall 130. B.T.N.R., Ginger Walk.

Cause undetermined. Globular or more or less elongated deformation of the stem or of the petiole for about 1 cm.

Coelodepas glanduligerum Pax. Hoffm. Gall 71. B.T.N.R., Jungle Valley track. (Pl. 11, a).

Midge-gall. Abaxial disc-shaped gall, 5 mm in diam., by 1 mm in height, depressed in its centre. The rim formed in this way is irregular and has a brownish-red tint. The central depression is cylindrical, 1 mm in diam., 0.5 mm in height. In it a fine epidermic pellicle forms the roof of the gall-cavity where one midge-larva is found. At maturity the parasite leaves the gall through a semi-circular orifice formed by piercing the membrane. On the adaxial side, the gall presents itself as a yellowish rounded spot which has a very slight central brownish point.

Macaranga triloba Muell. Arg. Gall 124. B.T.N.R., North View Path.

Midge-gall. Ovoid, attached to the abaxial face of the lamina, 4 mm long by 1 mm wide; its surface is green and covered with long white hairs. Its attachment is marked on the adaxial face of the lamina by a slight protuberance covered with white hairs. The exit of the gall-maker is adaxial.

Distribution: Singapore — Java, Sumatra, Malacca (Bib. 10, p. 80, no. 232.–12, p. 32, no. 304, fig. 131.–14, no. 31.–22, p. 313, no. 771.–28, p. 455, no. 1675 & 1676, fig. 983).

Mallotus penangensis Muell. Arg. Gall 111. B.T.N.R., North View Path.

Psyllid-gall? All the galls found were already open and devoid of gall-makers. Adaxially this leaf-gall is in shape of a hemispheric hollow dome 6 mm in diam., covered with long hairs. Abaxially the walls of the gall are divided into several reflexed lobes.

FAGACEAE

Castanopsis wallichii King Gall 25. B.T.N.R., on the corner of Main Road and Jalan Kutu. (Pl. 6, d, e).

Midge-gall. Gall of the stem and the leaves affecting the axillary and terminal buds, the petiole and the veins. The parasitic midges provoke hypertrophy and inhibit growth of the attacked organ.

— Petiole: fusiform swelling, 3 mm wide.

— Veins: the gall, especially visible abaxially, presents itself as a fusiform swelling 3 mm in width on the midrib, and 1 mm in width on the side-veins. Moreover, the lamina is deformed and curved around the attacked zone, caused by inhibition in growth.

— Terminal bud: hypertrophy of its axis transforms the bud into an irregular sphere 8 or 9 mm in diam. From this sphere contorted leaf-shoots project. Inside are many midge-larvae.

Lithocarpus conocarpus (Oudem.) Rehd. Gall 120 I. B.T.N.R., between Main Road and Jalan Kutu. (fig. 7, c, d; Pl. 6, c).

Wasp-gall (probably a cynipid). Brown ovoid cylindrical gall protruding more or less equally on both faces of the lamina, reaching 2 mm in total height and 1 mm in width. The apex of the gall on the adaxial face is equiped with a flat lid that has a small central erect prickle. The gall is sessile, detaches itself before maturity from the orange wasp-larva contained in its large cavity and leaves an alveole in the lamina (Pl. 6, c). This gall has a rapid development from January to March (see p. 20).

Idem. Gall 135 II. B.T.N.R., between Ginger Walk and Jalan Kutu. (fig. 7, b).

Moth-gall. Fusiform swelling of the midrib, 1.5 cm long, 0.6 cm wide at its centre, visible on both faces of the lamina, and is of woody consistence. The interior is a long gall-chamber.

Idem. Gall 135 III. B.T.N.R. (fig. 7, a; Pl. 6, a, b).

Moth-gall developed on stem and petiole.

— Stem: fusiform swelling of the stem. One moth-larva makes a central long gall-chamber. It induces the fragmentation of the cambium into four parts; after departure of the gall-maker, this divided cambium keeps on functioning and leads to the formation of four stem units (pl. 6, b). Due to the proliferation of these internal stem-tissues, the gall-cavity disappears and the bark is fragmented into four longitudinal strips. At the end of its development this gall reaches 2.5 cm in length and 8 mm in width (Pl. 6, a; fig. 7, a).

— Petiole: level with the insertion of the petiole on the stem, adaxial side, the internal hypertrophic tissues become a small irregular growth about 3 mm diam. (fig. 7, a).

Lithocarpus sundaicus (Bl.) Rehd. Gall 153 IV. B.T.N.R., very close to the summit. (fig. 8; 9).

Gall caused by a coccid that belongs to the family Diaspididae fide Beardsley in litt. The young Homoptera are localised at the axil of young leaves of lateral buds (fig. 8, a). They create:

— Shortening of the internodes; the leaves are tufted in a rosette (fig. 8, d). Their bases become hypertrophic (fig. 8, c, d).

— Cessation of growth of the principal axis.

— Formation of secondary and tertiary shoots by axillary buds (fig. 8, a, b). The young leaves are modified in rhabdodes.

One notices the development of vigorous shoots under the gall-zone which appear to be the strongest shoots in the plant (fig. 9, d); this poses the problem of causal determination. According to Dr. Cusset in litt. it might only be due to an inherent phenomenon in the considered species if the normal growth of the plant is either monopodial with flush (fig. 9, a) or sympodial and more or less acrotonic (fig. 9, b). But if the normal growth of the plant is monopodial and without rhythm (fig. 9, c), it might be a phenomenon linked to the remote action of the cecidiogenous agent. One could then take in consideration the possible interaction between the distal zone with axillary buds *abundantly* developed (BA), and the subjacent zone with axillary buds *strongly* developed (BS), fig. 8, d.

GUTTIFERAE

Calophyllum ferrugineum Ridl. Gall 68 I, 101, 136, 141. Widespread in B.T.N.R. (fig. 13, d; Pl. 5, e)

Midge-gall. This species belongs to the subfamily Cecidomyiinae, supertribe Cecidomyiidi, but the genus seems to be undescribed fide Nijveldt in litt. Parasites or inquilines: thrips and wasps. The latter are chalcids of the family Eulophidae, belonging to the genus *Tetrastichus* fide Kerrich in litt. The gall is formed by the edges of the lamina which fold downwards thus resulting in a cylinder 1.5 mm. in diam. One can, parallel to the midrib, distinguish three parts in each half lamina, the behaviour of which is different in the morphogenetic movement: proximal, median and distal zones, with respect to the midrib. The median zone only of each half lamina participates in the formation of the wall of the cylinder. This region of the lamina is considerably thickened and its surface is irregular. The proximal and distal zones are clung together, lower epidermis against lower epidermis (fig. 13, d). In the long cavity thus delimited, one finds many midge-larvae which at maturity protrude from the channel of the cylinder by sliding between the distal and proximal zones, where they leave their empty pupal integument. However the parastic wasps work their way out by piercing the wall of the cylinder.

Idem. Gall 68 II, 101, 136, 141. Rather wide-spread in B.T.N.R. (Pl. 5 f).

Midge-gall, affecting the stem, petiole and midrib. On the midrib the isolated gall looks like a hemispheroid swelling of 5 mm in maximum diam., more often abaxial, visible only one one side of the leaf. Frequently the swellings are fused and the whole vein looks hypertrophic. The attacked petiole is considerably larger (5 mm versus 2 mm). There are hemispheroid swellings laterally disposed on the stem.

Idem. Gall 141 III. Very rare in B.T.N.R., localised between Main Road and Jalan Kutu. (fig. 11, a).

Moth-gall. (See also description of gall 107 IV on *Calophyllum pulcherrimum* Wall. on p. 38). Swelling of both faces of the lamina, elongating parallel to the midrib, 25 mm in length, 8 mm in maximum width, and a few mm in thickness. The larvae eat the interior of the leaf except the epidermis. However it is a gall and not a mine: there is formation of a very definite growth due no doubt to a parenchymatous nutritive proliferation. The gall i.e. 141 III looks like that described on *Calophyllum inophyllum* L. (Bib. 22, p. 386, no. 989, 1st, fig. 705).

Calophyllum inophylloide King var. *singaporense* Henderson & Wyatt-Smith. Gall 43 I. MacRitchie Reservoir. (fig. 12, b).

Gall caused by a coccid: *Amorphococcus* sp. (Lecanodiaspididae), fide Dr. Beardsley in litt. The gall develops abaxially on the midrib. Each gall is made up in the same way as bivalve molluscs, of two shells contacting one another by the edge, limiting between them a large rounded gall-cavity containing the young coccids that form an orange mass surrounded by the product of their whitish waxy secretion. When the coccids settle on a young leaf they inhibit the development of the lamina and the internodes are shortened: the apex of the stem is crowned by a globular bunch of more or less spherical galls each 1 cm in diameter.

Idem. Gall 43 II. MacRitchie Reservoir. (fig. 12, a).

Psyllid-gall. The leaf becomes revolute. Each leaf-half can be affected separately, forming a cylinder, 1 mm in diam. Mr. D. H. Murphy notes that leaf roll galls of this type on *C. inophyllum* are well known and are caused by *Leptynoptera sulphurea.*

Calophyllum pulcherrimum Wall. Gall 107 I. Wide-spread in B.T.N.R. (fig. 10, a).

Psyllid-gall. The leaf is conduplicate and tends to become revolute. Its edges are undulated and crisped. The midrip is curved in a hook towards the abaxial leaf-side. The petiole is sometimes twisted, bringing the abaxial side of the leaf in adaxial position.

Idem. Gall 107 II. B.T.N.R. (fig. 10, c,d).

Midge-gall. The midge belongs to the genus *Bruggmanniella* but the species seems to be undescribed fide Nijveldt in litt. Fleshy spheroid gall 3 mm in diameter. pale-green or light-yellow, more often abaxially attached to the midrib by a little pedicel. In aging, it becomes yellow, orange, then brown and dries out. Inside the gall-cavity, one midge-larva is found. The gall is often attacked by parasitic wasps: its consistence is then firmer, and its color changes to dark green, marbled with brown. This gall i.e. 107 II looks like that described on *Calophyllum javanicum* Miq. (Bib. 22, p. 386, no 991, 1st, fig. 760).

Idem. Gall 107 III. Quite rare in B.T.N.R. (fig. 10, b).

Midge-gall. Swelling of the stem, petiole and midrib. The stem-gall is spheroid, about 1 cm across; it is due to a considerable hypertrophy of the central cylinder, and contains several cortical gall-chambers. When the stem is strongly attacked, the galls are more or less fused, linked by hypertrophic stem-tissue, i.e. without larval cavity.

Idem. Gall 167 IV and 107 IV. Rare in B.T.N.R. (fig. 11, b).

Moth-gall. See also description of gall 141 III on *C. ferrugineum* Ridl. on p. 37. Swelling visible on each face of the lamina; it is 4 cm long, 0.4 cm wide, 0.2 cm in height abaxially and about 1 mm in height adaxially. It is elongated parallel to midrib, in form of a "S", of which the basal extremity (petiole side), pushes away from the vein, while the distal extremity converges towards it. The adaxial dehiscence is caused by the wall of the gall collapsing inward.

LAURACEAE.

Actinodaphne sp. Gall 24 I, 67, 73, 93, 99, 138, 143. Wide-spread in B.T.N.R. (Pl. 7, a).

Gall caused by a mite "*Eriophyes* sp., very similar to Nalepa's *gyrographus* (on *Litsea*) and also close to Corti's *Linderae,* but the host species is different and Corti's mite makes conical galls." fide Dr. Keifer in litt. Pockets 1 cm high which appear like blisters on the adaxial leaf-surface. They are abaxially covered with a whitish erineum becoming brown on maturity.

Idem. Gall 24 II, 67, 73, 93, 99, 138, 143. Widespread in B.T.N.R., alongside Jalan Kutu; the trees are sometimes entirely covered with galls. (fig. 13, b; Pl. 7, b).

The gall-maker is a midge belonging to the subfamily Cecidomyiinae, supertribe Cecidomyiidi, fide Nijveldt in litt. Gall of the leaf, stem and petiole, On the stem it is a lateral spheroid outgrowth, attached by a large base. On the leaf (case of an isolated gall), it is a sphere 5 mm in diam., having the lamina as diametrical plane. The glabrous green galls are located principally on the midrib; they are very often fused, and the whole leaf can be affected. The dehiscence is abaxial (fig. 13, b). In the centre of the abaxial hemisphere one finds a small depression that eventually becomes the exit pore for the gall-maker. There is a cellular degeneration along a central axis, more or less perpendicular to the lamina. Often the galls are attacked by parastic wasps belonging to the superfamily Proctotrupoidea, family Scelionidae, *Platygaster* sp. fide Nixon in litt. Then the galls are dark green, marbled with brown.

Idem. Gall 99 III. B.T.N.R., at the extremity of Jalan Kutu, around point C on fig. 1, c. (Pl. 7, c, d).

Midge-gall. Spheroid acrocecidium reaching 3 cm in diam. with a greenish surface, marbled with brown spots more or less suberized. It contains a number of gall-cavities distributed in a median horizontal plane. The young galls carry modified leaves in the shape of spines, with lamina absent or very reduced. These appendages are adaxially plane, and abaxially rounded: there is therefore bilaterisation. The exact nature of these foliar appendages poses a morphological problem. One can admit that, under the influence of gall-makers, there is an inhibition of the foliarisation phenomenon depending on the stem-apex, and formation of rhabdodes. For experiments of microsurgery of the apex see Wardlaw, Bib. 51.

Idem. Gall 143 IV. B.T.N.R., at the corner of Main Road and Jalan Kutu, near a thinning of the forest. This gall is not widespread. (fig. 13, a).

Midge-gall. Spherical cecidium of 5 mm in diameter, more often attached abaxially to the midrib by a large base, and visible only on the side on which it finds itself. It is fleshy, chlorophyllous, covered with a brown suberized layer. The interior is a large rounded gall-chamber containing one midge-larva. The animal pierces the wall at maturity.

Cryptocarya sp. Gall 128. B.T.N.R.

Cause undetermined, but the presence of numerous ants at the interior of the rolled leaf suggests that it might be caused by Homoptera. Edges of lamina revolute. The leaf curves downwards forming a hook.

Endiandra sp. Gall 156 I. B.T.N.R., Main Road. (fig. 14).

Thrips-gall. Edges of lamina involute and crisp. The leaf is contorted, swollen, depigmented, yellow, marbled with brown.

Idem. Gall 156 III. B.T.N.R., Main Road near the summit. (fig. 14, b).

Cause undetermined. Cylindrical conical adaxial expansion on the midrib, 3 mm in height and less than 1 mm in diam. at the base. This gall is not very widespread.

Litsea elliptica (Bl.) Boerl. Gall 86. MacRitchie Reservoir. (Pl. 8, f).

Gall caused by a mite: *Eriophyes gyrographus* Nal. fide Keifer in litt. Pockets varying in size and height from a few mm to a few cm pouch out from the adaxial leaf-surface. They are covered abaxially with a bright erineum which browns on maturity. It is formed by unicellular clavate hairs.

Litsea grandis Hook. f. Gall 144. B.T.N.R.

Homoptera-gall. Spots, visible on both sides of the lamina; roundish, 1 cm in diam. approximately, often confluent and forming large depigmented patches. The gall-makers, fixed abaxially to the centre of the depigmented area, induce a very slight elevation of the lamina. They are surrounded by their whitish waxy secretion and are covered with an hemispheric shield (skin of the first larval instar) which lifts at maturity like a lid.

Nothaphoebe kingiana var. *malvescens* Gamble. Gall 92 I, 79, 94, 133. Wide-spread in B.T.N.R. (Pl. 8, d).

Psyllid-gall. The young psyllids fixed abaxially create adaxial laminal elevations 2 mm in diam. at base, and 1 mm in height.

Idem. Gall 94 II, 79, 92, 133. B.T.N.R. (fig. 15, d, e).

Midge-gall, visible on both faces of the lamina, forming a circular swelling 3 mm in diam. approximately, slightly thicker than the lamina, affecting especially the adaxial face. The midge-larva fills completely the small central gall-cavity. On the adaxial face the gall is dark green, almost black and lighter in its centre. At dehiscence the centre becomes white-grey adaxially and red-brown abaxially. The gall opens adaxially by a central ostiole.

Idem. Gall 133 III, 79, 94. Wide-spread in B.T.N.R. (fig. 15, b, c,; Pl. 8, e).

Mite-gall. Pouch-gall affecting both faces of the lamina, generally isolated, sometimes two or three are fused. Abaxially, the isolated gall is in the shape of a mushroom, 1.5 mm high, the cap is 2.5 mm in diameter. To the insertion point of the gall corresponds adaxially a depression 0.5 mm in depth, and 2 mm in diameter. The gall is formed abaxially by development of lips enclosing a space in which the parasites are lodged. This gall-cavity is crowed with fleshy parietal projections directed inward. The gall stays open by an ostiole situated in the centre of the slight apical depression of the cap; this orifice is surrounded by hairs.

LEGUMINOSEAE.

Dalbergia rostrata Grah. Gall 134, 162. Wide-spread in B.T.N.R. (Pl. 9, d, e).

Midge-gall. Leaflets conduplicate. The two leaflet-halves thicken and are more or less fused. The place of each gall-cavity is marked by peg-like pustules on the abaxial surface. The leaflets can be affected partially or entirely. In the latter case, they take the appearance of a pod.

Dialium maingayi Baker Gall 147. B.T.N.R., between Jalan Kutu and Main Road.

Thrips-gall. Leaflets revolute and retrorse. The distal extremity of the leaflet is not involved in the cecidiogenous morphogenesis. The gall surface is yellow-green, spotted with red.

Pithecellobium clypearia Benth. Gall 115 I. Quite wide-spread in B.T.N.R. (fig. 16, b, c; Pl. 9, a. b. c).

Gall caused by a midge belonging to the supertribe Asphondyliidi fide Nijveldt in litt. Gall occurs on the main leaf-stalk, on the midrib and veins of the leaflets. On the lamina, the galls on the veins are isolated, ovoid, 2.5 mm in length and 1.5 mm in maximum width. They are attached by a large base to the main vein, abaxially and sometimes adaxially. At the interior one finds a very large larval chamber. The circular emergence-hole is made on the gall-top. On the main leaf-stalk, the galls are less definite since they are often fused. The main leaf-stalk can be infected, starting from its distal extremity along a varied length; it is then hypertrophic and contorted.

Idem Gall 115 II. Very rare in B.T.N.R., located between Jalan Kutu and Main Road. (fig. 16, a).

Homoptera-gall? The leaflets tend to be conduplicate. Their lamina is entirely undulate. The distal end of the leaflets becomes retrorse.

LOGANIACEAE.

Fagraea fragrans Roxb. Gall 45, 87. MacRitchie Rerservoir. (Pl. 10, e).

Thrips-gall. The affected leaf becomes revolute. The surface of the gall is more or less granulate.

Strychnos sp. Gall 27, 74. B.T.N.R. (Pl. 11, e).

Gall caused by a midge the species of which belongs to the genus *Bruggmanniella* and seems to be undescribed fide Nijveldt in litt. Brownish or greyish fusiform swelling, 5 to 10 mm long, laterally affecting the stem, petiole or midrib. The galls are sometimes fused. At the interior one finds a larval cavity elongated in the direction of the axis of the organ.

MENISPERMACEAE.

Hypserpa cuspidata (Wall.) Miers Gall 123, 108. Wide-spread in B.T.N.R. (Pl. 13, a).

Coccid-gall; the gall-maker "appears to belong to the family Eriococcidae, . . . It probably represents an undescribed genus and species, . . . It is *not* closely related to the new Eriococcids from *Shorea pauciflora* King."* fide Beardsley in litt. Gall of the stem and leaf (lamina, petiole, veins). Under the effect of the gall-makers, there is an inhibition of growth and hypertrophy occurs. The young coccids are contained in large numbers in fine-walled bags 0.1 mm in diam. These bags fill completely the gall-cavity that opens out by a circular ostiole. They fit in the cavity and the short exit canal so that they have the form of a bottle with a large body and a very short neck. On the adaxial face of the lamina, the placement of the coccids is made visible by the local depigmentation which they cause: the leaf is punctuated by little yellow spots 0.5 mm across, with central ostioles, where a tuft of white filaments (waxy secretion of the coccids) comes out. During the development of the lamina-gall, one notices a slight augmentation in thickness of the lamina, located at the placement of the gall-makers, then necrosis and darkening of the gall-tissues. The coccids installed in the veins inhibit their growth and create a distortion of the leaves. The parasites localised in the stem create a general hypertrophy of this part which when thus affected can reach 8 mm across, and cause some inhibitions of growth: shortening of the internodes, contortion of the stem, inhibition of leaf-development.

MORACEAE.

Ficus pumila Linn. Gall 48, 150. B.T.N.R., Jalan Kutu and Main Road. (fig. 18).

Gall caused by a wasp belonging to the superfamily Chalcidoidea. Gall of terminal or axillary bud. This cecidium is fleshy, globulous, 1 cm in diam. approximately, often slightly elongated in the direction of the axis. It is light yellow when juvenile, becoming brown and drying out on maturity. At the interior of a young gall one finds three or four larval cavities, each containing a wasp-larva. Those chambers become united into one large irregular cavity as the larvae feed on the nutritive gall-parenchyma. The gall is situated in the leaf axil or at the apex of the stem: it is a bud gall. In fact the gall is largely constituted of the petiole of the first leaf fused with the axis of the bud, both enlarged. The lamina of the first leaf does not participate in the formation of the gall; it emerges from the globulous mass and is sessile or subsessile. The fusion between the lower part of the bud-axis and the petiole of the first leaf is proved by the presence of the stipules of the latter on the gall, and by the presence of the apex of the bud at the apex of the gall. There is a resemblance between the gall i.e. 48 and 150 and the wasp-gall on *Ficus recurva* Bl. of other authors (Bib. 22, p. 136, no 20145, fig. 172.–28, pp. 186–187, no. 679–680, fig. 385).

Ficus retusa L. Gall 33. Mangrove, West Coast Road.

Thrips-gall. Leaf conduplicate, with a brown surface, marked with red. It is one of the first thrips-galls that has been described and studied. Distribution: this gall is spread throughout tropical Asia (Singapore — Siam, Cochinchina, Hongkong, Malacca, Java, Sumatra, Celebes), and also in Africa. (Bib. 1, p. 250.–5, p. 154.–15, p. 30.–17, p. 54, no 18.–19, p. 272.–21, p. 128, no 31.–22, p. 140, no 269, 8th, fig. 14, Pl. IV.–25, pp. 56–58, no 108, fig. 103–108.–26, p. 95.–27, pp. 248–250.–28, p. 188, no 685, fig. 372–377.–30, pp. 131, 150, 152, 160.–31, pp. 302, 309, 314.–37, pp. 251–253.–46 pp. 423–424.–52, p. 117, Pl. XVI, fig. 16–18.).

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*See footnote p. 19.

Ficus sinuata Thunb. ssp. *sinuata* Gall 146. Tyersal Road and 44 Nassim Road. (Pl. 8, a, b, c).

Gall caused by a mite, "*Eriophyes* sp. which does not closely resemble any of Nalepa's *Ficus* spp. either as to mite description or gall . . ." fide Keifer in litt. Irregular adaxial outgrowth, nodulous or more or less conical, 5 mm in maximum height. To this corresponds a conical protuberance abaxially, 6 mm in maximum height, the apical extremity is perforated by an orifice leading to the gall-cavity. This cavity is crowded by parietal out-growths.

MYRISTICACEAE.

Knema communis J. Sinclair Gall 129 I. B.T.N.R., between Jalan Kutu and Main Road. (Pl. 13, d).

Insect-gall. Symmetrical gall in relation to the leaf surface. On the adaxial and abaxial faces, the gall presents itself as a conical growth 1 mm in height and 2 mm in diam. at the base. At dehiscence the outer wall of the gall divides into brown woody lobes which become reflexed, leaving a central erect column. This column forms a stopper that detaches itself at maturity, allowing therefore the exit of the gall-makers.

Idem. Gall 129 II. B.T.N.R., between Jalan Kutu and Main Road.

Thrips-gall? The edges of the leaf tend to become involute. Between the side-veins, the lamina is more or less crisped.

Gymnacranthera eugeniifolia (A. DC.) Sinclair var. *eugeniifolia* Gall 118. B.T.N.R., Jalan Kutu.

Cause non determined. Local inhibition of growth of the stem and the midrib, provoking contortion. Moreover the edges of the affected leaves tend to become revolute. The lamina is contorted and crisped.

MYRTACEAE.

General comments concerning the galls on genus *Eugenia:* the galls found in Singapore on the genus are of classic types, already described by many authors on different species of *Eugenia.* One can distinguish four types of galls:

(1) Stem-galls: spherical or fusiform swellings formed by hypertrophy and hyperplasy, caused by insects.

(2) Leaf-galls:

(*a*) Edges of the leaf involute or revolute, caused by thrips.

(*b*) Adaxially hemispheric, abaxially conical equipped with an ostiole, caused by psyllids.

(*c*) Conical elevation of the lamina due to the psyllids installed on the leaf.

Eugenia cumingiana Vidal Gall 155 I. B.T.N.R.

Wasp-gall. Fusiform swelling of the stem, containing a number of gall-cavities.

Idem. Gall 139 II. B.T.N.R.

Psyllid-gall. Conical depression of the lamina less than 1 mm in depth from base less than 1 mm in diameter.

Idem. Gall 157 III. B.T.N.R., Jungle Valley.

Thrips-gall? The edges of the leaf tend to become involute.

Eugenia malaccensis Linn. Gall 81. Singapore Botanic Gardens.

Psyllid-gall caused without doubt by *Megatrioza vitiensis*, the biology of which was studied by Zehnter but not consulted. Adaxially, it is a red hemisphere 5 to 8 mm in diam. containing a large gall-cavity. Abaxially, the young gall has the form of a conical hollow swelling 5 mm in height, the wall of which splits and curls at maturity. This gall is very wide-spread: Singapore–Java, Ceylon, Singapore, Malacca, Amboina, Sumatra, Salajar Island and Fiji Island (Bib. 3, p. 266.–4, p. 195.–5, p. 172, fig. 175.–12, p. 6, no 37.–13, p. 6, no 8.–14, p. 6, no 10.–15, p. 29, no 19.–21, p. 126, no 26.–22, p. 411, 1st, no 1074.–28, p. 594, No 2142, fig. 1235 & 1236.–33, p. 103, fig. 3, 4, 5.–49, p. 150.–52, p. 3, fig. 1 to 5.).

Eugenia rugosa (Korth.) Merr. Gall 158 I. B.T.N.R., Jungle Valley track. (fig. 17, c).

Psyllid-gall. Adaxially, hemispherical or conical protuberance, reaching 3 mm in height on a base 6 mm in diam. Abaxially, conical outgrowth 4 mm high, opening at the apex by a large circular ostiole. Galls are often fused, of a lighter green than the leaves, turning yellow or orange on maturity.

Idem. Gall 158 II. B.T.N.R., Jungle Valley track. (fig. 17, a, b).

Insect-gall. Spherical swelling of the stem, 1.5 cm in diam. All the tissues seem to participate in the cecidiogenous morphogenesis, in particular the vascular tissue, xylem and phloem, and the cortical parenchyma. The gall-cavity is irregularly surrounded by a red-brown parenchymatous nutritive tissue; at maturity the gall-makers pierce a cylindrical canal through the gall-tissues leading to a circular orifice.

Idem. Gall 158 III. B.T.N.R., Jungle Valley track.

Psyllid-gall. Conical depression of the lamina approximately 1 mm deep, caused by the psyllids fixed adaxially.

Idem. Gall 143 IV. B.T.N.R., Ginger Walk. (fig. 17, d).

Wasp-gall? Irregular fusiform swelling of the twig, containing a number of gall-cavities. The bark pushed by the internal tissues breaks into flakes.

Eugenia subdecussata Duthie Gall 148 I. B.T.N.R.

Psyllid-gall. Conical elevation of the lamina of 1 mm in height on a base 2 mm in diam.

Idem. Gall 166 II. B.T.N.R. (Pl. 10, d).

Thrips-gall? The leaf is involute. The surface of the gall is more or less marked with red spots.

Rhodamnia cinerea Jack (— *Rh. trinervia* Bl.). Gall 88 I. MacRitchie Reservoir. (Pl. 10, a, b).

Moth-gall. Woody fusiform swelling of the stem, reaching 6 cm in length and 1 cm in width. At the interior one finds a large gall-cavity containing only one larva.

Distribution: Singapore–Java, Sumatra (Bib. 21, p. 143, fig. 35.–22, p. 418 no 1098, 1st).

Idem. Gall 88 III. Mac Ritchie Reservoir.

Psyllid-gall. Adaxially it is a depression of the lamina 0.5 mm in depth on a base 0.5 mm in diam., caused by the psyllids installed adaxially.

Idem. Gall 72 IV. B.T.N.R. and Mac Ritchie Reservoir. (Pl. 10, c).

Homoptera-gall? Local inhibitions of growth of the veins, provoking the distortion of the leaf.

RHIZOPHORACEAE.

Anisophyllea disticha Baill. Gall 114. Everywhere in B.T.N.R. (Pl. 12, b).

Midge-gall. Gall pyriform with a long neck, 3 mm long and 1 mm wide, covered with long hairs, attached at the base of the leaf to the adaxial edge of the lamina, containing a large longitudinal gall-cavity, in which one finds a midge-larva. Galls are sometimes fused in twos or threes.

Distribution: Singapore–Bangka, Rhio–Archipellago (Bib. 22, p. 402, no 1040, fig. 746).

RUBIACEAE.

Lasianthus maingayi Hk. f. Gall 76. B.T.N.R.

Cause undetermined. Inhibition of growth of the veins, hence the contorted aspect of the leaf.

Psychotria ovoidea (Hook f.) Wall. Gall 110. B.T.N.R. (Pl. 12, d).

Midge-gall affecting the leaf. Abaxial roughly hemispherical outgrowth of the lamina, 5 mm in diam, corresponding adaxially to an umbonate outgrowth 2 mm in height. The gall develops by hypertrophy: spectacular elongating of the cells perpendicularly to the surface of the leaf, then division of the cells of the spongy mesophyll. In the centre of the gall one finds a large rounded gall-cavity. Exit of parasites abaxial.

Urophyllum hirsutum Hook. Gall 159. B.T.N.R., Jungle Valley track. (pl. 12, c).

Midge-gall. Fusiform swelling 6 mm in maximum width, affecting the stem, petiole and midrib. In the last case, the gall is mostly visible abaxially. The organ can be hypertrophic along a variable length. The gall-cavity is elongated in the direction of the spindle-axis.

SAPOTACEAE.

Palaquium obovatum (Griff.) Engl. var. *obovatum*. Gall 125. B.T.N.R.

Aphid-gall? Under the influence of the Homoptera fixed on them, the various organs of the host-plant (stem, veins), are submitted to inhibitions of growth that cause them to be twisted. The leaves are contorted, their edges become involute.

Palaquium semaram H. J. Lam. Gall 78, 116. B.T.N.R. (Pl. 12, a).

Midge-gall. Disc-shaped gall affecting both faces of the lamina, gall less than 1 mm thick, and diam. approximately 4 mm. Inside one finds a small larval cavity containing one midge larva. That larva leaves the gall through an adaxial emergence hole before pupating. The gall is yellowish, browning and drying out on maturity.

TILIACEAE.

Grewia blattaefolia Corner Gall 131. B.T.N.R., Jalan Kutu. (Pl. 12, e, f,).

Midge-gall. This light yellow spherical gall, less than 5 mm across is attached on the adaxial or abaxial side of the leaf, laterally to the veins. The pyriform gall-chamber stretches out perpendicular to the vein.

VERBENACEAE.

General comments concerning the galls occuring on the genus *Clerodendron*: Aphids are parasitic on a number of *Clerodendron* and provoke the formation of characteristic acrocecidia:

— Inhibition of the growth of the veins, hence the contorted aspect of the leaves.

— Inhibition of the growth of the internodes.

These galls were considered as pseudogalls by previous authors, on account of their inhibitionary effect. See an illustration of this type of gall Pl. 13, b. This type of gall has been found on:

C. deflexum Wall. Gall 95. B.T.N.R.

C. laevifolium Bl. (= *C. disparifolium* Bl.). Gall 119 I; 122. B.T.N.R.

Clerodendron laevifolium Bl. (= *C. disparifolium* Bl.) Gall 119 II, 219. B.T.N.R. (fig. 5, f).

Midge-gall. The edges of the lamina are involute. The distal end of the leaf does not participate to the gall-morphogenesis. The external surface of the gall is covered with white spots. Distribution: Singapore–Java (Bib. 22, p. 488, no 1300, fig. 934).

Clerodendron sp. Gall 137, 151. Coronation Road (garden).

Mycocecidium. Rounded elevation of the lamina, a few mm in height, and 5 to 8 mm in diam., abaxially covered by small whitish vesicles (sori), disposed concentrically. The yellowish gall turns brown on maturity, therefore causing the whole leaf to dry out.

Vitex pubescens Vahl. Gall 64, 160. B.T.N.R. and Cherengi Road. (Pl. 13, f).

Mite-gall caused by *Eriophyes cryptotrichus* Nal. fide Keifer in litt. Globulous and wart-like pockets that project from the adaxial leaf-surface, 0.5 to 6 mm in diam., covered adaxially by short hairs, and abaxially by a dense erineum. Distribution: this gall is very widespread. Singapore–Java, Sumatra, Sebesy Island, Malacca, Siam (Bib. 12, p. 49, no 342, fig. 153.–14, p. 19,no 49.–18, p. 61, no 34.–20, p. 311, no 77.–21, p. 148, no 82, fig. 44.–22, p. 493, no 1317, fig. 943.–28, p. 766, no2756.–42, p. 59).

Vitex vestita Wall. Gall 126. B.T.N.R.

Mite-gall. Whitish erineum browning at maturity, covering the lamina in rounded or reticular blotches abaxially but also adaxially.

VITACEAE.

Vitis gracilis Wall. Gall 80, 163, B.T.N.R.(Pl. 13 c).

Psyllid-gall. The psyllids fixed adaxially create a depression of the lamina, less than 0.5 mm in depth on a base 0.5 mm in diam.

PTERIDOPHYTES. OLEANDROIDEAE.

Nephrolepis biserrata (Sw.) Schott Gall 240 I. Catchment Area. (Pl. 13, e).

Gall caused by a mite, *Nothopoda pauropus* Nal. fide Keifer in litt. Small finger-galls that project out from the adaxial and more frequently the abaxial surface of the fronds. It is conical, 3 mm high, 1 mm wide at the base, having an apical ostiole surrounded by hairs. The internal wall of the gall-cavity is glabrous and longitudinaly fluted. When galls develop at margin of pinnae they are sub-globular, about 2 mm high and 4 mm wide.

BIBLIOGRAPHY

Bequaert J.

1. 1914. Sur quelques cécidies observées en Algérie. Rev. Zool. Afr. Bruxelles, Vol. III.

Corner E. J. H.

2. 1963. A Dipterocarp clue to the biochemistry of Duraniology. Annals of Botany, New Series, Vol. 27, No. 106, Pp. 339–341, Fig. 1–2.

Crawford D. L.

3. 1915. Ceylonese and Philippine Psyllidae. Phil. Journal of Science, Vol. X, Pp. 257–267, Pl. I.

4. 1919 The jumping lice of the Paleotropic and the South Pacific Islands. Phil. Journal of Science, Vol. XV, Pp. 139–205, Pl. I–III.

Dammerman K. X.

5. 1919. Landbouwdierkunde van Oost-Indië. De Bussy, Amsterdam.

Docters Van Leeuwen-Reijnvaan J. and W.

6. 1909. Einige Gallen aus Java No. 1–23, Marcellia, Vol. XVIII, Pp. 21–35.

7. 1909. Einige Gallen aus Java. Zweiter Beitrag No. 24–90, Marcellia, Vol. VIII, Pp. 85–122.

9. 1910. Einige Gallen aus Java. Vierter Beitrag, No. 151–200, Marcellia Vol. IX, Pp. 168–193.

10. 1911. Einige Gallen aus Java. Beitrag V, No. 201–250, Marcellia, Vol. X, Pp. 65–91.

11. 1911. Einige Gallen aus der Insel Madoera. Marcellia, Vol. X, Pp. 91–92.

12. 1912. Einige Gallen aus Java. Beitrag VI, No. 251–350, Bull. du jard. Bot. de Buit., Series 2, No. III, Pp. 1–52.

13. 1912. Begleitwort zu der Sammlung von Niederländisch Ost-Indischen Gallen. Series I, No. 1–25, Semarang.

14. 1916. Niederländisch Ost-Indische Gallen. No. 8. Beschreibungen von Gallen aus Sumatra and Simaloer. Bull. du Jard. Bot. de Buit., Series II No. XXI, Pp. 1–19.

15. 1916. Niederländisch Ost-Indische Gallen No. 9. Beschreibungen von Gallen aus Celebes und aus den Inseln südlich von Celebes. Bull. du jard. Bot. de Buit., Series II, No. XXI, Pp. 21–45.

16. 1918. Niederlflndisch Ost-Indische Gallen No. 10. Einige Gallen aus Java. Beitrag VIII No. 501–700. Bull. du jard. Bot. de Buit., Series III, Vol. I, Pp. 17–76.

17. 1920. The galls of Krakatau and Verlaten Eiland. (Desert Island in 1919). Ann. du jard. Bot. de Buit., Vol. XXXI, Pp. 83–92.

18. 1922. Contribution to the knowledge of the Insect-Galls of Siam. Journal of the Siam Society, Vol. XV, Part I, Pp. 44–65.

19. 1922. Some Galls from Hongkong. Bull. du jard. Bot. de Buit., Series III, Vol. IV, Pp. 268–278.

20. 1922. The galls of the islands of the Krakatau-group and of the island of Sebesy. Bull. du jard. Bot. de Buit., Series III, Vol. IV, Pp. 288–314.

21. 1924. Some galls of the Malacca Peninsula. Bull. du jard. Bot. de Buit. Series III, Vol. VI, Pp. 116–157.

22. 1926. The zoocecidia of the Netherlands East Indies. Batavia, 601 pages, 1088 Figs., 7 Pls.

Fistié P.

23. 1960. Singapour et la Malaisie. Coll. Que sais-je? PUF Paris, 127 pages.

Houard C.

24. 1906. Glanures cécidologiques. Marcellia Avellino, Vol. 5, Pp. 65–69.

25. Les zoocécidies du Nord d'Afrique. Ann. Soc. entom. de France. Paris, Vol. LXXXI, Pp. 1–236 Pl. I & II.

26. 1912. Sur les maladies parasitaires des Figuiers et des Peupliers d'Algérie. Caisse Rech. scient. 1911, Rapport annuel, Melun, Pp. 95–96.

27. 1912. Recherches biologiques sur les maladies des Figuiers et des Peupliers l'Algérie. Caisse Rech. scient. Travaux 1911, Melun, Pp. 248–253.

28. Less zoocécidies des plantes d'Afrique, d'Asie, d'Océanie. Paris; Jules Hermann Ed.
1922. Vol. I, 496 pages.
1923. Vol. II Pp. 503–1056.

Johansen D. A.

29. 1940. Plant microtechnique. McGraw-Hill Book Company, Inc. New-York and London. 523 pages.

Karny H.

30. 1912. Gallenbewohnende Thysanopteren aus Java. Marcellia, Vol. XI, Pp. 115–169.

31. 1923. Gallenbewohnende Thysanopteren von Celebes und den Inseln Südlich davon. Treubia, Vol. III, Pp. 300–326.

32. 1926. Phylogenetic considerations. In Biblio. 22, Pp. 37–47.

Kirkaldy G. W.

33. 1907. On two new Vitian Chermidae. Proc. Hawaian ent. Soc. Honolulu, Vol. I, Pp. 103–104.

Kloft W.

34. 1956–1957. Untersuchungen über pflanzensaugende Insekten und Reaktionen des Wirtspflanzengewebes. Ber. Physik. medizin. Ges. Würzburg, NF. No. 68, Pp. 64–72.

Küster E.

35. 1915. Pathologische Pflanzenanatomie. Jena, Verlag von Gustav Fischer, 447 pages.

Mani M. S.

36. 1964. The ecology of plant galls. 434 pages. Dr W. Junk, The Hague.

Marchal P.

37. 1908. Sur une nouvelle espèce de Thrips nuisible au Ficus en Algérie. Bull. entomol. Paris, Pp. 251–253.

Maresquelle H. J. et Meyer J.

38. 1965. Physiologie et morphogénèse des galles d'origine animale (zoocécidies). In Handbuch d. Pflanzenphysiologie Bd. XV/2, Pp. 280–329, 24 Figs..

Meyer J.

39. 1955–1969. Revue Marcellia, nouvelle série, Supplément au T. 30 et T. 31–36.

Nalepa A.

40. 1906. Ueber das Praeparieren und Konservieren des Gallmilben. Marcellia, Vol. V, P. 49.

41. 1909. Eine Gallmilbe als Erzeugerin der Blattgallen von Cinnamomum zeylanicum Breyn. Marcellia Avellino, Vol. VIII, Pp. 3–6.

42. 1914. Eriophyden aus Java. Marcellia Avellino, Vol. XIII Pp. 51–87.

43. 1923. Eriophyden aus Java IV. Treubia. Buitenzorg, Vol. III, Pp. 423–432.

44. 1929. Neuer Katalog der bisher beschriebenen Gallmilben, ihrer Gallen und Wirtpflanzen. Marcellia, Vol. 25, Pp. 67–183.

Owen Evans G., Sheals J. G. et Mac Farlane D.

45. 1961. The terrestrial Acari of the British Isles. An introduction to their Morphology, Biology and Classification. The Trustees of the British Museum ed.

Rivière C.

46. 1907. Insecte qui attaque les Ficus en Algérie. Bull. Soc. nat. acclim. Paris, Vol. LIV, Pp. 423–424.

Schnell R.

47. 1952. Mélanges botaniques I. F. A. N. Mémoires, No. 18, chap. III, Pp. 239–334, 57 Figs.

48. 1960. Techniques d'herborisation et de conservation des plantes dans les pays tropicaux. Museum National d'Histoire naturelle. Labo. d'Agro. Trop., Vol. VII, 48 pages, 9 Figs..

Trotter A.

49. 1917. Miscellane cecidologiche V. Marcellia Avellino, Vl. XVI, Pp. 147–151.

Van Steenis C. G. G. J.

50. 1950. Flora Malesiana T. I, Series I, 639 pages Noordhoff-Kolff N.V. ed. Djakarta.

Wardlaw C. W.

51. 1965. Organization and evolution in plants. 499 pages, Longmans ed.

Zehnter L.

52. 1900. De Gallen der Djamboe-bladeren. De Indische Natuur. Algemeen Natuurwetensch. Bijblad van het Archief voor Suikerindustrie Soerabaja. Jaargang 1, Fasc. I, Pp. 3–11.

Zimmermann A.

53. 1900. Ueber einige durch Tiere verursachte Blattflecken. Ann. du jard. Bot. de Buit., Vol. XVII, Pp. 102–124. Pls. XV & XVI.

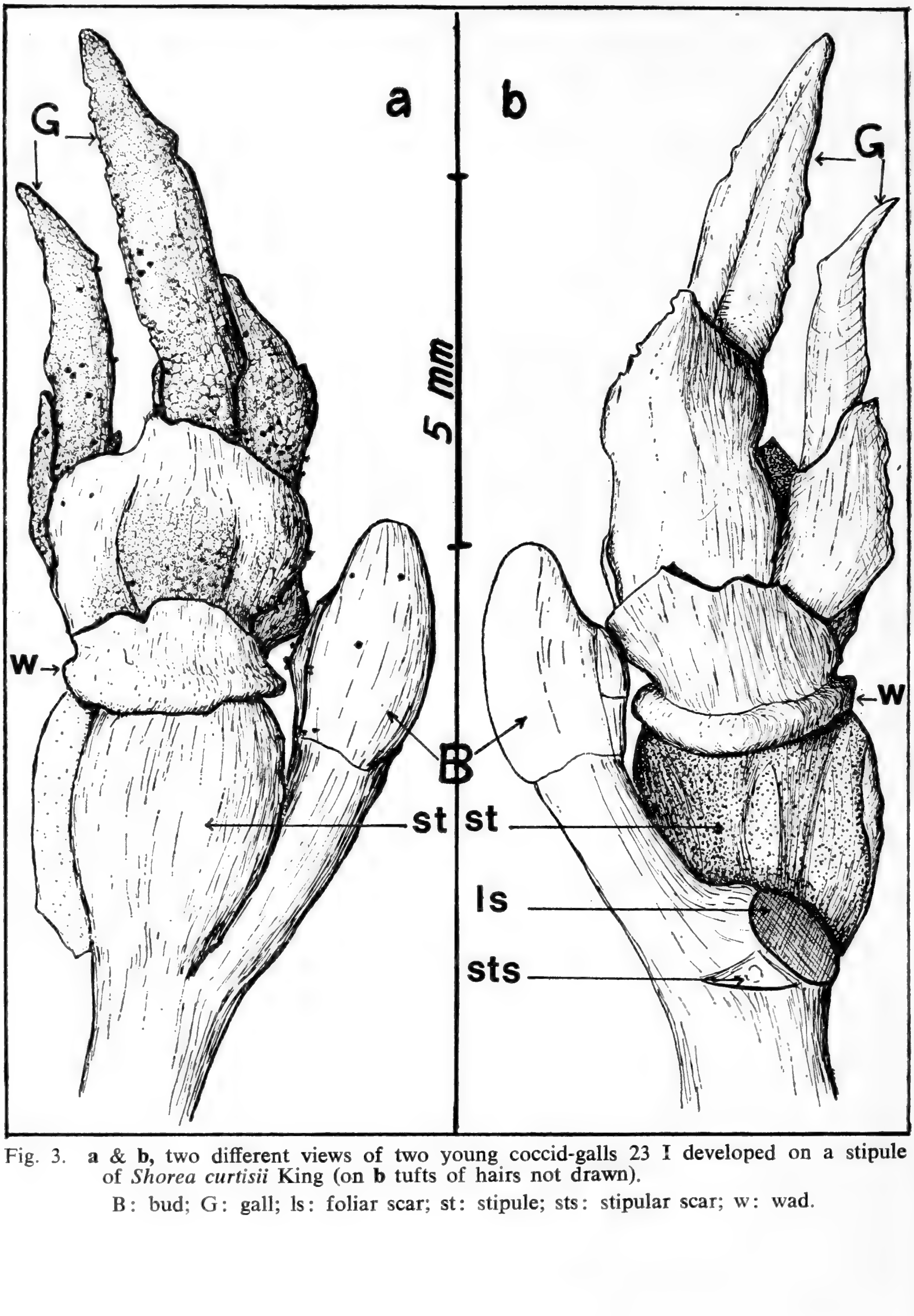

Fig. 3. **a** & **b**, two different views of two young coccid-galls 23 I developed on a stipule of *Shorea curtisii* King (on **b** tufts of hairs not drawn).

B: bud; G: gall; ls: foliar scar; st: stipule; sts: stipular scar; w: wad.

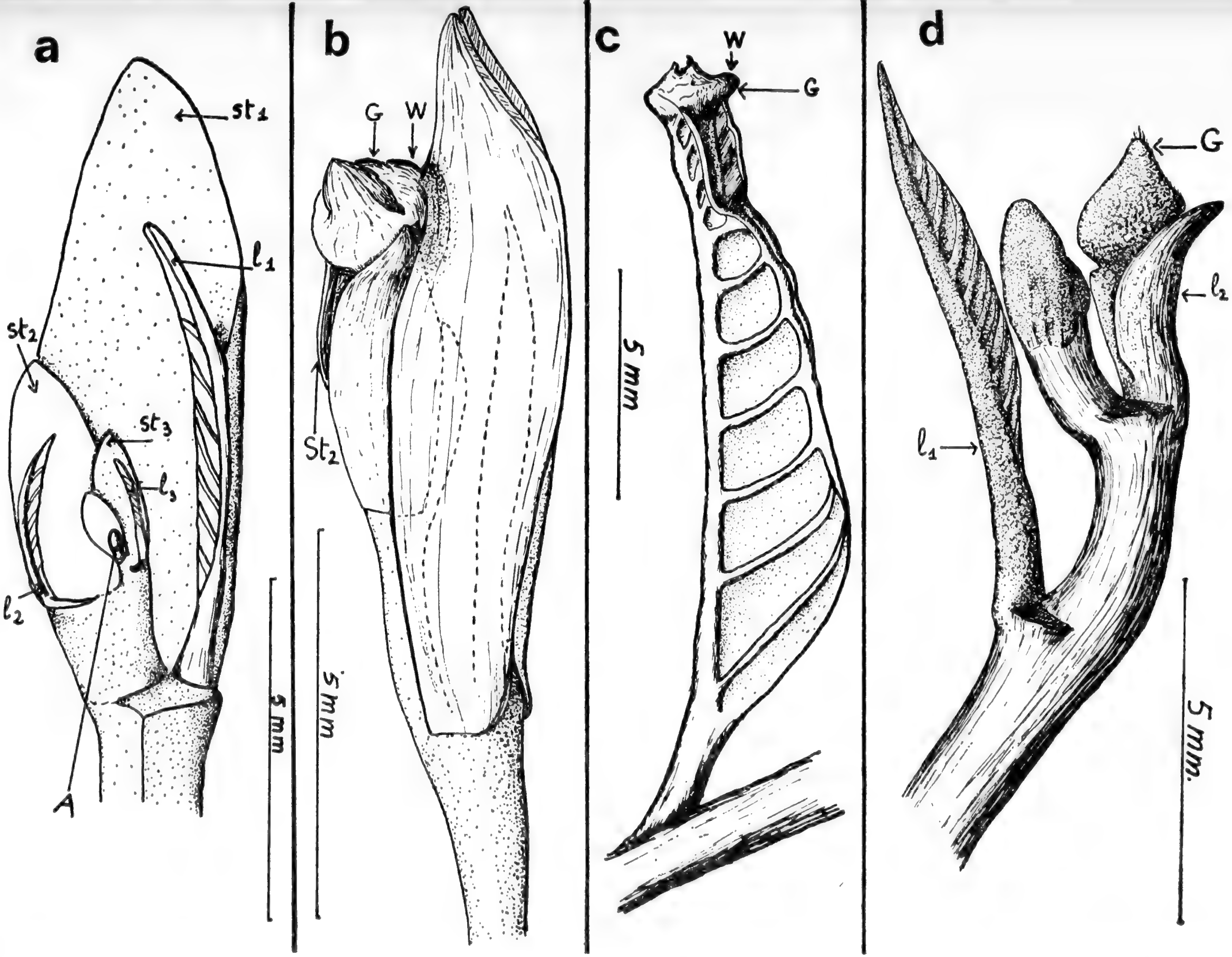

Fig 4. Some aspects of the young coccid-galls 23 I on *Shorea curtisii* King; **a,** normal bud. One stipule of each pair has been removed; **b,** early stage of a gall developed on one of the stipules of the second order; **c,** young gall developed at the tip of the midrib; next to the gall the lamina is very reduced, but the rest of the leaf is normal; **d,** young gall developed on a leaf that has become completely atrophic. It corresponds to an earlier stage of attack than case **c.**
A: growing point; G: gall; *l*1, *l*2, *l*3, each a leaf of the respective order: similarly st 1, st 2, st 3 for stipules; W: wad.

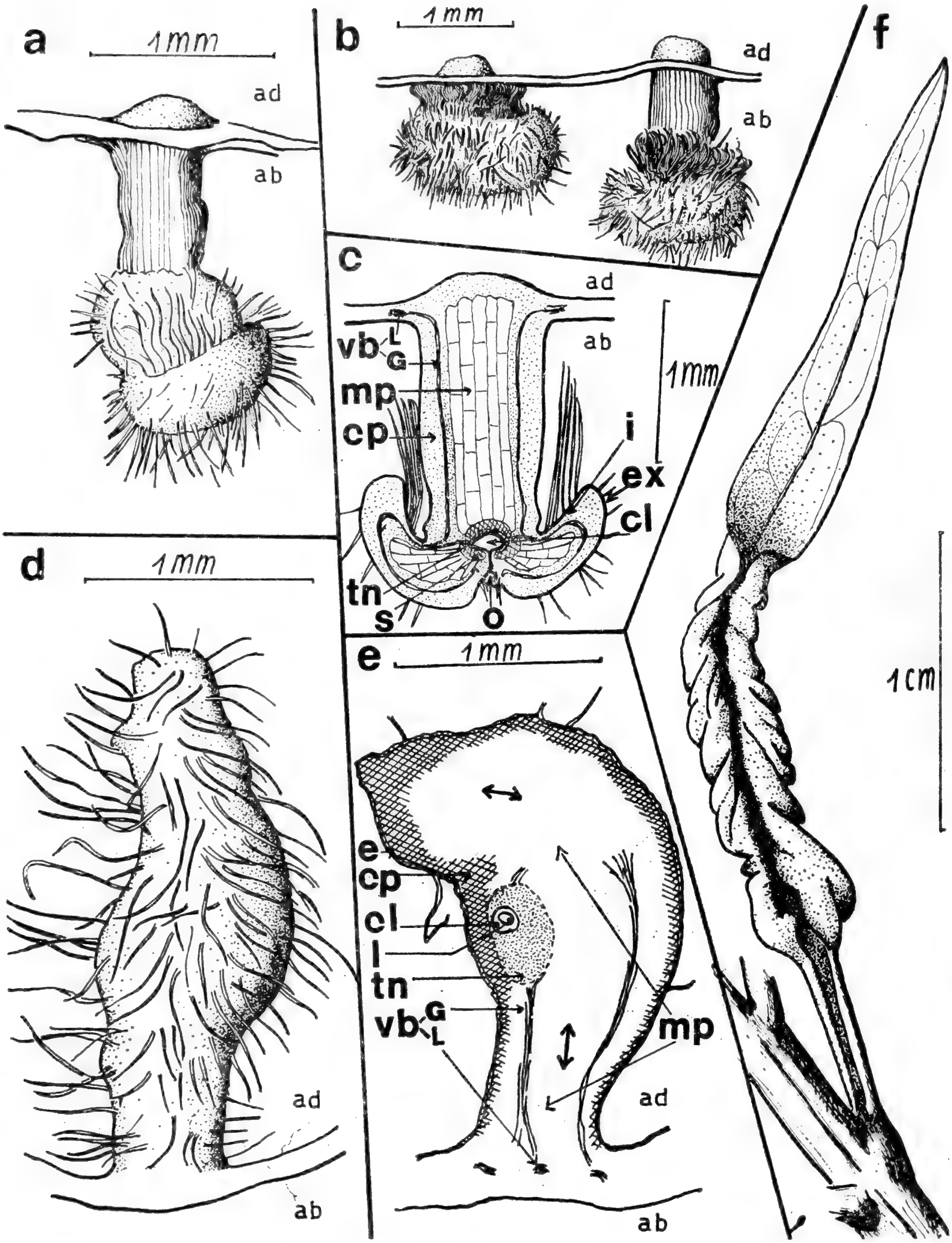

Fig. 5. a-e, galls on *Shorea curtisii* King; **a,** midge-gall 23 III attacked by a parasitic chalcid; **b,** two developing stages of the midge-gall 23 III (left: early stage; right: older stage.); **c,** longisection of the midge-gall 23 III; **d,** wasp-gall 23 II; **e,** longisection of the same; **f,** thrips gall 219 on *Clerodendron laevifolium* Bl. ab: abaxial leaf-surface; ad: adaxial leaf-surface; cl: larval cavity; cp: cortical parenchyma; e: epidermis; ex: external cap-side; i: internal cap-side: l: larva; mp: medullar parenchyma; o: ostiole; s: shell; tn: nutritive tissue; Vb-L/G: vascular bundles of the leaf/gall.

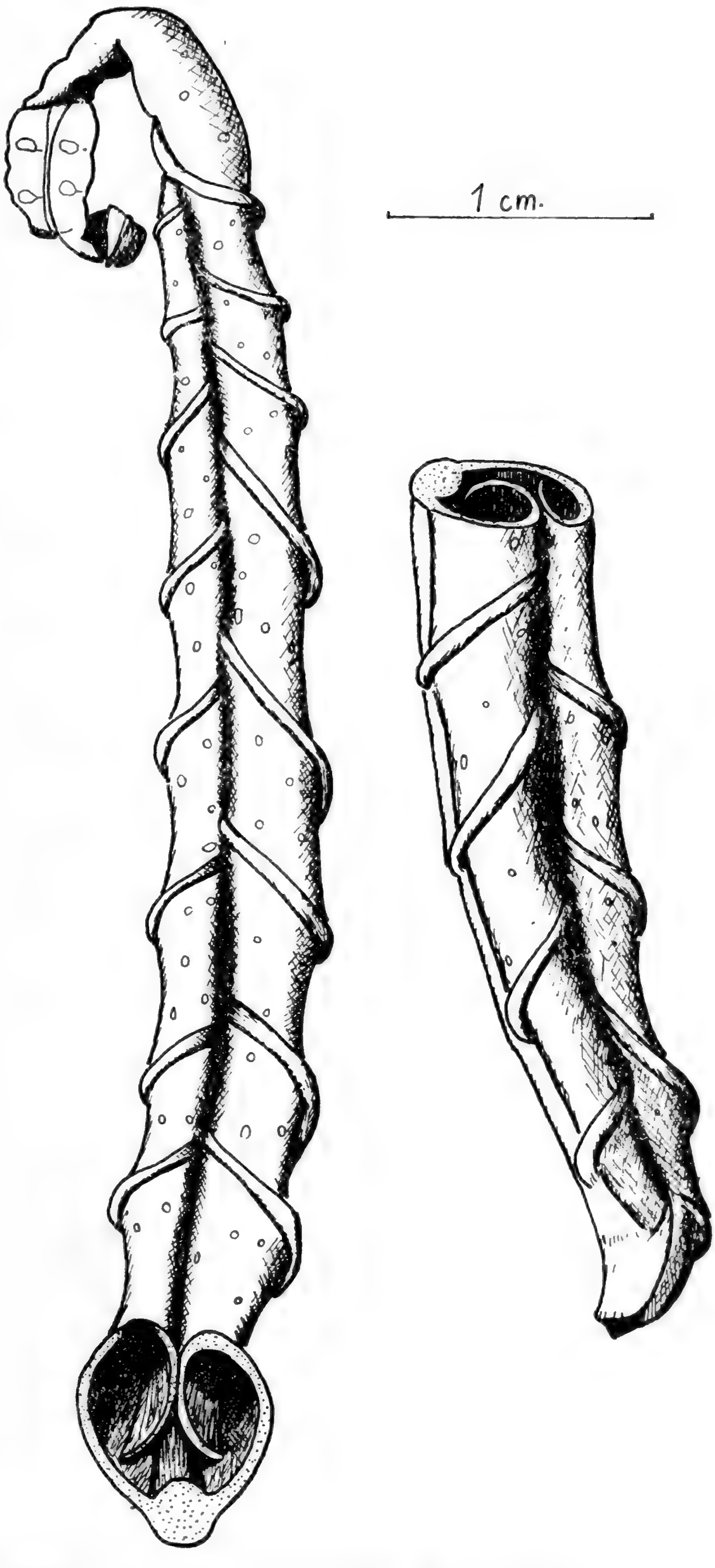

Fig. 6. **Thrips-gall 98 I on *Aporosa benthamiana* Hk. f. & Th.**

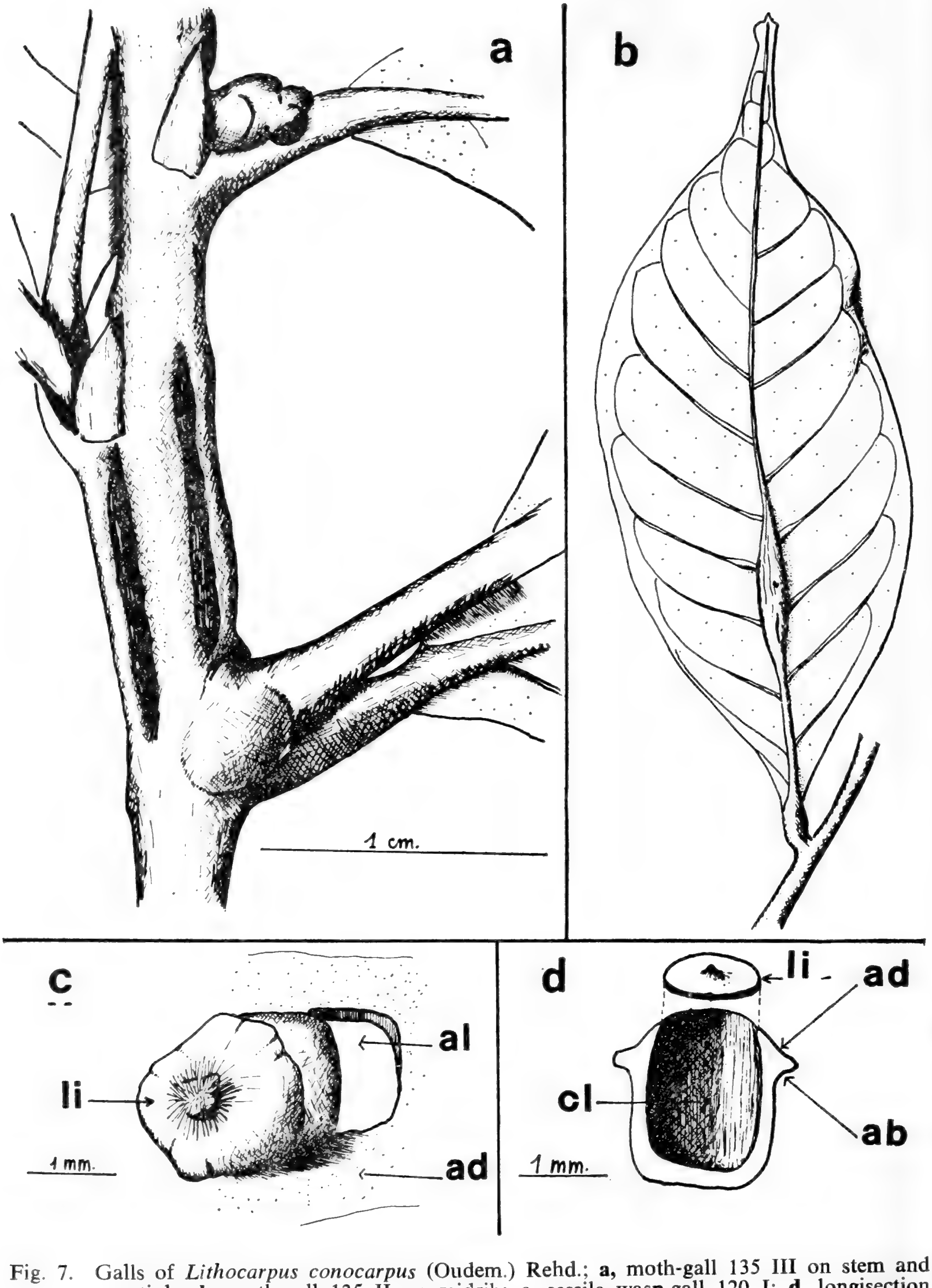

Fig. 7. Galls of *Lithocarpus conocarpus* (Oudem.) Rehd.; **a,** moth-gall 135 III on stem and petiole; **b,** moth-gall 135 II on midrib; **c,** sessile wasp-gall 120 I; **d,** longisection of the gall 120 I. On top, the detached lid of the gall.
ab: abaxial leaf-surface; ad: adaxial leaf-surface;
al: alveole; cl: larval cavity; li: gall-lid.

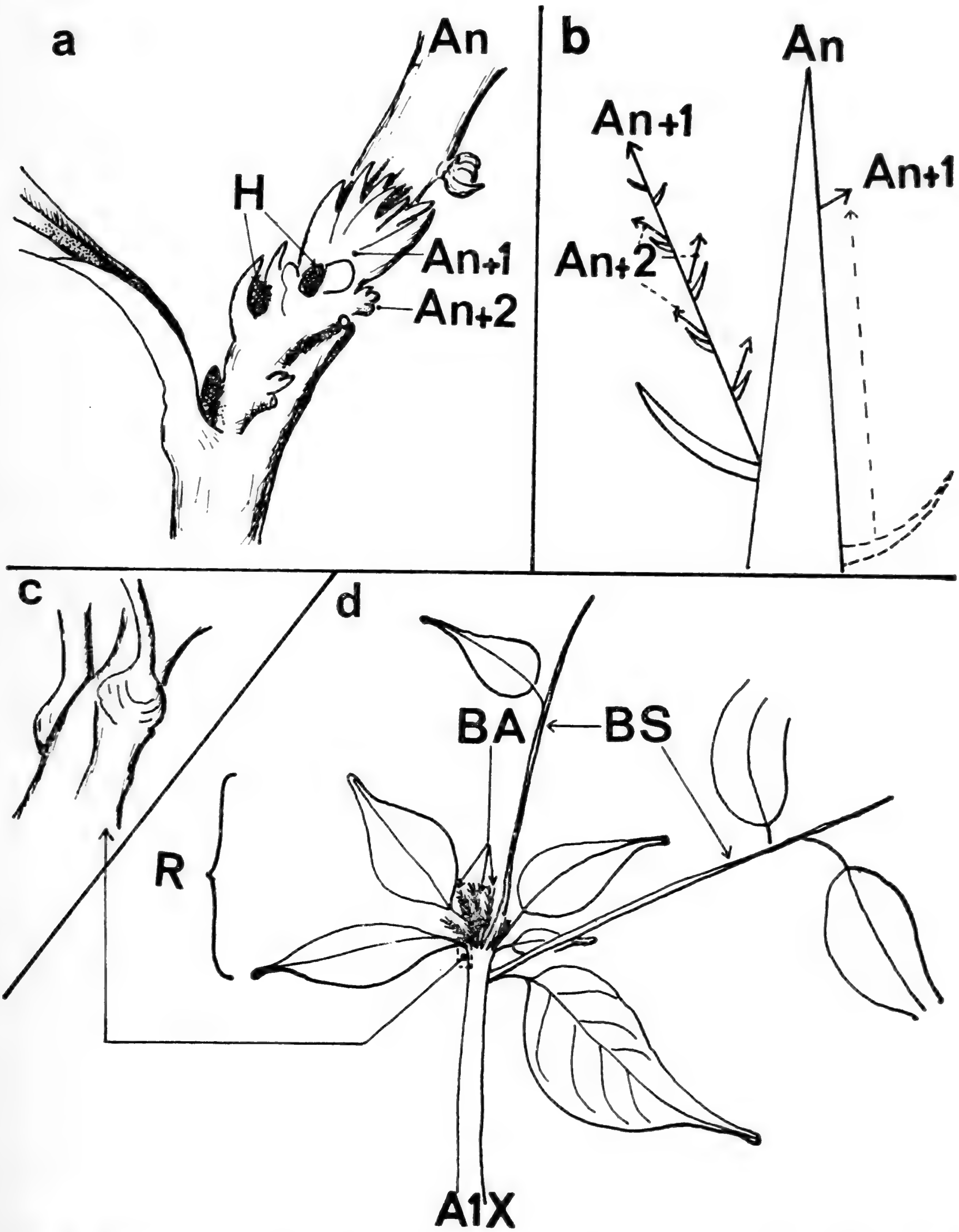

Fig. 8. Witches' broom 153 IV caused by coccids on *Lithocarpus sundaicus* (Bl.) Rehd. **a,** pathological development of an axillary bud: formation of secondary and tertiary shoots and reduction of leaves; **b,** sketch of the line drawing **a, c,** hypertrophic base of a leaf; **d,** sketch of the witches'broom.
A1X: cessation of growth of the principal axis; An, An+1, An+2, each a shoot of the respective order; H: Homoptera; R: rosette of leaves due to the shortening of internodes; BA: axillary buds abundantly developed; BS: axillary buds strongly developed.

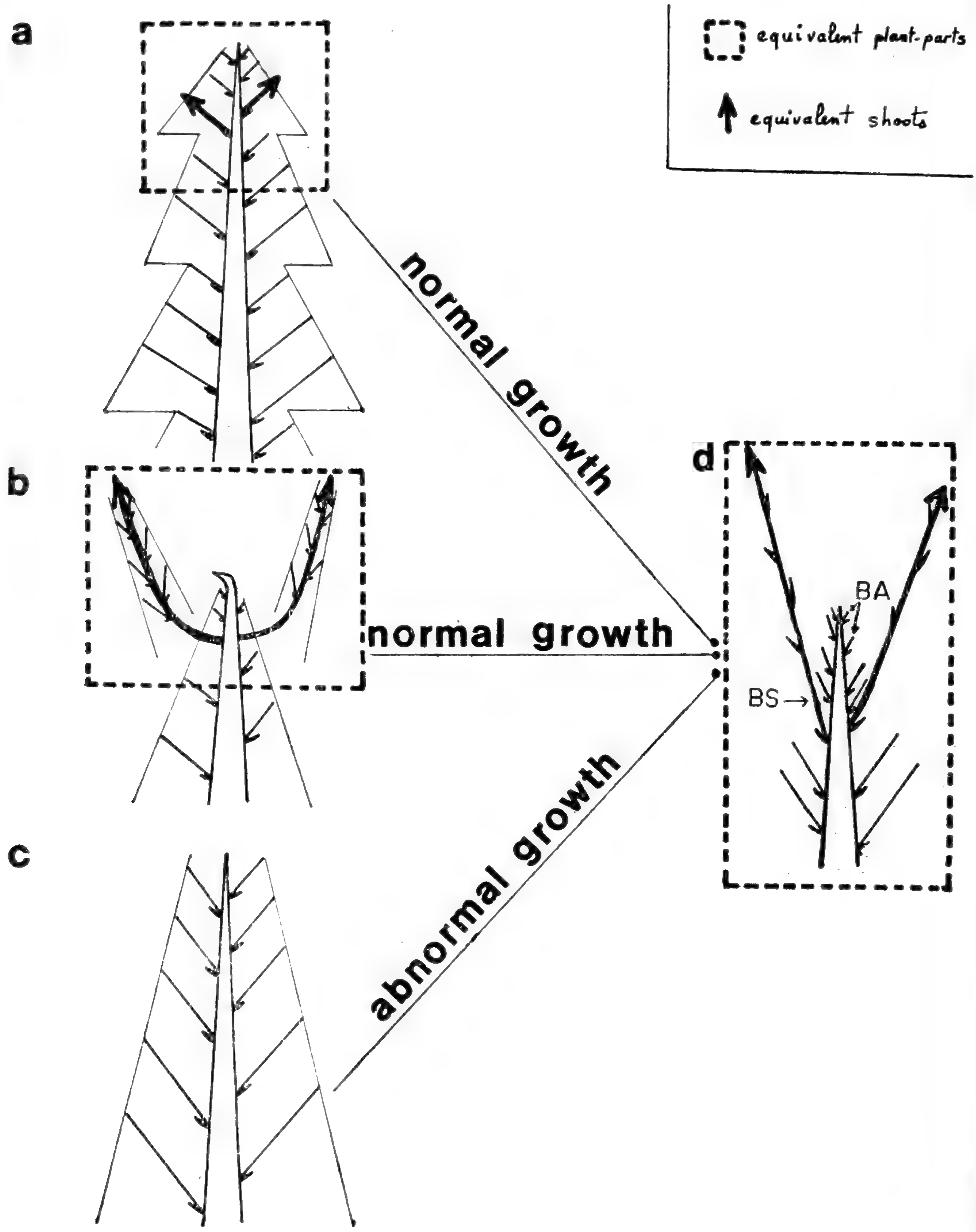

Fig. 9. Hypothesis on the growth vigor under the gall-zone, fide Dr. Cusset in litt. (see p. 36 in text); **a,** monopodial growth with flush; **b,** sympodial and more or less acrotonic growth; **c,** monopodial growth without rhythm; **d,** observed gall-growth. BA: axillary buds abundantly developed; BS: axillary buds strongly developed.

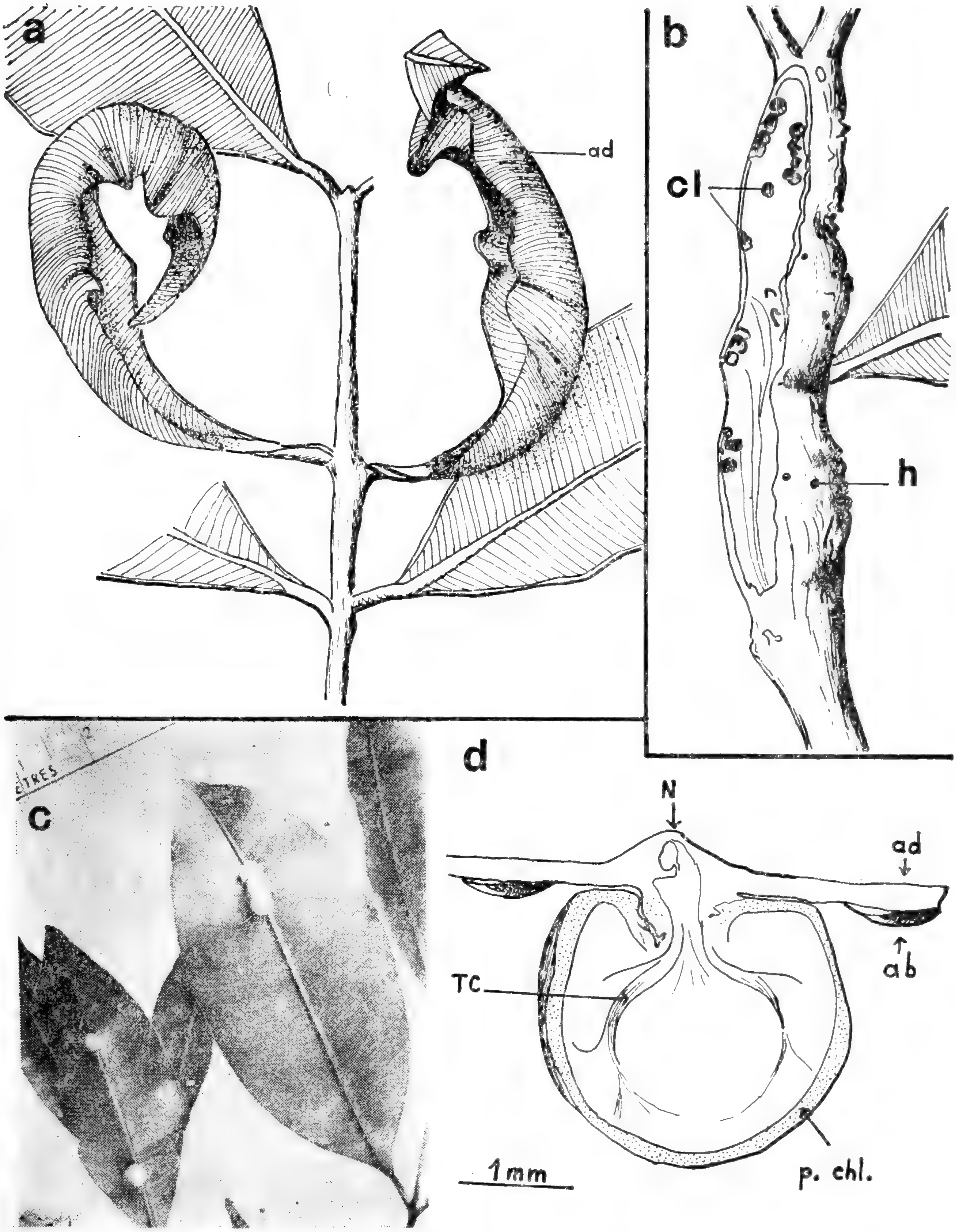

Fig. 10. Galls on *Calophyllum pulcherrimum* Wall.; **a,** psyllid-gall 107 I; note the twisted petioles; **b,** midge-gall 107 III on stem longitudinally cut on the left; **c,** midge-galls 107 II; **d,** longisection of gall 107 II.
ab: abaxial leaf-surface; ad: adaxial leaf-surface cl: larval cavity; h: emergence hole; N: midrib; p. chl; parenchyma with chlorophyll; TC: vascular bundle.

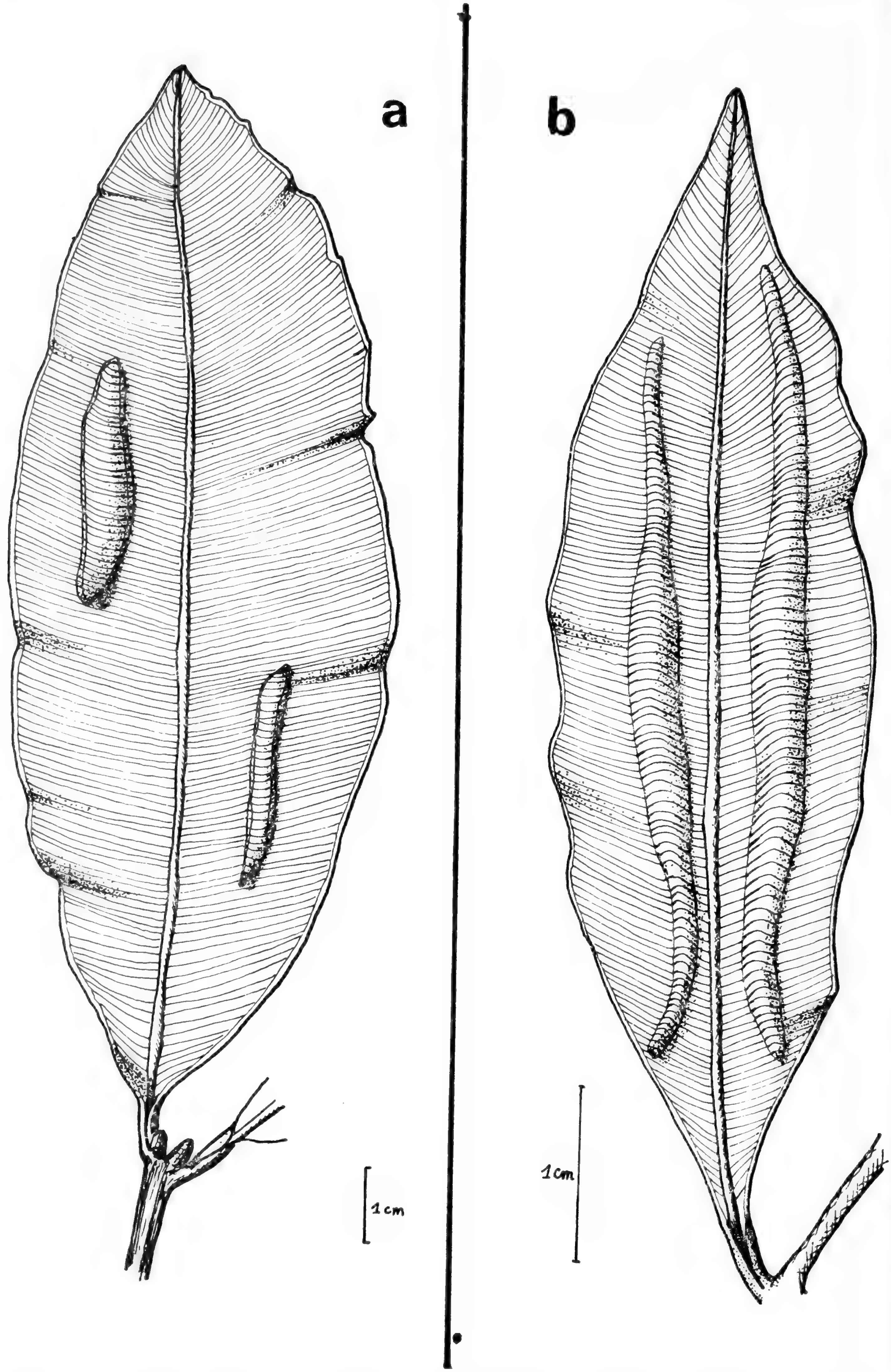

Fig. 11. Leaf-galls caused by moths; **a,** *Calophyllum ferrugineum* Ridl. gall 141 III; **b,** *Calophyllum pulcherrimum* Wall. gall 167 IV.

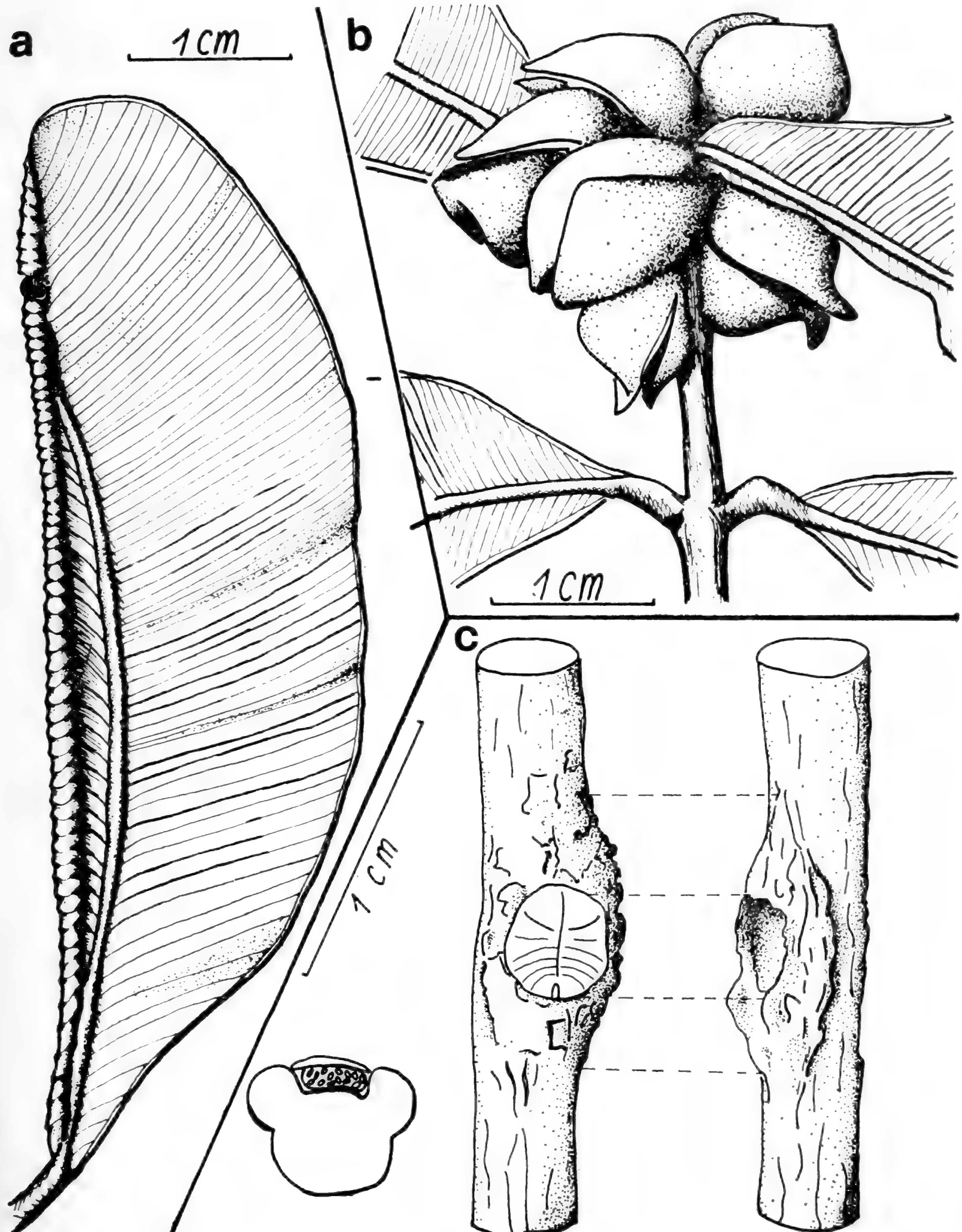

Fig. 12. **a,** psyllid-gall 43 II on *Calophyllum inophylloide* King; **b,** coccid-galls 43 I on same; **c,** coccid-gall 154 on stem of *Xylopia malayana* Hk. f. & Th.

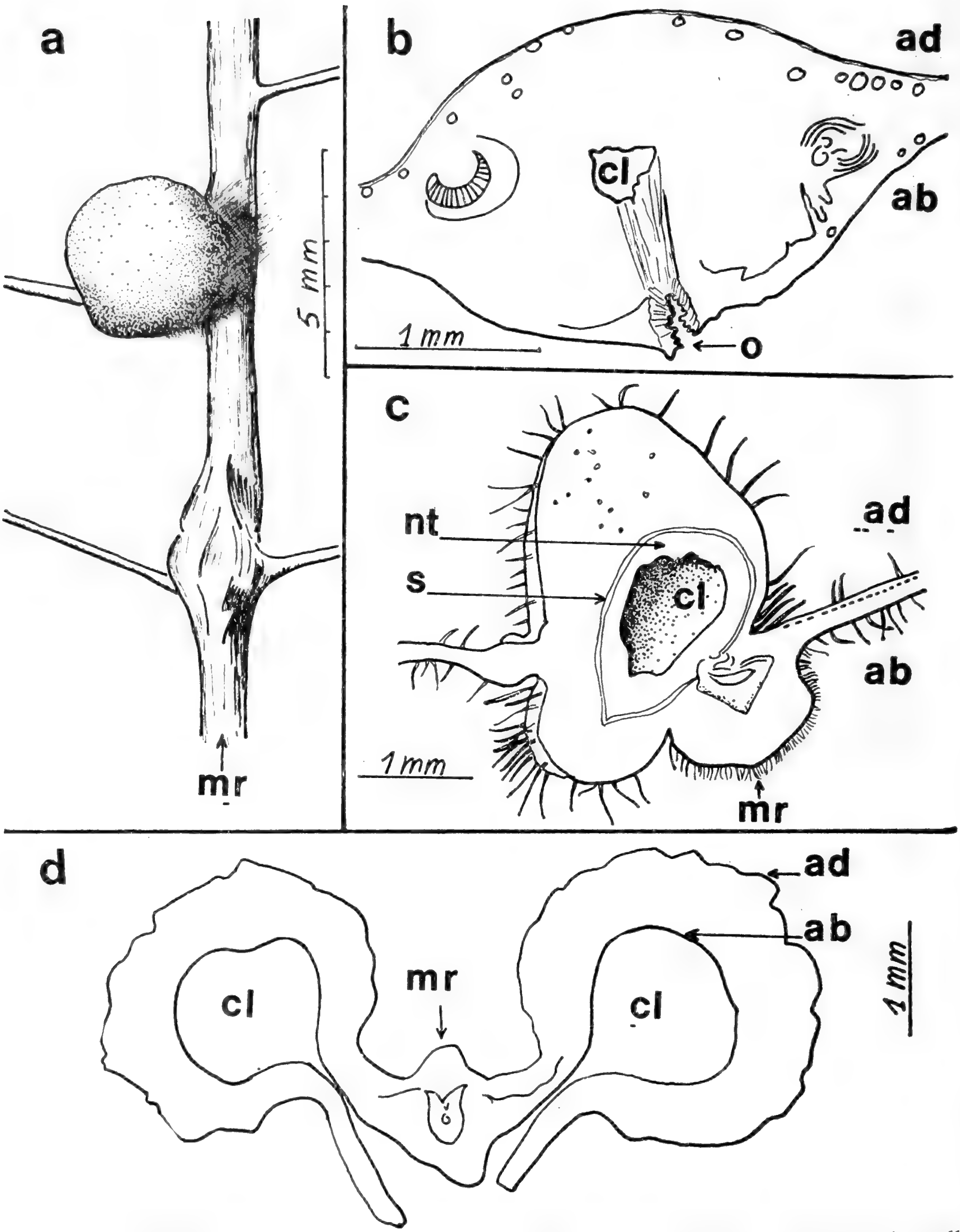

Fig. 13. **a**, midge-gall 143 IV on vein of *Actinodaphne* sp; **b**, longisection of the midge-gall 138 II on leaf of same; **c**, longisection of the midge-gall 151 on midrib of *Popowia tomentosa* Maingay; **d**, transection of the midge-gall 68 I on leaf of *Calophyllum ferrugineum* Ridl.

ab: abaxial leaf-surface; ad: adaxial leaf-surface;
cl: larval cavity; mr: midrib; nt: nutritive tissue;
o: ostiole; s: shell.

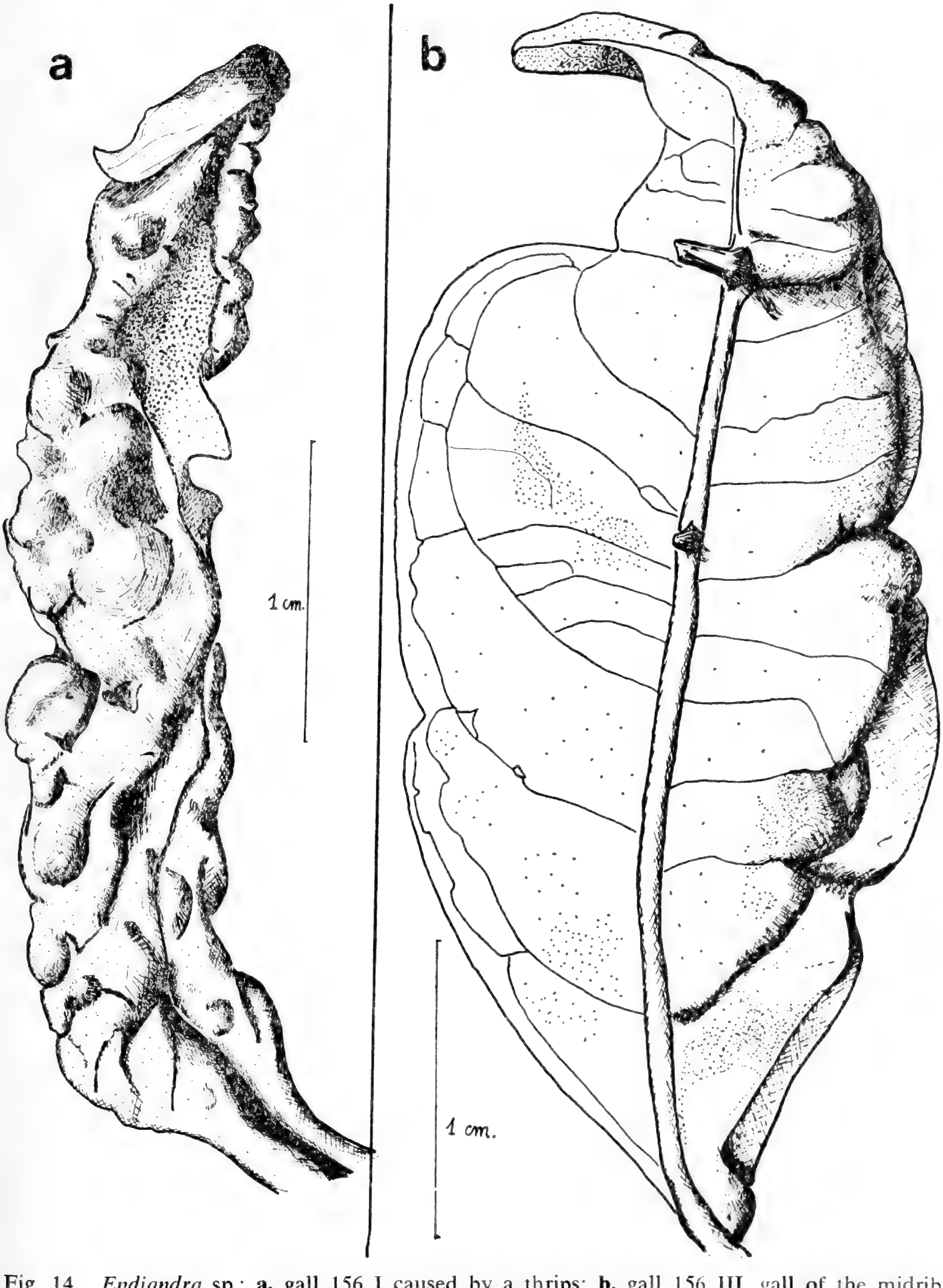

Fig. 14. *Endiandra* sp.; **a,** gall 156 I caused by a thrips; **b,** gall 156 III, gall of the midrib developed on the upper-surface of the leaf and gall 156 I caused by a thrips, on the right part of the leaf.

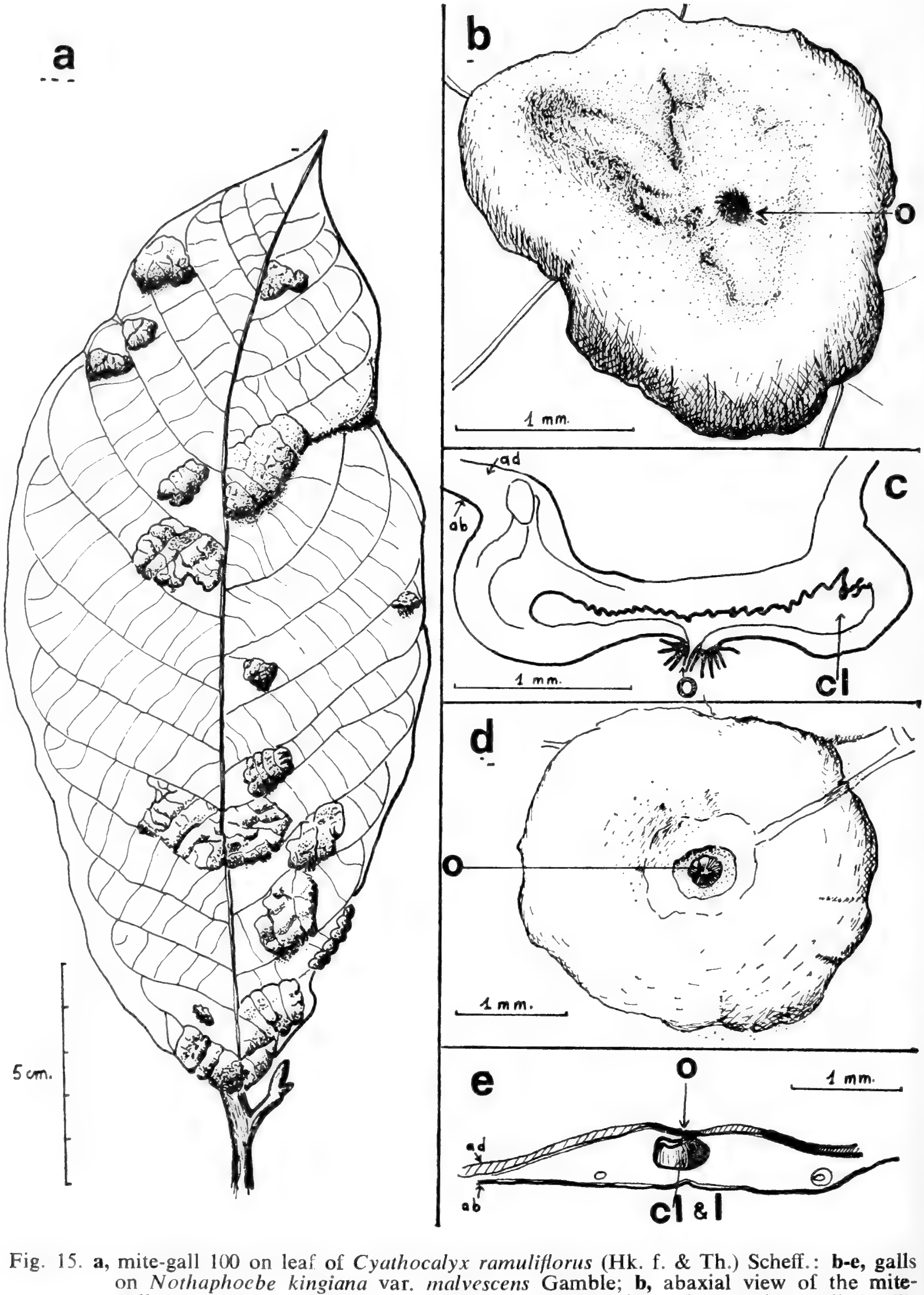

Fig. 15. **a,** mite-gall 100 on leaf of *Cyathocalyx ramuliflorus* (Hk. f. & Th.) Scheff.: **b-e,** galls on *Nothaphoebe kingiana* var. *malvescens* Gamble; **b,** abaxial view of the mite-gall 133 III; **c,** section of the same; **d,** adaxial view of the midge-gall 94 II; **e,** section of the same.
ab: abaxial leaf-surface; ad: adaxial leaf-surface;
cl: larval cavity l: larva: o: ostiole.

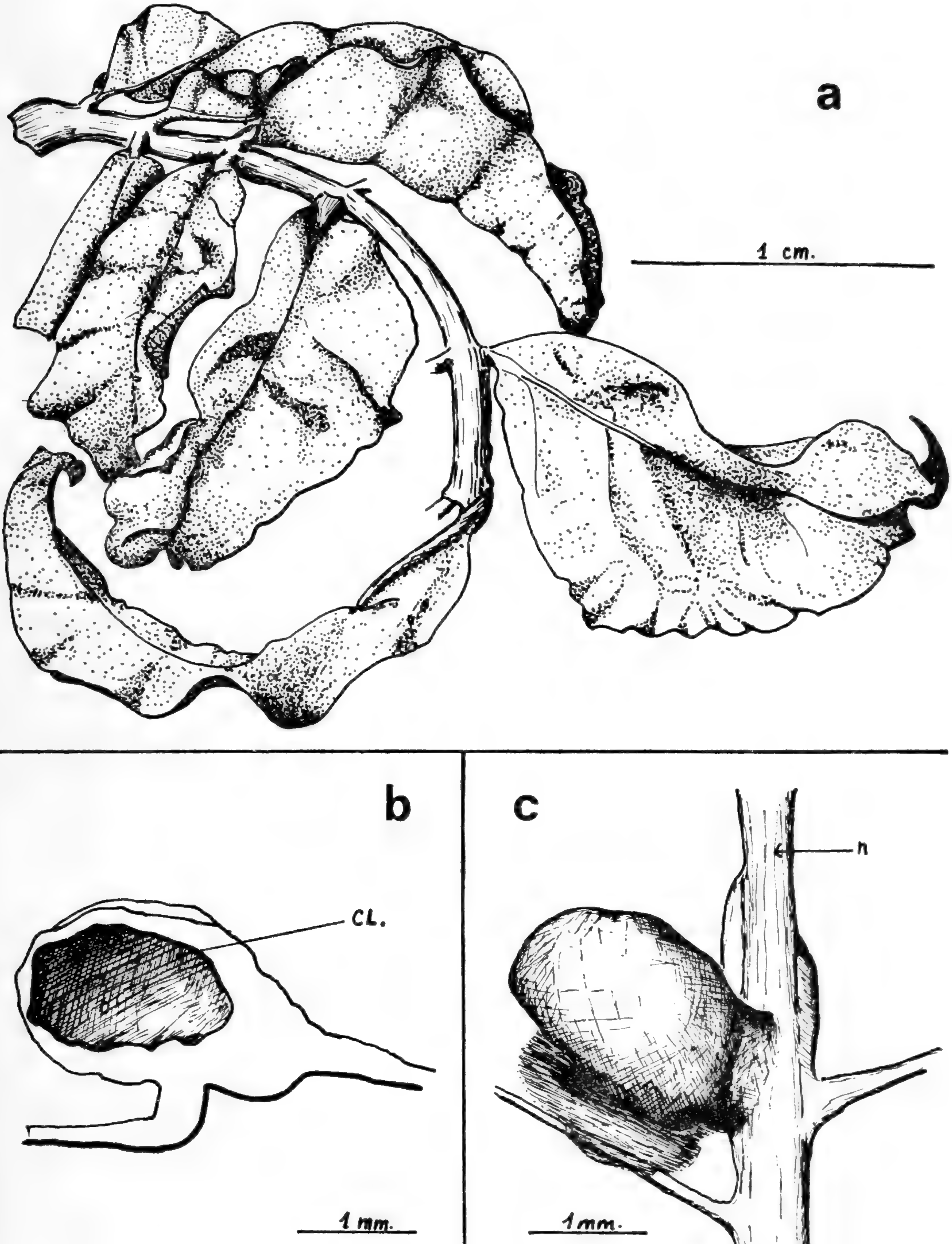

Fig. 16. *Pithecellobium clypearia* Benth.; **a,** gall 115 II, probably caused by Homoptera; **b,** gall 115 I, median longisection of the midge-gall, showing the large larval chamber (CL); **c,** midge-gall 115 I abaxially attached to the midrib (n).

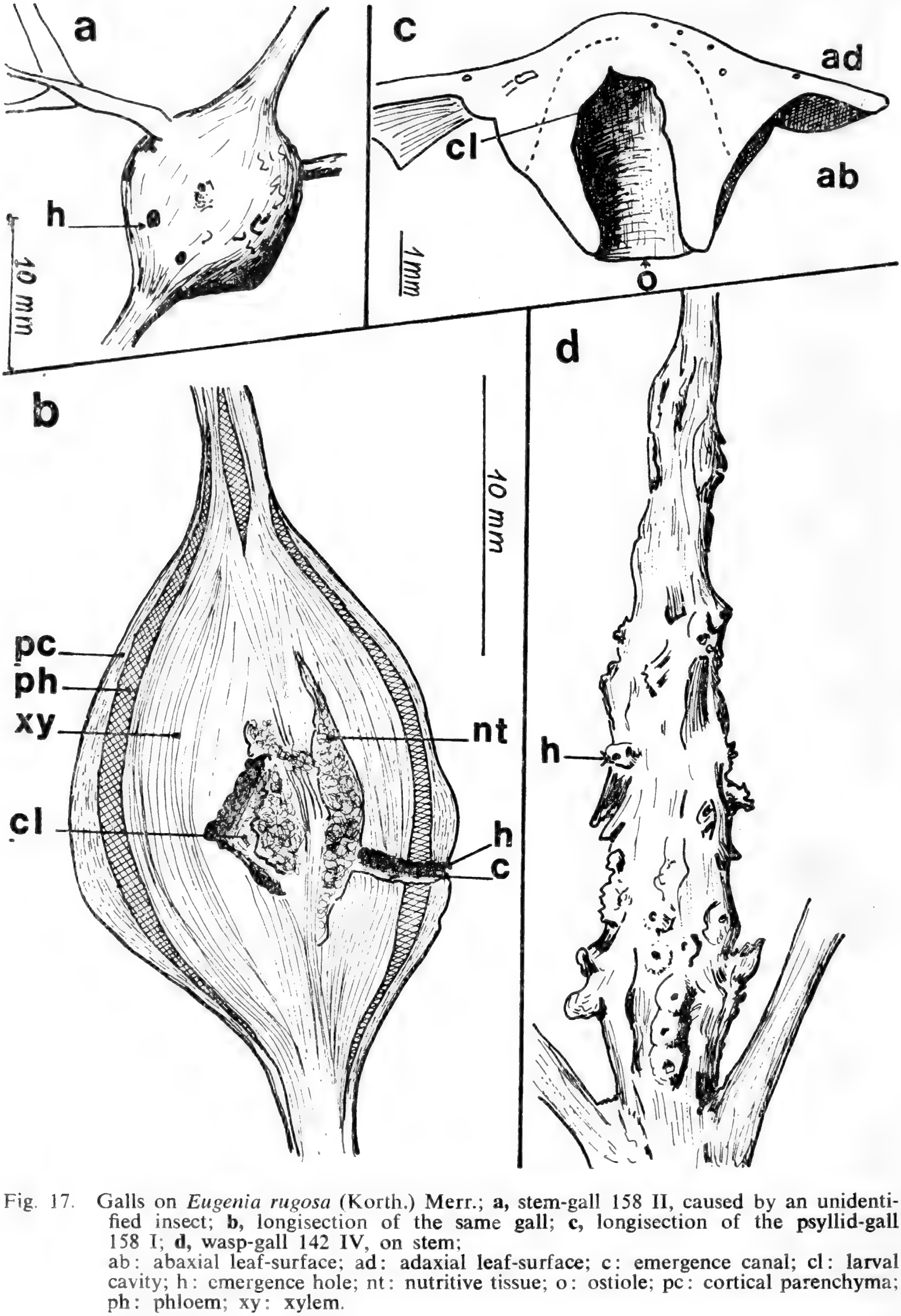

Fig. 17. Galls on *Eugenia rugosa* (Korth.) Merr.; **a,** stem-gall 158 II, caused by an unidentified insect; **b,** longisection of the same gall; **c,** longisection of the psyllid-gall 158 I; **d,** wasp-gall 142 IV, on stem;
ab: abaxial leaf-surface; ad: adaxial leaf-surface; c: emergence canal; cl: larval cavity; h: emergence hole; nt: nutritive tissue; o: ostiole; pc: cortical parenchyma; ph: phloem; xy: xylem.

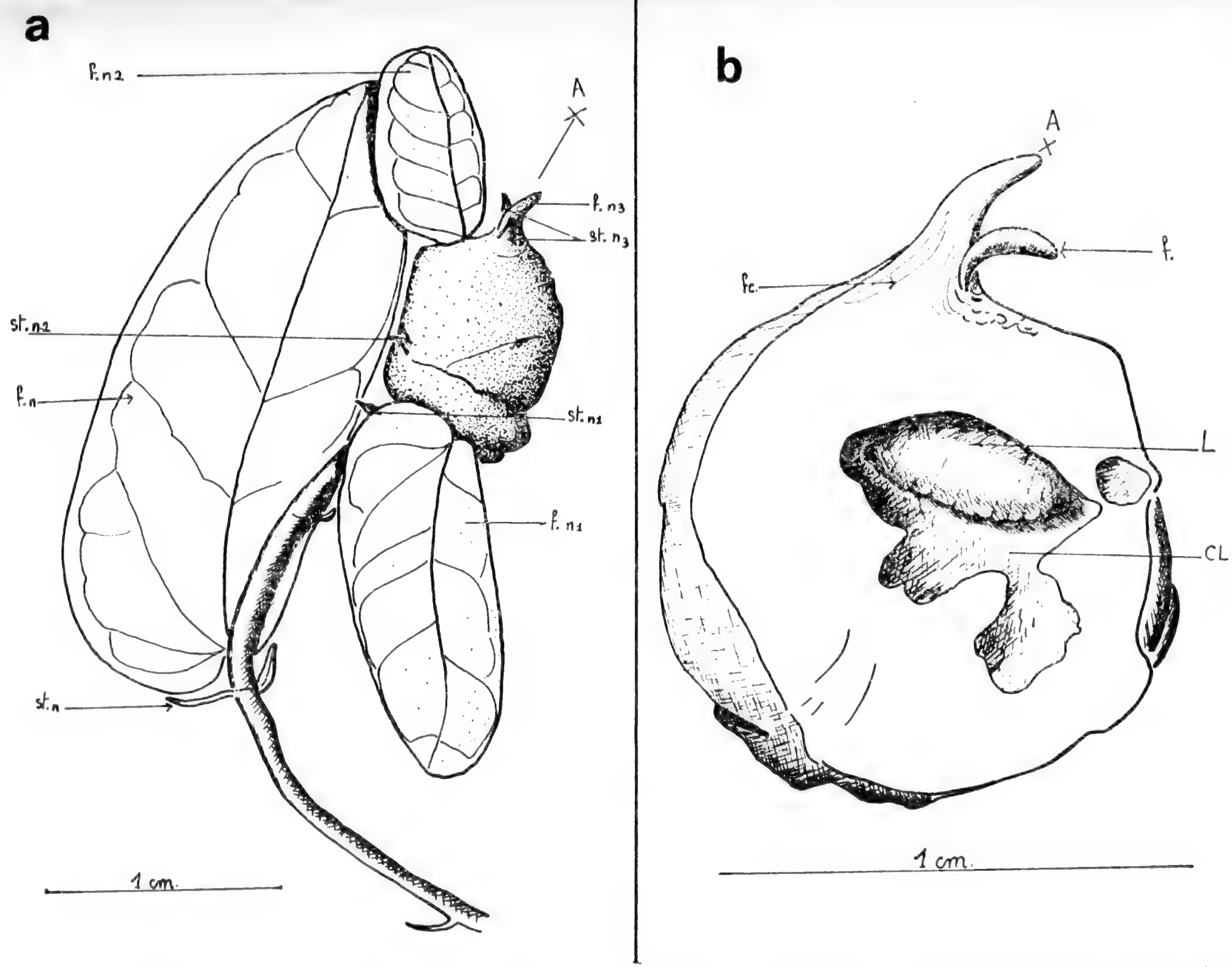

Fig. 18. Wasp-gall 150 on *Ficus pumila* Linn.; **a,** morphology of the gall (A: inhibited growing point of the stem; f.n: leaf of nth order; st.n: stipule of nth order.); **b,** longisection of the gall showing the gall-chamber (CL) and one larva (L), (f.: leaf; fc: vascular bundle.).

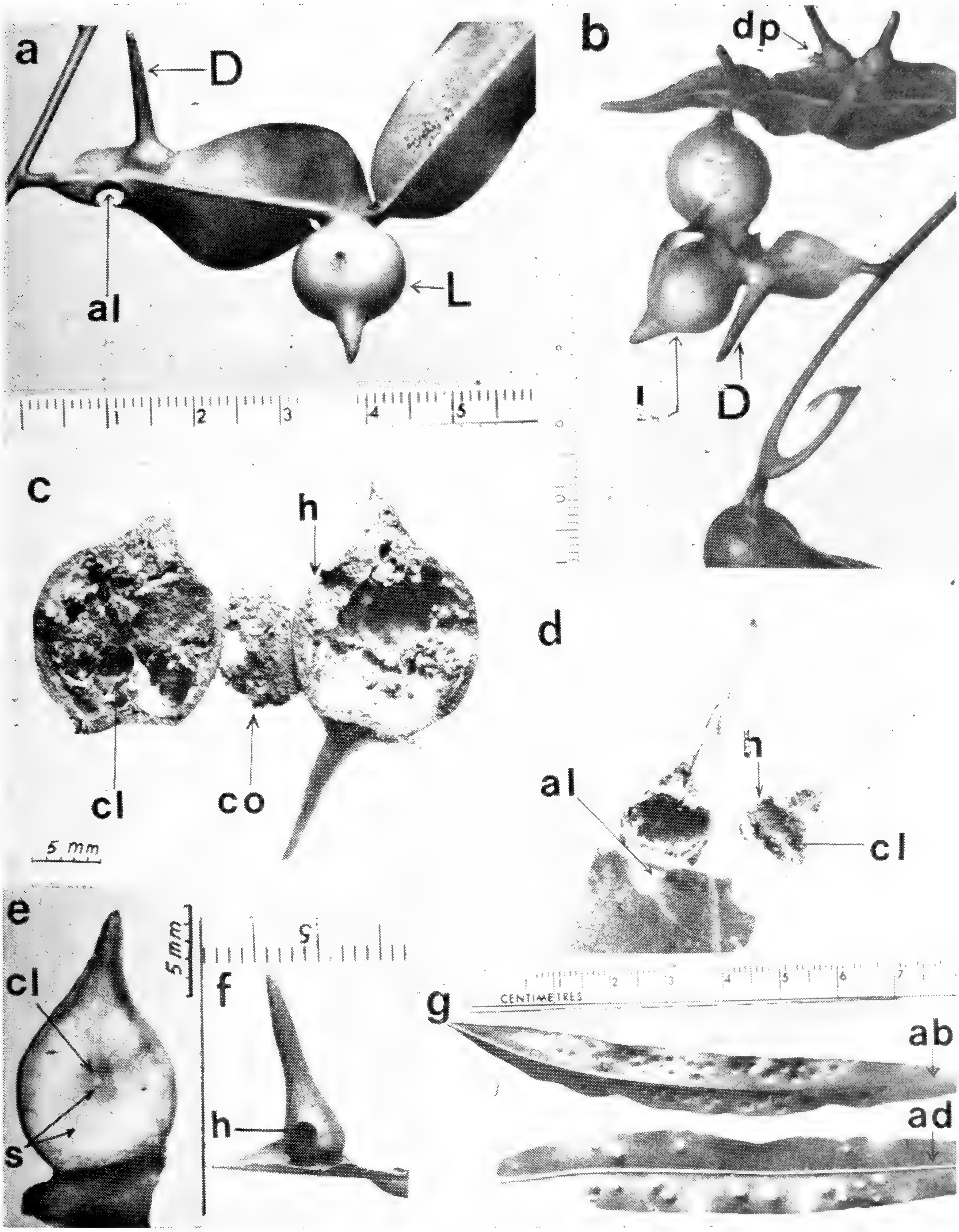

Plate 1. Galls on *Artabotrys suaveolens* Bl.; **a-f,** midge-gall 22 I; **a,** & **b,** fully developed midge-galls (D) and galls containing a parasitic moth (L); **c,** longisection of a gall after emergence of parasitic moth with cocoon left behind in the gall cavity; **d,** longisection of a gall after emergence of the midge; **e,** longisection of a young midge-gall; **f,** a dehiscent midge-gall; **g,** psyllid-gall 22 II on abaxial (ab) and adaxial (ad) sides.

al: alveole; cl: larval cavity; co: moth-cocoon; dp: pupal integument of midge; h: emergence hole; s: protective shell.

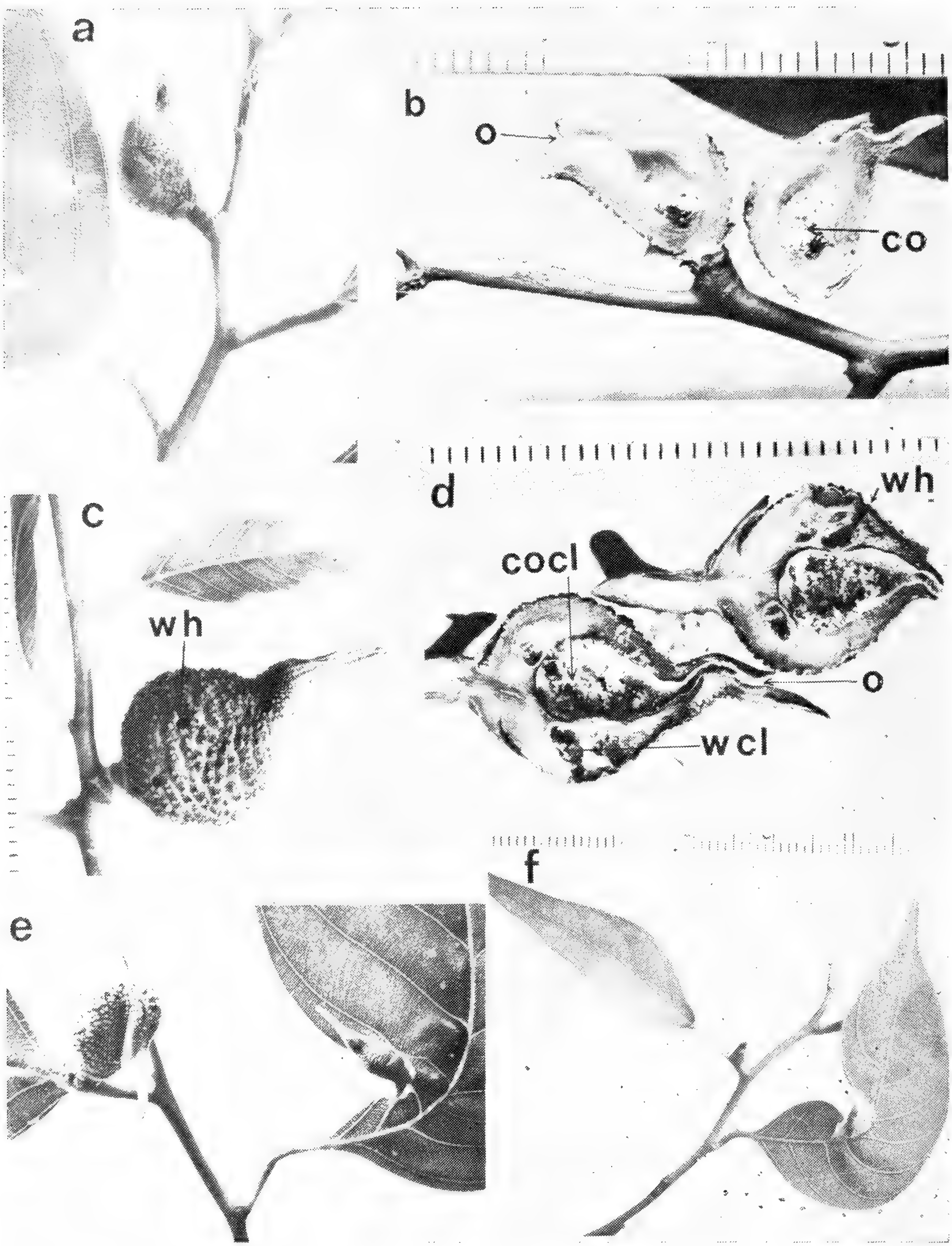

Plate 2. Coccid-gall 23 I on *Shorea curtisii* King; **a,** a fully developed gall; **b,** longisection of the same; **c,** a coccid-gall attacked by parasitic wasps; **d,** longisection of the; same; **e,** fully developed galls on the petiole (left) and on the leaf-margin (right); **f,** young gall developed on the petiole (left) and on the leaf-margin (right). co: coccids; cocl: larval cavity of coccids; o: ostiolar emergence canal; wcl: larval cavity of wasp; wh: emergence hole of wasp.

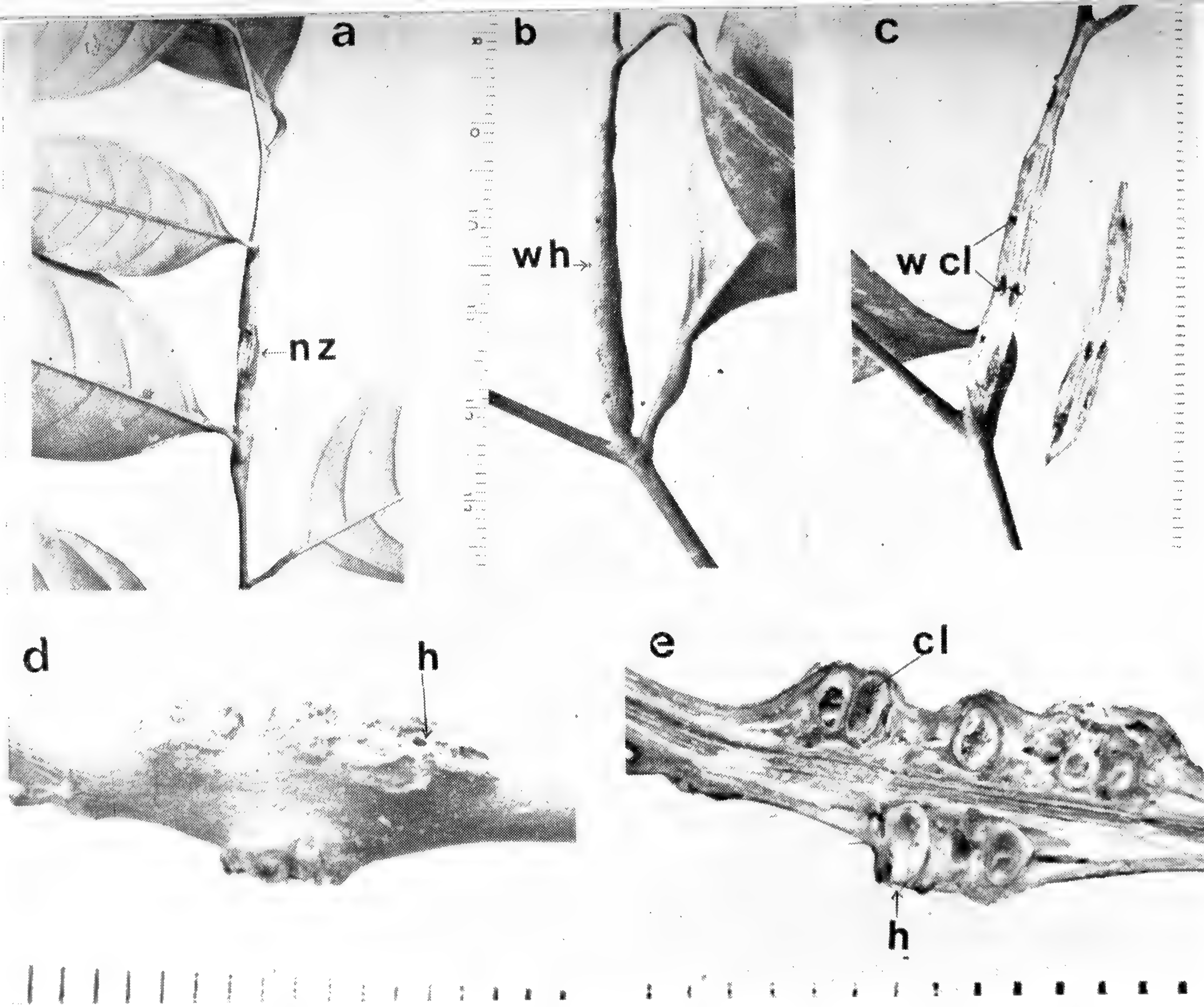

Plate 3. Stem-galls on *Shorea curtisii* King; **a,** a dehiscent coccid gall 23 IVb; **b,** the same gall containing parasitic wasps; **c,** longisection of the same; **d,** a wasp-gall 23 IVa; **e,** longisection of the same.
cl: larval cavity of gall-maker; h: emergence hole of the same; nz: necrotized plant-tissues due to coccids; wcl: larval cavity of parasitic wasp; wh: emergence hole of the same.

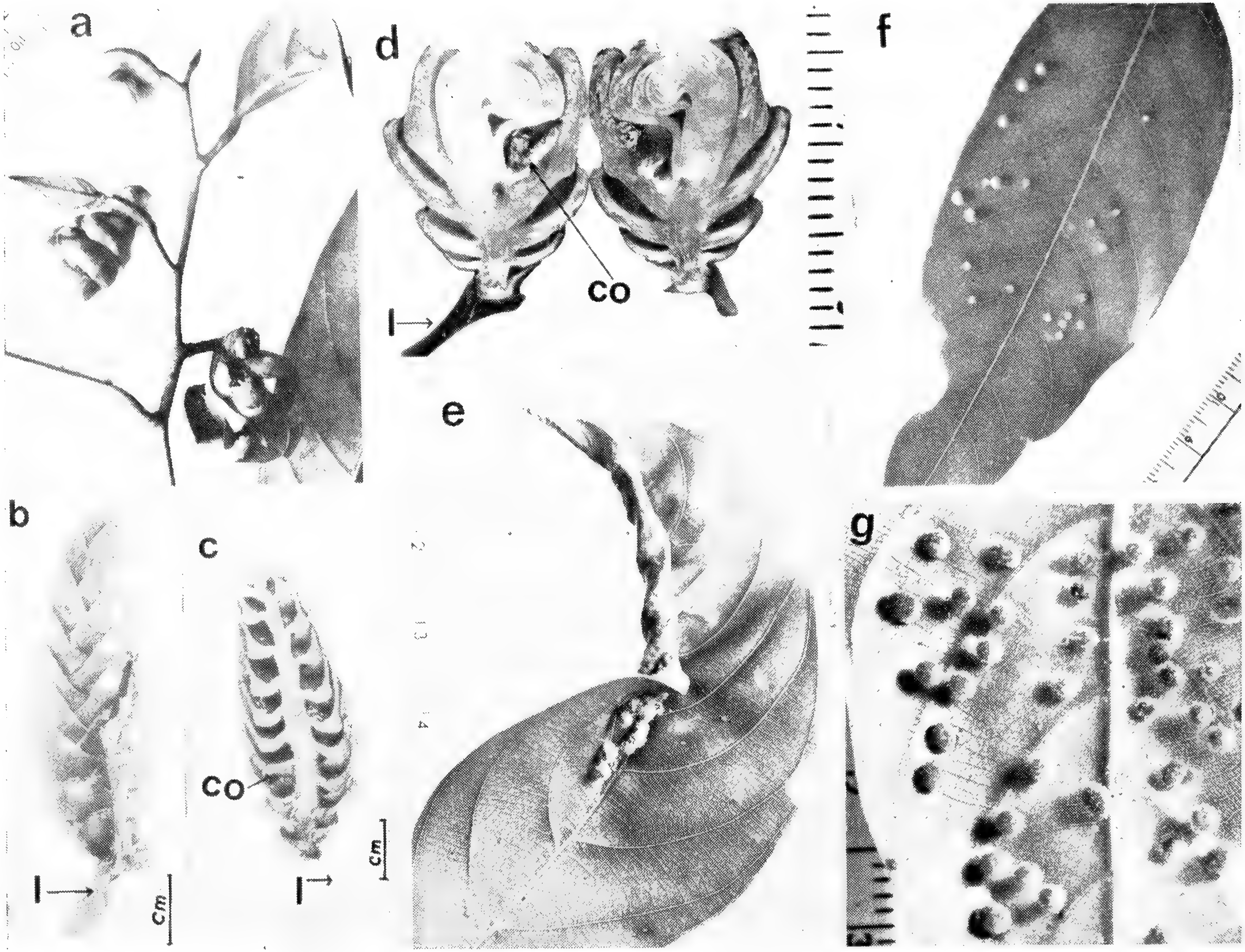

Plate 4. Leaf-galls on *Shorea curtisii* King; **a-d,** coccid-gall 23 V; **a,** starting from the terminal bud, the top two leaves show early stage of cecidiogenesis: notice enlargement and bent midrib; the third leaf is much reduced and bears a developed gall; the fourth and its two galls are dried out; **b,** fully developed gall; **c,** longisection of the same showing the gall "internodes" which are well elongated; **d,** longisection of mature gall showing coccids located in the axil of the fourth foliaceous appendage starting from the base of the gall; **e,** wasp-gall 23 II; **f,** midge galls 23 III developed on abaxial face of the leaf.

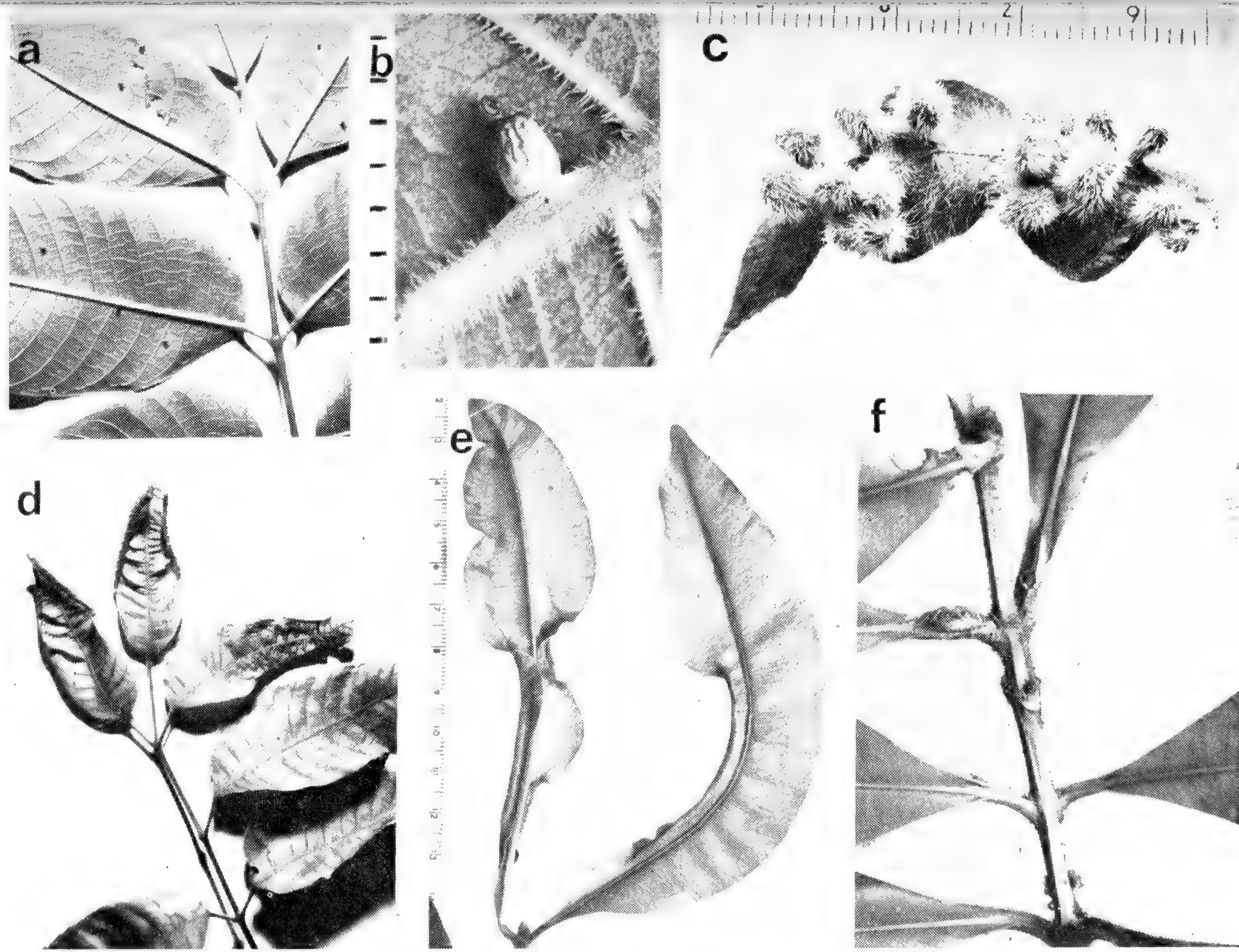

Plate 5. **a,** midge-galls 121 III on leaflets of *Canarium pilosum* A. W. Benn.; **b,** a dehiscent gall opening by a lid; **c,** mite-galls 69 I on leaflet of the same; **d,** gall 121 IV on the same host; **e,** midge-galls 68 I on leaf of *Calophyllum ferrugineum* Ridl.; **f,** midge-gall 68 II on leaf-petiole of the same.

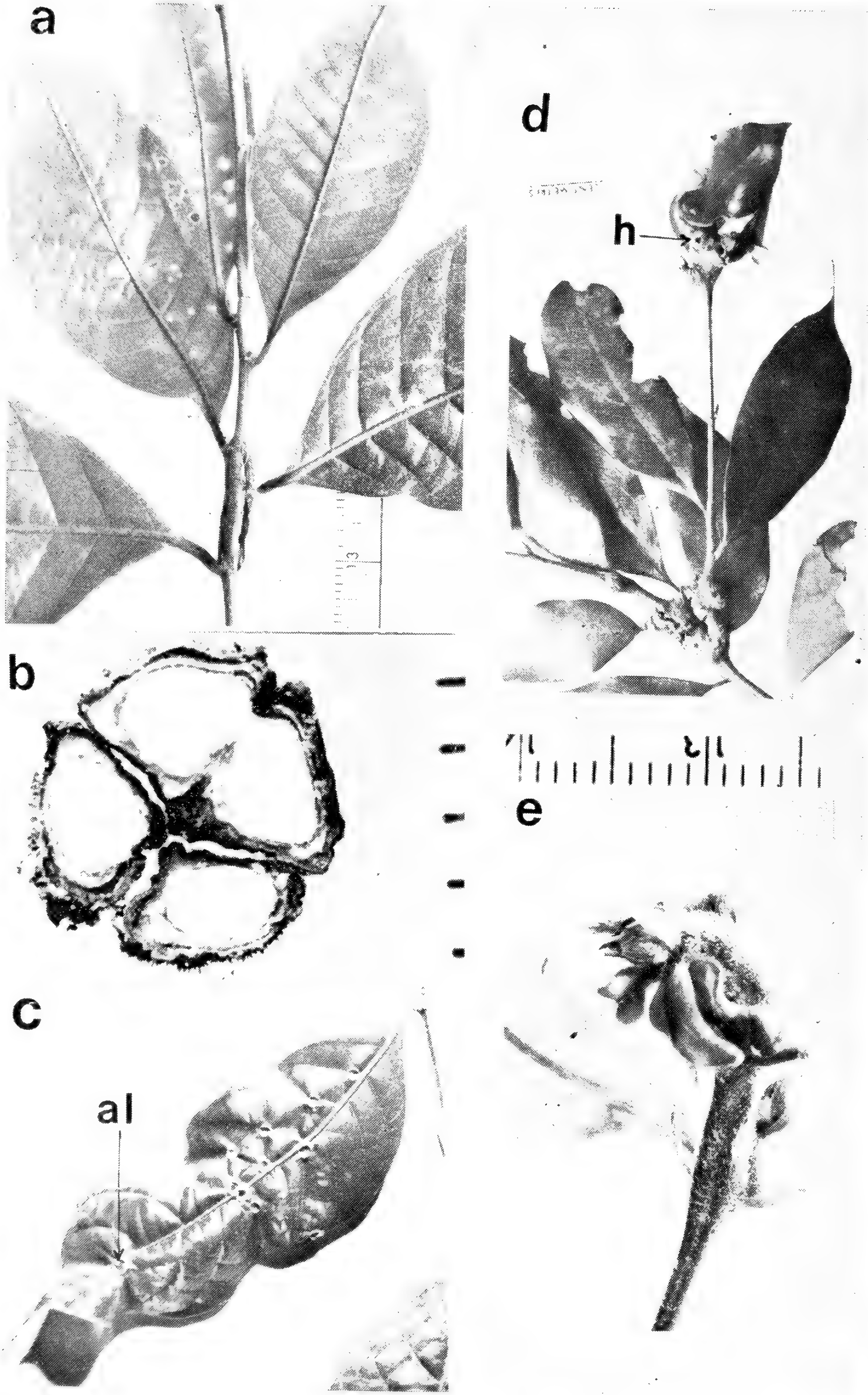

Plate 6. **a**, moth-gall 135 II on stem of *Lithocarpus conocarpus* (Oudem.) Rehd.; **b,** transection of the same; **c,** leaf of the host with alveoles (al) left by the sessile wasp-galls 120 I after they detach from the leaf; **d,** mature midge-gall 25 on *Castanopsis wallichii* King (h: emergence hole); **e,** young stage of the same gall.

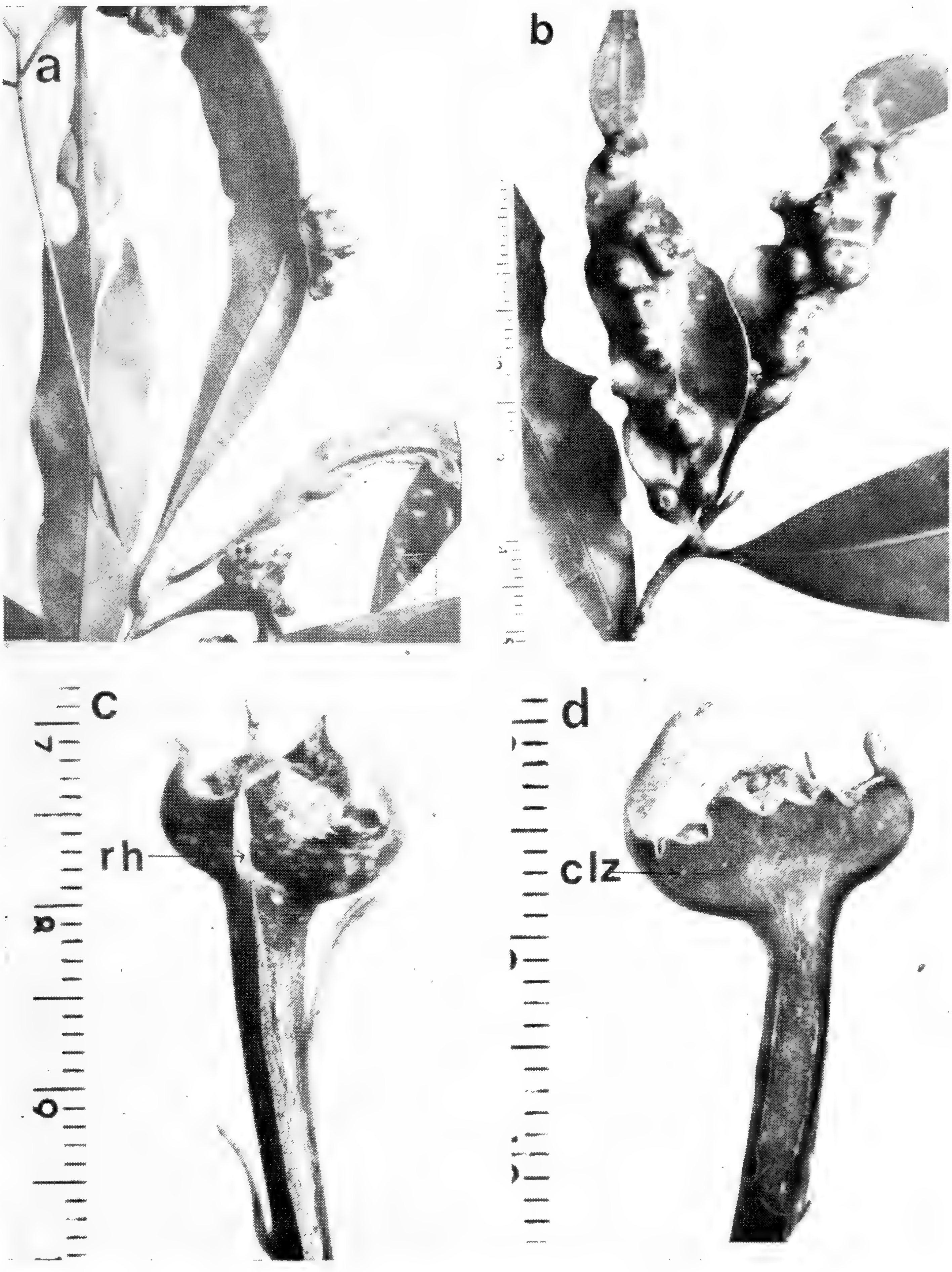

Plate 7. Gall on *Actinodaphne* sp. **a,** mite-galls 24 I; **b,** midge-galls 24 II; **c,** acrocecidium 99 III caused by midges (rh : rhabdodes); **d,** longisection of the same gall showing larval cavities distributed in a median zone (clz).

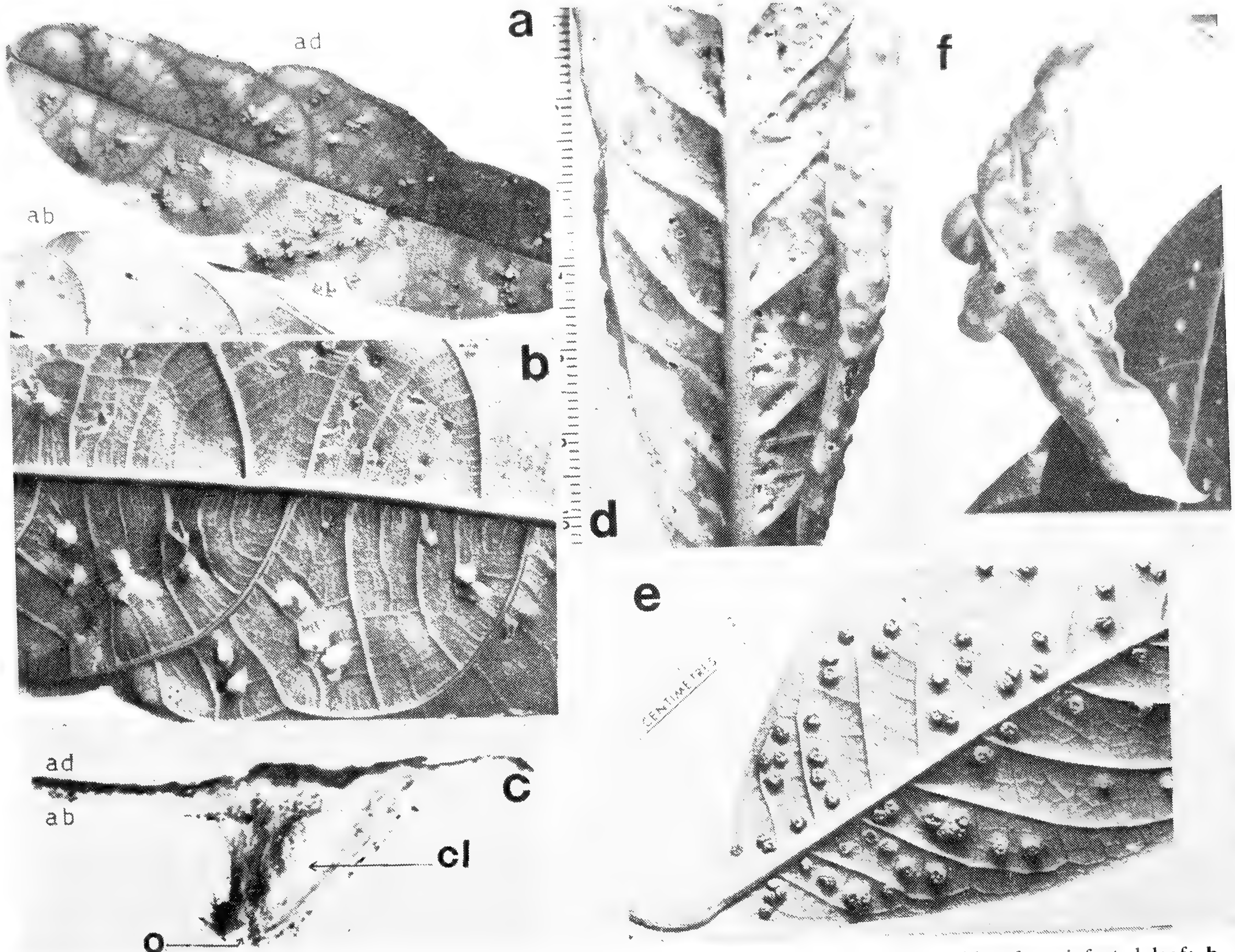

Plate 8. **a-c,** mite-galls 146 on *Ficus sinuata* Thunb. ssp. *sinuata;* **a,** adaxial and abaxial side of an infected leaf; **b,** the abaxial side enlarged; **c,** longisection of a gall (cl: larval cavity; o: apical ostiole.); **d,** psyllid-galls 92 I on *Nothaphoebe Kingiana* var *malvescens* Gamble; **e,** mite-galls 133 III on the same host; **f,** mite-galls 65 on *Litsea elliptica* (Bl.) Boerl.

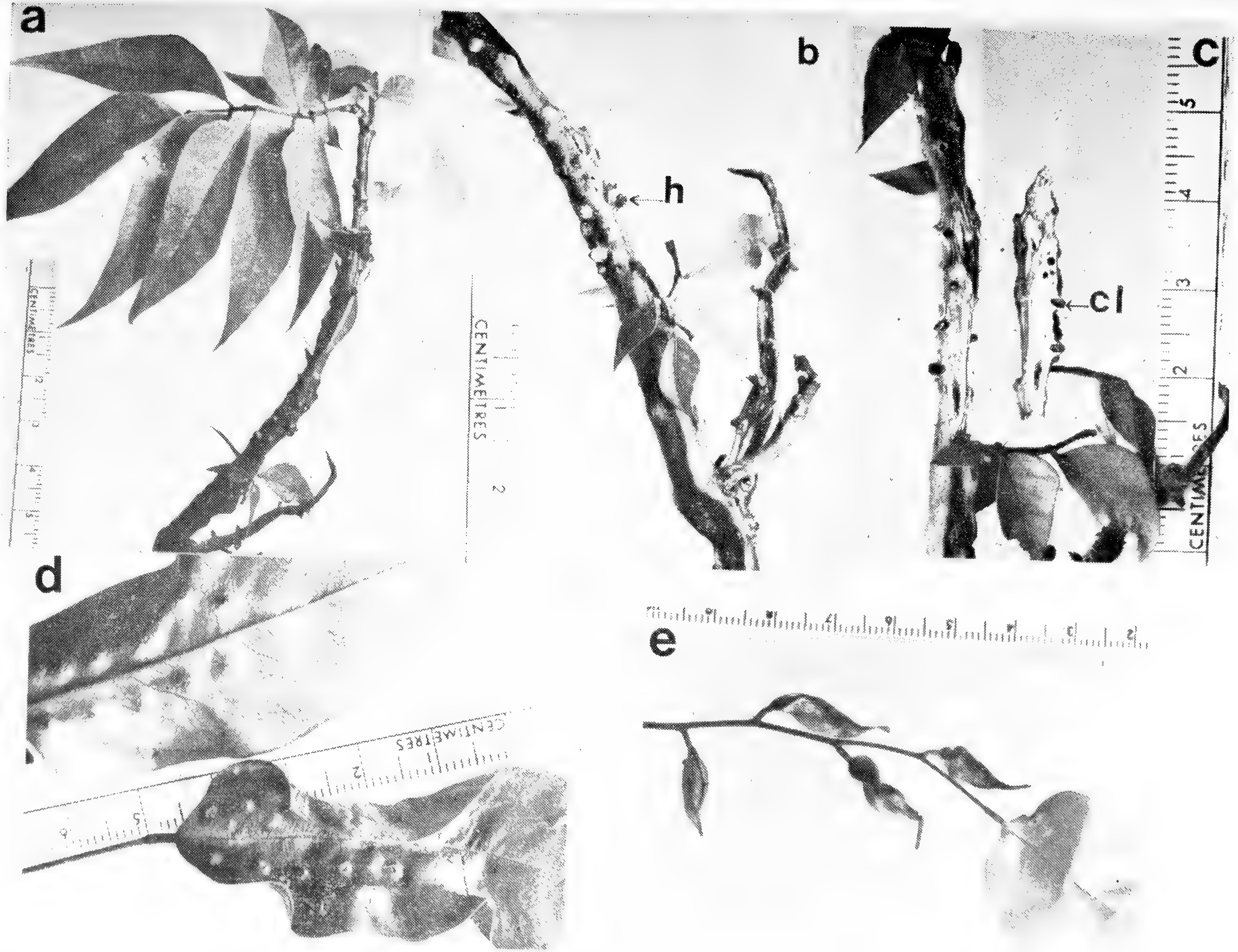

Plate 9. **a, b, c** (longisection), showing midge-galls 115 I on twig and main leaf-stalk of *Pithecellobium clypearia* Benth. (cl: larval cavity; h: emergence hole.); **d, e,** midge-gall 134 of leaflets of *Dalbergia rostrata* Grah., leaflet partially affected in **d,** and entirely affected in **e.**

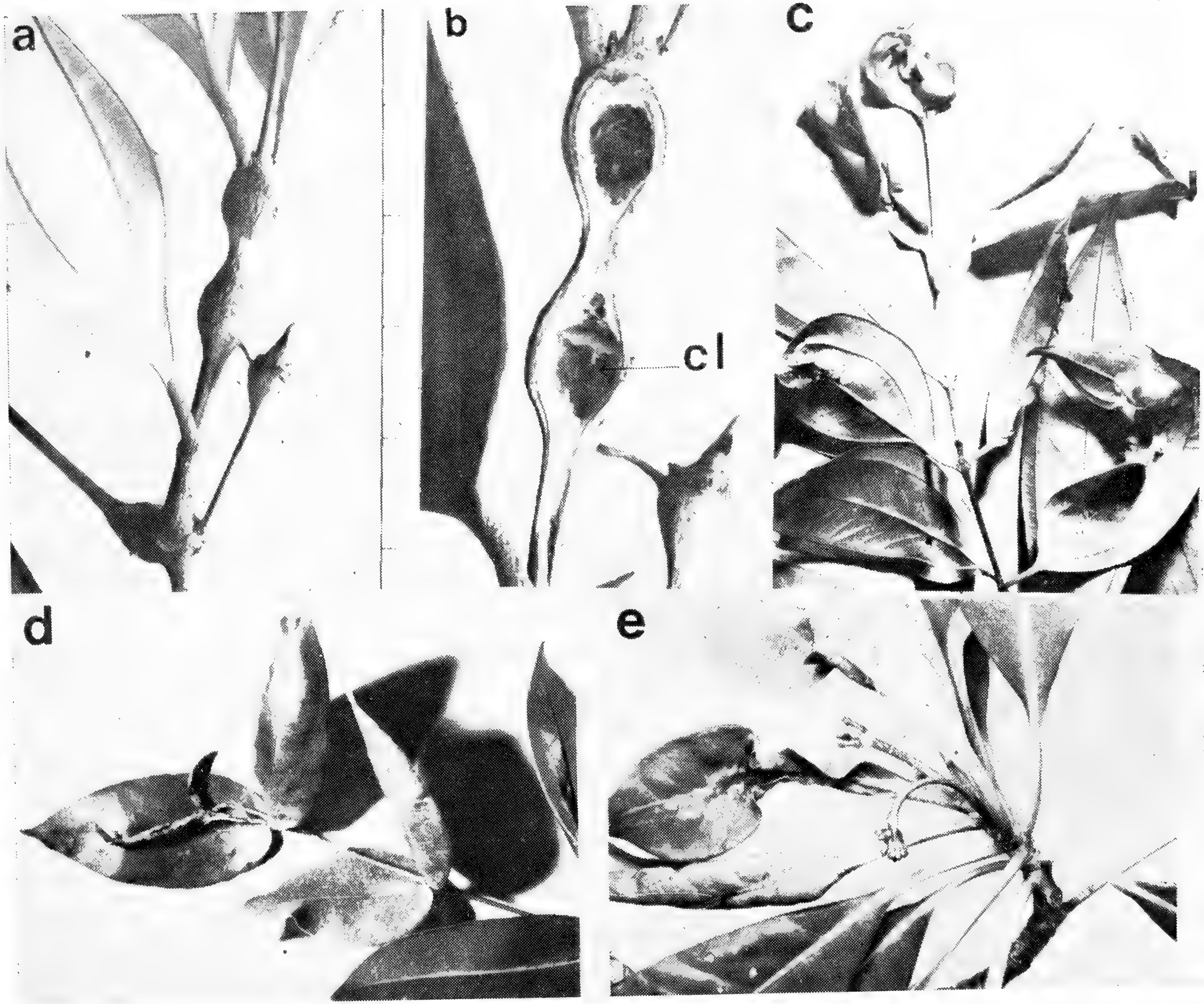

Plate 10. **a-c,** galls on *Rhodamnia cinerea* Jack (= *Rh. trinervia* Bl.); **a,** moth-galls 88 I; **b,** longisection of the same (cl: larval cavity); **c,** Homoptera? galls 72 IV: **d,** thrips-gall 166 II on leaf of *Eugenia subdecussata* Duthie; **e,** thrips-gall 45 on leaf of *Fagraea fragrans* Roxb.

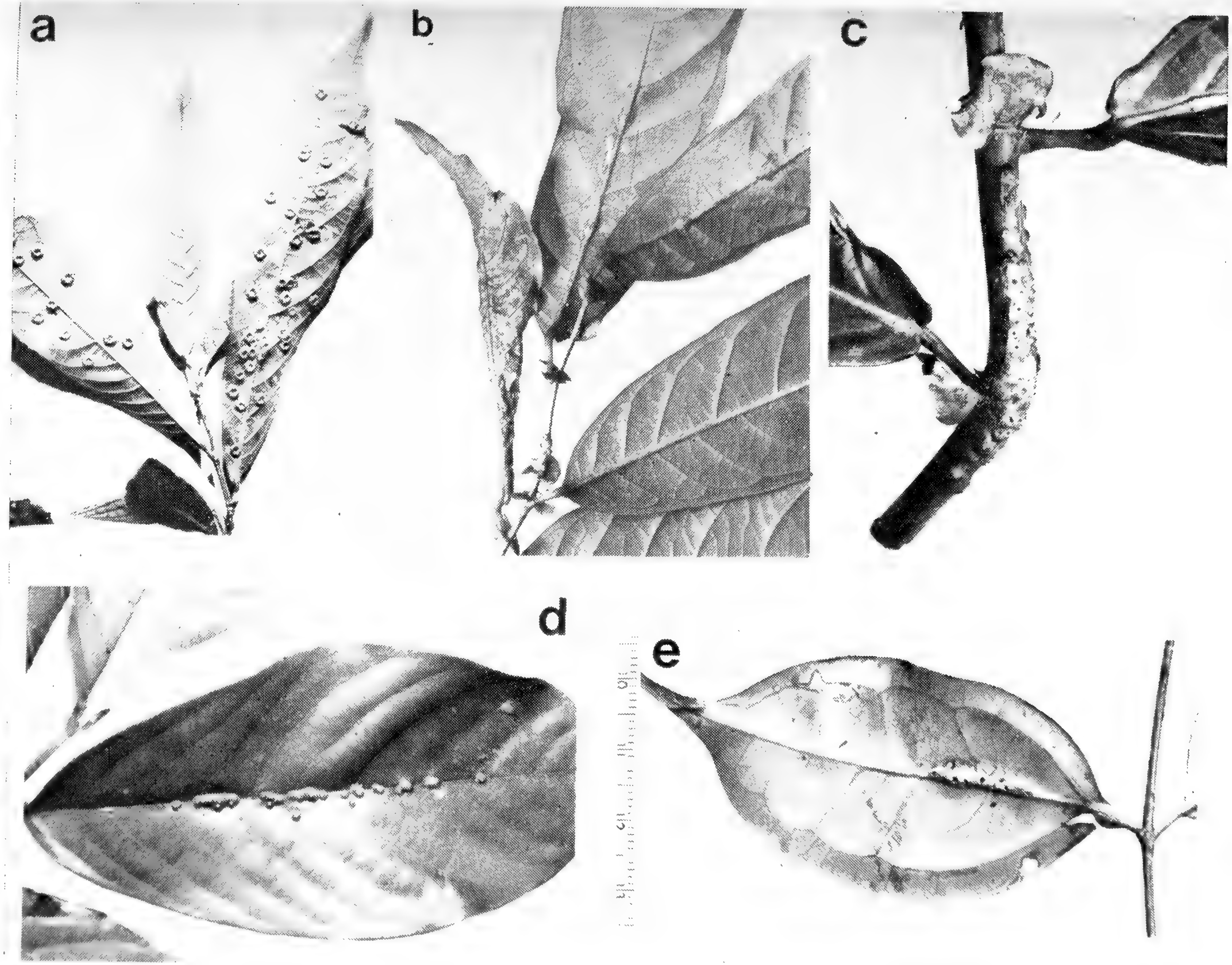

Plate 11. **a,** midge-galls 71 on abaxial leaf-surface of *Coelodepas glanduligerum* Pax. Hoffm; **b, c,** galls on *Aporosa benthamina* Hk. f. & Th.; **b,** on left leaf, thrips-gall 98 I; on midrib of upper two leaves, insect-gall 98 III, **c,** wasp-gall 98 IV of the stem; **d,** midge-galls 151 on the midrib of *Popowia tomentosa* Maingay; **e,** midge-galls 74 on midrib and petiole of *Strychnos* sp.

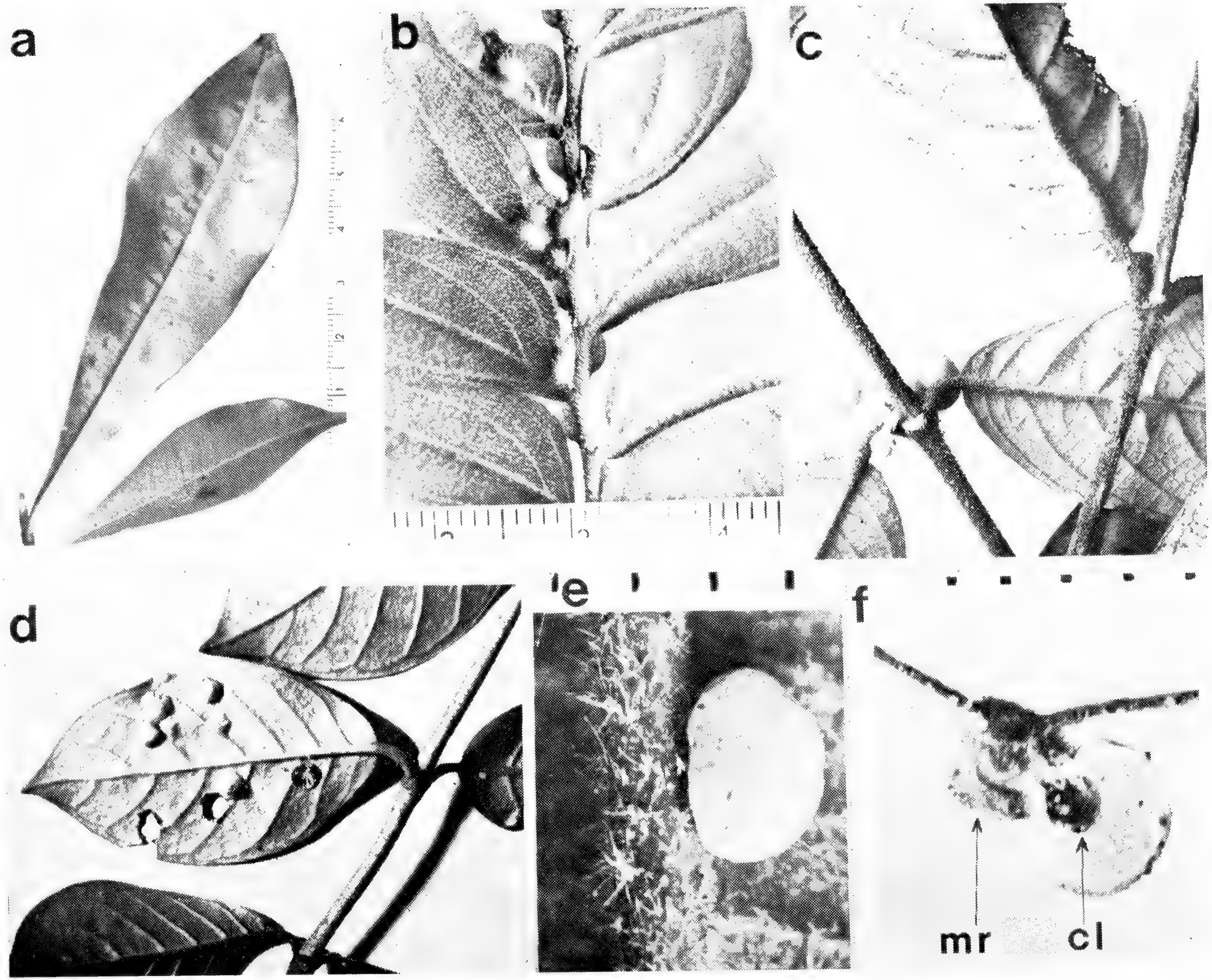

Plate 12. Some midge-galls on leaves of miscellaneous hosts; **a,** midge galls 78 on *Palaquium semaram* H. J. Lam, abaxial side; **b,** midge-galls 114 on *Anisophyllea disticha* Baill.; **c,** midge-gall 159 on midrib *Urophyllum hirsutum* Hook. (abaxial side); **d,** midge-gall 110 on *Psychotria ovoidea* Wall. ex Hk. f. (abaxial side); **e,** midge-gall attached abaxially to midrib of *Grewia blattaefolia* Corner; **f,** longisection of the gall showing pyriform larval cavity (cl) and midrib (mr).

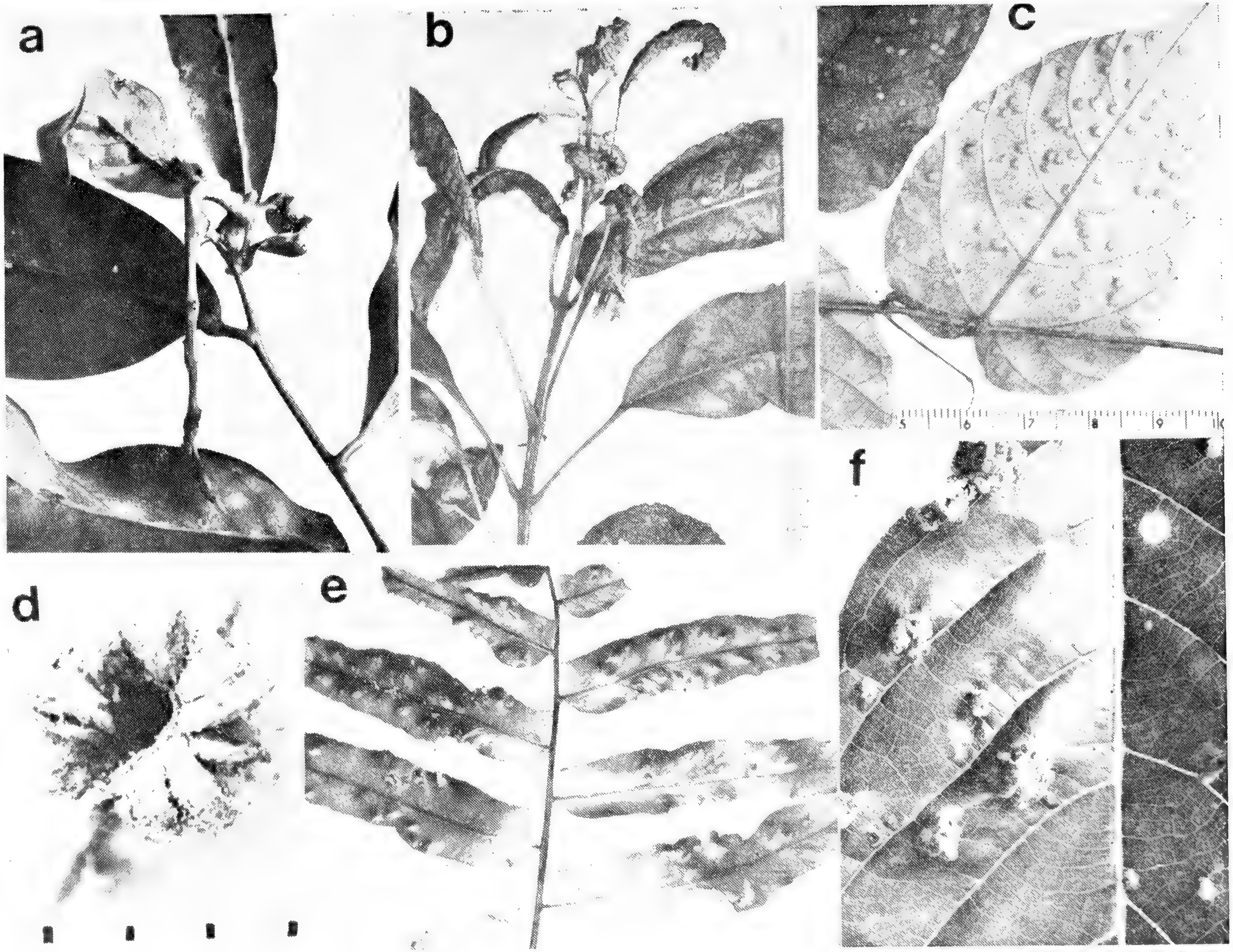

Plate 13. **a,** coccid-gall 123 on stem and leaves of *Hypserpa cuspidata* (Wall.) Miers; **b,** aphid-gall 119 I on *Clerodendron laevifolium* Bl.; **c,** psyllid-gall 163 on *Vitis gracilis* Wall.; **d,** abaxial view of a dehiscent insect-gall 129 I on leaf of *Knema communis* J. Sinclair; **e,** mite-gall 240 I on *Nephrolepis biserrata* (Sw.) Schott; **f,** mite-gall 160 on adaxial leaf-surface of *Vitex pubescens* Vahl.

Annotated list of seed plants of Singapore (II)

by

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University of Singapore

II. Angiosperms — Dicotyledons

8. MAGNOLIACEAE

Key to the genera

A. Flowers terminal.

B. Aggregate fruit of a mass of fleshy, indehiscent and fused carpels; perianth-segments 18 or more, narrow (less than 1cm wide) *Aromadendron*

B. Aggregate fruit of dry, dehiscent and ± free carpels; perianth-segments 15 or less, relatively broader.

C. Mature carpels dehiscing along the dorsal (or outer) side *Magnolia*

C. Mature carpels dehiscing along the ventral (or inner) side, and separating from the floral axis *Talauma*

A. Flowers axillary; mature carpels free, dehiscent along the dorsal side *Michelia*

Aromadendron elegans Bl.

Large tree with grey bark; flowers white, sweet-scented; fruit an ovoid mass; found on Bukit Timah (*Ngadiman 243*), very rare. Vern. *Champaka hutan.*

Magnolia maingayi King

Shrub or small tree; flowers scented, white; formerly also found in Gardens' jungle, now only on Bukit Timah (*Ngadiman 36547*), very rare.

Magnolia coco (Lour.) DC.

Shrub; flowers white, nodding, scented, the petals falling off shortly after blooming; native of China. 夜香木蘭。

Michelia alba DC.

Tree; flowers white, strong scented; native of S. China, propagation by marcots. Vern. *Champaka puteh,* 白玉蘭。

Michelia champaca Linn.

Tree; flowers orange, strongly scented; native of India, Thailand and northern Malaya, producing viable seed. Vern. *Champaka kuning,* 黃玉蘭。

Michelia figo (Lour.) Spr.

Small shrub; flowers ivory-coloured, scented but barely opened; native of S. China. 含笑花。

Talauma singaporensis Ridl.

Small tree; leaves very large; flowers white, large; carpels glabrous; formerly found at Chua Chu Kang (*Ridley* s.n. date 1894) and elsewhere, now surviving in Water Catchment Area, rare.

Talauma villosa Miq.

Recorded as *T. lanigera* Hook. f. in Ridley's Flora; small tree; flowers white, large; carpels woolly; formerly near Chua Chu Kang, Ang Mo Kio, Kranji and elsewhere, now limited to Water Catchment Area (Nee Soon, *Keng & Jumali 6354*), rare.

9. SCHISANDRACEAE

Kadsura scandens Bl.

Big woody climber with smooth or rough bark; flowers rosy, on stems; Gardens' jungle, Bukit Timah (*Ridley 6354*), rare. (A small leaved form of this species was formerly called *K. cauliflora* Bl.) Vern. *Akar dama-dama,* 南五味子。

10. ANNONACEAE

Key to the *common* genera

A. Carpels united into a fleshy mass, especially in fruit (cultivated fruit trees; connective of anther truncate or oblong, concealing the anther locules.) *Annona*

A. Carpels free or slightly united but always quite free in fruit.

- B. Petals 2-seriate, one or both series imbricate in bud (inner petals with a broad base; anther connective broad).
  - C. Petals usually large (1-4 cm long), imbricate *Uvaria*
  - C. Petals smaller (below 8 mm long), valvate at base, imbricate at tips *Cyathostemma*
- B. Petals 2-seriate or sometimes 1-seriate, all valvate.
  - D. All petals, or the inner ones cohering (or connivent) by their edges.
    - E. Petals 3, entirely connate into a ± conical hood (flowers solitary, long-pedicelled, pendulous, 6-8 cm long; ripe carpels necklace-shaped; erect shrubs) *Desmos dasymaschala*
    - E. Petals 6 in 2 series, inner ones often shorter than the outer; cohering into a long hood.
      - F. Erect trees or shrubs; flowers axillary, inner petals clawed (ripe carpels bright red) *Goniothalamus*
      - F. Climbers; flowers extra-axillary; inner petals not clawed (ovary densely pubescent) *Friesodielsia*
  - D. All petals free or separating very readily or shortly connate at the base only.
    - G. Connectives narrow, pointed, not concealing anther locules; trees or errect shrubs.
      - H. Outer petals not or only slightly longer than calyx; the inner much larger with saccate base; ovaries numerous (ovules 1-2) *Miliusa*
      - H. Outer petals much longer than calyx; the inner not or only slightly longer than the outer, sometimes smaller.
        - I. Flowers 4 to many in cymes, only 1-2 in each cyme open at a time; petals with saccate base; all stamens perfect, ripe carpels ellipsoid, fleshy, 3-12 seeded *Alphonsea*
        - I. Flowers solitary; petals not with saccate base, sometimes obtuse; ripe carpels club-shaped, 2 valved, 1-2 seeded *Anaxagorea*

G. Connective widened and truncate, concealing anther locules.

J. Flowers borne on hooked, rigid, laterally compressed short shoots; base of petals cohering into a cap over stamens and carpels; climbers *Artabotrys*

J. Flowers not borne on such hooked, short shoots.

K. Outer petals slightly longer than calyx (the inner petals erect, concave inside; ripe carpels 1-2 seeded; trees or shrubs) *Popowia*

K. Outer petals much longer than calyx.

L. Anthers transversely septate (trees, flowers axillary, petals usually linear lanceolate; ripe carpels several seeded) *Xylopia*

L. Anthers normal, not septate.

M. Apex of connective acute; flowers very fragrant, in pendulous, umbellate inflorescence; petals lanceolate or linear-lanceolate; ovaries numerous; ripe carpels ellipsoid, 2-many seeded; trees *Cananga*

M. Apex of connective obtuse or truncate.

O. Flowers solitary, extra-axillary or opposite the leaves, pendulous, yellow; the inner petals clawed at base; ovaries many; ripe carpels necklace-shaped with 1-8 segments; shrubs often with drooping twigs *Desmos*

O. Not as above

P. Climbers, densely brown pubescent; flowers in terminal cymes or panicles; the outer petals erect or spreading, the inner slightly shorter; ovaries many, pubescent; ripe carpels stalked, subglobose, 1-8 seeded *Fissistigma*

P. Trees or erect shrubs, rarely slightly climbing.

Q. Flowers axillary, solitary or 2-3 together; petals subequal or the inner ones shorter; all stamens fertile, subequal; ovaries 2-5 with several ovules in 2 rows; ripe carpels thick-walled, fleshy, sessile *Meiogyne*

Q. Not as above.

R. Trees with a crown of branches near top; flowers usually opposite the leaves; petals linear or oblong, clawed; inner petals concealing the stamens and carpels by the broadened base; ripe carpels many-seeded *Cyathocalyx*

R. Trees or shrubs; flowers axillary or on branches or stem; petals usually spreading; ripe carpels 1-5 seeded *Polyalthia*

Alphonsea maingayi Hook. f. & Thoms.

Tall tree; flowers in cymose clusters, opposite the leaves; outer petals with reflexed tip and saccate base; ripe carpels oblong; seeds many; Chua Chu Kang (*Ridley 6758*), Gardens' jungle.

Anaxagorea javanica Bl.

Shrub; petals spreading, the edges very thick; ripe carpels of 4–8 clavate follicles; seeds 2, black, shining. Called *A. scortechinii* in Ridley's flora. In Singapore only found in Gardens' jungle (*Keng & Jumali 3027*). 蒙蒿子。

Annona muricata Linn.

Shrub or small fruit tree; this and the two following species are native to trop. America. Vern. *Soursop, Durian belanda,* 刺番荔枝。

An. reticulata Linn.

Vern. *Custard apple, Bullock's Heart,* 牛心梨。

An. squamosa Linn.

Vern. *Sweet-sop, sugar apple,* 番荔枝，釋迦果。

Artabotrys costatus King

Climber; petals creamy white, tomentose; Mandai (*Ridley 10921*).

Art. crassifolius Hook. f. & Thoms.

Stout climber; petals rose-pink; Bukit Timah (*Ridley 10853*).

Art. maingayi Hook. f. & Thoms.

Climber; common in MacRitchie Reservoir jungle (*Sinclair 4876*); petals green to creamy yellow.

Art. suaveolens (Bl.) Bl.

Climber; young branches glabrous or nearly so; peduncles hooked; flowers creamy white, fragrant; the commonest species of the genus in Singapore; Peirce Reservoir (*Wee 184*).

Art. unicinatus (Lam.) Merr.

Scandent shrub, native of Ceylon and S. India, sometimes cultivated, known as *Art. odoratissimus* R. Br. 鷹爪花。

Art. wrayi King

Climber; petals pale yellow; Bukit Mandai (*Ridley 3630*).

Cananga odorata (Lamk.) Hook. f. & Thoms.

Tree, wild in N. Malaya and elsewhere, cultivated in gardens; Flowers very fragrant; called *Canangium odoratum* King in Ridley's Flora; a dwarf cultivated variety (var. *fruticosa* J. Sinclair) about 2 m. high, often has supernumerary petals but never sets fruit. Vern. *Kenanga.*

Cyathocalyx remuliflorus (Maingay ex. Hook. f. & Thoms.) Scheff.

Tall monopodial tree; branches spreading at top; Jurong (*Corner 26162*); called *Drepananthus ramuliflorus* Maingay in Ridley's Flora.

Cyath. ridleyi (King) Sinclair

Small tree, with pole-like trunk and crown branches at top; petals filiform, pale yellow, pink at base, the claws orbicular; Bukit Timah (*Sinclair 38449*) and elsewhere; called *Xylopia ridleyi* King in Ridley's Flora.

Cyath. sumatranus Scheff.

Tree, with a crown of spreading branches at top; petals green, tomentose with pink claws; Gardens' jungle (*Corner* s.n. in 1943); called *Xylopia curtisii* King in Ridley's Flora.

Cyathostemma hookeri King

Climber, twigs glabrous; petals waxy-yellow; Gardens' jungle (*Ridley 4790*).

Cyath. viridiflorum Griff.

Climber, often in swampy forest; flowers on stem, small petals, greenish yellow; fruit orange, large; Seletar Reservoir (*Sinclair SFN 39246*).

Desmos chinensis Lour.

Bushy shrub, wild in Malaya and elsewhere, occasionally cultivated.

Desmos dasymaschala (Bl.) Safford

Bushy shrub; petals cream coloured, 3–4 in one row (inner row absent); MacRitchie Reservoir (*Wee 49*).

Desmos dumosus (Roxb.) Safford

Straggling shrub; petals greenish yellow, 6 in 2 rows; Cluny Road (*Ridley 6305*).

Ellipeia cuneifolia Hook. f. & Thoms.

Climber, young twigs rusty; petals fleshy yellow; Gardens' jungle (*Ridley 4919*).

Fissistigma fulgens (Hook. f. & Thoms.) Merr.

Large climber; flowers few, in cymes opposite to a leaf; petals thick, ovate, orange; ripe carpels globose to oblong, 3–4 cm long; seeds several in 2 rows; called *Melodorum fulgens* Hook. f. & Thoms. in Ridley's Flora. MacRitchie Reservoir (*Wee 135*).

Fis. lanuginosum (Hook. f. & Thoms.) Merr.

Climber, young twigs rusty-tomentose; petals oblong-lanceolate, MacRitchie (*Wee 46*).

Fis. latifolium (Hook. f. & Thoms.) Merr. var. **ovoideum** Sinclair

Large climber, twigs rusty-tomentose; flowers like *F. fulgens* but larger; Seletar Reservoir (*Wee 301*).

Fis. manubriatum (Hook. f. & Thoms.) Merr.

Stout climber; flowers terminal, opposite a leaf; MacRitchie (*Wee 173*).

Friesodielsia biglandulosa (Bl.) Steenis

Climber; flowers extra-axillary; mature carpels ovoid or oblong, thin-walled, 1-seeded, usually stalked; Seletar Reservoir (*Sinclair 38870*); called *Oxymitra biglandulosa* Scheff. in Ridley's Flora.

Fri. glauca (Hook. f. & Thoms.) Steenis

Climber; Jurong (*Corner SFN 26151*).

Fri. latifolia (Hook. f. & Thoms.) Steenis

Climber; young branches rusty-tomentose; flowers solitary, extra-axillary; petals creamy white; ripe carpels ovoid, clustered; Gardens' jungle (*Ridley 10809*).

Goniothalamus malayanus Hook. f. & Thoms.

Shrub or small tree; flowers solitary, axillary or from the axils of fallen leaves; petals valvate, greenish yellow, outer ones oblong-ovate; ripe carpels oblong, 2–5 seeded, clustered; Seletar (*Ridley* s.n. in 1894).

Gon. ridleyi King

Tree; flowers in fascicles from warty tubers at base of trunk; ripe carpels numerous, obovoid, glabrous, 1-seeded, short-stalked; Bukit Timah (*Ridley 4450*).

Gon. tapis Miq.

Shrub or tree; flowers solitary or in pairs; leaves broader than *Gon. malayanus*; ripe carpels red, 1-seeded; Bukit Timah (*Ridley 8405*).

Mezzettia leptopoda (Hook. f. & Thoms.) Oliv.

Tall monopodial tree; petals linear, pale yellow, 1–1.2 cm long; fruit globose with a resinous odour; Mandai (*Corner SFN 33147*).

Meiogyne virgata (Bl.) Miq.

Tree; petals lanceolate, 1.5–2.5 cm long, greenish yellow or pink, reddish at base; ripe carpels oblong, brown-tomentose; Bukit Timah (*Ridley 4457*); called *Cyathocalyx virgatus* King in Ridley's Flora.

Miliusa longipes King

Shrub or small tree; flowers solitary, axillary, sepals and outer petals alike (resembling *Phaeanthus*); inner petals greenish yellow outside, dark red inside; ripe carpels globose, 1–2 seeded; Bukit Timah (*Ridley 8450*).

Mitrella kentii (Bl.) Miq.

Climber; leaves very variable; flowers 1–3, axillary; Bukit Mandai (*Ridley 2117*); called *Melodorum elegans* Hook. f. & Thoms. in Ridley's Flora.

Monocarpia marginalis (Scheff.) J. Sinclair

Tree; ripe carpels 1–3, subglobose, 4–6.5 cm across; called *Cyathocalyx maingayi* Hook. f. & Thoms. in Ridley's Flora.

Phaeanthus ophthalmicus (Roxb. ex Don) J. Sinclair

Small shrub, common in shady forests; flowers 1–2, extra-axillary; outer petals and sepals alike; inner petals large, green, flat, ovate-lanceolate; ripe carpels numerous, ovoid to oblong, 1-seeded; MacRitchie (*Keng & Jumali* s.n., April, 1961); called *Ph. nutans* in Ridley's Flora.

Polyalthia angustissima Ridley

Small tree; petals pink, linear; Bukit Timah (*Ridley 8050, type*).

Poly. cauliflora Hook. f. & Thoms.

Shrub or small tree; flowers arising mostly from woody tubercles on the trunk and branches; petals pinkish brown, narrow lanceolate; Bukit Timah (*Ridley 8117*), with 2 varieties, var. *beccarii* (King) Sinclair (with narrowed leaves) and var. *desmantha* (Hk. f. & Thoms) Sinclair (with denser brown tomentum esp. on midrib).

Poly. glauca (Hassk.) Boerl.

Tree; flowers fragrant; petals linear, oblong; Mandai (*Holttum 37706*).

Poly. hookeriana King

Tree; petals pale yellow; Fern Valley in B.T.N.R.* (*Sinclair 39149*).

Poly. hypoleuca Hook. f. & Thoms.

Tree; petals yellow, linear oblong; Jurong (*Corner SFN 26163*).

Poly. lateriflora King

Monopodial tree; leaves oblong, 20–40 cm long; petals pale yellow, with tinges of red; Mandai (*Corner SFN 33141*); another related species, *Poly. sclerophylla* Hook. f. & Thoms. with smaller leaves (15–20 cm long), also found in Mandai (*Kiah* s.n. in 1940).

Poly. macropoda King

Tree; petals green, yellowish to white; Seletar (*Ridley 429*, type); a closely related species, *Poly. clavigera* King with much longer stalked fruiting stalks (2–3.5 cm vs. 0.5 cm), was found at Fern Valley in B.T.N.R. (*Ridley 5851*).

Poly. rumphii Merr.

Tree; Gardens' jungle (*Ridley 3863*); called *Poly. scortechinii* King in Ridley's Flora.

Poly. sumatrana (Miq.) Kurz

Tree; petals greenish, linear, spreading; Seletar (*Wee 338*).

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* Bukit Timah Nature Reserve.

Popowia fusca King

Shrub or tree; leaves thinner than *Pop. pisocarpa*; ripe carpels 1–4 globose-falcate; Bukit Timah (*Ngadiman SFN 36364*).

Pop. pisocarpa Endl.

Shrub or small tree; flowers extra-axillary and leaf-opposed in small fasicies; ripe carpels globose, 1–4 seeded; common; MacRitchie (*Wee 153*). Called *Pop. ramosissima* Hk. f. & Th. in Ridley's Flora.

Pop. tomentosa Maing. ex Hook. f. & Thoms.

Tree; Gardens' jungle (*Ridley 4916*).

Pyramidanthe prismatica (Hk. f. & Th.) Sinclair

Climber; flowers axillary or terminal, solitary or in pairs; ripe carpels oblong, tuberculate, 3–5 cm long; seeds in 2 rows; Kranji (*Ridley 6344*). Called *Melodorum prisomaticum* Hook. f. & Th. in Ridley's Flora.

Uvaria curtisii King

Large climber; petals white or greenish-yellow; Bukit Timah (*Sinclair SFN 39652*).

Uvar. cordata (Dunal) Alston

Climber; petals dark-red; common; Seletar (*Wee* s.n., Dec. 1961). Called *Uvar. macrophylla* Roxb. in Ridley's Flora.

Uvar. grandiflora Roxb.

Climber; petals purplish red; common; Bukit Panjang (*Wee 90*). Called *Uvar. purpurea* Bl. in Ridley's Flora.

Uvar. hirsuta Jack

Woody climber; petals dark red; Bedok (*Ridley* s.n. in 1877).

Uvar. leptopoda (Ding) R. E. Fries

Climber, petals dark crimson; Bukit Mandai (*Ridley 4708,* type); called *Uvariella leptopoda* Ridl. in Ridley's Flora; often confused with *Uvar. rufa* Bl.

Uvar. lobbiana Hook. f. & Thoms.

Climber; collected once at Gardens' jungle (*Ridley 9211*).

Uvar. pauci-ovulata Hook. f. & Thoms.

Stout climber with rusty-brown, stellate-hairy twig; petals yellow-brown; Bukit Timah (*Ngadiman SFN 36432*).

Xylopia caudata Hook. f. & Thoms.

Tree; flowers very small; petals pale yellow; Jurong (*Corner SFN 26030*).

Xyl. ferruginea Hook. f. & Thoms.

Tree, with stilt roots; leaves ferrugineous pubescence beneath; ripe carpels numerous, elongate, constricted between the seeds; Gardens' jungle (*Abu Kassim 2687*).

Xyl. magna Maing. ex Hook. f. & Thoms.

Tree; petals linear, 8–10 cm long; Bukit Timah (*Sinclair SFN 39690*).

Xyl. malayana Hook. f. & Thoms.

Tree; flowers fragrant; petals pale yellow; ripe carpels 3 to many in a bundle, irregularly dehiscent; seeds 2–7 in 2 rows; common; Chua Chu Kang (*Ridley 6759*).

N.B. For the full range of species distribution of Annonaceae in Singapore, see J. Sinclair, *Gard. Bull. Sing*. (1955) **14**: 149–477.

11. MYRISTICACEAE

Key to the genera

A. Twigs not striate, often angled; leaves whitish beneath, reticulations not visible above (aril laciniate to the base or nearly so; androecium columnar; anthers free at apex) *Gymnacranthera*

A. Twigs striate (namely marked with fine grooves or ridges) or at least in the older parts.
  - B. Leaves often witish beneath.
    - C. Reticulations forming a dense, close network raised above in dried material, (aril laciniate at the apex only; androecium a stalked disc with free anthers) *Knema*
    - C. Reticulations few above, not forming a dense network, mostly sunk (aril laciniate to the base; anthers completely fused to the stalked column) *Myristica*
  - B. Leaves not whitish beneath (aril entire, covering the seed; androecium various, always sessile; anthers completely fused) *Horsfieldia*

Gymnacranthera bancana (Miq.) Sinclair

Tree, young twigs rusty-tomentose; flowers unisexual, in branched inflorescences; fruit rusty-tomentose, ovoid, 2.8 by 1.5 cm; Seletar (*Ridley 1835*), Mandai. Called *G. murtonii* Warb. in Ridley's Flora.

Gymn. eugenifolia (A. DC.) Sinclair

Bukit Timah, Woodlands (*Ridley 11646*).

Gymn. forbesii Warb.

Seletar (*Ridley 6270*, type), Mandai

Horsfieldia irya Warb.

Tree, often slightly buttressed, by streams in swampy places; fruit round, 2–3 cm across, in bundles of 2–4; ochre yellow to pinkish orange; aril orange-red; Changi (*Ridley 4814*), Gardens' jungle.

Horsf. macrocoma Warb. var. **canarioides** (King) Sinclair

Bukit Mandai (*Ridley 6324*), Jurong.

Horsf. subglobosa Warb.

Bukit Timah (*Ridley 6451*), Mandai

Horsf. sucosa Warb.

Gardens' jungle (*Ridley 6559*), Changi.

Horsf. superba Warb.

Bukit Timah (*Ngadiman 36141*), Seletar. Vern. *Pendarah.*

Horsf. tomentosa Warb.

Collected only once from Bukit Timah (*Cantley* 30); recorded in Thailand, Malaya and Sumatra. Vern. *Manchong.*

Horsf. wallichii Warb.

MacRitchie Reservoir (*Corner 33556*).

Knema conferta Warb.

Bukit Timah (*Ridley 442,* type), Mandai Vern. *Panara Batu.*

Knema curtisii Warb.

Bukit Mandai (*Goodenough 3376*), Jurong.

Knema furfuracea Warb.

Botanic Gardens (*Sinclair 39488*).

Knema glaucescens Jack

Jurong (*Ridley 3873*).

Knema globularia Warb.

Changi (*Ridley 13342*), Pulau Ubin.

Knema hookeriana Warb.

Small tree, leaves very large, densely covered with brown wool when young; fruit also covered with brown wool; Water Catchment Area, Bukit Timah (*Ridley 3701*). Vern. *Singgah putih.*

Knema intermedia Warb.

Bukit Timah (*Ridley 2107*), Changi, Jurong.

Knema latericia Elm.

Common in Water Catchment Area, Bukit Timah (*Cantley 21*).

Knema laurina Warb.

Water Catchment Area, Bukit Timah (*Cantley 3083*).

Knema malayana Warb.

Bukit Timah (*Cantley 20*), Seletar.

Myristica cinnamomea King.

Tree; fruit ellipsoid, reddish yellow, 7–8 cm long; aril thin, red, deeply laciniate; Sembawang, Bukit Mandai (*Ridley 3581a*). Nee Soon, Sungei Buloh. According to Ridley (Flora 3: 66), this is the only Malayan species in which the seed and aril have any spiciness. The seeds in all other species seem to be deficient in aromatic properties, and are not used by the villagers at all. Vern. *Maiang pahong.*

Myrist. crassa King.

MacRitchie Reservoir (*Sinclair 39490*).

Myrist. elliptica Hook f. & Th.

Bukit Timah (*Ridley 6920*), Seletar. Vern. *Tabah, Pala hutan.*

Myrist. fragrans Houtt.

The nutmeg of commerce is the seed, and mace is the red aril of the seed of this species. A native of the Moluccas, once plantation crop in Singapore. Vern. *Pokok pala.* 肉荳蔻。

Myrist. maingayi Hook. f.

MacRitchie Reservoir (*Corner 33555*).

Myrist. maxima Warb.

Bukit Timah (*Ridley 3363*) and Nee Soon.

N.B. For the full range of species distribution of Myristicaceae in Singapore, see **J. Sinclair**, *Gard. Bull. Sing.* (1958) **16:** 205–472.

12. MONIMIACEAE

Matthaea sancta Bl.

Large shrub; leaves opposite, light green; flowers yellow; drupe blue black. In forests and thickets, rare: Gardens' jungle, Chua Chu Kang, Ang Mo Kio; Bukit Timah (*Ridley 9165*).

13. LAURACEAE

Key to the genera

A. Hemi-parasitic herbaceous twiner; leaves totally reduced ... *Cassytha*

A. Trees or rarely shrubs; leaves normal, alternate, opposite or whorled.

- B. Inflorescence umbellate (in *Actinodaphne*, a very short panicle is seen on full expansion of the infl.), surrounded by an involucre of bracts.
  - C. Leaves alternate; bracts persistent; fruit seated on a cup formed by the persistent perianth-tube.
    - D. Anthers 2-loculate ... *Lindera*
    - D. Anthers 4-loculate ... *Litsea*
  - C. Leaves in false whorls; bracts deciduous; fruiting pedicels strongly thickened, fleshy ... *Actinodaphne*

B. Inflorescence paniculate.
 E. Fruit on naked pedicel, or if perianth persistent, not cup-like.
  F. Perianth in fruit hardened, clasping the base of fruit — *Phoebe*
  F. Perianth in fruit mostly deciduous, if persistent, neither hardened nor clasping the base of fruit.
   G. Fruiting pedicel strongly thickened, fleshy.
    H. Anthers 2-loculate — *Dehaasia*
    H. Anthers 4-loculate — *Alseodaphne*
   G. Fruiting pedicel hardly or not thickened.
    I. Anthers 2-loculate — *Beilschmiedia*
    I. Anthers 4-loculate.
     J. Anthers sessile — *Nothaphoebe*
     J. Anthers with long filaments — *Persea*
 E. Fruit seated either on a shallow or deep cup, or completely included in the persistent perianth-tube.
  K. Fruit seated on a shallow cup; anthers 4-loculate — *Cinnamomum*
  K. Fruit completely included in and adnate to the persistent and enlarged perianth-tube; anthers 2-loculate — *Cryptocarya*

Actinodaphne glomerata Nees

Tree; Bukit Timah, Bukit Mandai (*Ridley 6741*), Bukit Panjang.

Actin. hullettii Gamble

Botanic Gardens (*Cantley 38*); "A single tree on the bandstand, which died about 1911" (Ridley).

Actin. maingayi Hook. f.

Tree, in dense forests; Bukit Timah, Bukit Mandai, Pulau Ubin (*Ridley 9489*).

Actin. malaccensis Hook. f.

Tree, in forests; Gardens' jungle, Bukit Timah (*Ridley* s.n. in 1897). Vern. *Medang kachigawei.*

Actin. pruinosa Nees

Tree; Botanic Gardens, Changi (*Ridley 2768*).

Alseodaphne bancana Miq.

Shrub; Gardens' jungle, Bukit Timah, Mandai Road (*Sinclair 10900*).

Beilschmiedia kunstleri Gamble

Big tree; Bukit Timah (*Bayliss 5885*).

Beils. malaccensis Hook. f.

Tree; Bukit Timah, Gardens' jungle (no specimens available).

Cassytha filiformis L.

Leafless, hemi-parasitic twiner, yellow, common in open bushes near the sea; Changi (*Ridley 3380*). Vern. *Chemar hantu,* 無根籐。

Cinnamomum camphora Sieb.

The oriental camphor is obtained by distillation from the wood of this tree, native of S. China and Japan; occasionally planted. 樟樹。

Cinn. iners Reinw. ex Bl.

Small or medium-sized tree, very common in open places all over the Island; young leaves reddish; fruit blue-black; Tyersall Road (*Ridley 3370*). Vern. *Kayu manis*.

Cinn. javanicum Bl.

Tree, in dense woods: Bukit Timah (*Ridley 15621*), Gardens' jungle.

Cinn. ridleyi Gamble

"A single tree on the Changi Road near Changi" (Ridley), (no specimens).

Cinn. verum J.S. Presl

Native of S.W. India and Ceylon, formerly called *Cinn. zeylanicum* Garc. ex Bl.; of which the bark is cinnamon of commerce; a smaller flowered variety (or called *Cinn. deschampsii* Gamble) was found in the ground of Botanic Gardens. Vern. *Kayu manis*, 錫蘭肉桂。

Cryptocarya caesia Bl.

Tall tree; Bukit Mandai, Chua Chu Kang (no specimens), Vern. *Kayu Grisek*.

Crypt. ferrea Bl.

Big tree; Chua Chu Kang (*Ridley 6158*), Bukit Mandai. Vern. *Medang merah*.

Crypt. griffithiana Wight

Tree; Tempinis, Changi, Seletar, Tebau (*Goodenough 3382*). Vern. *Medang buaya*.

Crypt. impressa Miq.

Tall tree, rare; Gardens' jungle, Bukit Timah (*Ngadiman 36147*). Vern. *Munjuat*.

Crypt. kurzii Hook. f.

Tree; recorded from Chua Chu Kang (no specimens).

Dehaasia incrassata (Jack) Kosterm.

Tree, formerly known as *D. microcarpa* Bl.; Sungei Jurong, Bukit Mandai (no specimens).

Dehaas. nigrescens Gamble

Tree, once collected from Gardens' jungle (no specimens).

Lindera lucida (Bl.) Boerl.

Medium sized tree, formerly called *L. malaccensis* Hook. f. Small tree; Gardens' jungle, Tanglin, Bukit Timah, Seletar (*Ridley 3373*).

Litsea accedens (Bl.) Boerl.

Tree, formerly known as *Lits. singaporensis* Gamble; Gardens' jungle, Bukit Timah, Kranji (*Ridley 6740*), Tuas.

Lits. cordata Hook. f.

Tree; Kranji (*Mat. 4743*), Bukit Timah.

Lits. costalis (Bl.) Kosterm.

Large tree, formerly called *lits. megacarpa* Gamble; Tuas, Reservoir Jungle (*Corner* s.n. in 1930).

Lits. erectinervia Kosterm.

Tree, formerly called *Lits. griffithii* Gamble; Gardens' jungle, Reservoir woods (*Ridley 4823*).

Lits. ferruginea Bl.

Tree; Gardens' jungle, Seletar (*Ridley 6151*).

Lits. firma Hook. f.

Tree, fruit pink; Bukit Timah (*Ngadiman 35509*), Chua Chu Kang.

Lits. garciae Vidal

Tree, formerly called *Lits. sebifera* Bl.; native of Java, occasionally cultivated. Vern. *Malek.*

Lits. grandis Hook. f.

Tree, common in open places; Tanglin, Bukit Timah, Changi (*Ridley 4700*). Vern. *Medang busuk, Medang Daun Lebar.*

Lits. lanceifolia Hook. f.

Small tree; Gardens' jungle, Bukit Timah (*Ridley 12563*), Seletar.

Lits. lanceolata (Bl.) Kosterm.

Small tree, once collected from Reservoir woods (*Ridley 4817*); formerly called *Lits. sarawacensis* Gamble.

Lits. machilifolia Gamble

Tree; Gardens' jungle, Bukit Mandai (*Md. Shah & Kadim 413*).

Lits. myristicaefolia Hook. f.

Tall tree; Geylang, Changi, Tanglin (no specimens).

Lits. perakensis Gamble

Large tree; recorded once in Bukit Timah (no specimens).

Lits. petiolata Hook. f.

Large tree; highly valued in native medicine; Gardens' jungle, Cluny Road, Geylang (no specimens).

Lits. ridleyi Gamble

Small tree; Changi, Gardens' jungle, Bukit Mandai (*Ridley 5064*).

Lits. robusta Bl.

Tree; collected once from Singapore by Wallich (no specimens).

Micropora curtisii Hook. f.

Tree, recorded once from Jurong swamp forest (no specimens available). The monotypic genus *Micropora* Hook. f. is endemic to the Malay Peninsula (Penang) and Singapore.

Nothaphoebe coriacea Kosterm.

Tree; Tuas (*Goodenough* s.n. in 1890).

Notha. umbelliflora (Bl.) Bl.

Tree; Chua Chu Kang; Bukit Timah (no specimens). Vern. *Medang Losa.*

Persea americana Mill.

Native of C. America, cultivated in gardens for the large edible fruit known as "avacado" or "alligator pear". 鰐梨，酪梨。

Phoebe cuneata Bl.

Tree; once collected at Changi (no specimens).

Phoebe declinata Nees

Tree; Changi (no specimens).

Phoebe grandis Merr.

Tree; MacRitchie Reservoir (*Corner 37269*).

Phoebe opaca Bl.

Large tree, Gardens' jungle, Changi, Pulau Ubin (*Ridley 5915*).

14. HERNANDIACEAE

Hernandia nymphaeifolia (Presl) Kubitzki

Tree with large glossy peltate leaves; collected from Singapore coast by Wallich in 1822, no specimens available in Singapore; extinct long ago but survived in S. Johore and elsewhere; formerly called *H. peltata* Meisn. or *H. ovigera* L. 蓮葉桐。

Hern. cordigera Vieill.

A bush, native of New Caledonia, rarely cultivated and under the erroneous name of *Aralia triloba* Hort.; flowering frequently but never sets fruit.

Illigera trifoliata (Griff.) Dunn

Woody climber; leaves alternate, 3-foliolate; recorded from Bukit Timah forest (no specimens available); called *Illigera appendiculata* Bl. in Ridley's Flora.

15. RANUNCULACEAE

Clematis dioscoreifolia Levl. & Van. var. *robusta* Rehder

A slender twiner of Japanese origin (possibly also one or two other horticultural species), is sometimes cultivated in gardens for its white flowers and plumose achenes. 鐵線蓮。

16. MENISPERMACEAE

Key to the genera

A. Leaves distinctly peltate (namely, petiole attached to the under surface of blade); inflorescence a large panicle.
- B. Leaves round, with dense white tomentose hairs beneath ... *Coscinium*
- B. Leaves ovate or heart-shaped, not with white hairs beneath ... *Cyclea*

A. Leaves not peltate (namely, petiole attached to or near the base of blade).
- C. Inflorescence a few-flowered, axillary cyme; leaves 3-nerved from base.
  - D. Slender woody climber; leaves glabrous ... *Cocculus, Hypserpa*
  - D. Large woody climber; leaves tomentose ... *Limacia*
- C. Infl. raceme-like.
  - E. Racemes mostly solitary.
    - F. Leaves cordate, glabrous, 5-nerved from base ... *Tinospora*
    - F. Leaves ovate, tomentose, 3-nerved from base ... *Limxia*
  - E. Racemes few to many in fascicles from old twig; leaves ovate, glabrous, 3-nerved from base ... *Timomiscium*
- C. Infl. paniculate; leaves ovate, glabrous, 3-nerved from base ... *Fibraurea*

Cocculus trilobus (Thunb.) DC.

Slender climber, twining on bushes near sandy shore; formerly called *C. ovalifolium* DC.; Changi (*Sinclair 40021*). 木防已。

Coscinium wallichianum Miers

Woody climber with yellow sap; leaves large rounded, white tomentose beneath; flowers in dense globose heads, on racemose or paniculate infl.; Chua Chu Kang, Changi (*Ridley 3967*). Vern. *Akar Kunyit.*

Cyclea laxiflora Miers

Slender hairy climber; leaves ovate or heart-shaped; in hedges and forests; local medicinal plant; Changi, Bukit Timah (*Ridley* s.n. in 1898), Tanglin. Vern. *Akar gasing Bukit.*

Fibraurea chloroleuca Miers

Woody climber, with yellow sap formerly used in dyeing; fruit orange; common in forest; Bukit Mandai (*Ridley 3834*), etc. Vern. *Akar Kuning, Akar Kenching kerbau.*

Hypserpa cuspidata Miers

Woody climber, in hedges and thickets; Chua Chu Kang (*Ridley 6189*). Seletar, Tanglin. Vern. *Akar minyak.*

Limacia velutina Miers

Woody climber; branches and leaves covered with rusty hair; common in open thickets; Chua Chu Kang, Bukit Mandai (*Ridley* s.n. in 1893).

Tinomiscium petiolare Miers ex Hook. f. & Th.

Woody climber, similar to *Fibraurea chloroleuca* in general appearance but with profuse white sap and green fruit; common on forest edge; Bukit Mandai (*Goodenough* s.n. in 1892).

Tinospora crispa Miers ex Hook. f. & Th.

Woody climber with numerous warts on stem; native of India, cultivated as a medicinal plant.

17. NYMPHAEACEAE

Key to the genera.

A. Petiole stout; leaf-blade, high above the water; flower showy; carpels free, immersed on ob-conical receptacle ... *Nelumbo*

A. Petiole slender; leaf-blade generally floating on the water surface; carpels united into a many-chambered ovary.

- B. Flower hardly expanded; outer perianth-lobes (sepals) 5 ... *Barclaya*
- B. Flower showy; outer perianth-lobes (sepals) 4 ... *Nymphaea*

Barclaya motleyi Hook.

Aquatic, rhizomatous herb, in shallow muddy streams in thick jungle; leaves round, dark-green; Bukit Timah (*Ridley* s.n. in 1892), Ang Mo Kio, Nee Soon. Vern. *Daun kelapu*.

Nelumbo nucifera Gaertn.

"The Indian Lotus" is sometimes cultivated as an ornament; the rhizome imported from China as a vegetable. Native of India and China. 荷花，蓮。

Nymphaea capensis Thunb.

"The cape-blue water lily" originated from S. Africa. Leaves glabrous beneath; sepals without dark markings; petals blue-purple or purple.

Nymphaea nouchali Burm. f.

"Blue lotus of Egypt", often called *Nymphaea stellata* Willd., is a native of tropical Africa. Leaves glabrous beneath; sepals with dark lines or marks; petals light blue or purple. 埃及睡蓮。

Nymphaea pubescens Willd.

Sometimes erroneously called *Nymphaea lotus* (non L.), native of Africa; leaves densely short hairy beneath; flowers mostly white, occasionally pink or red.

18. CERATOPHYLLACEAE

Ceratophyllum demersum L.

Hornwort, a submerged water plant with whorls of simple, but finely dissected leaves; occasionally found growing in aquaria. 金魚藻。

Morphology and ecology of some introduced herbaceous legumes

by

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Abstract

Eight tropical herbaceaus legumes were introduced into Singapore and evaluated for their possible roles in soil fertility improvement and soil erosion control on the island, and also in the other wet tropical areas. *Desmodium canum* is too woody and grew into a small bush in two years; *Desmodium intortum* is seriously attacked by insects; *Desmodium sandwicense* has upright growth habit and poor nodulation; *Glycine wightii* is attacked by insects and has not flowered in Singapore; *Phaseolus atropurpureus* and *Phaseolus lathroides* are two climbers and can be used as ornamental plants on fence; *Stylosanthes humilis* is an annual plant and not well adapted to the wet tropics. *Desmodium uncinatum* is the only legume showing potentials in fertility improvement and erosion control of soils in Singapore. It has moderate vegetative growth, spreading growth habit and strong stoloniferous development. It nodulates well, regrows fast after being cut and is well adapted to the wet tropics.

Introduction

In addition to the direct use as food and feed, the herbaceous legumes play a significant and fundamental role in the soil fertility improvement and soil erosion control. They are characterized by two important morphological features: 1) Their roots bear nodules containing *Rhizobium* species which play a unique and vital role in nitrogen fixation; and 2) they tend to root at the stem nodes and produce stolons which are essential in soil erosion control.

The purpose of this study is to examine morphologically and ecologically some introduced herbaceous legumes grown under the natural conditions in Singapore so as to evaluate their usefulness on soil fertility improvement and soil erosion control.

Materials and methods

Eight herbaceous legumes had been introduced from 4 tropical and subtropical areas and grown for morphological and ecological investigations. A list of the legumes and seed sources is presented in Table 1.

Table 1. Legume species introduced to Singapore for morphological and ecological studies

Species	Identification	Seed Source
Desmodium canum (Gmel.) Schin. & Thell.	PI 317045	Hawaii
Desmodium intortum (Mill.) Urb.	Greenleaf	Australia
Desmodium sandwicense E. Mey.	PI 322470	Brazil
Desmodium uncinatum (Jacq.) DC	Silverleaf	Australia
Glycine wightii (R. Grah. ex Wight & Arn.) Verdc.	Perenn. soybean	Brazil
Phaseolus atropurpureus DC.	Siratro	Australia
Phaseolus lathyroides L.	Phasemy bean	Puerto Rico
Stylosanthes humilis H.B.K.	Townsville style	Australia

One hundred seeds of each species were counted and weighed to the nearest mg and scarified by rubbing between two fine carborundum papers before germination. Each lot of hundred seeds were placed on moistened blotting paper in a petri dish. The time interval leading to germination was recorded. When the radicle reached length of about 1 cm, all the young seedlings from each lot were transplanted to 8 cm-diameter plastic pots containing local soil on which *Desmodium triflorum* and *Desmodium heterophyllum* have previously been grown. The two legume species nodulated well so that the soil contained sufficient nitrogen-fixing bacteria. The pots were placed under shade and gently watered twice daily. When the seedlings reached the 5th true-leaf stage, they were transplanted to the field in the Department of Botany at the University of Singapore and grown under natural conditions. At the time of transplanting, the field is fully covered with grass-legume mixture, with about 20–30% of legumes, mainly *Desmodium heterophyllum* and *Desmodium triflorum*.

Morphological descriptions, measurements, and other observations of seed, seedling and adult plant are recorded under individual species. Leaflet size was measured by automatic area meter (Model AAM-5 by Hayashi Denko & Co. Ltd.) to the nearest mm^2. Pubescence on stems and leaves were classified into 4 classes, namely glabrous, slightly pubescent, pubescent, and densely pubescent.

Ecological observations are aslo listed under each species. A minimum of 5 plants from each species were examined for nodulation. The nodulation value for each species were recorded according to the following scale:

Rate 0 no nodulation.
Rate 1 poor nodulation: Sparse, small nodules.
Rate 2 fair nodulation.
Rate 3 good nodulation.
Rate 4 excellent nodulation: Abundant, large nodules.

Results and Discussions

Desmodium canum (Gmel.) Schinz & Thellung, Kaimi clover. — Plate 1A and 1B

This species originated from West Indies (Bryan, 1966). Younge *et al* (1964) reported that it has been naturalized in the Hawaiian Islands and is known to the farmers as Kaimi clover. This legume has been tested in Queensland, where it persisted in spite of severe competition with the aggressive grasses.

Morphology

Seeds: Yellow to light brown, kidney-shaped, 1.2 × 2.0 × 3.5 mm, 1000-seed weight 4.5–5.0g (180,000–220,000 seeds per kg); hilum oval, dark brown, at the centre of straight edge; germination epigeal; time to germination at 27°C, 52 hours.

Seedlings: Cotyledons oblong, 4–5 × 6–8 mm; eophylls 2, opposite, unifolioliate, cordate, 8–10 × 10–12 mm, margin entire, apex obtuse, base cordate; hypocotyl 6–8 mm; time to first true leaf, 25 days.

Stems: Decumbent to erect, cylindrical, green to brown, pubescent, fairly woody, internodes 3–4 cm long, rooting at nodes.

Leaves: Alternate, pinnately trifolioliate, dark green, slightly pubescent on both surfaces; petioles 3–5 cm long, pubescent; terminal leaflet oval, 8.8 cm^2, 2–3 × 4–5, margin entire; lateral leaflet 7.3 cm^2; stipules deltoid, 3–4 × 6–8 mm, apex pointed, stipels minute, lanceolate.

Inflorescence: A terminal raceme, 10–20 cm long, with 20–30 flowers; flowers small 5–6 mm long, paired at node; pedicels 3–4 mm long, calyx campanulate, 5-cleft, joined at base, teeth lanceolate; corolla pink to red, 4–5 mm long.

Pods: Straight, sickle-shaped toward end, 2–4 cm long, 5 mm wide, 4–8-seeded, deeply indented at lower suture, covered with hooked hairs, indehiscent, readily breakable into single-seeded segments.

Ecology

Kaimi clover has fairly big seed, about 4–5 grams per 1000 seeds, as compared with other *Desmodium* species (Rotar and Urata, 1966). It germinated slowly and the percentage of plant establishment was low, less than 20% under intensive care. It is a slow-growing plant and took 4 months to reach the flowering stage.

This legume was reported as a long-day plant (Chow, 1972). It flowered throughout the year under the natural day length in Singapore. The percentage of pod formation was low, less than 15%. Because of its low seedling vigour and poor pod formation, it has difficulties in establishment and regeneration. However, once it is established, it is very persistent and drought-tolerant, and competes very well with the aggressive grasses. It was hardly attacked by insects and also roots freely at nodes.

The plant did not nodulate well, with an average nodulation value of 1.1. Moreover, the plant grew into a small bush in two years because of its very woody stems. Thus it is concluded that this legume is fair in soil fertility improvement but good in soil erosion control.

Desmodium intortum (Mill) Urb., Greenleaf Desmodium or Kuru vine. — Plate 1C and 1D

D. intortum originated in Central and South America. It is found at altitudes up to 2,500 m at the equator and at about 800 m at its geographical limit of latitude 25°N and S (Bryan, 1969). This legume is used primarily for grazing. It recovers rapidly and can be grazed periodically throughout the growing season (Younge *et al.*, 1964). This legume has grown in popularity in Queensland, Australia and commercial seeds are available under the name "Greenleaf desmodium".

Morphology

Seeds: Light brown to brown, kidney-shaped, 0.6–1.0 × 0.8–1.2 × 1.0–1.4 mm, 1000-seed weight 1.5 g (400,000 seeds per kg); non-shattering; hilum small, nearly round, covered with dark brown material, at the centre of the nearly straight edge; germination epigeal, time to germination at 27°C, 26 hours.

Seedlings: Cotyledons oblong, 2–3 × 4–5 mm; eophylls 2, opposite, unifoliolate, ovate, 7–10 × 8–12 mm, margin entire, apex obtuse, base obtuse; hypocotyl 4–6 mm; time to first true leaf, 22 days.

Stems: Decumbent to sub-erect, cylindrical to triangle, green to reddish brown, pubescent, internode 4–8 cm long, 2–4 mm in diameter; rooting readily at nodes.

Leaves: Alternate, trifoliolate, green to dark green, pubescent on both surfaces; margin entire; petioles 3–4 cm long, pubescent; terminal leaflet ovate, size 24.9 cm^2, 5–6 × 6–8 cm, pubescent, with brown flecking; apex acute, base obtuse; lateral leaflets smaller, 16.8 cm^2, 4–5 × 5–7 cm; stipules deltoid, 3–4 × 4–5 mm; stipels small, linear.

Inflorescence: This plant has not flowered under the natural day length in Singapore.

Ecology

Greenleaf desmodium has rather small seeds, about 1.5 g per 1000 seeds, but the percentages of seed germination and seedling establishment were high. The plant started slow at seedling stage, and then grew fast and vigorously after it was established. The plant is not very tolerant to drought; vegetative growth of this plant is limited to a certain extent in the drier season. This legume seems to be best adapted to humid and subhumid climates in the tropics and subtropics.

The plant rooted freely at the stem nodes and nodulated very well. The average nodulation value was 3.2, the highest among the legumes in this study. The leaves of this plant were seriously attacked by insects (Chrysomelidae spp. and Cicadellidae spp.). For many old leaves, only mid-ribs were left. *D. intortum* is a shortday plant and flowered during December to March in Hawaii or under 10 to 11 hours of light (Rotar and Chow, 1971). Under the natural photoperiod in Singapore, it has not flowered.

Although greenleaf desmodium is one of the most important legumes for grazing animals in the tropics and subtropics, it can not be grown in Singapore for soil conservation due to two reasons: (1) The plant is seriously attacked by insects and (2) it does not flower with the intermediate day length at the equator, thus will have difficulties in regeneration.

Note: Taxonomists have not clearly distinguished between *D. intortum* and *D. aparines* (Link). DC. The type specimen of *D. intortum* is from Jamaica with articles of the loment almost symmetrical. Some materials from Mexico, Central and South America resemble the type but the loment articles are smaller and asymmetrical. *D. intortum* ranges from southern Mexico, through Central America, Jamaica and Haiti, into north Colombia and western Venezuela. *D. aparines* reportedly occurs from Lake Titicaca northward, through the highlands of Venezuela and Central America, to Vera Cruz in Mexico.*

This species designation of *D. intortum* has been used in this study.

Desmodium sandwicense E. Mey., Spanish clover. — Plate 2A and 2B

This legume originated in South America and has been introduced into tropical and subtropical Asia, Africa and Australia. It crosses readily with *Desmodium intortum* and *Desmodium uncinatum*, the two most important pasture species in the genus *Desmodium* (Rotar and Chow, 1971), and thus it was suggested that this legume could be used as bridging species to combine genes from these two species.

Morphology

Seeds: Light brown to brown, kidney-shaped, 1.2 × 2.0 × 3.0 mm, 1000-seed weight 3–4 g (250,000–330,000 seeds per kg): non-shattering; hilum oval, dark brown, at the centre of straight edge; germination epigeal, time to germination at 27°C, 24 hours.

Seedlings: Cotyledons oblong, 4–6 × 8–10 mm; eophylls ovate, 6–10 × 5–8 mm, margin entire, apex obtuse, base obtuse; hypocotyl 10–14 mm; time to first true leaf, 18 days.

Stems: Erect to sub-erect, cylindrical, 1.5–3.0 mm in diameter, green, brown or dark red, woody, glabrous; internode 3–5 cm long.

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* Correspondence from B. G. Schubert, Arnold Herbarium, Harvard University.

Plate 1. *Desmodium canum*, *A:* seedling, *B:* plant. *Desmodium intortum*, *C:* seedling, *D:* plant.

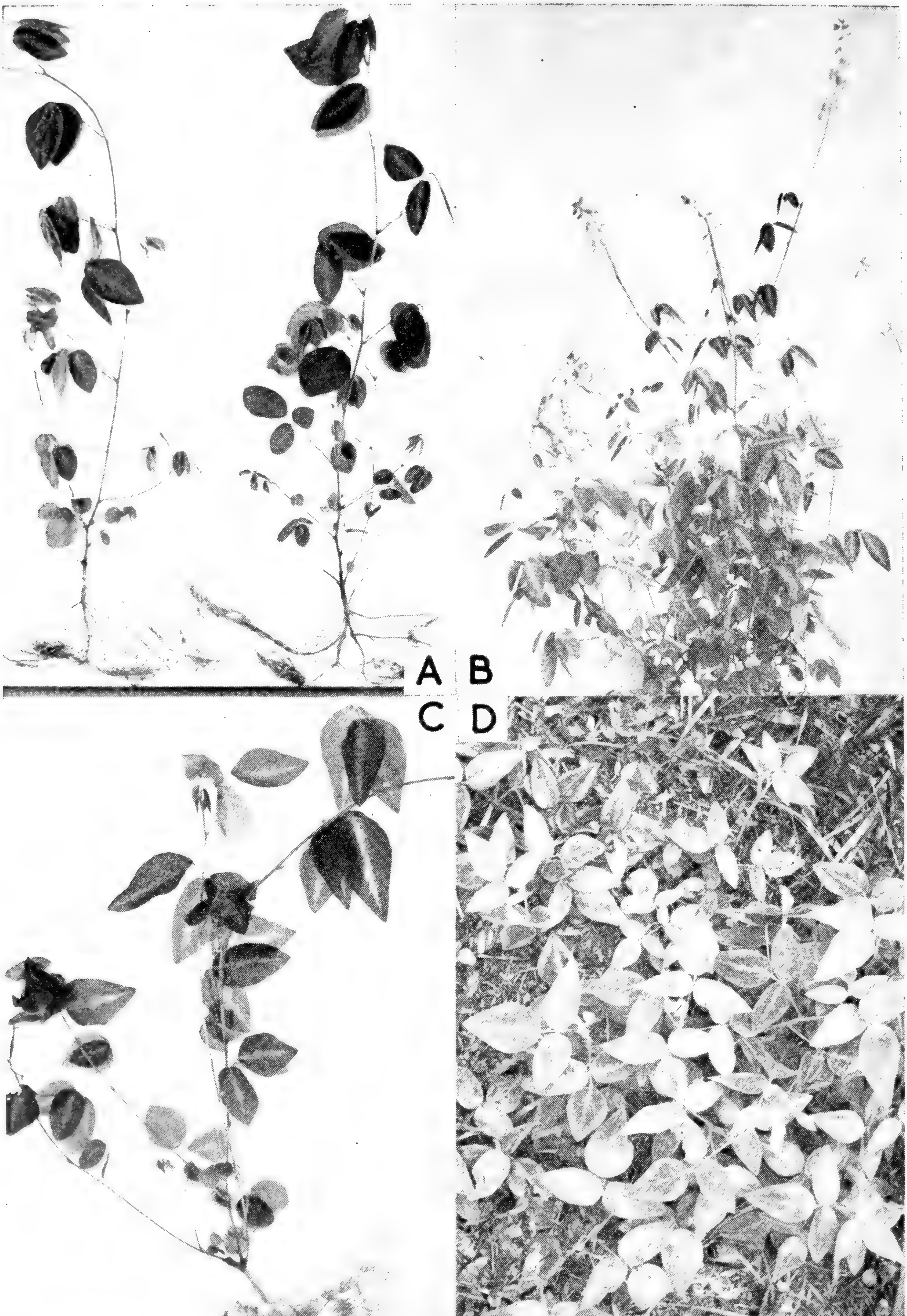

Plate 2. *Desmodium sandwicense, A:* seedling, *B:* plant.
Desmodium uncinatum, C: seedling, *D:* plant.

Leaves: Dark green, glabrous above, slightly pubescent beneath, margin entire; petioles 4–8 cm long, glabrous; terminal leaflet lanceolate, 9.8 sq. cm, 3–4 × 4–6 cm; apex acute, base acute; lateral leaflet smaller, 8.4 sq. cm, 2–3 × 4·5 cm; stipules small, deltoid, 2–4 mm long, 1 mm wide, stipels minute, linear.

Inflorescence: A terminal raceme, 15–25 cm long, with 30–40 flowers; flowers 1 cm long, paired at node; pedicels 3–5 mm long, calyx campanulate, 5-cleft, joined at base, teeth lanceolate; corolla 8 mm long, pink.

Pods: Brown, straight, sickle-shaped toward apex, 3–5 cm long 0.5 cm wide, 5–11-seeded, covered with hooked hairs, deeply indented at lower suture, indehiscent, readily breakable into several single-seeded segments.

Ecology

Desmodium sandwicense showed high percentages of seed germination and seedling establishment. The plant grew well and fast at seedling stage, but vegetative growth slowed down when the plant started to flower which took place within two months from seeding. The plant flowered profusely but did not set seed well; percentage of pod formation was less than 10% under the natural environment in Singapore. This was probably owing to the high temperatures.

The plant had rather woody stems, and thus had upright to intermediate growth habit. Nodulation was poor, with an average nodulation value 1.4. The leaves were attacked by insects. It is concluded that this legume is not well adapted to the rainforest conditions and is not recommended to grow in Singapore.

Desmodium uncinatum (Jacq.) DC., Silverleaf desmodium. — Plate 2C and 2D

This legume is native to tropical America, most likely Brazil (Bryan, 1969). Its distribution is restricted to humid or subhumid tropical or subtropical climates with a rainfall of 1000 mm or more. This species is one of the most promising tropical pasture legumes. However, it is susceptible to 'legume little leaf' and is not as palatable as *D. intortum* selections (Hutton, 1960).

Morphology

Seeds: Light brown, kidney-shaped, 1.5 × 2.3 × 3.3 mm, 1000-seed weight 5 g (200,000 seeds per kg); non-shattering; hilum oval, dark brown, at the centre of straight edge; germination epigeal, time to germination at 27°C, 25 hours.

Seedlings: Cotyledons oblong, 4–6 × 7–11 mm, apex obtuse, base obtuse; eophylls 2, opposite, unifoliolate, ovate, 8–12 × 10–15 mm, margin entire, apex obtuse, base obtuse; hypocotyl 8–12 mm; time to first true leaf 20 days.

Stems: Decumbent, cylindrical to angled, green to light brown, 3.5 mm in diameter, soft, densely covered with hooked hairs, very sticky; internodes 6–10 cm long, rooting at the nodes on moistened soils.

Leaves: Alternate, pinnately trifoliolate, dark green with very distinctive silver marking on the mid-rib, densely covered with hooked hairs on both surfaces; petioles 6–8 cm long, densely pubescent; terminal leaflet elliptic and ovate, 15.5 cm^2, 3–5 × 5–8 cm, margin entire, apex acute, base obtuse, lateral leaflets smaller, 12.5 cm^2, 3–4 × 4–5 cm; stipules deltoid, 2–3 × 5–8 mm, apex pointed; stipels minute, 3–4 mm long, lanceolate, pointed.

Inflorescence: A terminal raceme, 30–50 cm long, with 25–45 flowers; flowers 1.3–1.5 cm long, paired at node, pedicels 1–1.5 cm long, densely pubescent; calyx campanulate, 5-cleft, joined at base, teeth acuminate, densely pubescent; corolla pink, 1.1–1.4 cm long.

Pods: Sickle-shaped, 5–9-seeded, 4–6 cm long, 0.6 cm wide, upper suture straight, lower suture deeply indented, covered with harsh and hooked hairs, very sticky, indehiscent but readily breakable into several single-seeded segments.

Ecology

Silverleaf desmodium has fairly large seeds, 5 g for 1000 seeds, and grew well at seedling stage. It is a short-day plant and flowered under 11 hours of photoperiod (Chow, 1972). In the natural environment of Singapore, it took 6 months to reach flowering stage. The plant flowered well throughout the year but pod formation was poor, less than 10%. Most of the flowers dropped within two days after opening. This is probably due to the high temperatures in Singapore. Rotar and Chow (1971) reported that pod formation of *D. intortum* and *D. uncinatum* was negatively correlated with temperatures. Pods harvested in Singapore contained an average of 2.8 seeds which is significantly less than the average of 4.5 seeds per pod reported by Rotar and Chow (1971) under the natural conditions in Hawaii in winter.

After flowering, vegetative growth slowed down considerably. The plant rooted freely at stem nodes and also nodulated well, with an average nodulation value 2.6. Owing to its heavy pubescence, the plant is hardly attacked by insects. It is also tolerant to shade, grew well in dry season, and regrew fast after being cut. It is concluded that this legume shows potentials in soil fertility improvement and soil erosion control in the wet tropics because of its high nodulation value, stoloniferous habit, moderate vegetative growth, and tolerance to insects, shade and drought. It has a spreading growth habit and builds up a dense ground cover in half a year.

Glycine wightii (R. Grah. ex Wight and Arn.) Verdc., Glycine, perennial soybean or Rhodesian Kudzu — Plate 3A and 3B

This legume is a native of tropical Africa, most likely Kenya. It is now widely distributed in India, Ceylon, Malaya, and Java (Hutton, 1968). This plant has received much attention in Australia, Africa and South America as a pasture legume for semi-arid and for moderately humid tropics. In Kenya, Bogdan (1966) reported that glycine mixed well with a number of cultivated grasses and is suitable for improved permanent pastures.

Morphology

Seeds: Dark brown to black, oblong, 1.5 × 2.0 × 2.5 mm, 1000-seed weight 5.8 g (172,000 seeds per kg); hilum very small, circular, white, at the centre of straight edge; germination epigeal, time to germination at 27°C, 28 hours.

Seedlings: Cotyledons oblong, 5–7 × 8–12 mm; eophylls 2, ovate, 1.4–2.0 × 1.2–1.8, margin entire, apex obtuse, base obtuse; hypocotyl 10–14 mm; time to first true leaf, 20 days.

Stems: Twining, cylindrical, soft, green, pubescent; internodes 8–15 cm long, rooting at nodes.

Leaves: Green, pubescent on both surface; petioles slender, 3–5 cm long, pubescent; terminal leaflet ovate, 14.1 sq. cm, 3–4 × 4–6 cm, margin entire, apex obtuse, base obtuse; lateral leaflet smaller, 10.6 sq. cm; stiples small, deltoid, 3–4 × 6–8 mm, apex pointed; stipels minute, linear.

Inflorescence: This plant has not flowered under the natural day length in Singapore.

Ecology

Glycine wightii grew slowly at seedling stage. Wilson (1972) stated that the slow growth of this species at seedling stage was due to the relative slow initial nodule development in this species. The plant grew and nodulated fairly well after being established, with an average nodulation value of 2.2. This legume is a short-day plant and has not flowered in Singapore. The leaves of this legume have been attacked by insects, but not very seriously. Furthermore, this legume is a climber and does not root well at stem nodes, and thus is not recommended for use in soil conservation in Singapore.

Phaseolus atropurpureus DC., Siratro — Plate 3C and 3D

This species is native to Mexico, Central America and parts of South America. It is usually found in drier areas at sea level or in the drier transition zones at around 300 m elevation between the wet coastal lowlands and the higher sub-coastal plateau (Hutton, 1962).

Morphology

Seeds: Dark brown, oblong-ellipsoid, 2.0 × 2.5 × 3.5 mm, 1000-seed weight 12.54 g (80,000 seeds per kg); hilum oval, small, central, white; germination epigeal, time to germination at 27°C, 31 hours.

Seedlings: Cotyledons oblong, thick, small, 3 × 5 mm; seedling leaves 2, opposite, cordate, 1.5–2.0 × 1.5–2.5 mm, apex, obtuse, base obtuse; hypocotyl 8–12 mm; time to first true leaf, 15 days.

Stems: Trailing or climbing, cylindrical, green, soft, slightly pubescent; internodes elongating.

Leaves: Alternate, trifoliolate, dark green, margin entire, pubescent beneath; petioles 4–8 cm long, slightly pubescent; terminal leaflet ovate, size 11.8 cm^2, 3–4 × 4–6 cm, apex obtuse, base obtuse; lateral leaflet smaller, 8.4 cm^2; stipules small, deltoid, 2–3 mm long, 1 mm wide, apex pointed; stipels minute, 1–2 mm long, deltoid.

Inflorescence: An axillary raceme, with 6–10 flowers crowded at the apex of the raceme; flower 1.5–2.0 cm long; calyx campanulate 5-cleft, joined at base, teeth short, pubescent; corolla dark purple, much exserted, keel prolonged, spirally twisted, style filiform, wings conspicuous, 15–17 mm across.

Pods: Linear straight, 7–10 cm long, 0.4 cm wide, containing 11–13 seeds, dehiscent when ripe, splitting along both edges.

Ecology

The percentage of seedling establishment for this legume was low, and the seedlings grew slowly in the environment of Singapore. The plant, however, grew well after being established and flowered profusely throughout the year. Despite the hot climate, it produced a large number of seeds. The pods of this legume are dehiscent upon maturity. The plant did not volunteer well due to its poor seedling establishment in wet and hot environment.

This legume is very resistant to insects and nodulated fairly well, with an average nodulation value of 1.7 when the plant was 6 months old. The plant rooted poorly at stem nodes. It is thus not recommended for soil conservation use in the wet tropics. Being a climber, this legume can be used as an ornamental plant on fence.

Phaseolus lathroides L., Phasemy bean — Plate 4A and 4B

This legume originated in India and is now widely grown in many parts of the world. The plants are palatable and highly nutritive to animals. However, it is susceptible to bean virus 2 and is badly attacked on occasion by bean flies (*Agromyza phaseoli* Coq.) in Queensland, Australia, particularly at the seedling stage (Hutton, 1962). In Australia, this legume is being replaced by 'Siratro' (*Phaseolus atropurpureus* L.) in many areas.

Morphology

Seeds: Gray, mottled with brown spots, oblong with rounded ends, solid, 1.6 × 2.0 × 2.2 mm, 1000-seed weight 6.5 g (150,000 seeds per kg); hilum oval, central; germination epigeal, time to germination at 27°C, 19 hours.

Seedlings: Cotyledons oblong, small, thick, 3–4 × 4–6 mm; eophylls 2, opposite, unifoliolate, cordate, 1.2–1.5 × 1.5–2.0 cm, margin entire, apex obtuse, base cordate; hypocotyl 10–15 mm; time to first true leaf, 14 days.

Stems: Sub-erect, climbing, cylindrical, purplish green, slightly pubescent, soft; internodes elongating.

Leaves: Trifoliolate, alternate, green, glabrous on upper surface, slightly pubescent on lower surface; margin entire; petioles 4–6 on long, slender; terminal leaflet ovate, size 12.5 cm^2, 3–4 × 5–6 cm, apex obtuse, base obtuse; lateral leaflet size 9.2 cm^2, deltoid, 1–2 × 4–6 mm, apex acuminate, stipules minute, 1–2 mm long, lanceolate.

Inflorescence: An axillary raceme, 20–30 cm long, with 5–10 flowers crowded at the top of raceme; flowers 1.5–2.0 cm long, purplish red, pedicels 0.5 cm long; calyx campanulate, 5-cleft, joined at base, teeth short, pubescent; corolla purplish red; keel prolonged, spirally twisted; wings conspicuous 16–18 mm across; style filiform.

Pods: Linear, 10–14 cm long, 3 mm wide, covered with brown hairs, nearly straight, containing 15–25 seeds, dehiscent when ripe, splitting along both edges.

Ecology

The seeds of phasemy bean germinated well, the seedlings grew fast and the plants were very vigorous after being established. It flowered profusely throughout the year in Singapore. The percentage of pod formation was about 65% and each pod contained approximately 20 seeds, thus it produced a great number of seeds. The pods dehisced when ripe and the plant volunteered well.

The young plants of two months old nodulated well, with an average nodulation value of 3.1. For 6-month-old plants, the nodulation value decreased to 1.5. The fast growth at the seedling stage of this legume is probably due to the fast initial nodule development. Phasemy bean is probably a biennual plant. Its growth slowed down considerably in the second year and gradually died off. The plant is very resistant to insects.

The above results indicate that this legume is very well adapted to the natural environment in Singapore. It is good on soil fertility improvement but fair on soil erosion control because it is a climber and produces stolons poorly. It can be used as an ornamental plant on fence. However, precaution has to be taken to prevent the plant from growing beyond control.

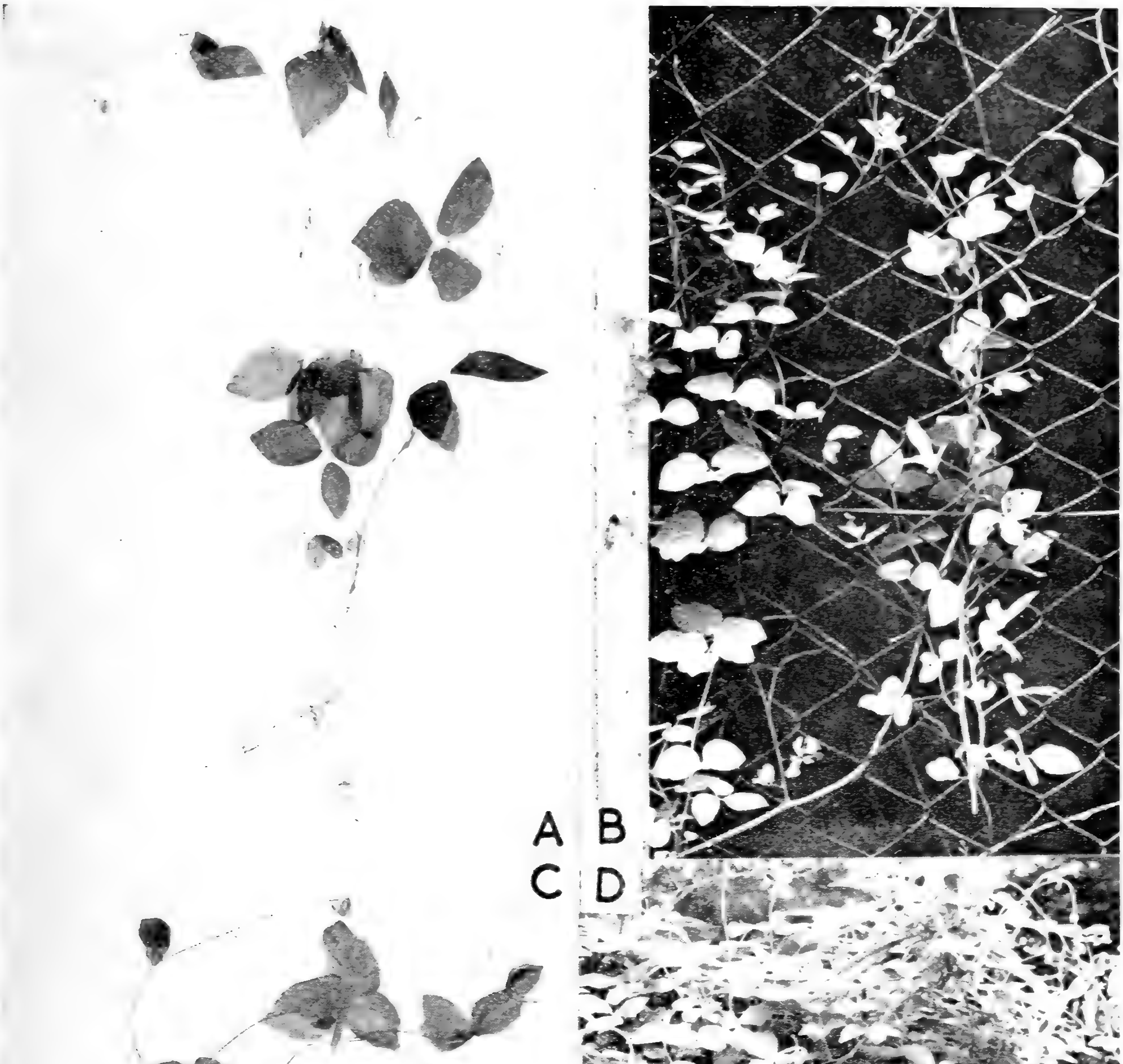

Plate 3. *Glycine wightii, A:* seedling, *B:* plant.
Phaseolus atropurpureus, C: seedling, *D:* plant.

Plate 4. *Phaseolus lathroides; A:* seedling, *B:* plant.
Stylosanthes humilis; C: seedlings, *D:* plants.

Stylosanthes humilis H.B.K., Townsville style — Plate 4C and 4D

This legume is a native of South America. It was introduced into Queensland, Australia through the port of Townsville in the early years of this century (Shaw et al., 1961). By 1945 this plant had become naturalized over a wide area in the northern part of Queensland and is the only annual pasture legume in the sub-tropical areas of the world. Hutton (1968) stated that the success of this legume in Australia comes from its adaptability, good seed production — as high as 1,000 lb per acre — ease of re-establishment, and tolerance to grazing due to moderate palatability.

Morphology

Seeds: Brown or light brown, glossy, somewhat rhombic, with one end beaked, 1.2 × 1.5 × 2.0 mm, 1000-seed weight 2.13 g (470,000 seeds per kg); hilum small, circular, brown, near the beaked end; germination epigeal, time to germination at 27°C, 20 hours.

Seedlings: Cotyledons oblong, 2–4 × 4–7 mm; eophyll 1, trifoliolate, lanceolate, 2–4 × 5–9 mm, margin entire, apex obtuse, base obtuse, hypocotyl 6–10 mm; days to first true leaf, 20.

Stems: Erect or sub-erect, attaining 0.5 m high or more, green, soft, cylindrical when young and slightly angled when old, pubescent; internodes 3–6 cm long.

Leaves: Alternate, palmately trifoliolate, green, slightly pubescent on both surfaces; petiole slender, 1–2 cm long, pubescent; terminal leaflet lanceolate, size 0.78 cm^2, 0.5 × 2–3 cm, apex acute, base acuminate; lateral leaflets smaller, 0.41 cm^2, 0.4 × 1.5–2.5 cm; stipules conspicuous, 5–8 mm long, adnate to petioles, forming a sheath of 1 cm long at the base; stipels absent.

Inflorescence: terminal or axillary head with 5–10 flowers; flowers 0.8 cm long, yellow or light orange; calyx tubular, 5-cleft, joined at base, teeth acuminate, short, covered with fine hairs.

Pods: Single-seeded, dark brown, 2–3 mm long, 2 mm wide, with a fine and hooked stalk extending from one end, indehiscent.

Ecology

Townsville style has small, rhombic seeds which germinate well in petri dish. The plant grew slowly at seedling stage and vegetative growth was somewhat limited under the natural conditions in Singapore. It flowered profusely after 4 months from seeding and set a large number of shrivelled seeds. This is probably due to the high temperatures. This species is annual and started to die off after 10 months from seeding in Singapore. The plant is very resistant to insects. It did not produce any stolons and nodulated poorly. Thus this species is not recommended to be grown in Singapore for soil conservation purpose. This species has been reported to be best adapted to the drier areas in the tropics (Fisher, 1969).

Literature Cited

Bogden, A. V. 1966. *Glycine javanica* under experimental cultivation in Kenya. Trop. Agr. 43: 99–105.

Bryan, W. W. 1966. The pasture value of species of *Desmodium*. Inter. Grassld. Congr. Proc. 10: 311–315.

————. 1969. *Desmodium intortum* and *Desmodium uncinatum*. Herbage Abs. 39 (no. 3): 183–191.

Chow, K. H. and L. V. Crowder. 1972. Hybridization of *Desmodium canum* (Gmel.) Schin. & Thell. and *Desmodium uncinatum* (Jacq.) DC. Crop Sci. 12: 784–785.

Chuang, C. C. and C. Huang. 1965. The leguminosae of Taiwan for pasture and soil improvement. JCRR, Taipei, Taiwan. 268 pp.

Fisher, M. J. 1969. The growth and development of Townsville lucerne (*Stylosanthes humilis*) in ungrazed swards at Katherine, N.T., Aust. J. Exp. Agr. & Anim. Husb. 9: 199–208.

Hutton, E. M. 1960. Flowering and pollination in *Indigofera spicata, Phaseolus lathroides, Desmodium uncinatum* and some other tropical pasture legumes. Emp Jour. Exp. Agr. 28: 235–243.

————. 1962. Siratro — a tropical pasture legume bred from *Phaseolus atropurpureus*. Aust. J. Exp. Agr. & Anim. Husb. 2: 117–125.

————. 1968. Australia's pasture legume. J. Aust. Inst. Agr. Sci. 34: 203–218.

Rotar, P. P. and K. H. Chow. 1971. Morphological variation and interspecific hybridization among *Desmodium intortum, Desmodium sandwicense* and *Desmodium uncinatum*. Hawaii Agr. Exp. Stat. Tech. Bull. No. 82, 28 pp.

Shaw, N. H., C. T. Gates and J. R. Wilson. 1966. Growth and chemical composition of Townsville lucerne (*Stylosanthes humilis*). 1. matter yield and nitrogen content in response to superphosphate. Aust. J. Exp. Agr. & Anim. Husb. 6: 150.

Wilson, J. R. 1972. Comparative nodulation, nitrogen fixation and growth of *Glycine wightii* cv. Cooper and *Phaseolus atropurpureus* cv. Siratro seedlings. Aust. J. Agr. Res. 23: 1–8.

Younge, O. R., D. L. Plucknett and P. P. Rotar. 1964. Culture and yield performance of *Desmodium intortum* and *Desmodium canum* in Hawaii. Hawaii Agr. Exp. Stat. Tech. Bull. No. 59. 28 pp.

Anatomical Features of the Dipterocarp Timbers of Sarawak

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Summary

Economically, the family Dipterocarpaceae is one of the most important in Malaysia, producing timber and other commodities.

The timber of some 200 species of dipterocarps indigenous to Sarawak has been anatomically examined and found to conform to about a dozen homogeneous groupings corresponding, in the main, to generic categories. The characteristics of these categories are described in detail and summarised in tabular form. Anatomical relationships between the groupings are discussed and attention is directed to similarities and differences between them. Also, indicative specific gravities for the 200 species examined have been listed.

A key to the timber groupings, which have commercial application, has been prepared.

Introduction

About two-thirds of the total area of Sarawak is occupied by forests. Browne (1955) has remarked upon the fact that, although these forests may contain as many as 3,000 different species, they are dominated by the Dipterocarpaceae. This family of commercially valuable trees is, with the exception of the sub-family Monotoideae which occurs only in Africa, confined to the Indo-Malaysian region where the timber is used locally for many purposes and is an important component of the nation's overseas trade. In addition, these trees furnish dammar (amber) used in the manufacture of varnish and an oil which is used in foodstuffs, medicines and cosmetics. This oil is obtained from illipe nuts — the fruits of the Engkabang (*Shorea* spp.) trees.

Over 200 species of Dipterocarpaceae have been recognised from Sarawak but, for commercial purposes, these fall into about a dozen categories corresponding, in the main, to generic groupings. The appearance and properties of many of the timbers within the family are very similar and the differences between the several groupings are not always easy to recognise.

Desch (1957) has described the gross structure of the dipterocarp timbers of West Malaysia. Metcalfe and Chalk (1950) have summarised the anatomical features of all the genera within the family but make little reference to specific differences within each genus. This paper presents the results of an intensive study of specific variation in the 9 genera of dipterocarp indigenous to Sarawak. The results of this study have been summarised in the form of two tables, one dealing with the anatomical features characteristic of each genus, the other setting out the densities of the 200 species examined. In addition, a key for the separation of the various timber groupings recognised by the timber trade has been prepared.

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In the text, genera have been described in alphabetical order, regardless of natural affinities. Field characteristics have been summarised from descriptions published by Browne (1955) or Ashton (1964). The technical description of the wood structure conforms to the usage of the International Association of Wood Anatomists (1957). The density classification proposed by Kauman and Kloot (1968) has been accepted as conforming sufficiently closely to commercial differences in the dipterocarp timbers.

A projection microscope and superimposed scale (designed by F.P.R.L., Princes Risborough, U.K.) were used to measure the sizes of pores/vessels and rays, and the sizes quoted conform to the system of the British Forest Products Research Laboratory (1960). Hardness was determined subjectively, by shaving the end-grain with a pocket knife, the rating being: —

soft, moderately hard, hard and *very hard*.

Acknowledgements

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KEY TO THE DIPTEROCARP TIMBERS OF SARAWAK

1 (a) Pores exclusively solitary 2
(b) Pores not exclusively solitary 7

2 (a) Wood distinctly yellow .... MERSAWA (*Anisoptera* spp.)
(b) Wood not yellow 3

3 (a) Axial intercellular canals in long tangential series .... KAPUR (*Dryobalanops* spp.)
(b) Axial intercellular canals not in long tangential series 4

4 (a) Axial intercellular canals diffuse; wood texture fine 5
(b) Axial intercellular canals in short tangential series; wood texture coarse .... KERUING (*Dipterocarpus* spp.)

5 (a) Pores numerous to very numerous 6
(b) Pores moderately few .... PENYAU (*Upuna borneensis*)

6 (a) Silica present .... RESAK (*Cotylelobium* spp.)
(b) Silica absent .... RESAK (*Vatica* spp.)

7 (a) Crystals in parenchyma, chambered, usually in long strands .... WHITE SERAYA (*Parashorea* spp.)

(b) Crystals in parenchyma, not chambered, usually not in long strands 8

8 (a) Wood below 60 lb. per cu. ft. air-dry 9

(b) Wood over 60 lb. per cu. ft. air-dry 14

9 (a) Pores in characteristic groups of 3–5; silica present .... WHITE MERANTI (*Shorea* spp.)

(b) Pores not in groups of 3–5; silica absent 10

10 (a) Wood texture fine .... SELANGAN (*Hopea* spp.)

(b) Wood texture coarse 11

11 (a) Wood yellow; radial intercellular canals always present; rays bright yellow (transverse section) .... YELLOW MERANTI (*Shorea* spp.)

(b) Wood not yellow; radial intercellular canals present only in a few species of Red Meranti; rays not bright yellow 12

12 (a) Wood parenchyma prominent, tending to short lines between rays; axial intercellular canals prominent on all surfaces 13

(b) Wood parenchyma not prominent; axial intercellular canals distinct on all surfaces but not prominent .... LIGHT RED MERANTI (*Shorea* spp.)

13 (a) End cut glistening or waxy .... RED SELANGAN (*Shorea* spp.)

(b) End cut dull .... DARK RED MERANTI (*Shorea* spp.)

14 (a) Diameter of axial intercellular canals considerably smaller than that of vessels; wood texture coarse .... SELANGAN BATU (*Shorea* spp.)

(b) Diameter of axial intercellular canals often as large or larger than that of vessels; wood texture fine .... GIAM (*Hopea* spp.)

SUMMARY OF QUANTITATIVE VALUES

DENSITY CLASSES (see Kauman & Kloot, 1968)

Light	$<$ 30 lb. per cu. ft.
Medium	30 — 45 lb. per cu. ft.
Heavy	45 — 60 lb. per cu. ft.
Very heavy	$>$ 60 lb. per cu. ft.

PORE NUMBER (see F.P.R.L., Princes Risborough, 1960)

Very few	< 12 per 10 mm^2
Few	12 — 30 per 10 mm^2
Moderately few	30 — 65 per 10 mm^2
Moderately numerous	65 — 125 per 10 mm^2
Numerous	125 — 250 per 10 mm^2
Very numerous	> 250 per 10 mm^2

PORE and RAY SIZE (see F.P.R.L., Princes Risborough, 1960)

Size	Vessel Diameter — Tangential		Ray Width (Transverse section)	
	Microns		Microns	
2	< 50	Very small		
3	50 — 100	Moderately small	> 50	Fine
4	100 — 200	Medium	50 — 100	Medium
5	200 — 300	Moderately large	100 — 200	Moderately broad
6	> 300	Very large	200 — 400	Very broad

Anisoptera

FIELD CHARACTERISTICS

Of the five species of *Anisoptera* (Mersawa) known to occur in Sarawak, two are rare and of no commercial importance. Of the other three species *A. grossivenia* is the most common but not enough to rate the genus as important a timber source as it is in the forests of northern West Malaysia, Thailand and Indo-China. Commercial stands of this species and of *A. laevis* are found in the lowland forests whereas *A. marginata* is restricted to peat swamp forests. The genus usually occurs on yellow sandy soils, calcareous shales or sandstone hills and on peat. All species develop into medium to large-sized trees, maximum height between 150–180 feet, with a girth of about 15–18 feet, with straight, cylindrical boles. Buttresses are prominent, thick and rounded. Bark surface is dull brown, dotted with warty lenticels, rather irregularly fissured. Dammar (amber) exuding from surface fissures appears as smears on the bole.

WOOD ANATOMY

Pores/Vessels. Almost exclusively solitary, with a few radial, tangential and oblique pairs, uniformly distributed, moderately numerous, generally oval, medium-sized to moderately large (size 4–5); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses abundant.

Parenchyma. Paratracheal, as incomplete sheaths to the vessels, occasionally aliform; apotracheal, diffuse and in short uniseriate bands between rays, the uniseriate bands being most distinct and numerous in *A. laevis*; around the axial intercellular canals, sometimes forming more or less continuous tangential layers.

Rays. Mostly 2–7 cells wide (medium-sized), uniseriates (fine) short and rare, less than 2 mm. in height; heterogeneous (Kribs's types III and II) with 1–3 marginal rows of square or upright cells.

Vessel-ray Pitting. Simple, round, with large aperture.

Tracheids and Fibres. Fibres with moderately conspicuous bordered pits, walls thick. Cells intermediate between vasicentric tracheids and fibre-tracheids occur in the immediate proximity of the vessels.

Intercellular Canals. Axial canals scattered singly and in pairs throughout the fibres, sometimes in more or less continuous tangential rows; diameter usually less than that of the vessels; canals commonly blocked with chalky deposits.

Crystals. Wanting.

Silica. Abundant in all species in ray cells, occasionally in parenchyma.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood fairly distinct, pale yellow; about 2 inches wide.

Heartwood yellow, later darkening to yellow-brown.

The timber is moderately hard and medium to heavy, with an average density of 47 lb. per cu. ft. (range: 42–56 lb. per cu. ft.) air-dry.

Grain shallowly to rather deeply interlocked; texture moderately coarse, even.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals distinguishes this timber from non-dipterocarps.

(ii) The diffuse axial canals preclude the possibility of confusing this timber with other dipterocarp timbers except Keruing (*Dipterocarpus* spp.), Resak (*Cotylelobium* spp. and *Vatica* spp.) and Penyau (*Upuna borneensis*).

(iii) The timber can be separated from Keruing, Resak and Penyau by its distinctive yellow colour. Further, the timber of *Anisoptera* is much coarser in texture, and less hard, than Resak and Penyau.

Cotylelobium

FIELD CHARACTERISTICS

Three species of this genus are known to occur in Sarawak on a variety of soils on sandstone ridges and limestone hills. In Sarawak, all species of *Cotylelobium* and *Vatica* are collectively known as Resak, although as trees, the two genera are quite distinct in many of their characters. All species of *Cotylelobium* grow to medium-sized trees, with a maximum height of 120–140 feet and a girth of 8–12 feet. Frequently, the trees have twisted boles, with low and rounded buttresses, similar to *Vatica*. Bark surface is at first smooth, greyish and hoop-marked, becoming irregularly, shaggily flaked with age. Creamy or yellow smears of dammar present on the bole.

WOOD ANATOMY

Pores/Vessels. Exclusively solitary, generally round, numerous, moderately small to medium-sized (size 3–4); intervascular pitting rare, alternate, moderately coarse, pits vestured; perforation plates simple; tyloses present.

Parenchyma. Paratracheal, usually as incomplete borders to the vessels, abaxially aliform, occasionally confluent; diffuse and diffuse-in-aggregates, sometimes tending to short, uniseriate bands between rays; also around the axial intercellular canals.

Rays. Uniseriate (fine) and 2–8 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's types II and III, type I occasionally present in *C. burckii*) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present.

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Fibres with moderately conspicuous bordered pits, walls very thick.

Intercellular Canals. Axial canals scattered singly and sometimes in pairs throughout the fibres, diameter less than that of the larger vessels but as large as some of the smaller; canals commonly blocked with chalky deposits.

Crystals. Wanting.

Silica. Present in ray cells of all species, occasionally in parenchyma but rarely in fibres.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood yellow-brown and distinct from heartwood; about ½–1 inch wide.

Heartwood red-brown when freshly sawn, later darkening to dark brown.

The timber is very hard and very heavy, with an average density of 64 lb. per cu. ft. (range: 58–67 lb. per cu. ft.) air-dry.

Grain straight or shallowly interlocked; texture fine and even.

DISTINGUISHING FEATURES

(i) The timber of *Cotylelobium* and *Vatica* are so similar in appearance and properties that the common name Resak is used for both. They may be recognised as dipterocarps by the presence of axial intercellular canals and separated by the presence of silica which is abundant in the ray cells of *Cotylelobium* but absent from *Vatica*.

(ii) By the arrangement of its diffuse axial canals, this timber is readily distinguished from Kapur (*Dryobalanops* spp.), Selangan Batu and all Merantis (*Shorea* spp.), Selangan and Giam (*Hopea* spp.) and White Seraya (*Parashorea* spp.). In those four genera, the axial canals are arranged in long tangential series.

(iii) *Cotylelobium* can be readily distinguished from Keruing (*Dipterocarpus* spp.) and Mersawa (*Anisoptera* spp.) by its finer texture and higher density.

(iv) The numerous pores and presence of silica in *Cotylelobium* readily distinguish the timber from Penyau (*Upuna borneensis*).

Dipterocarpus

FIELD CHARACTERISTICS

All thirty-two species of *Dipterocarpus,* which occur in Sarawak are known as Keruing. It is one of the most characteristic trees of the lowland dipterocarp forests, extending into the hills to an altitude of about 3,000 feet, although one or two species are to be found in the peat swamps. *Dipterocarpus* usually occurs on yellow sandy soils, narrow shale ridges, clay hillsides, alluvium or peat. Some species are widespread but others tend to be localised. *Dipterocarpus* trees are large, with a maximum height exceeding 200 feet and a girth of over 20 feet; but more commonly they occur as trees of 150–180 feet in height with a girth range of 12–16 feet, according to species. The trees have tall, straight, cylindrical boles, with thick, rounded, buttresses. Bark surface is pale or dark grey to orange-brown, sometimes pink-brown, flaked or shaggy, with prominent warty lenticels. Dammar does not occur on unbroken bark surfaces but appears rapidly as clear sticky drops on freshly cut surfaces.

WOOD ANATOMY

Pores/Vessels. Almost exclusively solitary, rarely with radial pairs, oblique in arrangement, generally oval in outline, usually moderately few, medium-sized to moderately large (size 4–5); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses present.

Parenchyma. Paratracheal, as incomplete sheaths to the vessels; diffuse; forming short tangential layers around the axial intercellular canals.

Rays. Uniseriate (fine) and 2–8 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's types II and III, type I occasionally present) with 1–3 marginal rows of square or upright cells; sheath cells sometimes present.

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Vasicentric tracheids observed in most species.

Fibres with moderately conspicuous bordered pits, walls thick.

Intercellular Canals. Axial canals arranged singly and in short tangential series of 2–7, diameter considerably less than that of the vessels; canals blocked with whitish resinous contents.

Crystals. Wanting.

Silica. Abundant in ray cells of all species except *D. borneensis* in which it is sparse.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood grey-brown or yellow-brown and distinct from heartwood; $1\frac{1}{2}$–3 inches wide.

Heartwood pink-brown, purple-brown or red-brown, with a purple tinge, darkening on exposure.

The timber of *Dipterocarpus* is hard but varies in density, ranging between 38–62 lb. per cu. ft. air-dry, according to species. An average air-dry density of 45 lb. per cu. ft. may serve as an useful criterion to separate the timber into two classes, the medium weight and the heavy weight.

Grain straight or shallowly interlocked; texture moderately coarse to coarse and even.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals, arranged singly and in short tangential series of 2–7, can be used to distinguish the timber of *Dipterocarpus* from that of non-dipterocarps and from that of most other dipterocarps.

(ii) Two features can be used to distinguish the timber of *Dipterocarpus* from that of *Anisoptera* (Mersawa): (*a*) the timber of *Dipterocarpus* has a pink-brown cast, that of *Anisoptera* a yellowish colour; (*b*) in *Dipterocarpus* the pores are arranged in an oblique pattern but, in *Anisoptera*, are evenly distributed with no apparent pattern.

(iii) Confusion with Resak (*Cotylelobium* spp. and *Vatica* spp.) or Penyau (*Upuna borneensis*) is unlikely because of the much coarser texture of *Dipterocarpus*.

Dryobalanops

FIELD CHARACTERISTICS

Six species of *Dryobalanops* (Kapur) are known to occur in Sarawak. They are common trees of the lowland and hill forests but one species, *D. rappa* is to be found in the peat swamps. They usually grow on shallow yellow sandy soils derived from ferrugineous sandstone, white sand terraces, clay soils derived from basalt, sandy loam soils or peat. All species develop into large or very large trees, often growing to a height of over 200 feet and a maximum girth of 20 feet. The trees have tall, straight and cylindrical boles, with long, concave, rather thick, plank buttresses. Bark surface is of variable colour according to the species, evenly or persistently flaked, with distinct lenticels on fresh surfaces. Dammar is not exuded from cut surfaces, nor does it occur on the bole. Some species (*D. aromatica, D. lanceolata*) produce crystalline camphor in fissures within the heartwood.

WOOD ANATOMY

Pores/Vessels. Almost exclusively solitary, with a few radial multiples of 2–3, oblique in arrangement, generally round to oval in shape, moderately numerous, medium-sized to moderately large (size 4–5); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses abundant.

Parenchyma. Paratracheal, as incomplete borders to the vessels, aliform, occasionally confluent; diffuse and diffuse-in-aggregates; forming continuous tangential layers around the axial intercellular canals.

Rays. Uniseriate (fine) and 2–6 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's types II and III, type I occasionally present in *D. beccarii*) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present. Rays tend to be storied or arranged in echelon (except *D. rappa*).

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Fibres with moderately conspicuous bordered pits, walls thick. Cells intermediate between vasicentric tracheids and fibre-tracheids often occur in the immediate proximity of the vessels.

Intercellular Canals. Axial canals in continuous tangential rows, diameter considerably less than that of the vessels; canals filled with whitish resinous contents.

Crystals. Only in *D. fusca* and *D. rappa* in idioblasts and parenchyma, rhomboidal in shape.

Silica. Abundant in ray cells of all species except *D. rappa* in which silica is sparse.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood yellow-brown and clearly differentiated from heartwood; 1–2½ inches wide.

Heartwood red-brown or pink-brown, darkening on exposure.

The timber is hard and heavy; air-dry density of the hill species (Kapur Bukit) averaging about 50 lb. per cu. ft. (range: 45–55 lb. per cu. ft.) and the swamp species (Kapur paya) being a little lighter, averaging only 45 lb. per cu. ft. (range: 42–48 lb. per cu. ft.).

Grain straight or shallowly interlocked; texture moderately coarse and even; freshly cut wood has a pronounced camphor-like odour but the smell tends to disappear on seasoning.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals arranged in long tangential series provides a reliable diagnostic feature for distinguishing this timber from non-dipterocarp timbers and from Keruing (*Dipterocarpus* spp.), Mersawa (*Anisoptera* spp.), Penyau (*Upuna borneensis*) and Resak (*Cotylelobium* spp. and *Vatica* spp.). In those four dipterocarps, the axial canals are diffuse or in short tangential series.

(ii) The timber can be distinguished from all Merantis and Selangan Batu (*Shorea* spp.), Selangan and Giam (*Hopea* spp.) and White Seraya (*Parashorea* spp.) by its almost exclusively solitary pores and camphor-like odour when freshly cut.

Hopea

FIELD CHARACTERISTICS

In this genus a considerable amount of taxonomic work has still to be done but, already, about forty species of *Hopea* are recognised in Sarawak where they form a very variable group in both the lowland and the hill forests. Within the genus two groupings of species are commonly recognised: (i) Giam — a very hard, heavy, durable timber closely related to the Selangan Batu group (*Shorea* spp.); common species *H. nutans, H. pentanervia,* and *H. semicuneata* (ii) Selangan (Merawan in West Malaysia) — timber less hard and heavy than Giam; common species *H. beccariana, H. nervosa* and *H. sangal*. Some *Hopea* species are locally abundant, usually growing on alluviums, calcareous shales, clay soils or yellow sandy soils on ridges and hillsides, but a few are to be found on damp hillsides, near rivers, shallow peat or swampy soils overlying white sand. The trees are usually small, occasionally medium-sized, maximum height 90–120 feet, with a girth of 6–10 feet. Boles are usually tapering, frequently branching low. Buttresses are usually thin, sometimes thick; stilt roots sometimes present. Bark surface is at first smooth, chocolate- and grey-mottled, hoop-marked, becoming cracked and flaked or fissured. The Giam trees usually have a pale yellowish, the others a clear white dammar, sometimes in stalactitic form.

WOOD ANATOMY

Pores/Vessels. Solitary and sometimes in radial multiples of 2–4, occasionally in small clusters, round in shape, moderately numerous to numerous, evenly distributed, moderately small to medium-sized (size 3–4); intervascular pitting alternate, moderately fine, pits vestured; perforation plates simple; tyloses abundant.

Parenchyma. Paratracheal, usually as incomplete borders to the vessels, aliform, occasionally confluent; apotracheal, in irregularly spaced, narrow, terminal bands or in short, uniseriate lines between rays; forming continuous tangential layers enclosing the axial intercellular canals.

Rays. Uniseriate (fine) and 2–5 cells wide (medium-sized), occasionally up to 7 cells wide; low, less than 2 mm. in height; heterogeneous (Kribs's types II and III, sometimes type I) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present.

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Vasicentric tracheids present in all species, the cells irregular in shape and with conspicuous bordered pits. Fibres with indistinctly bordered pits, walls moderately thin in the Selangan group but very thick in Giam.

Intercellular Canals. Only axial canals present, in continuous tangential rows, variable in size, usually equal to or smaller than that of the vessels but sometimes larger; canals usually blocked with chalky deposits.

Crystals. Always present, rhomboidal in shape, in ray cells or parenchyma or both, occasionally chambered or sub-divided, sometimes in idioblasts.

Silica. Wanting.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood lighter in colour than the heartwood, about 1–2 inches wide, often with a greyish tinge, poorly differentiated from the heartwood.

Heartwood yellow or light yellow-brown when freshly cut, darkening to red-brown on exposure.

Timber weighing over 60 lb. per cu. ft. air-dry, i.e. Giam, is hard and durable; the lighter wood (40–60 lb. per cu. ft. air-dry), i.e. Selangan, moderately hard, less durable.

Grain, usually shallowly interlocked, sometimes wavy or spiral; texture fine or moderately fine, even.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals in continuous tangential series separates the timber from non-dipterocarps.

(ii) The same feature serves to distinguish *Hopea* from Keruing (*Dipterocarpus* spp.), Mersawa (*Anisoptera* spp.), Resak (*Cotylelobium* spp. and *Vatica* spp.) and

Penyau (*Upuna borneensis*), all of which have axial canals in a diffuse arrangement or in short tangential series.

(iii) Giam can be distinguished from Selangan Batu (*Shorea* spp.) by its finer texture.

(iv) Selangan resembles Yellow Meranti (*Shorea* spp.), but can be distinguished from it by the absence of radial canals in its rays and the even distribution of its pores. In Yellow Meranti, pores have a radial arrangement.

Parashorea

FIELD CHARACTERISTICS

Four species of *Parashorea* (White Seraya) are known to occur in Sarawak, usually growing on damp sticky clay on hillsides near rivers and streams or on well drained clay spurs and ridges. The genus has not been recorded from west of the Batang Lupar. All species grow to large trees, maximum height 150–180 feet, with a girth of about 12 feet. The trees have tall, straight and cylindrical boles, with large, rounded and slightly concave buttresses. Bark surface is distinctly mauve-grey to purplish, with narrow, shallow fissures, broad, smooth or flaking flat ridges, and numerous conspicuous large pale corky lenticels. Dammar is creamy to yellowish, exuding from rows of resin canals on cut surfaces.

WOOD ANATOMY

Pores/Vessels. Solitary and sometimes in radial multiples of 2–4, generally round to oval, moderately few, medium-sized to very large (size 4–6), mostly moderately large (size 5); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses present.

Parenchyma. Paratracheal, vasicentric, aliform, occasionally confluent; diffuse and diffuse-in-aggregates; forming continuous tangential layers surrounding the axial intercellular canals.

Rays. Uniseriate (fine) and 2–7 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's type III, occasionally type II), commonly with 1 marginal row of square or upright cells; sheath cells sometimes present.

Vessel-ray Pitting. Simple, round, with large aperture.

Tracheids and Fibres. Vasicentric tracheids always present, the cells irregular in shape and with conspicuous bordered pits. Fibres with simple pits, walls thin in *P. macrophylla* and *P. malaanonan* but thick in *P. parvifolia* and *P. smythiesii*.

Intercellular Canals

(i) Axial canals in continuous tangential rows, often rather widely spaced, diameter considerably less than that of the vessels; canals usually filled with chalky or yellow-white contents.

(ii) Radial canals absent from all the Sarawak specimens but observed in *P. smythiesii* of Sabah origin.

Crystals. Always present, usually rhomboidal, in parenchyma, chambered, usually in long strands; in ray cells, sometimes more than one per cell.

Silica. Wanting.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood paler in colour than the heartwood, usually 2–3 inches wide, commonly stained with fungus; fairly distinct from the heartwood.

Heartwood pinkish or straw-coloured, darkening to light brown on exposure, with a distinctive brownish tinge.

The timber of *Parashorea* may be divided into two classes, based on its density: (i) *P. malaanonan* and *P. macrophylla* are of medium weight, averaging between 35 and 42 lb. per cu. ft. air-dry; (ii) *P. parvifolia* and *P. smythiesii* are heavy timbers, averaging between 48 and 52 lb. per cu. ft. air-dry. Both groups of timber are moderately hard.

Grain interlocked; texture rather coarse, even.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals distinguishes the timber of *Parashorea* from non-dipterocarps.

(ii) The presence of axial canals in long tangential series serves to separate the timber of *Parashorea* from *Keruing* (*Dipterocarpus* spp.), Mersawa (*Anisoptera* spp.), Resak (*Cotylelobium* spp. and *Vatica* spp.) and Penyau (*Upuna borneensis*).

(iii) In *Parashorea,* the pores are often in radial multiples of 2–4, an arrangement quite different from Kapur (*Dryobalanops* spp.) in which the pores are almost exclusively solitary.

(iv) The timber is unlikely to be confused with Selangan and Giam (*Hopea* spp.) since those timbers are of a fine texture.

(v) Confusion with *Shorea* — see under *Shorea.*

Shorea

This is the largest genus within the family Dipterocarpaceae with at least one hundred and twenty species known to occur in Sarawak. All are trees capable of yielding commercial timbers but some are of no commercial importance because of inaccessibility or scarcity. Symington (1934) pointed out that, in West Malaysia, groups of species within the genus could usually be recognised in the field from bark and slash characters combined with the gross timber morphology. This grouping of species corresponds closely with local practice in the Sarawak timber industry.

In Sarawak, the accepted grouping of species within the genus generally corresponds to anatomical features or timber properties and the differences between the groups are both constant and distinct. The four groupings recognised in Sarawak are: —

I THE RED MERANTI GROUP
- Sub-group 1. Light Red Meranti
- Sub-group 2. Dark Red Meranti
- Sub-group 3. Red Selangan (Red Balau)

II THE SELANGAN BATU (BALAU) GROUP

III THE WHITE MERANTI GROUP

IV THE YELLOW MERANTI GROUP

FIELD CHARACTERISTICS

The Red Meranti Group

Botanists recognise sixty-two species of *Shorea* in the Red Meranti group which is the most important group of timber trees in Sarawak. Red Merantis are to be found in all types of forest, except the mangroves, from sea-level to about 3,000 feet altitude. All species develop into medium- to large-sized trees with, according to species, a maximum height of 120 feet to over 200 feet. Trees with a girth of 24 feet are not unknown, although 12–14 feet is more common. The trees usually have clean, straight boles, with large, thick, rounded buttresses. The bark surface is very variable, but the inner bark is red, pink-brown, orange-brown, rarely coffee coloured, and usually fibrous and relatively soft. Dammar exudations are commonly present, of variable colour when fresh but oxidising from cream to yellow on exposure.

The Selangan Batu (Balau) Group

Twenty-five species of Selangan Batu (in West Malaysia under the name of Balau) are known to occur in Sarawak. Some are abundant locally, usually on well-drained sandy soils. They are common in the lowland forests but do not occur in the swamp and mangrove forests. The trees are usually small to medium-sized, maximum height 100–150 feet according to species, but giants of about 220 feet with a girth exceeding 20 feet are occasionally found. Boles are variable. Buttresses are prominent, narrow and sharp. Bark surface is longitudinally cracked, thinly or shaggily flaked; dull grey-brown, yellow-brown, tawny or chocolate and indistinctly lenticellate. Dammar is frequently present as pale yellowish to brown smears on the bole.

The White Meranti Group

Of the eight species of White Meranti known to occur in Sarawak, seven are fairly common in the lowland forests and one in the heath forests; they are not found in the peat swamp forests. The trees usually grow on well-drained or sandy clay soils on ridges and hillsides, on relatively fertile soils derived from igneous rocks, or on shallow podsolic sandy soils. Most species develop into medium- to large-sized trees, maximum height 150–165 feet, with a girth of about 12–15 feet. The trees usually have tall, straight, cylindrical boles except *S. ochracea* which is frequently twisted or crooked. Buttresses are prominent, thick and rounded. Bark surface is pale or dark, irregularly fissured. Dammar exudation is pale yellow.

The Yellow Meranti Group

Twenty-five species of this group are found in Sarawak, occurring from lowland to hill forests in a wide variety of habitats. Yellow Meranti is usually found on well-drained soils or on soils derived from calcareous shales or igneous rocks, but never on deep peats. With some exceptions, they are large trees reaching a maximum height of over 200 feet with a maximum girth in excess of 25 feet. Boles are variable. Buttresses are small or prominent, of medium thickness, narrowly rounded. Bark surface is at first smooth, chocolate and grey dappled, becoming pale or dark tawny-brown, rarely chocolate-brown, irregularly and longitudinally cracked or flaked, closely and deeply fissured. Dammar is characteristically dull, dark grey-brown to black, readily exuding on cut surfaces; stalactitic exudations are usually abundant on the bole.

WOOD ANATOMY

Pores/Vessels. Solitary and sometimes in radial multiples of 2–4, in characteristic groups of 3–5 in the White Meranti; generally round to oval in shape, moderately few to moderately numerous, usually moderately small to medium-sized (size 3–4) in Light Red Meranti, Selangan Batu and Yellow Meranti, but in Dark Red Meranti, Red Selangan and White Meranti, medium-sized to moderately large (size 4–5); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses usually abundant.

Parenchyma. Paratracheal, vasicentric, aliform, occasionally confluent; diffuse and diffuse-in-aggregates; forming continuous tangential layers around the axial intercellular canals.

Rays. Uniseriate (fine) and 2–8 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's types II and III) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present.

Vessel-ray Pitting. Simple, round, with large aperture.

Tracheids and Fibres. Vasicentric tracheids always present, the cells irregular in shape and with conspicuous bordered pits. Fibres with simple pits, walls thin in Light Red Meranti, White Meranti and Yellow Meranti; thick in Dark Red Meranti, Red Selangan and some species of Yellow Meranti, but in Selangan Batu, very thick.

Intercellular Canals

(i) Axial canals in continuous tangential rows, diameter considerably less than that of the vessels except in Dark Red Meranti where the canals are often as large as the vessels; canals usually blocked with chalky or yellowish deposits.

(ii) Radial canals present in all species of Yellow Meranti and the following species of Red Meranti:—*Shorea leprosula, S. ovata, S. parvistipulata, S. scabrida* and *S. teysmanniana.*

Crystals. Occasionally present in all groups except White Meranti; in idioblasts, usually rhomboidal in shape, in parenchyma and ray cells.

Silica. Present in White Meranti in ray cells, but totally absent from other groups.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Red Meranti Group

Sapwood distinct, light yellow-brown or light grey-brown; about 1–2 inches wide.

Heartwood red or red-brown in Light Red Meranti; in Red Selangan and Dark Red Meranti, deep purple-red or dark red-brown, with prominent white or yellow-white lines of resin canals on all surfaces.

The timber of Light Red Meranti is soft to moderately hard, light to medium in weight averaging about 35 lb. per cu. ft. (range: 25–45 lb. per cu. ft.) air-dry; Dark Red Meranti and Red Selangan are harder and heavier, with the average air-dry densities of 45 lb. per cu. ft. (range: 42–55 lb. per cu. ft.) and 55 lb. per cu. ft. (range: 48–60 lb. per cu. ft.) respectively.

Grain straight or shallowly interlocked; texture even, rather coarse in Dark Red Meranti but finer in Red Selangan and Light Red Meranti.

Selangan Batu (Balau) Group

Sapwood fairly distinct from, and lighter in colour than the heartwood; about 1–2 inches wide.

Heartwood yellow-brown, grey-brown or brown, on exposure darkening to dark brown or dark red-brown.

The timber is very hard and heavy, averaging about 63 lb. per cu. ft. (range: 58–70 lb. per cu. ft.) air-dry.

Grain usually interlocked and wavy; texture moderately fine and even.

White Meranti Group

Sapwood lighter in colour than the heartwood and fairly distinct from it; about 2 inches wide.

Heartwood almost white when freshly sawn, later darkening to yellow-brown or buff-coloured.

The timber is moderately hard and medium-heavy, with an average air-dry density of 41 lb. per cu. ft. (range: 36–47 lb. per cu. ft.).

Grain usually shallowly interlocked; texture moderately coarse and even.

Yellow Meranti Group

Sapwood lighter in colour than the heartwood, with a greenish tinge and fairly distinct from the heartwood; 1–2½ inches wide.

Heartwood light yellow-brown, darkening on exposure.

The timber is moderately hard and medium-heavy, average weight 44 lb. per cu. ft. (range: 36–56 lb. per cu. ft.) air-dry.

Grain usually shallowly interlocked and sometimes wavy; texture moderately coarse and even.

Key to the timber groups in Shorea

1. (a) Silica present in the ray cells*; pores in characteristic groups of 3–5; wood white .... WHITE MERANTI
   (b) Silica absent; wood not as above 2
2. (a) Wood over 60 lb. per cu. ft. air-dry; wood very hard .... SELANGAN BATU
   (b) Wood below 60 lb. per cu. ft. air-dry; wood never hard 3
3. (a) Wood yellow; ray tissue bright yellow; radial intercellular canals always present* .... YELLOW MERANTI
   (b) Wood red or red-brown; ray tissue not bright yellow; radial intercellular canals present only in a few species of Red Meranti 4
4. (a) Wood parenchyma prominent, tending to short lines between rays; axial intercellular canals prominent on all surfaces 5
   (b) Wood parenchyma not prominent; axial intercellular canals distinct on all surfaces but not prominent .... LIGHT RED MERANTI
5. (a) End-cut glistening or waxy .... RED SELANGAN
   (b) End-cut dull .... DARK RED MERANTI

*Microscopic feature.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals arranged in long tangential series precludes the possibility of confusing the timber of *Shorea* with non-dipterocarp timbers and with Keruing (*Dipterocarpus* spp.), Mersawa (*Anisoptera* spp.), Penyau (*Upuna borneensis*) and Resak (*Cotylelobium* spp. and *Vatica* spp.). In those four Dipterocarps, the axial canals are diffuse or in short tangential series.

(ii) The timber of *Shorea*, with pores in radial multiples of 2–4 is readily distinguished from that of Kapur (*Dryobalanops* spp.) in which the pores are almost exclusively solitary. Further, unlike *Shorea* which is odourless, Kapur has a camphor-like odour when freshly cut.

(iii) Superficially the wood of *Hopea* species (Selangan and Giam) may resemble that of Yellow Meranti and Selangan Batu (*Shorea* spp.), especially in colour. The absence of any radial arrangement in the vessels and of radial canals in the rays can be used to separate Selangan from Yellow Meranti. Although both Giam and Selangan Batu are very heavy timbers, Giam may be recognised by its finer texture.

(iv) When White Seraya (*Parashorea* spp.) is confused with Red or White Meranti, it may sometimes be distinguished by its coarser texture and distinctive brownish tinge. In doubtful cases, a microscopic examination of White Seraya will reveal distinctive, chambered, crystalliferous parenchyma in long strands; these strands do not occur in Red or White Meranti although silica is to be found in the ray cells of White Meranti and Red Meranti may have some crystalliferous parenchyma.

Upuna

FIELD CHARACTERISTICS

Upuna is a monotypic genus with *U. borneensis* as the only species. *U. borneensis,* locally known as Penyau, is scattered through the lowland forests, on well drained ridges and deep yellow sandy clay soils. In Sarawak, it is widely distributed but never abundant. This species develops into a large tree, attaining a height of 160 feet and a girth of 18 feet. The tree has a tall, straight, cylindrical and well-shaped bole, with buttresses varying from small and stout to very large. Bark surface is dark purple-brown to chocolate, irregularly scaly. Dammar is pale yellow.

WOOD ANATOMY

Pores/Vessels. Exclusively solitary, generally round to oval in outline, moderately few, moderately small to medium-sized (size 3–4); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses present.

Parenchyma. Paratracheal, as incomplete borders to the vessels; apotracheal, diffuse and diffuse-in-aggregates; around the axial intercellular canals, occasionally forming more or less continuous tangential layers.

Rays. Uniseriate (fine) and 2–7 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's types II and III) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present.

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Fibres with moderately conspicuous bordered pits, walls very thick.

Intercellular Canals. Axial canals scattered singly and in pairs throughout the fibres, sometimes in more or less continuous tangential rows, diameter usually smaller than that of the vessels.

Crystals. Wanting.

Silica. Wanting.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood pale to light brown and distinct from heartwood; about ½–1 inch wide.

Heartwood brown, later darkening to dark brown.

The timber is very hard and very heavy, with an average air-dry density of 65 lb. per cu. ft. (range: 60–70 lb. per cu. ft.).

Grain shallowly interlocked and wavy; texture fine and even.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals, arranged singly and sometimes in more or less continuous tangential series distinguishes the timber from non-dipterocarps and from most other dipterocarps.

(ii) The timber of *Upuna borneensis* resembles Resak (*Cotylelobium* spp. and *Vatica* spp.), but the comparatively fewer pores in *Upuna borneensis* preclude the possibility of confusing it with Resak. In Resak, the pores are numerous to very numerous. *Upuna borneensis* which has no silica is readily distinguished from *Cotylelobium* spp.

(iii) The timber can be separated from Mersawa (*Anisoptera* spp.) and Keruing (*Dipterocarpus* spp.) by its higher density and much finer texture.

Vatica

FIELD CHARACTERISTICS

A widely distributed genus consisting of about twenty-eight species in Sarawak. A few species occur in the peat swamps, and the remainder in the lowland and hill forests. All species of *Vatica*, as well as *Cotylelobium*, are commonly known as Resak. *Vatica* is usually found on clay soils on hillsides and ridges, white sandy soils on terraces, rentzinas on limestone hills, peat soils, clay alluviums or on shale, basalt and dacite slopes at higher altitudes. The trees are mostly rather small, maximum height between 80 and 100 feet, with a girth of about 3–5 feet. Boles are frequently sinuate. Buttresses are thick, rounded, concave and usually small. Bark surface is usually grey-mottled, smooth, hoop-marked, becoming patchily flaked and occasionally scroll-marked in large trees. Dammar is rare on bark surfaces but clear when it exudes from cut surfaces.

WOOD ANATOMY

Pores/Vessels. Mostly solitary with occasional radial, tangential and oblique pairs, evenly distributed, generally round, numerous to very numerous, moderately small to medium-sized (size 3–4); intervascular pitting alternate, rare, tending to opposite or scalariform in *V. granulata, V. havilandii, V. mangachapoi, V. sarawakensis* and *V. umbonata,* pits vestured; perforation plates simple; tyloses present.

Parenchyma. Paratracheal, as incomplete borders to the vessels, sometimes abaxially aliform, confluent; diffuse and diffuse-in-aggregates; around the axial intercellular canals.

Rays. Uniseriate (fine) and 2–10 cells wide (medium-sized); usually low, but sometimes up to 2 mm. in height; heterogeneous (Kribs's types II and III) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present.

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Fibres with moderately conspicuous bordered pits, walls very thick.

Intercellular Canals. Axial canals scattered singly and sometimes in pairs throughout the fibres, diameter less than that of the larger vessels but as large as some of the smaller vessels; Canals usually packed with chalky deposits.

Crystals. Sometimes present, usually rhomboidal in shape, in chambered parenchyma or ray cells or both, rarely more than one per cell.

Silica. Wanting.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood pale brown or yellow-brown, usually 1–3 inches wide, sharply differentiated from the heartwood when green, but less so when dry.

Heartwood red-brown, with a pink tinge, darkening to deep or dark reddish brown.

The timber of *Vatica* varies in hardness, density and durability. The local people often distinguish *Resak Batu,* the harder, heavier and more durable species, from *Resak Bunga* which is lighter and of lower durability. An average air-dry density of 60 lb. per cu. ft. may serve as an useful criterion to separate the two classes. However, it should be noted that the timber of a given species will be either *Resak Batu* or *Resak Bunga* according to density of individual trees, although *V. mangachapoi* and *Cotylelobium* usually produce timber of only the Resak Batu Class.

DISTINGUISHING FEATURES

(i) The timber of *Vatica* resembles that of Penyau (*Upuna borneensis*) from which it can usually be distinguished by its more numerous and smaller pores. In Upuna the pores are exclusively solitary; with *Vatica* this is not so.

(ii) Separation from other timbers — see under *Cotylelobium.*

Table 1—SUMMARY OF ANATOMICAL CHARACTERISTICS OF 9 GENERA OF THE DIPTEROCARPACEAE OCCURRING IN SARAWAK

Genus And Group	No. of Species Examined	Vessels: Percentage Solitary	Vessels: Tangential Diameter-micron	Vessels: Inter-vascular Pitting: Arrangement, Alternate	Vessels: Inter-vascular Pitting: Pits Vestured	Vessels: Perforation Plates Simple	Vessels: Tyloses	Parenchyma: Paratracheal: Paratracheal To Vasicentric	Parenchyma: Paratracheal: Aliform To Confluent	Parenchyma: Apotracheal: Diffuse	Parenchyma: Apotracheal: Tending To Short Lines	Parenchyma: Apotracheal: Narrow Bands	Rays: Width – No. of Cells	Rays: Heterogeneous, kribs's Types: I	Rays: Heterogeneous, kribs's Types: II	Rays: Heterogeneous, kribs's Types: III	Rays: Sheath Cells	Vessel-ray Pitting Simple, Round To Elongated	Vasicentric Tracheids	Fibres With Moderately Conspicuous Bordered Pits	Intercellular Canals: Axial: In Long Tang'l. Series	Intercellular Canals: Axial: Diffuse Or In Short Series	Intercellular Canals: Axial: Diameter: Less Than Vessels	Intercellular Canals: Axial: Diameter: Equal To, Greater Than Vessels	Intercellular Canals: Radial	Crystals: In Idioblasts	Crystals: In Parenchyma	Crystals: In Ray Cells	Crystals: Chambered	Crystals: More Than One Per Cells	Silica Present In The Ray Cells
Anisoptera ..	4	88–96	192–226	+	+	+	+	+	+	+	+	–	1–7	–	+	+	–	+	– (1)	+	(+)	+	+	–	–	–	–	–	–	–	+
Cotylelobium ..	3	95–98	124–137	+	+	+	+	+	+	+	(+)	–	1–8	(–)	+	+	(+)	+	–	+	–	+	+	+	–	–	–	–	–	–	+
Dipterocarpus ..	30	87–97	187–264	+	+	+	+	+	–	+	–	–	1–8	(+)	+	+	(+)	+	(+)	+	–	+	+	–	–	–	–	–	–	–	+ (2)
Dryobalanops ..	6	89–95	180–232	+	+	+	+	+	+	+	–	–	1–6	(–)	+	+	(+)	+	– (1)	+	+	–	+	–	–	(–)	(–)	–	–	–	+ (2)
Hopea ..	28	52–84	102–172	+	+	+	+	+	+	+	+	+	1–5	(+)	+	+	(+)	+	+	–	+	–	+	+	–	(+)	+	+	(+)	–	–
Parashorea ..	4	78–86	239–307	+	+	+	+	+	+	+	–	–	1–7	–	(+)	+	(+)	+	+	–	+	–	+	–	–	–	+	+	+	(+)	–
Shorea —Red Meranti	60	50–89	179–275	+	+	+	+	+	+	+	(–)	–	1–7	–	+	+	(+)	+	+	–	+	–	+	(–)	(–)	(+)	(+)	(+)	(–)	–	–
—Selangan Batu	24	49–82	134–217	+	+	+	+	+	+	+	–	–	1–7	–	+	+	(–)	+	+	–	+	–	+	–	–	(+)	(+)	–	(+)	–	–
—White Meranti	7	53–71	153–254	+	+	+	+	+	+	+	–	–	1–6	–	+	+	–	+	+	–	+	–	+	–	–	–	–	–	–	–	+
—Yellow Meranti	22	46–66	146–233	+	+	+	+	+	+	+	–	–	1–8	–	+	+	(+)	+	+	–	+	–	+	–	+	–	(+)	(+)	(–)	(–)	–
Upuna ..	1	98	162–197	+	+	+	+	+	–	+	–	–	1–7	–	+	+	+	+	–	+	(+)	+	+	–	–	–	–	–	–	–	–
Vatica ..	21	47–90	88–147	+	+	+	+	+	+	+	–	–	1–10	–	+	+	(+)	+	–	+	–	+	+	+	–	–	(+)	(+)	(+)	(–)	–

\+ = Present.
– = Absent.
(+) Usually present, majority of species conforming.
(–) Usually absent, present in some species.
(1) & (2) See text under generic description.

TABLE 2 THE DENSITY OF THE DIPTEROCARP TIMBERS OF SARAWAK

Botanical Name	Local or Vernacular Name	Number of Trees	Density—lb. per cu. ft. (at 12% m.c.)	
			Mean	Range
Anisoptera (4 spp.) ..	Mersawa			
—grossivenia V. Sl. ..	Mersawa kunyit ..	6	49.2	44.4—56.2
—laevis Ridl.	Mersawa durian ..	4	44.8	40.5—50.5
—marginata Korth. ..	Mersawa paya .. .	5	45.3	41.5—49.7
—reticulata Ashton ..	—	1	48.4	—
Cotylelobium (3 spp.) ..	Resak			
—burckii Heim. ..	Resak durian	5	66.6	62.0—71.1
—malayanum V. Sl. ..	Resak bukit	3	67.3	63.7—72.4
—melanoxylon (Hook f.) Pierre	Resak hitam	5	58.3	55.9—61.0
Dipterocarpus (30 spp.) ..	Keruing			
—acutangulus Vesque ..	Keruing beludu ..	6	51.0	49.3—56.7
—applanatus V. Sl. ..	Keruing arong	6	48.3	43.1—51.8
—apterus Foxw. ..	Keruing latek	5	39.3	38.2—39.9
—borneensis V. Sl. ..	Keruing sindor	5	50.5	47.4—54.7
—caudiferus Merr. ..	Keruing puteh	6	44.1	41.8—48.7
—confertus V. Sl. ..	Keruing kobis	5	53.3	48.2—58.0
—conformis V. Sl. ..	Keruing beludu kuning ..	3	49.0	44.8—54.0
—coriaceus V. Sl. ..	Keruing paya	5	42.8	40.7—45.1
—costulatus V. Sl. ..	Keruing kipas	2	50.5	46.9—54.0
—crinitus Dyer ..	Keruing mempelas ..	6	59.2	54.9—61.8
—cuspidatus Ashton ..	Keruing runching ..	4	50.1	48.0—53.7
—eurynchus Miq. ..	Keruing baran	2	46.1	44.6—47.6
—exalatus V. Sl. ..	Keruing kuntum puteh ..	5	41.8	38.7—45.0
—fagineus Vesque ..	Keruing pipit	1	50.2	—
—geniculatus Vesque ..	Keruing kerubong ..	4	47.9	45.4—50.9
—globosus Vesque ..	Keruing buah bulat ..	5	52.0	47.8—55.8
—gracilis Bl.	Keruing kesat	5	48.1	43.4—54.0
—humeratus V. Sl. ..	Keruing latek bukit ..	2	48.7	45.5—51.8
—lowii Hook f. ..	Keruing sol	3	49.3	44.1—55.2
—mundus V. Sl. ..	—	2	49.7	49.5—49.9
—nudus V. Sl. ..	Keruing lichin	5	53.9	50.5—56.7
—oblongifolius Bl. ..	Keruing neram ..	5	47.8	40.6—51.2
—pachyphyllus Meijer ..	Keruing sol padi ..	5	52.2	47.4—55.2
—palembanicus V. Sl. ..	Keruing ternek ..	5	45.8	42.2—48.8
—penangianus Foxw. ..	Keruing gasing ..	5	55.8	53.3—58.0
—rigidus Ridl. ..	Keruing utap	5	49.9	43.7—53.7
—sarawakensis V. Sl. ..	Keruing layang	5	49.4	45.1—55.2
—stellatus Vesque ..	Keruing daun nipis ..	5	56.1	49.3—60.0
—tempehes V. Sl. ..	Keruing tepayan ..	5	41.0	37.7—45.9
—verrucosus V. Sl. ..	Keruing merah ..	5	53.6	52.4—56.0
Dryobalanops (6 spp.) ..	Kapur			
—aromatica Gaertn. f. ..	Kapur peringgi	5	55.0	53.5—56.2
—beccarii Dyer ..	Kapur bukit	5	49.0	46.9—50.0
—fusca V. Sl. .	Kapur empedu . .	5	54.0	52.7—55.5
—lanceolata Burck ..	Kapur paji	5	45.0	42.1—48.3
—oblongifolia Dyer ..	Kapur kelansau ..	5	54.0	47.4—59.9
—rappa Becc. ..	Kapur paya	5	45.0	40.1—48.4
Hopea (28 spp.) ..	Giam, Selangan(merawan), etc.			
—aequalis Ashton ..	—	1	54.3	—
—altocollina Ashton ..	Luis gunong	2	49.0	46.4—51.6
—andersoni Ashton ..	Luis somit	5	59.1	56.4—62.4
—argentea Meijer ..	Luis timbul	2	58.6	56.8—60.4
—beccariana Burck ..	Selangan penak ..	4	57.7	56.2—59.3
—bracteata Burck ..	Merawan padi	5	42.3	39.7—45.8

TABLE 2 THE DENSITY OF THE DIPTEROCARP TIMBERS OF SARAWAK—*continued*

Botanical Name	Local or Vernacular Name	Number of Trees	Density—lb. per cu. ft. (at 12% m.c.)	
			Mean	Range
—centipeda Ashton	—	4	47.2	40.5—50.9
—cernua T. et B.	—	3	58.0	55.6—62.3
—dasyrrhachis V. Sl.	—	1	70.5	—
—dryobalanoides Miq.	Mata kuching hitam	4	48.6	44.9—53.3
—dyeri Heim	Merawan palit	4	52.8	50.9—57.2
—enicosanthoides Ashton	Luis selukai	1	56.6	—
—fluvialis Ashton	Merawan Ayer	2	69.1	68.6—69.6
—griffithii Kurze	Luis jantan	1	67.2	—
—latifolia Sym.	Merawan daun bulat	2	58.7	54.0—63.4
—megacarpa Ashton	—	1	60.5	—
—mesuoides Ashton	—	1	59.3	—
—micrantha Hook f.	Merawan kerangas	2	47.4	46.6—48.1
—nervosa King	Merawan jangkang	3	48.8	43.3—54.9
—nutans Ridl.	Giam	1	63.0	—
—pachycarpa (Heim.) Sym.	Merkoyong	5	52.2	47.8—56.1
—pedicellata (Brandis) Sym.	Mata kuching bukit	1	50.5	—
—pentanervia Sym.	Mang	7	72.9	68.5—76.1
—pterygota Ashton	—	1	62.7	—
—sangal Korth.	Gagil	2	46.9	43.3—50.5
—semicuneata Sym.	Sama rupa chengal	2	57.3	55.3—59.3
—tenuinervula Ashton	—	1	63.7	—
—treubii Heim	Merawan daun tebal	2	58.6	58.5—58.7
Parashorea (4 spp.)	WHITE SERAYA			
—macrophylla Wyatt-Smith ex Ashton	Peran	7	42.3	38.4—45.4
—malaanonan (Blanco) Merr.	Urat mata	4	35.8	32.0—42.4
—parvifolia Wyatt-Smith ex Ashton	Urat mata bukit	5	48.8	46.4—54.5
—smythiesii Wyatt-Smith ex Ashton	Meruyun	6	51.9	47.4—54.0
Shorea (56 spp.)	RED MERANTI GROUP			
—acuta Ashton	Meranti kawang tikus	1	34.3	—
—albida Sym.	Alan bunga	5	28.3	23.4—32.8
	Alan	7	51.0	41.8—57.0
—almon Foxw.	—	5	34.4	31.3—38.1
—amplexicaulis Ashton	Meranti kawang pinang lichin	5	35.9	30.8—37.8
—andulensis Ashton	Meranti daun puteh	1	43.1	—
—argentifolia Sym.	Meranti binatoh	6	42.5	38.2—45.6
—beccariana Burck	Meranti langgai	6	40.1	36.4—43.1
—bullata Ashton	Meranti melechur	2	49.9	47.4—52.3
—carapae Ashton	Abang uloh	1	42.2	—
—coriacea Burck	Meranti tangkai panjang	5	50.6	46.7—54.3
—cristata Brandis	Meranti kawang pinang	3	38.8	38.1—40.3
—curtisii Dyer	Seraya	5	50.1	48.2—52.1
—dasyphylla Foxw.	Meranti batu	3	32.8	29.8—36.8
—elliptica Burck	Meranti lang	3	43.6	40.1—48.5
—fallax Meijer	Engkabang layar	5	39.4	35.3—43.2
—ferruginea Dyer ex Brandis	Meranti menalit	6	42.0	34.5—47.4
—flaviflora Wood ex Ashton	Selangan merah bukit	5	47.0	43.7—51.1
—flemmichii Sym.	Meranti raya	1	48.0	—
—inaequilateralis Sym.	Semayor	5	56.4	53.1—60.6
—kunstleri King	Damar laut merah	3	58.3	56.0—60.7
—leprosula Miq.	Meranti tembaga	5	37.9	36.2—40.4
—leptoclados Sym.	Meranti Majau	3	34.0	32.7—35.6
—macrantha Brandis	Engkabang bungkus	4	51.5	46.1—55.5

TABLE 2 THE DENSITY OF THE DIPTEROCARP TIMBERS OF SARAWAK—*continued*

Botanical Name	Local or Vernacular Name	Number of Trees	Density—lb. per cu. ft. (at 12% m.c.)	
			Mean	Range
—macrophylla (De Vr.) Ashton	Engkabang jantong . .	4	29.9	24.7—33.3
—macroptera Dyer . .	Meranti melantai . .	5	41.2	37.7—44.4
—mecistopteryx Ridl. . .	Engkabang larai . .	5	35.4	31.8—38.6
—monticola Ashton . .	Meranti gunong . .	5	49.0	45.4—54.1
—myrionerva Wood ex Ashton	Meranti sepit undang . .	2	41.1	40.1—42.1
—ovalis (Korth) Bl. . .	Meranti kepong . .	3	34.9	31.1—41.9
—ovata Dyer ex Brandis	Meranti sarang punai bukit	5	53.2	49.6—55.5
—pachyphylla Ridl. ex Sym.	Meranti kerukup . .	5	54.8	50.4—57.6
—palembanica Miq. . .	Engkabang asu	3	42.3	40.0—46.7
—pallidifolia Ashton . .	—	1	54.9	—
—parvifolia Dyer . .	Meranti sarang punai . .	6	35.6	32.6—40.6
—parvistipulata Heim . .	Engkabang pinang bersisek	6	45.5	41.2—49.3
—pauciflora King . .	Engkabang cheriak . .	7	46.3	43.7—52.4
—pilosa Ashton . .	Kawang bulu	4	32.4	28.2—39.0
—pinanga Scheff. . .	Meranti langgai bukit . .	5	33.0	29.0—38.7
—platycarpa Heim . .	Meranti paya	5	47.5	45.7—49.1
—platyclados V. Sl. ex Foxw.	Meranti bukit	5	50.2	45.2—54.5
—praestans Ashton . .	—	2	46.1	41.2—50.9
—pubistyla Ashton . .	Meranti bulu merah . .	1	46.8	—
—quadrinervis V. Sl. . .	Meranti sudu	6	41.2	33.8—43.1
—retusa Meijer . .	Meranti daun tumpul . .	3	35.6	33.6—38.9
—rubella Ashton . .	Meranti laut puteh . .	4	39.7	36.1—43.3
—rubra Ashton . .	Meranti merah kesumba . .	7	39.2	35.9—45.6
—rugosa Heim . .	Meranti buaya hantu . .	5	46.5	42.2—52.8
—sagittata Ashton . .	Meranti luang	3	37.0	35.6—39.0
—scaberrima Burck . .	Meranti paya bersisek . .	5	42.2	38.4—45.6
—scabrida Sym. . .	Meranti lop	6	45.5	41.9—48.1
—slooteni Wood ex Ashton	Meranti kepong kasar . .	5	51.1	45.9—55.9
—smithiana Sym. . .	Meranti rambai . .	5	35.4	31.2—39.3
—stenoptera Burck . .	Engkabang rusa . .	3	42.9	41.0—45.7
—teysmanniana Dyer . .	Meranti lilin	5	42.3	39.1—46.9
—uliginosa Foxw. . .	Meranti buaya	5	45.1	41.5—47.8
—venulosa Meijer . .	Meranti tangkai panjang padi	6	50.3	44.0—55.5
Shorea (22 spp.) . .	SELANGAN BATU(BALAU)GROUP			
—atrinervosa Sym. . .	Selangan batu hitam . .	2	61.8	60.6—63.0
—biawak Ashton . .	Resak biawak	2	64.0	62.4—65.7
—brunnescens Ashton . .	Selangan batu tinteng . .	6	63.1	59.7—67.1
—crassa Ashton . .	Selangan batu daun tebal . .	4	66.9	63.0—72.4
—domatiosa Ashton . .	Selangan batu lobang idong	6	65.4	62.4—68.6
—exelliptica Meijer . .	Selangan batu tembaga . .	1	64.9	—
—flava Meijer . .	Selangan batu kuning . .	5	67.3	64.9—70.5
—foxworthyi Sym. . .	Selangan batu bukit . .	3	64.5	63.7—65.5
—geniculata Sym. ex Ashton	Upun penyau	1	61.2	—
—glaucescens Meijer . .	Selangan batu daun nipis . .	6	57.5	53.0—63.0
—havilandii Brandis . .	Selangan batu pinang . .	3	70.3	68.6—72.4
—hypoleuca Meijer . .	Selangan batu kelabu . .	2	64.0	58.7—69.3
—inappendiculata Burck . .	—	2	67.0	65.3—68.6
—isoptera Ashton . .	Selangan batu main bulu ayam	4	62.9	62.4—63.7
—ladiana Ashton . .	Selangan batu kilat . .	1	68.5	—
—laevis Ridl. . .	Kumus	6	61.5	59.3—66.1
—lunduensis Ashton . .	—	1	58.9	—
—maxwelliana King . .	Kumus hitam	5	65.3	59.3—69.9
—obscura Meijer . .	Selangan batu padi . .	4	66.5	64.3—72.4
—scrobiculata Burck . .	Selangan batu zang . .	1	64.5	—
—seminis (De Vr.) V. Sl.	Engkabang terendak . .	5	58.8	56.8—63.0
—superba Sym. ex Wood. .	Selangan batu tulang ikan . .	5	63.9	61.2—66.8

TABLE 2 THE DENSITY OF THE DIPTEROCARP TIMBERS OF SARAWAK—*continued*

Botanical Name	Local or Vernacular Name	Number of Trees	Density—lb. per cu. ft. (at 12% m.c.)	
			Mean	Range
Shorea (7 spp.)	WHITE MERANTI GROUP			
—agami Ashton	Meranti puteh timbul	6	39.4	36.2—43.7
—bracteolata Dyer	Meranti pa'ang	4	46.9	42.1—50.0
—cordata Ashton	—	1	39.3	—
—lamellata Foxw.	Meranti lapis	1	47.0	—
—ochracea Sym.	Raruk	4	39.0	38.1—41.8
—resinosa Foxw.	Meranti belang	1	39.5	—
—virescens Parijs	Meranti sulang sulang	4	36.3	32.5—39.4
Shorea (20 spp.)	YELLOW MERANTI GROUP			
—acuminatissima Sym.	Lun runching	3	45.0	34.3—53.5
—angustifolia Ashton	Damar hitam bukit	5	49.0	40.4—54.7
—collaris V. Sl.	Lun kelabu	1	44.3	—
—cuspidata Ashton	Lun runching padi	1	44.9	—
—dolichocarpa V. Sl.	Damar hitam gondol	6	55.5	50.5—59.9
—faguetiana Heim	Lun siput	6	41.0	34.3—44.3
—faguetioides Ashton	Damar hitam daun nipis	7	45.9	43.4—48.7
—gibbosa Brandis	Lun gajah	4	45.5	41.8—49.7
—hopeifolia (Heim.) Sym.	Lun siput jantan	4	46.5	43.7—48.7
—iliasii Ashton	Lun siput daun besar	6	41.6	38.0—44.9
—induplicata V. Sl.	Lun puteh	1	37.4	—
—longiflora (Brandis) Sym.	Damar hitam paya	2	44.6	42.4—46.8
—macrobalanos Ashton	Engkabang melapi	1	39.9	—
—mujongensis Ashton	—	1	54.3	—
—multiflora (Burck) Sym.	Damar hitam	6	42.3	38.5—46.6
—obovoidea V. Sl.	—	2	35.6	34.3—36.8
—patoiensis Ashton	Damar hitam padi	6	44.4	40.6—48.7
—resina-nigra Foxw.	Lun meranti	5	39.2	38.1—40.6
—subcylindrica V. Sl.	—	3	46.7	44.9—49.1
—xanthophylla Sym.	Lun barun	2	40.5	39.9—41.2
Upuna (1 sp.)				
—borneensis Sym.	Penyau	5	64.5	60.1—70.4
Vatica (21 spp.)	Resak			
—badiifolia Ashton	—	1	61.3	—
—borneensis Burck	Resak kemudi	1	70.5	—
—brunigi Ashton	—	1	59.3	—
—coriacea Ashton	Resak daun tebal	2	70.7	66.5—74.9
—dulitensis Sym.	Resak tiong	4	54.4	52.1—57.9
—endertii V. Sl.	—	2	51.5	51.2—51.8
—globosa Ashton	—	2	60.7	57.5—63.8
—granulata V. Sl.	Resak ranting bersisek	5	52.8	50.2—57.8
—havilandii Brandis	Resak degong	3	55.7	53.7—57.4
—maingayi Dyer	Resak lidi	1	56.8	—
—mangachapoi Blanco	Resak julong	5	59.3	55.5—67.4
—micrantha V. Sl.	Resak hijau	5	58.3	55.5—63.3
—nitens King	Resak daun panjang	5	57.7	53.4—64.7
—oblongifolia Hook f.	Resak membangan	5	52.8	48.4—55.5
—odorata (Griff) Sym.	Resak runting kesat	5	49.1	46.0—52.9
—papuana Dyer	—	2	57.4	53.6—61.1
—rynchocarpa Ashton	—	2	51.3	49.9—52.7
—sarawakensis Heim	Resak daun besar	3	47.8	44.5—55.8
—umbonata (Hook f.) Burck	Resak ayer	5	46.8	43.7—51.0
—venulosa Bl.	Resak letop	3	45.7	42.8—48.5
—vinosa Ashton	Resak tangkai ungu	3	58.1	54.4—61.8

References

Ashton, P. S., 1964 — Manual of the Dipterocarp Trees of Brunei State, Oxford University Press.

————. 1968 — A Manual of the Dipterocarp Trees of Brunei State and of Sarawak — Supplement, Borneo Literature Bureau.

Brown, H. P., Panshin, A. J. & Forsaith, C. C., 1944 — Textbook of Wood Technology, Vol. 1, McGraw-Hill Book Company, Inc.

Browne, F. G., 1955 — Forest Trees of Sarawak and Brunei, Government Printing Office, Kuching.

Burgess, P. F., 1966 — Timber of Sabah, Sabah Forest Records No. 6.

Chu, F. Fei-Tan, 1969 — A Preliminary Study of Fibre Characteristics of Timbers of the Peat Swamp Forests of Sarawak, Malayan Forester, Vol. XXXII, No. 3.

Committee on Nomenclature International Association of Wood Anatomists, 1957 — International Glossary of Terms Used in Wood Anatomy, Tropical Woods No. 107.

Desch, H. E., 1957 — Manual of Malayan Timbers, Vol. 1, Malayan Forest Records No. 15, Reprint.

Forest Department, Sarawak, 1964 — Common Sarawak Timbers, Borneo Literature Bureau.

Forest Products Research, 1960 — Identification of Hardwoods (A Lens Key), Bulletin No. 25, Her Majesty's Stationery Office, London.

Forest Products Research, 1961 — Identification of Hardwoods (A Microscope Key), Bulletin No. 46, Her Majesty's Stationery Office, London.

Kauman, W. G. & Kloot, N. H., 1968 — Technological Appraisal of Little-Known or Unused Timber Species, C.S.I.R.O., Division of Forest Products, Australia.

Meijer, W. & Wood, G. H. S., 1964 — Dipterocarps of Sabah, Sabah Forest Records No. 5.

Menon, P. K. Balan, 1956 — Siliceous Timbers of Malaya, Malayan Forest Records No. 19.

Metcalfe, C. R. & Chalk, L., 1950 — Anatomy of the Dicotyledons, Vol. I & II, Oxford University Press.

Murthy, L. S. V., 1965 — Silica in Sarawak Timbers, Malayan Forester, Vol. XXVIII, No. 1.

Symington, C. F., 1934 — Notes on Malayan Dipterocarpaceae, Gardens' Bulletin II.

Review

T. C. Whitmore, *Palms of Malaya*

Oxford University Press, Kuala Lumpur, Malaysia, 1973. Pp. v + 132, 106 text figures and 16 photographic plates.
Price: Malaysian $35.00

Most people do not seem to realize that among flowering plants, the palm family is, in economic importance, only next to the grass family to which numerous cereals belong. For instance, the climbing rattans supply cane for furnitures, the trunk of some palms is strong enough for building huts or simple houses while the pith of the sago palms yields starch which was at one time the first substitute for rice. The leaves supply material for thatch, baskets, etc. The large terminal buds of several palms were, in some cases wastefully consumed as vegetables while the sap of the sugar palms yields sugar, and that of the coconut, on fermentation, forms an alcoholic drink known as toddy. The fruit of many palm species is edible, the coconut oil, extracted from the solid endosperm, is used in cooking and for industry; the coconut milk which is the liquid endosperm is an invaluable medium for tissue culture besides being a popular drink. Moreover, the fibrous, fleshy outer-wall or mesocarp of the oil palm fruit yields palm oil which is fast becoming one of the most important economic products in this part of the world.

The flora of the Malay Peninsula and Singapore is extremely rich in palm species. According to Dr. Whitmore, there are almost as many palms recorded from Singapore Island (18 genera, 46 species) as on the whole of the African continent (15 genera, 50 species). In addition, there are a large number of introduced species of palms which has been naturalised and become a part of our flora.

Even so, there were no general accounts available on Malayan palms. Understandably they were excluded from *Wayside Trees of Malaya* by E. J. H. Corner and *Malayan Wild Flowers* by M. R. Henderson, as palms, rather like bamboos and pandans, are in a strict sense neither tree nor herb but represent categories of their own kinds. Abundant information on Malayan palms, nevertheless, is scattered in the famous *Dictionary of Economic Products* by I. H. Burkill. Also a series of valuable taxonomic treatises on various groups of palms by C. X. Furtado were published in the Gardens' Bulletin, Singapore and elsewhere.

It is for this reason, that Dr. Whitmore's new book on palms is especially welcome. Inside the green, glossy jacket, a general introduction and descriptions of common Malayan palms form the two major parts. The first is so simple and clear that readers with elementary knowledge on botany can comprehend. In the second, taxonomic descriptions are kept to a minimum but there is ample information on the history, economic use, botanical interest and legends, presented in such a way that it is thoroughly enjoyable to read. It is Dr. Whitmore's intention to show the important part that palms play in our cultural and natural heritage. Not only has he achieved this but has done so remarkably well.

Regrettably the author resisted the use of the name *Johannesteijsmannia*. The name is indeed long and cumbersome but does not appear more "of a mouthful" than *Bougainvillea, Dieffenbackia* and *Mesembryanthemum*. Besides, it is a legitimate name. Binomials in the text are not complemented by authors' names though they are in the *Checklist of Malayan Palms*. The three indices to vernacular and English palm names are somewhat incomplete. At least one reference is inexact, i.e. "rattan" on page 101 really refers to its section "The Rattan Industry" and should have been page 98. It being a principle reference should have been in boldface.

Apart from these minor defects, the book is a most welcome publication and is highly commendable. Production of the book is of high quality and text is well written. The keys are easy to use. Of the text figures, many are extremely instructive and the photographs are excellently reproduced. It is the reviewer's sincere hope that the publisher will soon put up a cheaper edition to enable this book to reach a much broader spectrum of readers as it is well deserved.

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New Plant Disease Records for Sarawak for 1972

by

KUEH TIONG-KHENG

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This list of new plant disease records for Sarawak is a follow-up of those given by Johnston (1960), Turner (1963, 1964, 1966, 1967, 1969 and 1971) and Kueh (1973). It consists of fungal diseases together with diseases caused by algae and plant parasitic nematodes, collected and investigated by the writer during the year 1972. Sixteen of these records appear in the Annual Report of the Research Branch, Department of Agriculture, Sarawak, for the year 1972.

The microorganisms are arranged under their respective host plants which are listed alphabetically under their botanical names. For each host plant a common name and a Malay name are given where available. The frequency of occurrence of a disease is given together with the Commonwealth Mycological Institute Herbarium serial number, where identification has been carried out by the Institute. Identifications performed by the Royal Botanic Gardens, Kew, and Commonwealth Institute of Helminthology, Herts, are indicated by Kew and CIH respectively.

In the list that follows, *One, Occ., Comm.* stand for *one record, occasionally* and *common* respectively.

Acacia auriculaeformis A. Cunn. ex Benth. (Black Wattle)			
Pink disease	*Corticium salmonicolor* Berk. & Br.	One	—
Ageratum conyzoides Linn. (Rumput Tahi Ayam)			
Leaf rot and Dieback	*Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.	Occ.	171127
Thread blight	*Marasmius pulcher* (Berk. & Br.) Petch	One	—
Allium cepa L. (Onion, Bawang)			
Leaf blight	*Alternaria tenuissima* (Kunze ex Pers.) Wiltshire	Occ.	168326b
Leaf blight	*Colletotrichum circinans* (Berk.) Vogl.	Occ.	168326c
Leaf blight	*Curvularia eragrostidis* (P. Henn.) J. A. Meyer	Occ.	168326a
Leaf blight	*Curvularia penniseti* (Mitra) Boedijn	Occ.	168326e
Leaf blight	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	Occ.	168326g
Leaf blight	*Nigrospora sacchari* (Speg.) Mason	Occ.	168326f
Leaf rot	*Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.	One	—
Ananas cosmosus Merr. (Pineapple, Nanas)			
Leaf blight	*Botryodiplodia theobromae* Pat.	One	174347a
Leaf blight	*Phomopsis* sp.	One	174347b
Areca catechu Linn. (Betel Palm, Pinang)			
Frond base decay	*Marasmiellus inoderma* (Berk.) Singer	One	Kew

Artocarpus heterophyllus Lam. (Jackfruit, Nangka)			
Inflorescence rot	*Rhizopus artocarpi* Racib.	One	—
Asparagus officinalis Linn. (Asparagus, Saparu Keras)			
Stem blight	*Phoma herbarum* Westend.	One	168321
Bassia latifolia Roxb. (Indian Butter Tree, Mowa Tree)			
Red rust	*Cephaleuros virescens* Kunze	Occ.	171125a
Sooty mould	*Trichomerium? crotonis* Bat.	One	171125b
Sooty mould	*Tripospermum* sp.	One	171125b
Sooty mould	*Phaeosaccardinula? tenuis* (Earle) Seaver & Chardon	One	171125b
Begonia sp.			
Root knot	*Meloidogyne incognita* (Kofoid & White, 1919) Chitwood, 1949.	Occ.	CIH
Root knot	*Meloidogyne javanica* (Treub, 1885) Chitwood, 1949.	Occ.	CIH
On root	*Helicotylenchus dihystera* (Cobb, 1893) Sher, 1961	Occ.	CIH
Bixa orellana L. (Anatto, Kesumba Keling)			
Stem lesion	*Cephaleuros virescens* Kunze	One	—
Borreria latifolia Schum. (Broad Leaved Button-Weed, Rumput Setawar)			
Leaf blight	*Curvularia borreriae* (Viégas) M. B. Ellis	Occ.	173903
Brassica chinensis Linn. (Chinese Cabbage, Pak Choy, Sawi Putih)			
Leaf spot	*Peronospora parasitica* (Pers. ex Fr.) Fr.	One	168330
Brassica oleracea var. *capitata* Linn. (Cabbage, Pow Chai)			
Circular spot	*Alternaria brassicicola* (Schw.) Wiltshire	One	171119a
Circular spot	*Leptosphaerulina trifolii* (Rostr.) Petr.	One	171119b
Canangium odoratum Baill. (Kenanga)			
Sooty mould	*Meliola canangae* Stev.	Occ.	171124
Carica papaya Linn. (Papaya, Betik)			
Fruit anthracnose	*Cladosporium oxysporum* Berk. & Curt.	One	166644b
Celosia argentea Linn.			
Leaf speckle & Inflorescence mould	*Cercospora celosiarum* Kar & Mandal	Comm.	168915
Celosia cristata Linn. (Cockscomb)			
Leaf spot	*Cochliobolus geniculatus* Nelson	Occ.	168907a
Leaf spot	*Phyllosticta celosiae* Thüm.	Occ.	168907b
Chrysanthemum sp.			
Leaf blight	*Stemphylum lycopersici* (Enjoji) Yamamoto	One	173904
Leaf blight	*Cochliobolus geniculatus* Nelson	One	174346a
Leaf blight	*Phomopsis* sp.	One	174346b
Citrullus vulgaris L. (Water Melon, Semangka)			
Leaf spot	*Cercospora citrullina* Cooke	Comm.	168317
Fruit rot	*Cochliobolus geniculatus* Nelson	Occ.	172113
Fruit rot	*Curvularia senegalensis* (Speg.) Subram.	Occ.	167057

Citrus aurantifolia **(Christm.) Swingle (Lime, Limau Masam)**		
Red rust	*Cephaleuros virescens* Kunze	Comm. —
Citrus grandis **(L.) Osb. (Pomelo, Limau Besar)**		
Dieback	*Fusarium coccophilum* (Desm.) Wr.	One 163736
Velvet blight	*Septobasidium lepidosaphis* Couch	Occ. 168911
Gummosis	*Phytophthora nicotianae* B. de Haan var. *parasitica* (Dastur) Waterh.	Occ. 167053
Citrus nobilis **Lour. (Mandarin Orange, Limau Cina)**		
Leaf rot	*Corticium solani* (Prill. & Delacr.) Bourd. & Galz.	One —
Citrus sinensis **Osb. (Sweet Orange, Limau Manis)**		
Dieback	*Botryodiplodia theobromae* Pat.	Comm. 166649
Cocos nucifera **L. (Coconut, Kelapa, Nyiur)**		
Leaf mould	*Pseudoepicoccum cocos* (F. L. Stevens) M. B. Ellis	Occ. 166651c
Cucurbita pepo **DC. (Pumpkin, Buah Labu)**		
Leaf spot	*Cercospora citrullina* Cooke	One 171121
Curcuma domestica **Valeton (Turmeric, Kunyit)**		
Sclerotial wilt	*Corticium rolfsii* Curzi	One —
Desmodium umbellatum **(L.) DC. (Sea Parkia, Petai Laut)**		
Leaf spot	*Cercospora* sp.	One 168912
Dieffenbachia sequina **L. (Dumbcane)**		
Leaf blotch	*Macrophomina phaseolina* (Tassi) Goid	Occ. 173900
Digitaria marginata **Link**		
Leaf spot	*Pyricularia grisea* (Cooke) Sacc.	One 173902
Dracaena sanderiana **Hort. Sand**		
Leaf blight	*Stemphylium lycopersici* (Enjoji) Yamamoto	One 171117a
Leaf blight	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	One 171117b
Durio zibethinus **Murr. (Durian)**		
Sooty mould	*Capnodium moniliforme* Fraser	One 174350
Elaeis guineensis **Jacq. (Oil Palm, Kelapa Sawit)**		
Frond base rot	*Porogramme ravenalae* (Berk. & Br.) Pat.	One Kew
Elettaria cardamomum **Maton (Cardamom)**		
Leaf spot	*Phaeotrichoconis crotalariae* (Salam & Rao) Subram.	Occ. 171115
Sooty mould	? *Asbolisia* sp.	One 171116
Sooty mould	? *Microxyphium* sp.	One 171116
Sooty mould	? *Cladosporium* sp.	One 171116
Erechtites hieraciifolia **Rafin.**		
Leaf spot	*Colletotrichum* sp.	One 168908a
Erechtites valerianifolia **DC. (Malayan Groundsel)**		
Leaf spot	*Cercospora erechtitis* Atkinson	Comm. 168909 & 173899

Eugenia aromatica Kuntze (Clove, Cengkih)		
Red rust	*Cephaleuros virescens* Kunze	Comm. 168328
Ficus sp.		
Thread blight	*Marasmiellus scandens* (Mass.) Dennis & Reid	One —
Gerbera jamesonii Bolus (Barberton Daisy)		
Leaf spot	*Cercospora gerberae* Chupp & Viégas	One 174344
Glycine max (L.) Merr. (Soybean, Kacang Bulu Limau)		
Leaf blight	*Negrospora sphaerica* (Sacc.) Mason	One 173907a
Leaf blight	*Botryodiplodia theobromae* Pat.	One 173907g
Leaf blight	*Cladosporium cladosporioides* (Fresen.) de Vries	One 173907f
Leaf blight	*Cochliobolus lunatus* Nelson & Haasis	One 173907d
Leaf blight	*Cochliobolus geniculatus* Nelson	One 173907e
Leaf blight	*Phaeoseptoria* sp.	One 173907h
Pod spotting	*Cercospora kikuchii* (Mat. & Tom.) Gardner	One 168325
Root disease	*Marasmiellus inoderma* (Berk.) Singer	One Kew
Hibiscus esculentus L. (Ladies' Fingers, Kacang Lender)		
Root knot	*Meloidogyne incognita* (Kofoid & White, 1919) Chitwood, 1949.	One CIH
Root lesion	*Practylenchus brachyurus* (Godfrey, 1929) Filipjev & Schuurmans Stekhoven, 1941	One CIH
Hibiscus syriacus Linn.		
White root disease	*Fomes lignosus* (Klotzsch) Bres.	One —
Hydrangea hortensia Siebold		
Leaf spot	*Corynespora cassiicola* (Berk. & Curt.) Wei	One 171126a
Leaf spot	*Cercospora hydrangeae* Ell. & Ev.	One 171126b
Impatiens balsamina L. (Balsam)		
Stem blight	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	Occ. 168906a
Imperata cylindrica Beauv. (Lalang)		
Thread blight	*Marasmius pulcher* (Berk. & Br.) Petch	One Kew
Ischaemum digitatum Brongn.		
Leaf spot	*Colletotrichum graminicola* (Ces.) Wilson	One 166640
Ischaemum magnum Rendle		
False smut	*Sphacelotheca hainanae* Zundel	Occ. 166687
Lycopersicum esculentum Mill. (Tomato)		
Leaf rot	*Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.	One —
Mangifera indica Linn. (Indian Mango)		
Premature fruit drop	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	One 166650

Mangifera foetida **Lour. (Horse Mango, Bacang)**		
Leaf spot	*Coniothyrium fuckelii* Sacc.	One 166646c
Grey leaf blight	*Pestalotiopsis* sp.	One 166646d
Leaf spot	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	One 166646b
Leaf spot	*Phomopsis mangiferae* Ahmad	One 166646a
Melastoma malabathricum **L. (Singapore Rhododendron, Engkodok)**		
Sooty mould	*Trichomerium* sp.	Occ. 168318
Michelia alba **DC. (Cempaka Putih)**		
Red rust	*Cephaleuros virescens* Kunze	Occ. —
Morus alba **Linn. (Mulberry)**		
Leaf mould	*Cercospora mori* Hara	Comm. 168319
Leaf spot	*Cercospora* sp.	One 163735
Cutting necrosis	*Colletotrichum capsici* (Syd.) Butler & Bisby	One 167054a
Nephelium lappaceum **L. (Rambutan)**		
Root rot	*Sphaerostilbe repens* Berk. & Br.	One —
Rim blight	*Pestalotiopsis cruenta* (Syd.) Steyaert	Comm. 166648
Rim blight	*Pestalotiopsis* sp.	Occ. 173905a
Oryza sativa **L. (Rice, Padi)**		
On panicle	*Tetraploa aristata* B. & Br.	One —
Passiflora edulis **Sims (Passion Fruit)**		
Flower blight	*Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.	One —
Pennisetum purpureum **Schumach. (Napier Grass)**		
Leaf spot	*Curvularia leonensis* M. B. Ellis	One 166645a
Leaf spot	*Nigrospora sphaerica* (Sacc.) Mason	One 166645b
Phaseolus atropurpureus **(Moc. & Sesse) ex DC.**		
Leaf & Stem rot	*Corticium rolfsii* Curzi	Occ. —
Piper colubrinum **L.**		
Black leaf spot	*Phytophthora palmivora* (Butler) Butler	One 172112
Piper nigrum **L. (Black Pepper, Lada)**		
On berries & leaves	*Corticium rolfsii* Curzi	One —
Root knot	*Meloidogyne incognita* (Kofoid & White, 1919) Chitwood, 1949	Occ. CIH
Leaf blight	*Curvularia eragrostidis* (P. Henn.) J. A. Meyer	One 168910a
Leaf blight	*Leptosphaeria suffulta* (Fr.) Niessl.	One 168910b
Pogostemon cablin **Benth. (Patchouli)**		
Slow decline	*Fusarium solani* (Mart.) Sacc.	Comm. 172115
Leaf spot	*Cercospora* sp.	Occ. 173901b
Leaf spot	*Colletotrichum capsici* (Syd.) Butler & Bisby	Occ. 173901a
Psidium guajava **L. (Guava)**		
Leaf blight	*Pestalotia psidii* Pat.	Occ. 166641
Raphanus sativus **L. Var. *hortensis* Backer (Chinese Radish, Lobak)**		
Circular leaf spot	*Alternaria brassicicola* (Schw.) Wiltshire	Occ. 168329

Ricinus communis **L. (Castor Oil Plant)**			
Thread blight	*Marasmiellus scandens* (Mass.) Dennis & Reid	One	—
Leaf rot	*Corticium solani* (Prill. & Delacr.) Bourd. & Galz.	One	—
Rosa sp. (Rose)			
Sooty mould	*Trichomerium* sp.	One	171120
Sanseviera laurentii (N.E. Br.) De Wild.			
Rim blight	*Botryodiplodia theobromae* Pat.	One	166642a
Rim blight	*Cochliobolus geniculatus* Nelson	One	166642b
Rim blight	*Fusarium oxysporum* Schlecht.	One	166642c
Sauropus androgynus Merr. (Cangkok Manis)			
Leaf spot	*Cercospora phyllanthicola* Shakil & Kamal	One	168320
Stem blight	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	Occ.	168905a
Stem blight	*Alternaria* sp.	Occ.	168905b
Leaf rot	*Alternaria macrospora* Zimm.	One	174345a
Leaf rot	*Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.	One	174345b
Leaf rot	*Corynespora cassiicola* (Berk. & Curt.) Wei	One	174345c
Stenolobium stans Seem.			
Sooty mould	*Trichomerium* sp.	One	168913
Sooty mould	*Podoxyphium* sp.	One	168913
Stylosanthes gracilis H.B.K. (Stylo)			
Leaf & stem rot	*Corticium rolfsii* Curzi	Occ.	—
Theobroma cacao L. (Cocoa, Koko)			
Sooty mould	*Tripospermum gardneri* (Berk.) Speg. ex Hendrickx	Occ.	166639
Vanilla planifolia Andr. (Vanilla)			
Leaf blight	*Curvularia leonensis* M. B. Ellis	One	168322a
Leaf blight	*Cochliobolus lunata* Nelson & Haasis	One	168322b
Leaf blight	*Myrothecium gramineum* Lib.	One	168322c
Vigna sesquipedalis (L.) Fruw. (Long Bean, Kacang Panjang)			
Leaf anthracnose	*Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav.	One	168327a
Associated with leaf anthracnose	*Ascochyta phaseolorum* Sacc.	One	168327b
Leaf rot	*Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.	Occ.	—
Voandzeia subterranea Thouars (Kacang Bogor)			
Leaf & stem rot	*Corticium rolfsii* Curzi	One	—
Xanthophyllum aff. *pulchrum* King			
Sooty mould	*Trichomerium* sp.	One	168914

Zingiber officinale Rosc. (Ginger, Haliya)

Leaf blotch	*Glomerella cingulata* (Stonem.) Spauld. & Schrenk	One	168902b
Leaf tip dieback	*Mycospharella* sp.	One	168916b
Leaf scorch	? *Pseudocercosporella* sp.	One	171122b
Leaf scorch	*Curvularia eragrostidis* (P. Henn.) J. A. Meyer	Occ.	172114b
Leaf spot	*Phoma eupyrena* Sacc.	Occ.	172114a
Leaf scorch	*Curvularia senegalensis* (Speg.) Subram.	One	167055
White root disease	*Fomes lignosus* (Klotzsch) Bres.	One	—

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References

Annual Report, (1972). Research Branch, Department of Agriculture, Sarawak. (In press).

Johnston, A. (1960). A preliminary plant disease survey in Sarawak. F.A.O. Rome (Mimeographed).

Kueh Tiong-Kheng, (1973). New plant disease records for Sarawak for 1970–1971. *Gardens' Bull. Singapore, 26: 263–268.*

Turner, G. J. (1963). New records of plant diseases in Sarawak for the years 1960–1961. *Gardens' Bull. Singapore, 20:* 285–288.

———. (1964). Ibid. 1962. *Gardens' Bull. Singapore, 20:* 369–376.

———. (1966). Ibid. 1963 & 1964. *Gardens' Bull. Singapore, 21:* 393–402.

———. (1967). Ibid. 1965. *Gardens' Bull. Singapore, 22:* 123–128.

———. (1969). Ibid. 1966 & 1967. *Gardens' Bull. Singapore, 24:* 181–184.

———. (1971). Fungi and plant diseases in Sarawak. Phytopath. Papers, No. 13, C'wealth Mycol. Inst., Kew, Surrey, England.

Review

Animal Life and Nature in Singapore

edited by S. H. CHUANG

Singapore University Press, Singapore 1973.
Pp. xiv + 302, 34 text figures including 10 line drawings, 9 maps, 12 charts and diagrams, and 11 coloured plates.
Price: Singapore $40.00

The arrival of this book on the Singapore scene is most welcome. For too long, keen naturalists in Singapore have had to be content with books on natural history which treated Singapore merely as a minor part of the Malay Archipelago.

It is true that the fauna of Singapore is basically an impoverished version of the Malaysian but, there are many interesting phenomena such as the adaptation of the fauna to artificial environments which can be better studied in Singapore than elsewhere.

The range of subjects included in this volume is wide. Besides chapters dealing with the animal life of Singapore, there are others which discuss the vegetation, climate, geology and the sea around the Island.

The change in the composition of the fauna of Singapore in the recent past is something which many of the writers have noted. They record the gradual replacement of some species by others, and mention these changes among both the vertebrates and invertebrates. As can be expected of a book compiled by ten different authors, the coverage given to each subject differs. Some have chosen to give broad general pictures of their fields, while other have chosen to highlight only certain aspects of their subjects. But whichever approach they chose to their subjects, the writers have all managed to produce articles which were factual at the time of publication. D. S. Johnson in particular has written a well researched piece about the changes in the composition of the bird life of Singapore in the recent past. In it he mentions the disappearance of the magpie robin and the increasing abundance of the mynah. He also makes observations on changes in the populations of crows, egrets, orioles and munias, and expounds some credible theories to explain these changes. He says that the widespread use of insecticides has led to a decrease in the numbers of insect feeders, and, modern grain handling methods which result in less spillage have led to a corresponding decline in the numbers of the birds which feed on spilled grain.

Similar changes in the sea life around Singapore have been recorded by Tham Ah Kow and S. H. Chuang in their chapters. In one, Chuang gives an interesting mathematical table showing the changes in the species of shells off Tanah Merah beach. Both Tham and Chuang write that the depletion of the marine life around Singapore is attributable to the increased pollution of the water.

R. E. Sharma has contributed a chapter on noxious and toxic animals. This chapter contains useful information for anyone venturing out to study nature in Singapore. In it, Sharma has mentioned practically every animal which could conceivably be a danger to human beings, and in many cases he outlines preventive measures which can minimise the danger.

Unfortunately, data for the book was collected up to 1969, and the authors could not possibly have foreseen the rapid pace of urbanisation in Singapore. Since that time, swamps have been filled in and forested areas cleared. The end result is that, while the book is currently still accurate as far as the various species of animals mentioned in it are concerned, their actual numbers should be regarded as an optimistic record. An example is the chapter by R. C. R. Morrell on butterflies and moths. In it he mentions that hawk moths are still fairly well represented in Singapore. This might have been true five years ago, but today, with the decrease in scrublands, increase in buildings and improved street lighting which attracts moths and makes them easy prey for bats and birds, hawk moths are certainly few and seen at longer intervals. His account of the butterflies here also tends towards optimism. While the species which he mentions are still to be found here, there is no doubt that their numbers have been greatly reduced.

The standard of photography is not as high as could be desired. Birds on Plate 9 are not shot artistically. Little attention is paid to background in Plates 3 to 9. As a result the photographs portray specimens in the laboratory rather than animals in life.

The treatment of "The Exploitation of Animals" is rather cursory. There are a few misnomers, e.g. "jambols" on page 253 are referred to "crested jays" which should have been "bulbuls".

Considered as a whole, this book is by no means comprehensive in its coverage but it does serve to give an accurate general picture of animal life in Singapore today. However, conditions here are changing so fast that it will come as no surprise if the material contained in it becomes outdated five years from now.

Despite the shortcomings, the book serves a very useful function. In it the authors have pointed out areas where there is plenty of scope for further study and research. It should therefore be considered more than merely a record of the fauna of Singapore and serve as the starting point from which students can undertake a serious study of animal life and nature in Singapore.

LEE CHU SAN
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The Genus Horsfieldia (Mvristicaceae) in and outside Malesia I: H. sabulosa and H. whitmorei J. Sinclair spp. nov.

† by J. Sinclair
Botanic Gardens
Singapore

The present paper comes from a manuscript which at the time of the author's demise was at Kew Herbarium, sent there in advance for his proposed completion of the work on the genus *Horsfieldia*. The Botanic Gardens in Singapore gratefully acknowledge the co-operation from individuals and herbaria who have loaned their specimens for the study by the late Mr. J. Sinclair and are grateful to Mr. J. P. M. Brennan, Keeper of the Kew Herbarium and Library for promptly taken steps in returning the script. The manuscript contains complete descriptions of 33 species and many varieties, and citations only of specimens under *H. macrocoma* and *H. irya*. Regretfully, the classification system, many keys, distribution maps, illustrations and the collector's index had not been written up. This article describes the two new species named by the author and is the first in the series. *Ed.*

Horsfieldia sabulosa J. Sinclair, **sp. nov.**

Species affinis *H. wallichii* a qua ramulis crassioribus, teretibus (nec apice leviter compressis), foliis multo angustioribus, apices ramulorum versus dense confertis, polystichis nec distichis, petiolis longioribus et nervis plerumque minus distinctis differt.

Arbor excelsa 10–37 m alta. *Cortex* ferrugineus longitudinaliter sulcatus; latex ruber, copiosus. *Ramuli* in innovationibus ferrugineo- vel griseo-ferrugineo-tomentelli, 0.7–1 cm crassi, in partibus inferis glabri, nigro-grisei et cum multis cicatricibus foliorum delapsorum spiraliter tecti, distaliter longo intervallo simplices ut videtur, forsitan multo inferne ramos primarios versus furcati, cortice interdum excidente. *Folia* polysticha, apices ramulorum versus dense conferta, coriacea, angustissime oblonga, marginibus fere parallelis minute revolutis, supra nitida, modice viridia, subtus glauca, siccitate supra griseo-viridia, hic illic nigricantia, subtus moribundo-brunnea, utrinque acuta, basi in petiolum paullo decurrentia, 15–18 cm longa, saepissime 16 cm longa, 4–6 cm lata, vulgo 4.5 cm lata; costa supra in sulcam depressa, subtus convexo-elevata ibique primo minute puberula deinde glabra; nervi 15–18–jugati, fere paralleli, supra depressi, tenues, similes incisuris apertis cultro tonsorio inflictis, subtus minus distincti et in partibus subevanidi; reticulationes invisibiles; petioli (pro laminis comparati longi) 3.5–5 cm longi, 3 mm crassi, minute tomentelli, glabrescentes. *Inflorescentia mascula* et *flores masculi* ignoti. *Inflorescentia feminea* immatura, nondum evoluta, 2 cm longa, bracteis pluribus bene munita: bracteae 1 cm longae, 2–4 mm latae, pilis dendroideis 1–1.5 mm longis dense indutae, dactyloideae, supra flores inflexae et eos celantes; flores minutissimi, enimvero multo immaturi, glabri, breviter pedicellati; ovarium glabrum. *Fructus* flavus, glaber, ovoideus, in sicco 4–4.5 cm longus, 3.5–4 cm latus, ei *H. wallichii* similis sed probabiliter paullo minor; pericarpium in vivo carnosum, in sicco lignosum, 5 mm crassum, non nitidum (opacum); stipes (pedicellus) 0.5–1 cm longus, 5 mm crassus. *Arillus* aurantiacus. *Semen* 3 cm longum, 2.7 cm latum.

Tall tree 10–37 m high (30–120 ft). *Bark* reddish brown, longitudinally furrowed; sap red, copious. *Twigs* in the innovations rusty- or rusty-greyish-tomentulose, 7 mm –1 cm thick, lower down glabrous, blackish grey and spirally covered with many scars of fallen leaves, apparently simple distally for some distance, probably branched far down near their junction with the main branches, the bark sometimes peeling off. *Leaves* in several rows, bunched towards the ends of the twigs, coriaceous, very narrowly oblong with the sides nearly parallel and minutely revolute, medium green and glossy above, glaucous beneath, drying greyish green above with some blackish patches and a faded brown beneath, acute at both ends with the base slightly decurrent on to the petiole, 15–18 cm long, many of them constantly 16 cm long, 4–6 cm broad, average 4.5 cm broad; the midrib sunk in a groove above, raised and convex beneath and there at first minutely puberulous, later glabrous; nerves 15–18 pairs, nearly parallel, sunk above, very slender and like open slashes with a razor blade, less distinct and vanishing in parts beneath; reticulations invisible; the petioles 3.5–5 cm long (long in proportion to their blades) 3 mm thick, minutely tomentulose becoming glabrous. *Male inflorescence* and *male flowers* unknown. *Female inflorescence* immature, not yet open, 2 cm long and well protected by bracts; the bracts 1 cm long and 2–4 mm broad, densely covered with 1–1.5 mm long dendroid hairs, finger-shaped, curving over the flowers and concealing them; flowers very small and indeed very immature, glabrous and shortly stalked; ovary glabrous. (The flowers are so small that there is no point in giving measurements and further details.) *Fruit* yellow, glabrous, ovoid, 4–4.5 cm long and 3.5–4 cm broad (measurements from dried material), similar to that of *H. wallichii* but probably a little smaller, the pericarp fleshy when fresh, woody and brown when dry, 5 mm thick, dull having the usual mat or parchment-like surface of dried *Horsfieldia* fruits; stalk (the pedicel portion) 0.5–1 cm long and 5 mm thick. *Aril* orange. *Seed* 3 cm long and 2.7 cm broad.

BORNEO

SARAWAK:

1st Division:—Gunong Gaharu, Serian, *Sinclair 10248* (A, E, K, L, SAR, SING): Sungei Sabal Tapang, Serian, *SAR Nos 12671* (SAR) and *12691* (SAR).*

3rd Division:—Aup, Sibu, *J. Wright 632* as *FA 412* (SAR, SING).

4th Division:—Niah-Jelalong Protected Forest, Sungei Meluang, Bintulu, *Brünig SAR 956* (K, L, SAN, SAR, SING).

BRUNEI:

Andulau Forest Reserve, Belait District, *Ashton & Whitmore BRUN 579* (BO, K, KEP, L, SING); *Smythies BRUN 828* (BO, K, L, KEP, L, SAR, SING); cpt 6, *Ashton, Smythies & Wood SAN 17560* (KEP, L) and ditto (north part) *Sinclair & Kadim bin Tassim 10437* (A, BM, E, FI, K, L, SAR, SING); Bukit Labi at the 5½ milestone; *Sinclair & Kadim 10491* (A, B, E, K, L, NY, SAR, SING).

* Author intended to check the identity of 12671 & 12691.

SABAH:

Interior Residency:—Mengalong Forest Reserve, Sibubu River, 3½ miles south-south-west of Sipitang, *Wood SAN 15146* (L, SAN, SING).

DISTRIBUTION: Borneo (as above).

TYPE MATERIAL: *Sinclair & Kadim 10491* (A, B, E, K holotype, L, NY, SAR, SING) Bukit Labi F.R., Brunei.

A tree of sandy soil or sand with a little peat; in Brunei sometimes growing with *Agathis alba* ssp. *borneensis*. It is closely allied to *H. wallichii* from which it should be distinguished vegetatively by the growth habit of its twigs and the narrower leaves with longer petioles. It is a pachycaul whereas *wallichii* is a leptocaul. Thus in *sabulosa* the leaves are all closely bunched towards the ends of the twigs in a spiral, non-distichous fashion. The twigs are much stouter than those of *wallichii* and are not flattened or compressed at their extremities. Below the innovations they bear numerous scars of fallen leaves also in several ranks. Such portions of twigs as conveniently fit a herbarium sheet are not branched; some of them probably branch far down near where they join on to the main branches. In contrast similar portions of the same length in *wallichii* are usually branched once on a herbarium sheet if not two or three times. The narrower leaves of *sabulosa* have their sides nearly parallel and do not broaden out just above the base. The 3.5–5 cm long petioles at once catch the eye as being long in proportion to the blade. They are 2 cm long on the average in *wallichii* with an overall range of 1–3 cm. The veins on the undersurface of the leaves are much fainter than those of *wallichii* and sometimes fade out altogether, but, as is the general rule in *Myristicaceae* thin-leaved specimens with more prominent veins not yet collected will probably turn up. A greyish brown indumentum on the young petioles, lower midrib and innovations may also help in identifying this species. Of the two, *sabulosa* seems to be the taller for the examples I collected in Brunei were from trees 100 and 120 feet high. Ashton also collected from trees 100 feet in height. Along with *H. ridleyana* all three have the same reddish brown, longitudinally furrowed bark and a rather similar firm fleshy fruit which has a minutely rough parchment-like surface when dry. The fruit of *sabulosa* is probably slightly smaller than that of *wallichii*, *ridleyana* having the smallest but this information requires confirmation.

It seems strange that with so different a vegetative habit the fruit of both species should be the same. It may be that *sabulosa* is after all only a variety or subspecies of *wallichii*, yet this seems rather unlikely. I have been waiting patiently since 1955 for male flowers to turn up, hoping that they may finally settle this problem. The female flowers from *Wood SAN 15146* collected near Sipitang, Sabah in 1955 are so very young as to be of no value in deciding. Even their inflorescences have not yet unfolded from the bud stage.

Horsfieldia whitmorei J. Sinclair, **sp. nov.**

H. novoguineensis (non Warb.) A. C. Smith in J. Arn. Arb. 22, 1 (1941) 62 *pro parte quoad Kajewski 2022* (*altera pars* = *H. irya et H. spicata*); *H. palewensis* (non Kanehira) Whitmore, Guide to the Forests of the British Solomon Islands (1966) 131 & 186 in check list, correct original spelling is *palauensis*).

Species endemica affinis *H. iryae* et *H. spicatae* et cum eis in Insulis Salomonis crescens. A priore dimidia parte floribus masculis longioribus et laxius dispositis in inflorescentia breviore et minus evoluta, fructibus oblongis, reticulationibus foliorum subtus scalariformibus nec retiformibus differt; ab altera floribus masculis minoribus globosis nec lateraliter elongatis, foliis pro rata angustioribus, costa in canaliculo petioli elevata, reticulationibus subtus saepius visibilibus, lenticellis minoribus recedit; ab ambabus floribus pallidioribus (cremeis), ramulis rubro-brunneis (non nigro-griseis ut in *irya* nec stramineis ut in *spicata*), subtilius striatis cum lineis duabus ex petiolo ad petiolum carentibus vel subnullis, nervis foliorum pro rata magnitudini laminae plus numerosis, inter se magis approximatis obliquis, in arcibus singulis, raro duplo-anastomosantibus cum arcibus marginalibus ipsis prominentioribus distinguitur.

Arbor 7–22 m alta, vulgo 12 m, sine radicibus adventitiis. *Cortex* fibrosus extus fuscus, intus rubro-brunneus vel subroseus, verticaliter fissuratus demum papyraceo-squamulosus; latex ruber copiosus. *Ramuli* 3–4 mm crassi rubro-brunnei (lateritii) teretes, in innovationibus cum pilis brevissimis stellato-dendroideis tomentelli, in partibus inferis glabri, striolati, nonnunquam lenticellati, hic illic in quibusdam internodis excavati. *Folia* chartacea, infrequenter coriacea, supra in sicco griseo-brunnea vel virido-brunnea, subtus pallidiora, nervis exceptis leviter rubrobrunneis, glabra, anguste oblonga cum lateribus fere parallelis, basi acuta, apice acuminata; costa supra sulcata, plana vel convexa, et itidem in sulco petioli conspicue elevata; nervi (16)–22–26–(30)–jugati, vulgo 23 paria, in foliis parvis 16 paria, inter se proximi, 7 mm –1.5 cm distantes, vulgo 8 mm, recti, paralleli vel saepe curvati, angulo 45–70° orti, supra impressi, subtus prominentes, prope marginem in arcibus singulis perspicue anastomosantes (tantum in foliis latissimis duplo conjuncti); reticulationes supra invisibiles, subtus subtiliter scalariformes; lamina 12–30–(42) cm, vulgo 21 cm longa, 3–6.5–(9) cm, vulgo 4.5 cm lata, petiolus 0.7–1–1.5 cm, vulgo 1 cm latus, 2 mm crassus. *Inflorescentia mascula* cum pilis minutis dendroideis ferrugineis vel pallido-brunneis vel griseis pubescens vel breviter tomentosa, gracilis, 2–8 cm longa, 1 cm in diam.; ramuli secundarii ac tertiarii 0.5–3 cm longi, primo adscendentes, deinde patentes vel reflexi, ultimi in cymas subracemosas terminantes. *Flores masculi* fragrantes, cremei vel flavidi semper coloris pallidi nunquam aurantii vel intense flavi, in textura variabiles, tenues vel coriacei, glabri vel saepe in partibus inferioribus tenuiter pilosi, globosi, in sicco 1.5 mm in diam., in vivo 2 mm, primum in lobos duos rotundos $\frac{1}{2}$-fissi, denique fissura perianthii deorsum suturam secus fere ad basin floris attingens, sutura ea plerumque prominens elevata, non-nunquam in sulcam circumferentialem depressa. *Columna staminalis* compresso-globosa, 1 mm in diam., brevissime stipitata vel fere sessilis, eius depressio apicalis stomatibus similis, primum angusta et fere clausa cum lateribus arcte compressis, postea ad plenum anthesin in latitudine augens, cavitas nunc profundior, $\frac{1}{4}$ partem totae columnae aequialta; antherae 10 in cupulam staminalis inflexae, apicibus interdum sublilberae; pedicelli 1.5–1.8 mm longi, aliquando 2–(2.5) mm longi, 0.2 mm crassi, pilis ut in inflorescentia pubescentes. *Inflorescentia feminea* 1.5–5 cm longa, ramuli eius quam ei inflorescentiae masculae breviores pauciores, 0.5–1 cm longi; inflor. fructifera 10 cm longam attingens. *Flores feminei* ovoideo-globosi, 2 mm in diam. (in sicco), aliter ut in masculi; pedicelli 1 mm longi, 0.5 mm crassi; ovarium tomentosum, 1.5 mm longum, 1–1.2 mm latum. *Fructus* pallido-flavus (probabiliter in maturitate rubescens) in sicco rubro-brunneus, glabrus, oblongus, utrinque rotundatus, 2–2.3 cm longus, 1.5 cm latus cum linea suturali prominenti; stipes 1 cm longus, 2–3 mm crassus. *Arillus* aurantiacus.

Tree 7–22 m high, average 12 m, stilt-roots absent. *Bark* fibrous, dark brown on the surface, reddish brown to pink inside, vertically fissured and finally flaking in small papery scales; sap red, abundant, free flowing. *Twigs* 3–4 mm thick, reddish brown (brick-red) terete, tomentulose in the innovations with very short stellate-dendroid hairs, lower down glabrous, finely striate and sometimes lenticellate, hollow here and there in certain internodes. *Leaves* chartaceous, infrequently coriaceous, drying greyish brown or greenish brown above, paler beneath except the reddish brown nerves, glabrous, narrowly oblong with the sides nearly parallel, the base acute, the apex acuminate; the midrib sulcate above, flat or convex and moreover in the same way conspicuously raised in the channel of the petiole; the nerves (16)–22–26–(30) pairs, mostly 23 pairs, 16 pairs in small leaves, close to each other, 0.7–1.5 cm apart, usually 8 mm, straight, parallel or often curved, arising at an angle of 45–70°, impressed above, prominent beneath, very clearly inter-arching near the margin in single loops (only in double loops in very large leaves); reticulations invisible above, very finely scalariform beneath; blade 12–30–(42) cm long, usually 21 cm long, 3–6.5–(9) cm broad, average 4.5 cm broad; petiole 0.7–1–1.5 cm long, average 1 cm long, 2 mm thick. *Male inflorescence* pubescent or shortly tomentose with minute rusty or pale brown or greyish dendroid hairs, slender, 2–8 cm long and 1 mm in diam.; the secondary and tertiary branches 0.5–3 cm long, at first ascending, later spreading and reflexed, the ultimate ones ending in subracemose cymes. *Male flowers* sweet scented, cream-coloured or pale yellow, always of a pale colour, never orange or a deep yellow, variable in texture, thin or coriaceous, glabrous or often thinly pilose, globose, 1.5 mm in diam. in dried specimens, 2 mm in diam. in fresh ones, at first split down $\frac{1}{2}$-way into the two rounded lobes, finally the split of the perianth reaching downwards along a suture almost to the base of the flower, the suture usually prominent and raised, sometimes sunk in a groove girdling the circumference. *Staminal column* globose but slightly flattened laterally, 1 mm in diam., very shortly stalked or almost sessile, its apical depression like that of stomata, at first narrow and almost closed with the sides tightly drawn together, later increasing in width at the peak of flowering, the cavity now deeper, $\frac{1}{4}$ as deep as the whole column; anthers 10, bent over into this staminal cup, sometimes slightly free at their apices; pedicels 1.5–1.8 mm long, occasionally 2–(2.5) mm long, 0.2 mm thick, pubescent with hairs as in the inflorescence. *Female inflorescence* 1.5–5 cm long, its branches shorter and fewer than those of the male inflorescence, 0.5–1 cm long; fruiting inflorescence reaching 10 cm long. *Female flowers* ovoid-globose, 2 mm in diam. (when dry), otherwise as in the male; pedicels 1 mm long and 0.5 mm thick; ovary tomentose, 1.5 mm long and 1–1.2 mm broad. *Fruit* pale yellow (probably reddening at maturity), reddish brown when dry, glabrous, oblong, rounded at both ends, 2–2.3 cm long, 1.5 cm broad with the line of suture prominent; stalk 1 cm long, 2–3 mm thick. *Aril* orange.

SOLOMONS

BOUGAINVILLE:

Koniguru, Buin, *Kajewski 2022* (A, BM, BO, BRI, G, L, NSW, S).

SHORTLAND ISLAND:

North-east end, *T. C. Whitmore's collectors BSIP 5905* (L, SING).

East end opposite Bembalama Island, *T. C. Whitmore BSIP Nos 4045* (L, SING) and *4046* (L, SING).

WAGINA ISLAND:

Whitmore's collectors BSIP 5529 (L, SING).

NEW GEORGIA GROUP:

Baga Island:—*Whitmore's collectors BSIP Nos 2811* (L, SING); *3052* (L, SING) and *5569* (L, SING).

Gizo Island:—*Whitmore's collectors BSIP Nos 3035* (L, SING) and *5617* (L, SING).

Kolombangara Island:—North coast, Rei Cove, *Whitmore 1537* (L, LAE, SING); east coast in swampy forest area, *Whitmore BSIP 4096* (L, SING); west coast, Merusu Cove, *Whitmore BSIP 1405* (L, LAE); Kape Harbour, flat land behind camp along Lever's enumeration Line, *Womersley & Whitmore BSIP 803* (L, LAE, SING).

New Georgia Island:—All from north-west part, Vaimbu River, *A. W. Cowmeadow BSIP 3679* (SING); near Jela, *Whitmore's collectors BSIP 3745* (L, SING); Kimbukimbu River, *Cowmeadow's collectors BSIP 3218* (SING); Lae River, *Cowmeadow's collectors BSIP 4834* (SING).

Vangunu Island:—Ridge in forest, near Merusu Island, *Whitmore BSIP 970* (L, LAE, SING); Sosole River, *J. W. P. Chapman 427* (K, SING).

Rendova Island:—Zaimane River, west coast, *Whitmore BSIP 1848* (LAE, SING).

SANTA ISABEL (YSABEL):

Maringe Lagoon, near Tiratona Village in dense forest over limestone, *Whitmore BSIP 2273* (L, LAE, SING); ultrabasic ridge half a mile due west of Tatamba, *Whitmore BSIP 2582* (L, SING).

MALAITA:

Are Are District, Kiu west coast, *Z. Lipaqeto BSIP 3406* (L, SING); 3 miles inland from Kiu, tributary of Wairaha River, *Lipaqeto & Whitmore BSIP 3481* (L, SING).

ULAWA ISLAND:

Between Haraina und Mwadoa *R. Teona BSIP 6230* (SING).

GUADALCANAL:

Rere River, 3 miles inland, *Lipaqeto BSIP 3318* (SING); forest adjacent to Tina River, 12 miles from the coast, *Whitmore & Womersley BSIP 1124* (L).

SAN CRISTOBAL:

Wairaha River, 5 miles from north coast, *Whitmore BSIP 4230* (L, SING).

DISTRIBUTION. Widely distributed throughout the Solomons, endemic.

TYPE MATERIAL. T. C. Whitmore BSIP 1848 (K, LAE, SING lectotype) Rendova Island, New Georgia Group.

The author has indicated in the M.S. that were he to find the KEW holding unsuitable as a holotype, the SING would be preferential. Since selection is not indicated, the latter is designated here as lectotype. *Ed.*

ECOLOGY. On a variety of habitats, but not in mangrove. Mostly in primary forest on flat land, ridge tops, and river banks, dry and swampy, also in secondary forest in well sheltered valley bottoms. Apart from alluvial, the kind of soil is not often stated but limestone, ultrabasic, igneous rock and red soil have been recorded. Therefore it may be concluded that this species is tolerant of a wide range of habitats and is not very "choosy". Flowers during all months from September to May with peak periods in December and April. Fruiting is from October to May with peak periods in January and May.

VERNACULAR NAMES. *Aininiu* (Kwara'ae language) the usual spelling. Other variations are *aininu, ainunu* and *ainynu; kisu-kisu* (Buin, Bougainville). The name *aininiu* is also the one in common use for *H. irya*.

It seems that *H. whitmorei* arose in the isolation of the Solomons from a gene pool supplied by only two species, namely *H. irya* and *spicata* for certain morphological features of both these ancestors reappear in this endemic. The resemblances are too close for it to have been in the Solomons before the arrival of *irya* and *spicata* or conversely also too close if we suppose that there was no connection. These two are the oldest members of the flora and must have been there first. They are more numerous in individuals than our present species and also seem to have a greater geographical range occurring in nearly all the islands of the Solomons. In fact *irya* has a very wide distribution throughout Malesia and not only there but it extends from Indo-China, Siam, Burma, the Andamans and Ceylon to Palau in the Carolines. It is the most widely collected species and the type of the genus. It has more synonyms and references in the literature than any other *Horsfieldia*. *H. spicata* begins in the Moluccas and also ends in Palau. It has been recorded from numerous islands in the Bismarck group as well as in New Guinea and it will have a wider range still if one unites it with *parviflora*.

One may argue that the genetical complex of *whitmorei* is drawn from more species than two and that it could have come from species now extinct in the Solomons. This is not very likely as the flora of the Solomons is poor in species in comparison with New Guinea and Malesia. Island floras are always poorer than those of adjacent mainlands. Whitmore on the very first page of his book, "Guide to the Forests of the British Solomon Islands" deals with this subject and also remarks about the poverty of the flora of Melanesia.

Our present species is much more than a hybrid between *irya* and *spicata*. It is a distinct species with quite a number of differences. It probably first arose with fertilization in the female tree of *spicata* by the pollen from *irya*. It has retained the oblong fruits of *spicata*; these are identical. The male flowers are like those of *irya* because of their globose shape, but being slightly larger, they take after *spicata* in size; yet none are as large as those of *spicata*. *Whitmorei* differs from them both in having no raised lines on the twigs but a faint indication of the two lines on more than one occasion has been seen.

Sterile or atypical specimens are often troublesome to identify so it is better to be thoroughly acquainted with details of the differences between the three. Besides the points mentioned above the following may be helpful.

Our present species has very finely striate brick-red twigs and the lenticels (not always present) are rather small. *H. irya* has blackish twigs with larger, more numerous lenticels and the two lines from petiole base to petiole base are raised and very distinct. *H. spicata* has pale straw-coloured twigs but it can have other colours as well such as medium to dark brown and greyish shades. The striations are generally coarser, the two lines present or absent and not usually so distinct as those of *irya*. The leaves are narrow with nearly parallel sides and thus look more like those of *irya*. There are some narrow-leaved specimens of *spicata* which at times are very close also to those of our present plant but they may be distinguished by their slightly different venation and the lack of a raised midrib in the groove of the petiole. *Whitmorei* has the nerves more strictly parallel and closer spaced than those of the other two. The nerves interarch at the margins with greater regularity and distinctness, forming single loops. Only in very large leaves are there double loops. They are much impressed on the upper surface of the leaf. The other two often have double loops while the primary loops may be faint, broken or indistinct in parts. The nerves of *irya* tend to leave the midrib at a much greater angle, sometimes almost at right angles. In such cases they curve more, ascending more gradually. Those of *spicata* are often more oblique and parallel but not quite so strictly parallel and equidistant as those of our present species. The reticulations, present on the lower surface, are scalariform. Those of the other two form a lax network. In *spicata* they are not so distinct and are often absent or seen only with a hand-lens. The lamina of all three may, at times, show whitish marks, patches or streaks when dry, but this feature is much commoner in *irya* than in the others. The inflorescence especially the male is much branched and well developed in *irya.* That of the other two is simpler, perhaps *spicata* would come next in order and then *whitmorei,* but in many cases there is not much difference in complexity or simplicity between these two and it would be hardly correct to put the one before the other. The globose male flowers are half as big again as those of *irya* but as already pointed out not so big as the turbinate or obtriangular ones of *spicata.* They are fewer in the inflorescence when compared with an inflorescence of *irya* but this is only natural: being larger they take up more room. They are cream coloured and therefore much paler than those of *irya* and *spicata.* Finally the fruit is oblong like that of *spicata, irya* having a perfectly spherical fruit. Such oblong fruits will match ones in *spicata* having the same size but the fruit is of various sizes in *spicata* and sometimes flattened, so it should be possible in some cases to identify the larger ones with *spicata.*

I must confess that without Dr. Whitmore's valuable Solomon Islands collections I should never have properly understood this species or been aware of its existence. Before the advent of his specimens I had only seen *Kajewski 2022* to which I had given various preliminary names including *novoguineensis, irya* and *spicata* and *Chapman 427* which I had wrongly dismissed at the time as something different. Incidentally the *Chapman* specimen is a very good example of *whitmorei* with very fine male flowers but it has coriaceous leaves that have dried a pale brown. Just because of the thickness of the leaves and their unusual colour it looks at first quite puzzling. The student will recall several instances of this sort of thing in *Horsfieldia* where chartaceous leaves are replaced by coriaceous ones of a darker or lighter colour, thus altering considerably the normal appearance of the species e.g. *glabra, polyspherula, reticulata, spicata, subglobosa* and others.

A. C. Smith also named *Kajewski 2022 H. novoguineensis.* In fact he referred the *Brass* and *Kajewski Horsfieldia* numbers from the Solomon Islands to this species; but actually his *novoguineensis* included all three of the Solomons species, namely, *irya spicata* and *whitmorei.*

I had therefore come to the conclusion that the *Brass* and *Kajewski* specimens were *irya* and *spicata* but there was some doubt about the latter as I thought some of those with narrow leaves might be *palauensis.* I should probably have finally concluded that *Kajewski 2022* was a narrow-leaved form of *spicata* but, as pointed out, I should not from a single gathering have recognized it as a new species. The next stage was the arrival of Whitmore's collection and his information that there were three species of *Horsfieldia* in the Solomons. At first we both thought that the third species might be *palauensis* because of its oblong fruit but I had not then examined flowering material of the latter nor had I any available in Singapore with which to make a comparison. In the meantime Whitmore's book was published. I did not pursue the matter any further at that time since I had then only just started to write up *Horsfieldia*. In the final stages when I did eventually come to examine *whitmorei* and *palauensis* I saw that they were not identical. The latter is not different from the wide-spread *spicata*. I am grateful to the herbaria of BISH, TI and TNS for the loan of material of *palauensis*.

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   Vols. 1–11, 1912–1947.
   Vol. 1 (1–5) January-May 1912 issued under title of **Agricultural Bulletin of the Straits & F.M.S.**
   Prices on application.

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Asplenium Linn., sect. Thamnopteris Presl

by

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Summary

The status of this section (also known as a genus *Neottopteris* J. Sm.) is discussed. A key to all known species is provided, with synonymy and a brief description for each. The importance of growth-habit (not shown by herbarium specimens) is stressed, and the need for more observation of living plants, especially on the islands of the Pacific Ocean. Two new species (*A. pacificum* and *A. spirale*) are described. Names of species which have been included by various authors in *Neottopteris* but which do not belong to this section are listed.

This section was established by Presl in 1836 (Tent. Pterid. 105); the sole species was *Asplenium nidus* L. and the only distinctive character described was the anastomosis of veins near the margin of the lamina. John Smith raised the section to generic rank in 1841 (Hook. Journ. Bot. 3:409 and 4:175) with citation also of other species. He chose a new generic name *Neottopteris,* and gave the superfluous new name *N. vulgaris* to the type species, listing *A. nidus* Linn. as a synonym; this was corrected when Hooker described and illustrated the genus in his *Genera Filicum* (1842) t. 113B. Presl later used the generic name *Thamnopteris* (Epim. Bot. 68; 1851) and in this was followed by Beddome (Handb. Ferns Br. India, 1883) but at the generic level *Neottopteris* has priority; it should be noted also that in 1849 Brongniart published the generic name *Thamnopteris* for a fossil fern stem of the family Osmundaceae.

The group of species which conform to Presl's description is certainly a natural one, but a decision on its status should be deferred until a scheme for a natural division of the large genus *Asplenium* (estimated 700 species) is established. On this subject Copeland made the following comments (Gen. Fil. 167; 1947): "in a genus so large, there are of course natural groups of species, some of them easily recognizable .... these groups are remarkably indefinable". He did not refer to John Smith's *Historia Filicum* (pp. 316–321; 1875) in which *Asplenium* is divided into many sections and subsections. In spite of Copeland, and without agreeing in detail with John Smith's arrangement, it seems to me probable that *Asplenium* could be subdivided into natural groups of species if someone would take time to make in intensive survey of the whole of it, noting characters not hitherto incorporated into specific descriptions.

John Smith (l.c. p. 316) cited *A. marinum* L. as type species, but Copeland (Gen. Fil. 164) cited *A. trichomanes* L. without mentioning Smith, whose selection should have priority. It appears to me that a considerable number of tropical species including the widely distributed *A. tenerum* Forst. are related to *A. marinum;* and in my book on the Ferns of Malaya (p. 415) I have noted the possibility that *A. nidus* belongs to this alliance. Therefore it is possible that if the genus *Asplenium* as now recognized were divided into several distinct genera, *A. nidus* and near allies would remain as a section of *Asplenium* s. str. For this reason I do not here recognize *Neottopteris* as a genus. I think it important that a full survey of *Asplenium* should be undertaken, so that natural groups of species can be found and delimited. Whether or not such groups are regarded as distinct genera, their recognition would provide a basis for comparative studies of a kind which are not now possible, and the distribution of the various groups would help towards an understanding of the possible history of *Asplenium* sens. lat. As Copeland has remarked, there is a tendency within *Asplenium* towards the reduction of fronds from a much-divided to a less divided condition, with the result that simple fronds, like those of *A. nidus,* have originated on various evolutionary lines. Paired sori facing each other have developed in some of these simple fronds; this is the *Phyllitis* (Scolopendrium) condition. Hooker (Spec. Fil. vol. 3) put all these species into a suborder Scolopendrieae and arranged them in four sections of *Scolopendrium* (others have since been discovered); but they are the ends of several evolutionary lines within *Asplenium* s. l. and we shall not well understand them until the species within *Asplenium* related to each are recognized. Section *Thamnopteris* is undoubtedly a distinct section, as shown by its venation and its distribution; it is in fact the only section of *Asplenium* which can at present be clearly delimited.

The characters of sect. *Thamnopteris* are: caudex erect, slow-growing, unbranched, bearing at its apex a series of almost sessile simple fronds in a very close spiral so that together they form a nest-like structure (except *A. spirale* and possibly *A. longum*); veins slender, parallel, close together, often forking once, less often twice, their tips always united in a series of short arcs just within the cartilaginous margin of the lamina; sori elongate, with narrow indusium; spores usually with a narrow translucent wing and some anastomosing cross wings. Distribution: tropics and subtropics of the Old World from East Africa to Hawaii; mostly epiphytes, but a few species specialized to a habitat on limestone rocks.

Cytology. In northern India Bir found n = 72 (tetraploid) for both *A. nidus* and *A. phyllitidis* (Current Science 29: 445; 1960); Abraham, Ninan and Matthew made the same observation for both species in southern India (Ind. Journ. Bot. 41 : 381; 1962). Vazart reported that a plant of *A. nidus* of unspecified origin, cultivated at Paris, had n = 144 (i.e. octoploid; Rev. Cyt. Biol. Veg. vol. 17, 1956) but his statement is not clearly expressed and needs confirmation.

The opposite key covers all species I have been able to discover. It needs to be critically considered by people who have access to living plants, especially on the islands of the Pacific Ocean. An important character in plants of this section is habit of growth, especially the angle each frond makes at its base with the vertical line of the caudex, and the curvature of the midrib. This character is not shown by herbarium specimens, and I have seen no reference to it in taxonomic works on ferns. Works on cultivated ferns sometimes describe habit, but may be unreliable in the use of names. Schneider's "Book of Choice Ferns" (3 volumes, 1892–1894) is still the most comprehensive of these. His published figure of *A. nidus* (vol. 1 p. 618) shows a plant with the habit of *A. australasicum;* but under *A. nidus* var. *australasicum* he describes the growth-habit typical of *A. nidus,* though associating it with the character of a keeled midrib, a condition I have not seen. Under *A. nidus* var. *musifolium* he states that the fronds "take an upright direction from the start" and that the sori extend nearly to the edge; neither statement is correct (the second probably copied from Hooker; see note on

A. musifolium below). I have seen no plants in cultivation in Britain which correspond to Schneider's description of var. *musifolium*. Under *A. nidus* in Nicholson's Dictionary of Gardening (vol. p. 132; 1884) and in the R. H. S. Dictionary of Gardening (vol. 1 p. 205; 1951) are published almost identical habit-drawings which correspond to *A. australasicum*. Bailey's Cyclopaedia of Horticulture (vol. 1 p. 414, edition of 1939) gives a different habit-drawing, also corresponding to *A. australasicum* but with the name *A. nidus*. In Exotica 3, pp 822 and 824 (1962) A. B. Graf publishes photographs of plants which have the habit of *A. australasicum*, though the fronds have wider basal halves than those now cultivated in Britain and those illustrated in the British publications quoted above.

The shape of fronds, even on the same plant, is somewhat variable, especially the shape of the apex, which is often damaged during the rather long period in which it remains in a tender actively-growing state (it is the last part of the frond to become hardened). Width of fronds certainly varies according to light intensity in plants of *A. nidus* in Malaya, as I have proved experimentally by taking a plant with narrow fronds from the weak light in which it was growing to a stronger light; the next frond was more than twice as wide as preceding ones. This is also true of plants in cultivation at Kew. But my impression is that in some other species (*A. phyllitidis*, and probably *A. australasicum*) this response to stronger light does not occur; in Malaya, *A. phyllitidis* does not grow in such exposed positions as *A. nidus*.

As herbarium specimens do not clearly indicate the curvature of the base of the frond, even if the base is present (often it is not), one object of the present account is to call attention to the need for field observation of the habit of growth. John Smith recognized this a century ago when he wrote: "The cultivated examples of four forms known to me, although difficult to recognize as distinct when put in the Herbarium, are however readily seen to be distinct species in the garden" (Historia Filicum, p. 329). He was implicitly criticizing W. J. Hooker, who did not pay sufficient attention to the living plants under John Smith's care at Kew.

KEY TO THE SPECIES OF SECT. THAMNOPTERIS

1. Fronds gradually narrowed from their widest part to the base
    2. Sori on almost all veins, including both branches of a vein which forks near costa; indusia less than ½ mm wide
        3. Fronds nest-forming
            4. Fronds ascending steeply; nest narrowly funnel-shaped
                5. Costa sharply keeled on lower surface .... 1. *A. australasicum*
                5. Costa not keeled on lower surface ...... 2. *A. pacificum*
            4. Fronds spreading horizontally at base and then curved upwards
                6. Fronds to c. 20 cm wide; apex gradually attenuate .... 3. *A. nidus*
                    7. Fronds unlobed and flat

8. Sori usually much more than 10 mm long
    9. Sori on basal $\frac{1}{3}-\frac{1}{2}$ (rarely $\frac{2}{3}$) of each vein .... var. *nidus*
    9. Sori on middle part of each vein .... var. *biseriale*
8. Sori not more than 10 mm long .... var. *curtisorum*

7. Fronds much lobed, or plicate
    10. Fronds much lobed .... var. *multilobum*
    10. Fronds plicate .... var. *plicatum*

6. Fronds 25–35 cm wide; apex broadly rounded .... 4. *A. musifolium*

3. Fronds not nest-forming
    11. Fronds to at least 70 x 10 cm .... 5. *A. longum*
    11. Fronds to c. 25 x 5 cm .... 6. *A. spirale*

2. Sori usually on one branch of each vein, indusium more than $\frac{1}{2}$ mm wide
    12. Fronds to 20 cm or more wide with dilated bases; indusia more than 1 mm wide .... 7. *A. cymbifolium*
    12. Fronds not over 12 cm wide, bases not dilated; indusia less than 1 mm wide
        13. Fronds of mature plants to at least 9 cm wide; costa little or not prominent on lower surface
            14. Wing of spores with short broad projections; sori not more than half length of veins .... 8. *A. carinatum*
            14. Wing of spores uniformly narrow; sori $\frac{3}{4}$ length of veins .... 9. *A. antiquum*
        13. Fronds of mature plants in many cases narrower; costae distinctly prominent on lower surface
            15. Fronds 3–4 cm wide; sori lying in a depression in the dried lamina, the depression with a distinct outer edge .... 10. *A. colubrinum*
            15. Fronds in some cases wider; sori not lying in a depression
                16. Fronds to 3 cm wide; scales on stipe not more than 5 mm long; sori at c. 45° to midrib .... 11. *A. simonsianum*
                16. Fronds commonly 4–8 cm wide (exceptionally wider); scales 10 mm or more long; sori usually at a wider angle ... 12. *A. phyllitidis*
                    17. Wings of spores of uniform width; fronds never more than 8 cm wide .... subsp. *phyllitidis*

17. Wings of spores bearing many slender projections equal in length to more than ½ width of spore; fronds sometimes to 12 cm or more wide .... subsp. *malesicum*

1. Fronds with basal half or more narrow and sterile, abruptly widened to fertile distal half

   18. Rhizome-scales c. 5 x 1½ mm; costa keeled on lower surface .... 13. *A. grevillei*

   18. Rhizome-scales 3–4 mm wide, little longer than wide; costa not keeled on lower surface

      19. Sterile base of frond 1½ cm wide at base, widening to 2½ cm .... 14. *A. antrophyoides*

      19. Sterile base of frond a very narrow wing, grading imperceptibly to a stipe .... 15. *A. humbertii*

1. **Asplenium australasicum** (J. Sm.) Hook., Fil. Exot. (1859) t. 88; Mett., Farngatt. VI (1859) 85. — *Neottopteris australasica* J. Sm., Cult. Ferns (1857) 49; Hist. Fil. (1875) 330. — *Thamnopteris australasica* (J. Sm.) Moore, Ind. Fil. (1859) 115. Type: cult. Hort. Bot. Kew., origin Australia (BM, in herb. J. Sm.).

Fronds to c. 100 x 15 cm, ascending at a small angle to vertical, together forming a funnel-shaped nest; frond widest just above middle, gradually narrowed towards base; midrib strongly and acutely keeled on lower surface; veins, sori and spores as in *A. nidus*, but sori often occupying more than half of the length of a vein. Hooker figures the base of the frond somewhat dilated, but this is not always so.

Distribution: Queensland and New South Wales; Norfolk Isl., Lord Howe Isl., New Caledonia, Fiji, Samoa, Tonga, Tahiti.

2. **Asplenium pacificum** Holtt., **sp. nov.**

Ab Asplenio nido differt: frondibus e basi suberectis, congerie frondium ut in A. australasicum infundibuliformi, sed costis subtus latis, paulo elevatis, non carinatis.

Largest frond seen 60 x 12 cm, widest about middle, gradually tapering to rather wide base and more narrowly to apex; small scales on lower surface very few, irregularly stellate with some dark-walled cells in the centre, terminal cells of arms not elongate; costa dark, broad, slightly prominent and rounded on lower surface, strongly prominent on upper surface; sori on all veins, from near midrib, extending a little more than half-way towards margin.

Type: cult. Hort. Bot. Kew., accession no. 584/65, grown from spores collected on Washington Island by W. A. Sledge (K).

3. **Asplenium nidus** L., Spec. P1. (1753) 1079; Holtt., Rev. Fl. Mal. 2 (1955) 419. — *Neottopteris vulgaris* J. Sm. in Hook. Journ. Bot. 3 (1841) 409; 4 (1841) 175, nom. nov. superfl. — *Neottopteris nidus* (L.) Hook., Gen. Fil. (1842) t. 113B; Brack. in Wilkes U.S. Expl. Exp. 16 (1854) 175. — *Thamnopteris nidus* (L.) Presl, Epim. Bot. (1851) 68; Bedd., Handb. Ferns Br. India (1883) 137. Type: Osbeck s.n., Java (LINN).

Asplenium ficifolium Goldm., Nova Acta Acad. Leop. Carol. 19, Suppl. 1 (1843) 461. Type: Meyen s.n., Manila (B, not seen).

Neottopteris stenocarpa Fée, Gen. Fil. (1852) 203. Type: Cuming s.n., Philippines (not seen).

Neottopteris elliptica Fée, Gen. Fil. (1852) 203. Type: Cuming s.n., Philippines (not seen).

Neottopteris mauritiana Fée, Gen. Fil. (1852) 204. — *Thamnopteris mauritiana* Presl, Epim. Bot. (1851) 68, nom. nud. Type: Sieber, Fl. Maurit. 46 (isotype K).

Neottopteris rigida Fée, Gen. Fil. (1852) 203. Type: Henslow s.n., Macao (not seen).

Neottopteris salwinensis Ching, Bull. Fan. Mem. Inst. Biol. Ser. 2, 1 (1949) 304. Type: T. T. Yu 19163, N. W. Yunnan, Salwin valley (PE, not seen).

Var. nidus. Fronds to about 150 x 20 cm, narrowed gradually to base and apex, at base growing out horizontally and curved gradually upwards; costa broad but only slightly prominent (not keeled) on lower surface, strongly prominent and ± 2-angled on upper surface except near base; small scales on lower surface of lamina of young fronds, near base, stellate with black-walled cells in centre, end-cells of rays pale, short, thin-walled; sori on all veins, usually extending from costa not more than ½ way towards edge; indusia less than ½ mm wide.

Distribution: E. Africa (Dar es Salaam, Tanzania Zanzibar); Madagascar, Mascarene Islands, Seychelles, Ceylon & S. India, N. E. India; Indo-China & S. W. China; Malesia; Solomon Islands to Tahiti and Hawaii.

Throughout much of its range, var. *nidus* is represented by abundant plants which grow in fairly exposed positions on branches of trees; these plants vary much in size, according to habitat conditions. Though I have not seen the types of Fée's species which are placed above as synonyms, I do not think that they are distinguishable entities; they differ in size and shape of fronds, length of sori etc, all very variable characters. In the Pacific region it appears that *A. nidus* and *A. australasicum* both occur in Samoa, and there the variation is greater than in the Malayan region. In the 1880's Thomas Powell sent many specimens to Kew, with annotations in which he attempted to distinguish several distinct varieties or species, but not all his specimens were kept, and those at present in the herbarium at Kew do not appear to me to show enough recognizable characters to establish new names. I have described var. *biseriale* from one collection of Powell's (see below) which he pointed out as most distinctive. He also stated that he regarded *A. australasicum* as distinct. It is possible that some of the variation in Samoa is due to hybridization between *A. nidus* and *A. australasicum;* a new local survey of these plants might yield interesting results. A similar survey is also desirable in other island-groups of the Pacific.

Var. bieriale Holttum, **var. nov.**; a varietate typica differt soris media venarum occupantibus, nec costam nec marginem accedentibus, lamina basi leviter dilatata.

Type: T. Powell 240, Samoa (K). See above discussion.

Var. curtisorum (Chr.) Holtt., **var. nov.** — *Asplenium curtisorum* Chr., Ann. Jard. Bot. Btzg 19 (1904) 39. — *Neottopteris curtisora* Hosokawa, Trans Nat. Hist. Soc. Formosa 31 (1941) 474. Type: Sarasin 2034, Gimpu, Central Celebes, 5 Sept. 1902.

The original specimens was described as having fronds 50 x 9 cm, short-acuminate, with sori about 10 mm long; there is no information about width of indusia. A report from the University Herbarium at Basel states that the type is not with the earlier Sarasin collections from Celebes; it may be at Paris. In Kew herbarium are specimens, as cited below, from Sabah and Sarawak which conform to the above description, also a plant from Sabah in cultivation at Kew. But there are other specimens from Borneo with sori 12–15 mm long, and I am not sure that var. *curtisorum* is sharply distinct.

Price's specimen from Mindanao has fronds 17 cm wide and sori 8–10 mm long close to the midrib. The collector reports that when fresh the upper surface of the midrib was prominent and rounded in section, not 2-angled as it usually is in *A. nidus*, but the dried specimens do not show this clearly so that a comparison with the Bornean specimens cannot be effectively made.

SABAH. Elmer 20943, Tawao. Cult. R. B. G. Kew, accession no. 455/63, origin Sabah (no locality) leg. Giles & Wolliams. SARAWAK. Clemens 21011, Mt Matang. Brooks s.n. Aug. 1909, without locality (BM). JAVA. Donk s.n. 5.4.1950, near Tjibodas (K).

PHILIPPINES. M. G. Price 2752, Mindanao, Agusan del Norte Prov., mountains above Cabadbaran.

Var. multilobum F. M. Bailey, Queensl. Agric. Journ. 1 (1897) 370, with photo. Type: Bailey s.n., Trinity Bay Ranges, N. Queensland (isotype K).

Fronds irregularly and deeply lobed; midrib pale in distal part (apparently dark near base), rather broad and rounded on lower surface; sori irregular, in some cases in pairs facing each other, as in *Phyllitis*.

It is possible that this should rank as a variety of *A. australasicum;* the Kew specimen consists of the apical part of the frond, and has slight indications of a keel on the lower surface of the midrib, which however is very broad, due probably to the frequent branchings. I have seen no later specimens, and have no information whether this variety persists.

Var. plicatum v.A.v.R., Handb. Malayan Ferns (1908) 440. Type: not cited, apparently at BO, from a cultivated plant.

Plant rather small, with lamina on each side of the midrib plicate or crimped so that it will not lie flat. A plant of this nature in cultivation at Kew has very thick rigid fronds; its origin is not recorded.

4. **Asplenium musifolium** Mett., Farngatt. VI (1859) 86; Hook., Spec. Fil. 3 (1860) 78, p.p. — *Thamnopteris nidus* var. *musifolia* Bedd., Handb. Ferns Br. India (1883) 139, p.p. — *Asplenium nidus* var. *musifolium* v.A.v.R., Handb. Mal. Ferns (1908) 439, p.p.; Holttum, Rev. Fl. Mal. 2 (1955) 418. Type: Cuming 89, Luzon p.p. (isotype K).

Asplenium nidiforme v.A.v.R., Bull. Jard. Bot. Btzg II, 7 (1912) 6; Handb. Suppl. (1917) 281. Type: Cult. Hort. Bog. II K XIV 39, origin New Guinea (BO).

Fronds growing out horizontally at the base, then curved upwards as in *A. nidus*, those of well-grown plants 25–35 cm wide, base gradually and then abruptly narrowed to a black stipe, apex rather abruptly and broadly rounded with a short mucro; costa rather strongly prominent on lower surface but not keeled; sori as in *A. nidus*.

Extreme forms of this look distinct from *A. nidus* (small plants also have proportionately broad fronds), but it is desirable to establish its distinctness by growing plants from spores.

Cuming's collection no. 89, on a specimen from which Mettenius based the first published description, was a mixed gathering, part being as described above and part being from a plant of *A. cymbifolium* (no. 7 below). Mettenius's specimen is probably lost with the destruction of the Leipzig herbarium, but his description leaves no doubt as to its identity, matching exactly a specimen of no. 89 in the Kew herbarium. Hooker's description of 1860 covers both species, including the statement that in one "form" the sori may reach almost to the edge of the lamina (this "form" was *A. cymbifolium*), and this was copied by Beddome and van Alderwerelt. John Smith first published the name as *Neottopteris musifolia*, citing Cuming 89, but without a description; he wrote the name *N. musifolia* on a specimen of *A. cymbifolium* in his herbarium, and may have intended it for that species, which is strikingly distinct, but the type of *A. musifolium* must be the specimen described by Mettenius.

The type specimen of *A. nidiforme*, of which I have seen a photograph, has fronds to 50 x 12½ cm, and I judge that it was an immature plant; the shape of frond is like that of *A. musifolium*.

A specimen from the Admirality Islands (Challenger Expedition, 1875) in the BM herbarium consists of a frond of the form of *A. musifolium*, 22 cm wide, but the midrib is decidedly keeled on the lower surface, as in *A. australasicum*. The curvature of the base of the frond cannot be judged. This is another indication of the complexity of sect. *Thamnopteris* in the Pacific, and of the need for more observation.

A plant in cultivation at Kew, from N. E. New Guinea (accession no. 247/70, 2351) has fronds of about the same size and shape as the type of *A. nidiforme*, but it has small scales on the lamina as in *A. phyllitidis*, and the spores are abortive; it is probably a hybrid.

5. **Asplenium longum** v.A.v.R., Bull. Jard. Bot. Btzg II, 28 (1918) 8. Type: Bünnemaijer 2131, Bangka, Mt Mangkol (BO; phot. at BM). — *Asplenium perlongum* v.A.v.R., l.c. Type Bünnemeijer 1846, Bangka, Mt Maras (BO; Phot. at BM).

"Not nest-forming" (v.A.v.R.); fronds of type of *A. longum* 70–80 x 10–15 cm, of *A. perlongum* to 145 cm long; sori of former not touching costa, of latter touching costa; little other clear difference. The photographs of type specimens do not indicate how the growth habit differs from that of *A. nidus*, nor is there clear distinction in form of fronds and sori. I place this species here to call attention to its description, in the hope that further information about plants on the island of Bangka may be obtained.

6. **Asplenium spirale** Holtt., **sp. nov.**

Caudex elongatus, c. 8 mm diametro, paleis nigris angustis c. 8 mm longis vestitus, frondes laxe spiraliter ferens. Stipes anguste alatus, 1–2 cm longus, lamina rigida, 18–24 cm longa, 4.2–5.0 cm lata, leviter oblanceolata, basi subabrupte ad alam angustata, apice late vel anguste acuta, non cuspidata; costa utrinque paulo elevata; venae more A. nidi prope marginem anastomosantes, c. 1 mm inter se distantes, sub angulo c. 45° a costa abeuntes; sori e costa dimidio marginem versus producti, indusia vix ½ mm lata; sporae alis angustis praeditae.

Type: Pulle 184, Lorentz River, W. New Guinea, 30 m (BM).

The fronds are shaped about as in *A. musifolium* but are small and rigid; they are attached to the caudex in an ascending spiral arrangement so that about 8 fronds are attached to a length of caudex 5 cm long. Thus the habit is quite distinct from that of *A. nidus*.

7. **Asplenium cymbifolium** Chr., Bull. Herb. Boiss. II, 6 (1906) 999; v.A.v.R., Handb. (1908) 440; Copel., Philip. Journ. Sci. 2C (1907) 130; Fern Fl. Philip. (1960) 451. — *Neottopteris cymbifolia* (Chr.) Tagawa, Journ. Jap. Bot. 22 (1949) 161. Type: Loher s.n., Mt Makiling, Luzon (P, not seen).

Fronds similar in size and shape to those of *A. musifolium* but broader and dilated in basal part; veins about 2 mm apart in middle of lamina; sori not on every vein, rather irregular in spacing and length, many extending almost to edge of lamina; indusia a little more than 1 mm wide. Scales on rhizome up to 4 mm wide; rather pale; small scales also abundant on edges of costa near base of frond.

Distribution: S. Sumatra, Borneo, Philippines, New Guinea, Samoa.

As noted above under *A. musifolium*, Cuming included specimens of this species under his no. 89. Mr Michael Price informs me that the species grows in the mossy forest near the summit of Mt Makiling, and that the bases of the fronds overlap so closely that the "nest" holds water. Roots of the fern grow up into the water, and tree-frogs lay eggs in it.

Forma lingganum v.A.v.R., Bull. Jard. Bot. Btzg III, 5 (1922) 184. Type: Bünnemeijer 7388, Lingga Arch., P. Singkep (BO; isotype K). Fronds to 60 x 6 cm, base dilated as in type of species; sori short. This may be a young plant. It appears to have been found in mangrove, where high average atmospheric humidity encourages abundant epiphytic growth on certain species of trees in quite bright light; some of these species do not occur in normal lowland forest in Malaya, but occur further north on mountains (e.g. *Ctenopteris moultonii* (Copel.) Holtt.)

8. **Asplenium carinatum** v.A.v.R., Bull. Jard. Bot. Btzg II, 28 (1918) 9, Type: Teysmann 12791, Maros, S. W. Celebes (BO).

Fronds 40–50 x 9 cm; apex rather abruptly short-pointed to cuspidate; lower part of frond gradually narrowed towards base, a very narrow wing extending almost to attachment of frond to caudex; costa strongly keeled on upper surface, not on lower; veins at c. 60° to costa; sori from costa along basal half of veins, or shorter, on alternate veins; indusium more than ½ mm wide; spores with wing of irregular width, not produced into filaments as in *A. phyllitidis* subsp. *malesicum*.

Only known from two collections from the type locality; the second is C. J. Brooks 16856 (BM), found growing on limestone near Maros Waterfall. This habitat is interesting, in view of the fact that species 13–15 of the present account occur only on limestone in mainland Asia.

9. **Asplenium antiquum** Makino, Journ. Jap. Bot. 6 (1929) 32; Tagawa, Col. Ill. Jap. Pterid. (1962) 147, 177, fig. 324. — *Thamnopteris antiqua* Makino, Journ. Jap. Bot. 8 (1932) 7. — *Neottopteris antiqua* Massumune, Trans. Nat. Hist. Soc. Formosa 22 (1932) 215. Type: "Hab. Japan, southern", not seen.

Fronds to c. 100 x 12 cm, narrowed gradually to base and more abruptly to apex; costa broad and only slightly prominent on lower surface, little more so on upper; veins in middle of lamina more than 1 mm apart; sori on alternate veins, ⅔ or more of length of veins; indusia more than ½ mm wide; spores winged as in *A. nidus*.

Distribution: Kyushu (Yakushima Isl.), Izu Isl., Okinawa.

10. **Asplenium colubrinum** Chr., Bull. Herb. Boiss. II, 6 (1906) 999; Copel., Fern Fl. Philip. (1960) 451. Type: Loher s.n. March 1906, Angilog, Luzon (P?; isotype K). Also cited Loher 18.4.1905, Mt Batay, 1380 m.

Fronds to almost 100 cm long, 3–4 cm wide, firm texture, rather uniform in width for a great part of their length, narrowed gradually to both base and apex which is sometimes short-acuminate; costa keeled on lower surface, not on upper; sori on alternate veins, occupying $\frac{3}{4}$ or more of length of veins, the sporangia lying in a depression in a dried frond, the edge of the depression distinct; indusia a little more than $\frac{1}{2}$ mm wide; spores with a narrow wing.

Distribution: Luzon, Mindoro.

Copeland described a variety *taeniophyllum* (Philip. Journ. Sci. 2C: 131; 1907) based on a specimen collected by Merrill (no. 5900) on Mt Halcon, Mindoro. He described the sori as occupying $\frac{1}{2}$–$\frac{3}{5}$ of the veins, with black indusia. I have not seen a specimen, but have seen another from Mt Halcon (Ramos & Edano 40623) which does not differ significantly from Loher's Luzon specimens.

Mr M. G. Price has recently sent a specimen (no. 440) from Mt Polis, Luzon, which agrees with the above description except that the sori do not lie in a depression in the surface of the frond. The fronds of this specimen are thinner than those of the type. The species is thus perhaps chiefly distinguished by its long narrow fronds.

11. **Asplenium simonsianum** Hook., Ic. Plant. 10 (1854) t.925. — *Thamnopteris simonsiana* (Hook.) Moore, Ind. Fil. (1857) L; Bedd., Handb. Ferns Br. India (1883) 141. — *Neottopteris simonsiana* J. Sm., Hist. Fil. (1875) 330. Type: Simons 232 (err. typ. 432 in Hook. l.c.), Khasya (K).

Scales dark, firm, 2–3 x 1 mm; stipe c. 2 cm long; frond to 40 x 3 cm, widest $\frac{1}{3}$ from apex, very gradually narrowed towards base, basal part a very narrow wing on each side of costa, apex rather abruptly narrowed to a cusp 15–20 mm long, $1\frac{1}{2}$–2 mm wide; costa prominent on both sides near base, rounded on lower side, on upper side grooved at base, above base raised and 2-angled when dry; veins at c. 45° to costa, distinct but not or little prominent either side; sori from near costa $\frac{3}{4}$ towards edge, usually with a sterile vein between sori; indusia over $\frac{1}{2}$ mm wide when young; spores with translucent narrow somewhat crisped wing.

Distribution: Assam, Sikkim, Chittagong, Vishakapatanam, on hills at about 3000 ft.

12. **Asplenium phyllitidis** Don, Prodr. Fl. Nepal. (1825) 7; Hook., Spec. Fil. 3 (1860) 80. excl. syn. *A. simplex* Bl. — *Neottopteris phyllitidis* (Don) J. Sm. in Hook. Journ. Bot. 3 (1841) 409. — *Thamnopteris phyllitidis* (Don) Presl, Epim. Bot. (1851) 68; Bedd., Ferns S. India (1863) t. 123. — *Thamnopteris nidus* var. *phyllitidis* Bedd., Handb. Ferns Br. India (1883) 139. — *Asplenium nidus* var. *phyllitidis* v.A.v.R., Handb. Suppl. (1917) 282; Tard. & C. Chr. in Fl. Gen. Indochine 7, pt. 2 (1940) 220. Type: Wallich, Nepal (not seen).

Thamnopteris orientalis Presl, Epim. Bot. (1851) 69; Holtt., Novit. Bot. Inst. Bot. Univ. Carol. Prag. 1968 (1969) 52. Type: Wallich 198, Nepal ? (PRC). In the Wallich Herbarium at Kew, there are 9 sheets of 198, not all from Nepal; only two agree with Presl's specimen.

Subsp. phyllitidis

Scales at least 10 mm long; fronds commonly 40–70 cm long, 4–8 cm wide, widest above middle, gradually narrowed to base, apex rather narrowly pointed or short-cuspidate; costa prominent and rounded on lower surface, on upper surface grooved near base, above base slightly prominent and 2-angled; veins c. $1\frac{1}{2}$ mm apart mid-way between costa and edge, uniting 1 mm or more from edge; sori from near midrib $\frac{2}{3}$–$\frac{3}{4}$ length of veins, usually on acroscopic branch of a vein which forks near costa, at an angle of more than 45° to costa; indusia more than $\frac{1}{2}$ mm wide; spores with a narrow wing.

Distribution: S. India, N. E. India, N. Thailand, Yunnan, Hainan.

Subsp. malesicum Holttum, **subsp. nov.**, a subspecie phyllitidi differt frondibus saepe majoribus, usque 12 (–15) cm latis, sporis semper ciliatis. Type: Cuming 319, Samar (K).

Asplenium nidus var. *simonsianum* sensu Chr., Bull. Herb. Boiss. 6 (1898) 151.

Asplenium oblanceolatum Copel., Philip. Journ. Sci. 9C (1914) 229. Type: Brooks 28, Lebong Tandai, Benkoelen, Sumatra (BM).

Asplenium phyllitidis sensu Holtt., Rev. Fl. Mal. 2 (1955) 420; sensu Copel., Fern Fl. Philip. (1960) 449.

Asplenium simplex sensu Kunze, Bot. Zeit. 6 (1848) 145; sensu Mett., Farngatt. VI (1859) 86; non Bl.

Thamnopteris simplex sensu Presl, Epim. Bot. (1851) 69, non (Bl.)

Fronds commonly to 100 x 8 cm, sometimes to 10–12 (–15) cm wide; sori varying in length, usually $\frac{2}{3}$–$\frac{3}{4}$ length of veins but sometimes shorter; spores always with a translucent wing which is produced into many slender points equal in length to more than half width of spores; scales on lower surface of young fronds, near base, very small, middle cells with pale walls, fringed with elongate orange glandular cells (these scales not seen on specimens of subsp. *phyllitidis*).

Distribution: throughout Malesia; in mainland Asia northwards to southern Burma and Thailand and to Tonkin.

In New Guinea there appears to be more variation than elsewhere. Two distinct forms are in cultivation at Kew, but herbarium specimens from New Guinea are in some cases intermediate. In one cultivated plant the nest has a very wide open base, fronds of a yellow-green colour, sori not over $\frac{2}{3}$ length of veins at a rather broad angle to costa, small scales on lower surface near base abundant; the other cultivated plant has more erect fronds (forming a less open nest) which are darker green, with sori almost the full length of the veins and at about 45° to costa, superficial small scales fewer with glandular cells less conspicuous.

13. **Asplenium grevillei** Wall. ex Hook. & Grev., Ic. Fil. (1831) t. 228. Tard. & C. Chr. in Fl. Gen. Indoch. 7, pt. 2 (1940) 217. — *Neottopteris grevillei* (Wall.) J. Sm. in Hook. Journ. Bot. 3 (1841) 409. — *Thamnopteris grevillei* (Wall.) Moore, Ind. Fil. (1857) L; Bedd., Handb. Ferns Br. India (1883) 139. Type: Wallich 1036, Tavoy, Burma (K).

Scales not well seen, apparently to 5 x 1$\frac{1}{2}$ mm, firm but thin; stipe very short; frond to 45 cm long, basal 20–25 cm a narrow wing on each side of costa, up to 1 cm wide or little more, rather abruptly widening to 4$\frac{1}{2}$–6 cm wide in distal part; texture thin; costa keeled on lower surface; veins c. 1 mm apart, at c. 60° to costa; sori from near costa $\frac{3}{4}$ or more towards edge; spores translucent with a narrow wing.

Distribution: Peninsular Burma and Peninsular Thailand; S. India and Ceylon.

14. **Asplenium antrophyoides** Chr., Bull. Geogr. Bot. Mans 20, pt. 1 (1909) 170, Tard. & C. Chr. in Fl. Gen. Indoch. 7, pt. 2 (1940) 218 — *Neottopteris antrophyoides* (Chr.) Ching, Bull. Fan Mem. Inst. Biol. Bot. 10 1941) 7. Type: Cavalerie 1877, Sept. 1907, Kweichow, Lo-fou (P).

Asplenium subspathulatum Rosenst. in Fedde. Rep. 13 (1913) 122. Type: Cavalerie s.n. Kweichow (isotype BM).

Scales c. 4 x 4 mm; fronds to c. 40 x 7 cm, spathulate, abruptly cuspidate, sessile; basal 15–17 cm gradually widening from base to 2½ cm wide, then less abruptly than in *A. grevillei* to the wide distal part; veins in broad part of frond c. 1½ mm apart; sori from 3–5 mm from costa to ¾ distance to edge, at c. 60° to costa; spores not translucent, with a fairly wide somewhat crisped wing.

Distribution: Kweichow, Tonkin, N. Thailand, on limestone.

15. **Asplenium humbertii** Tard., Aspl. du Tonkin (1932) 25, t. 2, f. 1, 2. Tard. & C. Chr. in Fl. Gen. Indoch. 7, pt. 2 (1940) 218. — *Neottopteris humbertii* (Tard.) Tagawa, Journ. Jap. Bot. 22 (1949) 161. Type: Balansa 68, Tonkin, Than Moi, sur les rochers calcaires, Jan. 1886 (P; K).

Scales as in *A. antrophyoides;* basal part of frond very narrow, 15–20 cm long, apical fertile part to 23 x 4.8 cm, apex abruptly cuspidate; sori from near costa along ⅔–¾ of veins.

Distribution: Tonkin, North Thailand, on limestone.

This species is very near *A. antrophyoides*, but appears to be distinct in the very narrow basal part of the frond. Specimens in Kew herbarium from N. Thailand are variable in the angle between sori and costa.

Excluded species which have been included in *Neottopteris*

Neottopteris squamulata (Bl.) Fée, Gen. Fil. (1852) 203 — *Asplenium squamulatum* Bl., Enum. Pl. Jav. (1828) 174. — *Thamnopteris squamulata* (Bl.) Presl, Epim. Bot. (1851) 260. Type: Blume, Java (L).

Neottopteris pachyphylla (Kunze) Fée, Gen. Fil. (1852) 203. — *Asplenium pachyphyllum* Kunze, Bot. Zeit. 6 (1848) 146. — *Thamnopteris pachyphylla* (Kunze) Presl, Epim. Bot. (1851) 69. Type: Zollinger 2414, Java (isotype K). = *A. squamulatum* Bl.

Neottopteris simplex (Bl.) Fée, Gen. Fil. (1852) 203. — *Asplenium simplex* Bl., Enum. Pl. Jav. (1828) 174, non Kunze Bot. Zeit. 6 (1848) 145, nec Mett. Farngatt. VI (1859) 86. — *Thamnopteris simplex* (Bl.) Presl, Epim. Bot. (1851) 69. Type: Blume, Java (L.) — *A. amboinense* Willd. sensu Backer & Posth., Varenfl. Java (1939) 133, but doubtfully identical with Willdenow's species, the type of which is a sterile frond.

Neottopteris taeniosa (Kunze) Fée, Gen. Fil. (1852) 203. — *Asplenium taeniosum* Kunze, Bot. Zeit. 6 (1848) 145. Type: Zollinger 2823, Java (isotype K). = *A. simplex* Bl.

Neottopteris stipitata J. Sm. and *N. ovata* J. Sm. are nomina nuda which have been cited by other authors but have no status.

A Commentary on Comparative Morphology in Zingiberaceae

by

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Summary

A critical commentary is presented on the statement on comparative morphology of Zingiberaceae in Malaya published in Gard. Bull. Sing. Vol. 13, part 1 (1950), and a comparison made with the account of the family prepared by Bakhuizen for the *Flora of Java* Vol. 3 (1968) where terms are differently used and a different view of some genera (*Achasma* and *Amomum*) is maintained. An attempt is made to correct inconsistencies in the use of terms in both accounts, especially in relation to inflorescence-structure which is of basic importance in this family. Floral morphology is only considered in reference to the genera *Nicolaia* (mis-named *Phaeomeria* in Holttum 1950), *Achasma* and *Amomum*. Some comments are made on the status of some generic names but no proposals for change of the scheme of 1950 are made. A suggestion is made that experimental work might throw light on the structure of the condensed lateral cymes and in demonstrating the essential uniformity of structure of the inflorescence in the family. A plea is made that taxonomic statements on tropical plants should no longer be limited by the defects of dried specimens in European herbaria.

Introduction

In Singapore, during World-war II, I prepared a systematic study of the family Zingiberaceae in Malaya, based on all available records in the herbarium and library at the Botanic Gardens, on a considerable number of species in cultivation and native in Singapore island, and on inflorescences of many species preserved in alcohol, the majority collected, with elaborate field notes, by E. J. H. Corner. In this study I was greatly helped by the published works of Valeton, who also had (at Bogor) a wide range of living plants at his disposal and was able to see clearly structures which are not well preserved in dried specimens, and thus were not considered, or not understood, by herbarium botanists, notably J. G. Baker (1892) and K. Schumann (1904). After the war, in the years 1946-1949, I was able to examine a considerable number of living plants, some of the species not seen previously, in various parts of Malaya, and thus to improve my manuscript. I made drawings in all cases from living plants, with use of a camera lucida.

In the *Flora of Java* Bakhuizen expressed disagreement with my opinions (and those of Valeton on which mine were largely based), quoting a statement of mine which he believed to be contradictory. This led me to re-read what I wrote in 1950, and in so doing I found some inconsistencies in the use of terms. I have therefore decided to re-write my statement on morphology, especially of the inflorescence, to remove inconsistencies, and to show where I think Bakhuizen has misunderstood not only my statement but also some specimens at his disposal. I judge that a large part of his difficulty was due to the fact that he had little or no living material available of most species. It is difficult or impossible to understand the detailed structure of the inflorescence of most Zingiberaceae from dried specimens unless such specimens have been specially prepared to demonstrate the significant characters. I have rarely seen specimens which do this effectively. However, the taxonomic study of tropical plants ought not to be limited by the imperfections of dried specimens.

Since Bakhuizen's publication, Burtt and Smith (1972) at Edinburgh have produced a most valuable critical report on the early history of taxonomic study of the family and on the significance of published generic names, accompanied by an excellent series of drawings. Burtt and Smith did not arrive at a conclusion as to the application of all the generic names, and in part such application depends on how genera are delimited. As I pointed out in 1950, I had no means of discovering the correct names for some of the groups I recognized as genera. I used the generic names which involved the least name-changes, and was chiefly concerned to characterize clearly the groups in question. In the present contribution I do not propose any changes in generic concepts, but I do offer some comments on the status of *Achasma* and *Nicolaia* (*Nicolaia* should replace the invalid name *Phaeomeria* of Holttum 1950).

Growth-habit

This is invariably sympodial, each new aerial stem arising from a bud at the base of the preceding stem. The new growth is first, for a short or longer distance, more or less horizontal and root-bearing, then erect. Erect leaf-bearing stems may have a terminal inflorescence, or flowering and leafy stems may be distinct from each other.

All leaves have a sheathing base, and a blade on a (usually short) stalk; the sheath is produced upwards above the attachment of the stalk into a ligule, so that the stalk appears to be a dorsal organ attached near the top of the sheath.

At the base of every stem, whether it bears fully developed leaves or not, are sheaths lacking leaf-blades. These are successively longer, and they often bear the rudiment of a blade just below the apex; the blade on the first blade-bearing sheath is small, later ones successively larger. The difference between leafy stems and flowering stems, where the two are different, lies solely in the fact that no blade-bearing sheaths are developed on the specialized flowering stems, which are covered with 2-ranked sheaths, often more numerous than those at the base of leafy stems but not otherwise different. In my work of 1950 I used the term *sheath* for these imperfect leaves. They might also be called cataphylls, but I prefer sheath because they represent exactly the sheaths of normal leaves. Bakhuizen calls them scales, but they are very different from the scale-like leaf-rudiments which cover the resting buds of dicotyledons. Exactly similar sheaths are found at the bases of new stems in many other families of Monocotyledons, but they are not always so conspicuously sheath-shaped as in most Zingiberaceae.

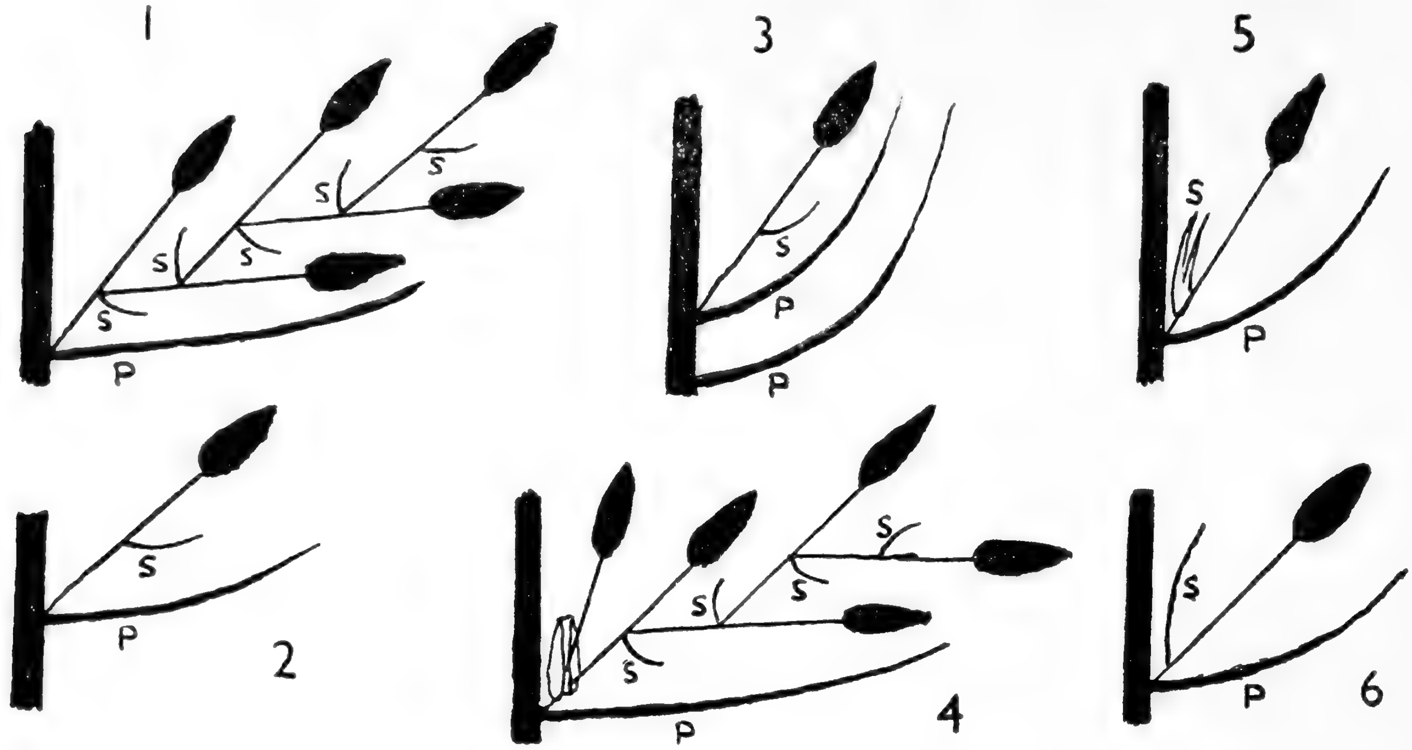
A flowering stem bears either 2-ranked complete leaves, or 2-ranked sheaths, below the flower-bearing part. The flower-bearing part bears bladeless sheaths *spirally* arranged (except in *Boesenbergia*, which needs more study). These are called the *primary bracts* of the inflorescence. If the inflorescence is at the top of a leafy stem, it is protected when young by the sheaths of the leaves on the lower part of the stem and emerges into free air only at a late stage of development. Correlated with this is the fact that the primary bracts of such an inflorescence are in many cases reduced (*Alpinia* and allied genera) or even absent; one may reasonably assume that the bracts have become reduced because their protective function is unnecessary. In cases where an inflorescence is borne on a short stem bearing short bladeless sheaths only, the primary bracts of the inflorescence are always well developed, and are exposed at an early stage of development.

The primary bracts, and the basal sheaths on all stems, whether flowering or not, are homologous, and *all* are essentially *leaves*. The primary bracts of the inflorescence are so called to indicate their position and function, not because they are essentially in any way different from ordinary sheath-leaves. In most inflorescences on short stems where the primary bracts are well developed, there is a leaf-blade rudiment just below the apex of each bract, just as on the sheaths at the base of a new stem.

At the transition from 2-ranked sheaths to spirally arranged primary bracts, on non-leafy flowering stems, there is often a gradual transition of *shape* between the uppermost 2-ranked sheaths and the lowest primary bracts. But the transition from the 2-ranked to the spiral arrangement is distinct, as can be seen from fig. 19A, 21A, 23A, 26A in Holttum 1950. The 2-ranked sheaths of the short flowering stems have no axillary buds, but the spirally arranged primary bracts normally bear flowers, or short cymose branch-systems, in their axils. There are however in Malaya and Java genera in which the lower primary bracts also are empty (*Nicolaia, Achasma, Hornstedtia*); in these cases the empty lower primary bracts are much larger than the upper ones (which have flowers in their axils) and completely enclose the latter. Bakhuizen (1968, p.51) states that he cannot see any difference between the 2-ranked sheaths and outer empty bracts, and therefore does not agree with my treatment of *Achasma* as a genus distinct from *Amomum*. I will revert to this matter later.

Inflorescence-structure

The spirally arranged primary bracts of an inflorescence bear in their axils either single flowers or more or less condensed monochasial cymes bearing several successive flowers. There is not a sharp distinction between the two conditions. In the genus *Catimbium* (Holttum 1950, p. 149) the same inflorescence may have 3-flowered cymes in the axils of basal primary bracts and only single flowers in the axils of upper primary bracts. As axillary monochasial cymes occur in other families of Monocotyledons, it is probable that this was the primitive condition in Zingiberaceae. The genera which have solitary flowers may thus be regarded as separate developments of reduction from the cymose state. In the genus *Zingiber* all species have solitary flowers except *Z. clarkei* King, which certainly belongs to the genus, as judged by the peculiar floral structure which occurs in no other member of the family.



TEXT-FIG. Diagrams showing branching of the inflorescence. In all cases the main axis of the inflorescence is shown bearing one bract which has in its axil a single flower or a monochasial cyme; P = primary bract, S = secondary bract. *1:* the condition of ***Curcuma***, with an axillary cyme. The first secondary bract is at right angles to the primary bract, and successive secondary bracts each at right angles to the preceding one. *2:* the condition of *Amomum*, the axillary cyme reduced to one flower. *3:* the condition of *Hornstedtia* and *Achasma*, with outer larger empty primary bracts and smaller inner ones each with one axillary flower. *4:* the condition of *Scaphochlamys*. The first secondary bract is a 2-keeled prophyll backing the main axis, the rest as no. 1. *5:* the condition of ***Kaempferia***, with deeply bilobed secondary bract backing the main axis, and one flower. *6:* the condition of *Zingiber*, with unkeeled secondary bract facing main bract, and a single flower.

The text-figure shows diagrammatically the postulated primitive type of inflorescence in Zingiberaceae, with an extended monochasial cyme in the axil of a primary bract. This cyme consists of a series of short axes each bearing one lateral bract and ending in a flower; a bud in the axil of the bract repeats the pattern. In this diagram for convenience, all branching is shown in the plane of the paper, but each bract appears to be at right angles to the preceding one, so that branching is not in one plane; the cyme is called a cincinnus. In practice, the cymes are in most cases so condensed (the successive axes being very short) that the exact relation of each bract to the preceding one is often difficult to see exactly. The situation is most easily observed in *Globba* and *Alpinia* (sensu Holttum 1950, p. 140); a condensed cyme of *Curcuma* is illustrated in Holttum 1950 fig. 4 B, C. The detailed development of these cymes needs more precise morphological study than I can attempt, especially in the case of *Scaphochlamys* (see below), by someone with access to ample fresh material.

The nomenclature of the bracts of the cincinnus needs clarification. In 1950, p. 7, I noted that these bracts could be called secondary bracts, to distinguish them from primary bracts, but that it was "more usual and more convenient to call them bracteoles", as Schumann (1904) did; however I was not consistent in this terminology, using both terms in later descriptions of genera and species. In the present statement all bracts on the cincinnus will be called *secondary bracts* only (see figure). They are developed on successive axes of the cincinnus and, though they are all regarded as having the same status, the later ones (at least when immature) are completely enfolded by the larger earlier ones when axes of the cincinnus are very short, for which reason I used the term "inner bracteole" on at least two occasions for small later secondary bracts, a term taken up by Bakhuizen in a way not clearly explained (see below).

Thus the first short axis of the cincinnus, with a flower at its apex, is in the axil of a primary bract; later ones are all in the axils of secondary bracts. In 1950 (following Schumann) I sometimes used the term "floral bract", which in some cases referred to a primary bract (e.g. *Achasma*), sometimes to a secondary bract (e.g. *Geostachys*). In *Achasma* I used it to distinguish the inner primary bracts, each having a flower in its axil, from the outer empty primary bracts.

The condition of *Amomum* and other genera in which the cincinnus is reduced to one flower is shown in fig. 2. The condition of *Hornstedtia, Achasma* and *Nicolaia* is shown in fig. 3. In the latter case, the sterile primary bracts, attached at a lower level on the main axis than those which have axillary flowers, are larger and often completely cover the upper ones; the lower ones are thus in practice "outer" bracts and the upper ones "inner" bracts, but all, being attached to the main axis of the inflorescence, are *primary*.

In the genus *Scaphochlamys* (which does not occur in Java, and is thus not dealt with by Bakhuizen) there is a peculiar development in the first secondary bract, at the base of each cincinnus. This bract is 2-keeled, like the organ commonly called a prophyll in Gramineae, Cyperaceae, Marantaceae and other families (the German term is *adossierte Vorblatt*). In these families a 2-keeled prophyll occurs at the base of every new branch, whether large or small, and its back is usually curved to fit the parent axis against which it is compressed. So far as I know, such a 2-keeled prophyll does not occur elsewhere in Zingiberaceae except in a simplified form in *Kaempferia*. The first secondary bract in *Curcuma* is certainly lateral, not facing the primary bracts (Holttum 1950, fig. 4B). Schumann (1904, p. 14) mentions an *adossierte Vorblatt* in his species *Alpinia orchioides* and *A. pterocalyx* from Celebes, which I have not seen and do not understand from his descriptions.

In *Scaphochlamys* the 2-keeled prophyll functions as an additional (basal) secondary bract on the first axis of the cincinnus (fig. 4) and has either one or two flowers in its axil; it is comparable to the utricle in *Carex*, which is a prophyll in the axil of which a female flower is borne. The rest of the cincinnus in *Scaphochlamys* has normal secondary bracts, but they are smaller than the 2-keeled one which at first enfolds them all (Holttum 1950, fig. 10). For this reason I used the term "outer bracteole" (= outer secondary bract) for the 2-keeled bract, in the generic description of *Scaphochlamys*, and I believe nowhere else (not in the descriptions of individual species, where I used the terms first bracteole for the 2-keeled secondary bract, and 2nd, 3rd bracteoles for the rest). Again, Bakhuizen has taken up this term and has given it another significance.

In *Kaempferia* (Holttum 1950, p. 117) there is only one flower in the axil of each primary bract. The only secondary bract is more or less deeply bilobed, sometimes divided to the base (fig. 5); it appears to be comparable to the 2-keeled first secondary bract in *Scaphochlamys*, which is certainly a related genus. In *Zingiber* the sole secondary bract faces its primary bract, in the same way as the first secondary bract in *Scaphochlamys*, but it is neither keeled nor bilobed (fig. 6).

The above statement is necessary to clarify and correct my terminology of 1950, and also to point out how Bakhuizen has used some of the same terms confusedly in his opening statement on the family (1968, p. 41). He begins by stating that the main axis of the inflorescence is "provided with spirally arranged primary bracts bearing in their axil a lateral axis (cincinnus) with bracts of lower rank". Here it should be noted that a cincinnus is not a single axis but a branch-system. Bakhuizen then adds a parenthesis stating that the secondary bracts are taxonomically important, but he does not define them. One may however infer that they are *not* on the primary axis of the inflorescence; yet in his description of *Nicolaia* (see further comment below) he uses the term secondary bract for the inner (upper) bracts of the primary inflorescence axis.

Next Bakhuizen writes: "the whole complex of the usually numerous bracts which together with the branch-system and the floral bracts constitutes the inflorescence consists in the most complete condition of 3 elements: 1° primary bracts (bearing in their axil a lateral shoot, therefore sterile), often firmer or in other respects more conspicuous than the internal bracts, sometimes called involucre when they both distinctly surround the other ones and greatly differ in size and/or shape; as a rule the difference is not remarkable, in most cases the bracts gradually pass from one kind to another, which makes distinction almost impossible, especially in herbarium material".

As indicated in my own statement above on inflorescence-structure, primary bracts bear in their axil either a cincinnus (sometimes reduced to one flower) or *nothing*. Bakhuizen's statement that they bear in their axil a lateral shoot and are therefore sterile is to me unintelligible. His statement that inner bracts (e.g. in *Nicolaia*) are sometimes smaller than outer ones, with no sharp distinction is true, but they are all *primary bracts*.

He continues: "2° secondary bracts and those of lower ranks (outer bracteoles in the sense of Holttum; the outer ones sterile, the innermost fertile". I used the term "outer bracteole" once only, in describing the non-Javan genus *Scaphochlamys*, as above explained. The terms outer and inner "outer bracteoles" are not intelligible to me.

Next follows: "3° bracteole ('inner bracteole' in the sense of Holttum) in the axil of the innermost 'outer bracteole', entirely or partly surrounding the true flower, sometimes absent". So far as I can see, I only used the term inner bracteole in two cases (generic description of *Scaphochlamys*, and fig. 20C of *Hornstedtia leonurus*) to describe the smaller secondary bracts which are enfolded by earlier ones. They are not bracts of a third order, a concept never mentioned by me.

In the whole of the above discussion on the three types of bracts Bakhuizen fails to mention to which axes the three classes of bracts or bracteoles are attached, and therefore one cannot be sure what he means. One can only infer from his later use of the terms in generic descriptions which are discussed below.

Comments on Bakhuizen's Key to the genera (1968, p. 42).

As shown in fig. 1, there is a cyme, or branch-system, in the axil of each primary bract of several genera. In one sense, this may be regarded as a branch of the inflorescence, but the axillary branch-system does not duplicate the structure of the main axis. In Malaya there are species in the genera *Plagiostachys* (Holttum 1950, p. 160), *Alpinia* (p. 140) and *Languas* (p. 156) which have true inflorescence branches in the axils of lower primary bracts (see Holttum 1950 fig. 16); these branches are identical in structure with the apex of the whole inflorescence (Holttum 1950 p. 6, last paragraph). But Bakhuizen, in his key to the genera, under "axis of the inflorescence branched" includes *Globba, Alpinia* and *Catimbium* where (in species of Java) the "branches" are not like the axis of the inflorescence but are cymes in the axils of primary bracts.

Apart from the ambiguity of the phrase "axis of the inflorescence branched", there are errors in the later part of the key. The characters given under *10 a* and *10 b* are mixed; they should be corrected as follows:

10 a. Bracts distichous, the upper ones flowering first; apex of bracteole entire; labellum often saccate, not strongly bilobed; axis of inflorescence distinctly elongate to short but not discoid .... 11. *Boesenbergia*

10 b. Bracts not distichous, lower ones flowering first; bracteole 1 (2-dentate or 2-partite) or 2 (unlobed, linear); labellum deeply bilobed, not saccate; axis of inflorescence discoid, flat or convex .... 10. *Kaempferia*

The characters under *11 a* and *11 b* are also confused. *11 a* should be corrected to "bracteoles tubular"; *11 b* needs the addition "bracteoles with free margin".

The genera Hornstedtia, Nicolaia and Achasma

Malayan species of these genera, so far as then known, were all included in *Amomum* by Baker (1892, pp 233-243) but mixed in his various subgenera. These genera all differ from *Amomum* by the fact that the lower primary bracts are larger than the later ones, which they enfold; these outer primary bracts are empty and serve for protection of the later-formed parts of the inflorescence. The three genera also differ from *Amomum* in floral structure. The basic pattern of the inflorescence is shown in fig. 3. As pointed out by Valeton (1904) and as shown in Holttum 1950 fig. 21, 22, 23, the floral structure in *Nicolaia* and *Achasma* is identical, and distinct from any species of true *Amomum*, but Bakhuizen maintains *Nicolaia* as a distinct genus and unites *Achasma* to *Amomum*. He distinguishes *Nicolaia* from *Amomum* in his key to the genera (1968, p. 42, 43) solely by the fact that in the former the inflorescence is on an erect peduncle, whereas in *Amomum* the peduncle is short and wholly or almost wholly subterranean. But in *Nicolaia solaris* (Bl.) Horan. the inflorescence is sometimes only just raised above the ground (van Steenis 1972, pl. 57, fig. 5), and in *N. hemisphaerica* (Bl.) Horan. (Bakhuizen 1968 p. 63) the peduncle is only $3\frac{1}{2}$–12 cm long. Thus Bakhuizen rates this single, not very distinctive character as of greater importance than the distinctive and uniform characters of floral structure. The coloured illustrations published by van Steenis (1972, pl. 57) show the great similarity between *N. solaris* and *Amomum* (Achasma) *coccineum* (Bl.) K. Schum. in general aspect of the inflorescence quite apart from details of floral structure.

Bakhuizen unites *Achasma* with *Amomum* because he cannot see, from herbarium specimens, that there is a clear distinction between the "outer stalk-scales [i.e. 2-ranked sheaths of the peduncle], involucral leaves [i.e. empty outer primary bracts] and bracts, which pass into one another in dried specimens". He states that in Holttum 1950, p. 183, I wrote that "involucral leaves and bracts pass into one another". What I did write was: "involucral bracts 2–8, much wider than the inner floral bracts ... Floral bracts with one flower to each, the inner ones narrow, the outer often wider and showing a transition to the involucral bracts". The "floral bracts" of this statement are the inner primary bracts which bear flowers in their axils and by this fact are distinguished from the empty outer involucral primary bracts. In the case of *Nicolaia*, which has an indentical inflorescence structure, Bakhuizen himself notes (1968, p. 62) that there is a gradual change from involucral bracts to the inner ones which have axillary flowers.

Bakhuizen further confuses the situation by using the term secondary bract for the inner primary bracts of *Nicolaia* which have axillary flowers, but in his description of *Amomum coccineum* (Bl.) K. Schum. (which belongs to *Achasma* and was so placed by Valeton) he does not. The basic distinctions between *Nicolaia* + *Achasma* and *Amomum* are that in the former the filament of the stamen and the base of the labellum are united in a separate tube beyond the apex of the corolla-tube, and the anther is massive, more or less cleft at the apex, never crested. In the key which is combined with the specific descriptions in *Amomum*, Bakhuizen (1968, p. 55, para. 8a) fails to mention these as distinctive characters; in his generic description of *Amomum* he includes "labellum ... usually not adnate to the filament, sometimes partly so", not indicating that the latter condition applies solely to *Achasma*, nor does he mention the distinctive character of the anther of *Achasma*. In his description of *Nicolaia* he does mention these identical distinctive characters. Thus he disguises the identity of floral structure in *Nicolaia* and *Achasma*. To the above distinctions may be added two others, mentioned by Valeton but not by Bakhuizen: in *Nicolaia* and *Achasma* the base of the labellum is rolled spirally inwards on withering (a conspicuous character on living inflorescences) and in both genera several flowers open simultaneously, forming a circle with the labella radiating outwards (van Steenis 1972, pl. 57, fig. 2, 5).

In my judgement, *Achasma* and *Nicolaia* should be united. The only differences are: (*a*) length of peduncle, (*b*) length of labellum, (*c*) fewer involucral bracts in some species of *Achasma*, (*d*) outer involucral bracts spreading in *Nicolaia*, not in *Achasma* (where they are prevented by the earth from spreading). These are relatively trivial characters, and none of them are very sharp. This has been noted above for the peduncle of *Nicolaia solaris*. *Amomum maingayi* Bak., which Schumann transferred to *Phaeomeria* (Holttum 1950, p. 180, fig. 21) is like *Nicolaia* in having a fairly long erect aerial peduncle, but its involucral bracts do not spread horizontally and its labellum is about intermediate in length between typical *Nicolaia* and typical *Achasma* (Valeton 1904, p. 96, suggested that such intermediates might occur.). Thus in characters *a*, *b*, and *d* there is no sharp distinction between the two genera, and in the floral characters mentioned there is quite uniform identity. As regards number of involucral bracts, in *Achasma* they are usually sufficiently numerous to give a quite distinctive aspect in living plants (which are very abundant locally in Malaya, though apparently not in Java) as shown in Holttum 1950, fig. 23A). But in two Malayan species which have only 1–3 flowers in an inflorescence the number of involucral bracts is fewer, sometimes only two. It seems to me possible that plants described as *Achasma pauciflorum* and *A. subterraneum* (Holttum 1950, p. 187) are only depauperate (or immature) forms of *A. macrocheilos* and *A. sphaerocephalum* respectively, with which species they agree in form of corolla and other details.

There is another complication to this situation, not mentioned in my work of 1950 nor by Bakhuizen, namely the existence of species in the eastern part of Malesia which were included by Valeton in the genus *Geanthus* (Valeton 1913, pp 930–936, pl. 162–166; 1914, pp 43, 55–58). These species have a floral structure as in *Nicolaia* and *Achasma* but have few or no involucral bracts. The original publication of the generic name *Geanthus* by Reinwardt (see Burtt and Smith 1972, p. 215) included species of *Hornstedtia, Achasma* and *Nicolaia. G. coccineus* (Bl.) Reinw. is recognized as the type of *Geanthus; Achasma* Griff., a later name, is certainly a synonym. But there is a much earlier generic name which certainly applies to the Malayan species *Achasma megalocheilos,* namely *Etlingera* Giseke (1792) based on a long and detailed description of *Amomum littorale* Koenig (1783; for references see Burtt and Smith 1972). It seems to me clear therefore that the species which I included in *Achasma* and *Phaeomeria* in 1950 should be transferred to the genus *Etlingera.* The problem is whether *Geanthus* sensu Valeton 1913 and 1914, which does not include an original species of *Geanthus* Reinw., should also be included.

Of the three Malayan genera recognized by me in 1950 which have large involucral bracts, *Hornstedtia* remains to be considered. Ridley (1924) included *Achasma* sensu Holttum 1950 in *Hornstedtia* because of the obvious similarity of the form of the inflorescence (which he could see from living plants). But the structure of flowers in the two genera (which Ridley did not observe carefully) is different, and they should certainly be separated. On this I have no new information, but I again call attention to the aberrant species *H. leonurus* (Holttum 1950, p. 167), which should perhaps be made the type of a new genus; excluding *H. leonurus, Hornstedtia* is very sharply distinct from *Achasma.* Bakhuizen's generic description of *Hornstedtia* (1968, p. 58) includes the following: "each involucral bract ... bearing in its axil (very) numerous secondary bracts (floral bracts), the outer ones of which (inner involucral bracts) still resemble the involucral bracts, the inner ones narrower". The fact is that all involucral bracts are *empty.* Again, as in *Nicolaia,* he refers to the bracts which subtend flowers as secondary, whereas they are primary bracts, attached to the primary axis of the inflorescence.

Alpinia and allied Genera.

As regards the genera of the *Alpinia* alliance in Malaya, Burtt and Smith point out that according to the present Code the name *Alpinia* should strictly apply to the species I have included in *Languas,* and that there is an earlier name which should replace *Catimbium.* But it is still not clear what name should replace *Alpinia* sensu Holttum 1950; this was the reason why I retained the name *Alpinia* for them (all but one had already names in *Alpinia*) and used *Languas* for *L. galanga* and its near allies. In correspondence, Mr Burtt has pointed out to me the great similarity between the flowers of *Alpinia* (*Languas*) *galanga* (L.) Willd. and *Alpinia allughas* (Retz.) Roscoe of Ceylon (Burtt and Smith 1972, fig. 3A, 3B); *A. allughas* clearly belongs to *Alpinia* sensu Holttum 1950, on account of its funnel-shaped secondary bracts. Mr Burtt suggests that *Languas* and *Alpinia,* of my arrangement of 1950, should be united, pending further study of non-Malayan species; but I still think that my *Alpinia* represents a species-group distinct from *Languas,* and that recognition of a distinct genus *Languas,* though in an illegitimate sense, is the simplest solution for the present situation, recognizing that there are extra-Malayan species which need further study and might indicate a different concept or the use of another generic name. Merely observing the rules of the Code does not ensure that one writes rational taxonomy.

Experimental investigation of inflorescence-structure

D. L. Smith (1967, p. 25) treated the developing inflorescence of a species of *Carex* with kinetin, and thereby induced the further development of a partial inflorescence which is normally reduced to one female flower. It occurs to me that treatment of young inflorescences of species of Zingiberaceae which have solitary flowers might induce the development of a branch of the cincinnus in the axil of the secondary bract which in such cases is normally empty, though no doubt experimental technique would be difficult in *Achasma* and other genera with tightly over-lapping primary bracts. If such an experiment were successful, it could throw new light on the basic inflorescence-structure in the family. Such treatment of *Kaempferia* and *Zingiber* might demonstrate that their secondary bracts are homologous with the 2-keeled first secondary bract in *Scaphochlamys;* in any event, a careful study of the development of cincinni in the group of genera called Hedychieae in my paper of 1950 is very desirable.

I have the impression that a detailed comparison of inflorescence-structure in Monocotyledons as a whole might throw much light on taxonomic problems, and that experimental work like that of D. L. Smith could be of much help in understanding relationships (perhaps in Dicotyledons also, but that is beyond the scope of my detailed knowledge). In most general taxonomic works there is detailed description of floral and fruit structure but very cursory information on branching of inflorescences. McClure (1934) was the first person to show that the bamboos of Asia show two distinct types of inflorescence-branching. Until Lane's paper of 1955 no description had ever been published of the peculiar branching of the inflorescence in *Orchidantha,* which is of much interest in relation to that of other families in Zingiberales (see Holttum 1970). Other examples might be quoted.

As Valeton showed (1904) a clearly defined classification of Zingiberaceae is impossible without reference to inflorescence-characters; Schumann's attempt (1904) to define genera on floral characters alone led to much confusion. I found that he had species of both *Boesenbergia* and *Scaphochlamys* in his genus *Gastrochilus* and also in *Kaempferia,* and some species of *Scaphochlamys* in *Curcuma.* Hutchinson's latest account of the family (1973) is still based mainly on Schumann (little changed by Loesener in 1930) and incidentally retains Ridley's "genera" *Conamumum* and *Carenophila.* Ridley's descriptions of these were so inaccurate that Schumann placed *Conamumum* and Loesener the later-described *Carenophila* in the tribe Hedychieae, whereas examination of the type specimens in Singapore shows that they belong to Alpinieae. *Conamomum* in Ridley 1924 consists of two species of *Amomum* and one of *Geostachys;* the sole species of *Carenophila* also belongs to *Geostachys.* The full classification of the family will not be understood until much further study, from fresh material, of the species in the eastern part of the Malayan region has been undertaken. It is very gratifying to know that such study is being pursued by Mr Burtt and Miss Smith at Edinburgh, but there is much still to be done.

Literature Cited

Bakhuizen van den Brink, R. C. Jr. 1968. Zingiberaceae, in Backer & Bakhuizen, Flora of Java, vol. 3: 41–76. Wolters-Noordhoff, Groningen.

Baker, J. G. 1892. Scitamineae, in J. D. Hooker, Flora of British India, vol. 6: 198 — 264. Reeve, London.

Burtt, B. L. and R. M. Smith. 1972. Key species in the taxonomic history of Zingiberaceae. Notes R. Bot. Gard. Edinburgh 31: 177 — 227.

Holttum, R. E. 1950. The Zingiberaceae of the Malay Peninsula. Gard. Bull. Singapore 13: 1 — 249, fig. 1 — 33.

——— 1970. The genus Orchidantha (Lowiaceae). Gardens Bull. Singapore 25: 239 — 246.

Hutchinson, J. 1973. The families of Flowering Plants, 3rd edition. Oxford, Clarendon Press.

Lane, I. E. 1955. Genera and generic relationships in Musaceae. Mitt. Bot. Staatssamml. München 13: 114 — 141.

Loesener, T. 1930. Zingiberaceae, in Engler & Prantl, Nat. Pflanzenfam. 2 Aufl. Bd. 15a.

McClure, F. A. 1934. The inflorescence in *Schizostachyum* Nees. Journ. Wash. Acad. Sci. 24: 541 — 548.

Ridley, H. N. 1924. Flora of the Malay Peninsula, vol. 4. Reeve, London.

Schumann, K. 1904. Zingiberaceae, in A. Engler, Das Pflanzenreich IV, 46. W. Engelmann, Leipzig.

Smith, D. L. 1967. The experimental control of inflorescence development in Carex. Ann. Bot., N. S. 31: 19 — 30.

Steenis, C. G. G. J. van. 1972. The mountain flora of Java. E. J. Brill, Leiden.

Valeton, T. 1904. Uber neue und unvollstandig bekannte Zingiberaceae aus West-Java und Buitenzorg. Bull. Inst. Bot. Buitenzorg 20: 1 — 99.

——— 1913. Zingiberaceae. Nova Guinea 8: 923 — 988, t. 162 — 179.

——— 1914. Die Zingiberaceen Deutsch-Neu-Guineas. Bot. Jahrb. 52: 40 — 100.

The Tree-ferns of the genus Cyathea in Borneo

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The most complete taxonomic account of the tree-ferns of Borneo is contained in Flora Malesiana, Series II (Pteridophyta) vol. 1, part 2 (1963), which covers the whole of Malesia and includes descriptions of 191 species. For identification of the 29 species of Borneo therefore it is necessary to use elaborate keys which were designed to cover a much wider range of species. The present paper is based on the work of 1963, since which little new information has been obtained, but the keys are revised and simplified to facilitate identification of Bornean species. Some additional information about local distribution is also given.

The present paper is written in the hope that it may help people who have the opportunity of making new observations on these plants. The descriptions are a summary of the characters of specimens seen by me, and anyone studying them in comparison with living plants will find gaps in the information here provided. I hope that some local naturalists will be able to take up this study, and I will do my best to help any such persons who will communicate with me. In particular, it is desirable that the keys to species should be revised, to include more characters which are easily observable in the field; many characters in the present keys can only be seen by careful use of a hand lens. Such a new key would help other local naturalists, and perhaps help to ensure that all species of this very interesting group of ferns are allowed to persist, in spite of increasing destruction of natural forest.

Almost all the species occur within the Mount Kinabalu National Park in Sabah or in neighbouring lowland forest, so that the present account covers the special needs of field botanists in the national park. Six* species are only known from Mt Kinabalu: *C. longipes, C. acanthophora, C. havilandii, C. stipitipinnula, C. discophora* and *C. megalosora*.

Cyathea plants may be recognized in nearly all cases by the presence of a trunk bearing moderately to very large bipinnate fronds which bear scales at the bases of their stipes (petioles). There is one tree-fern of the genus *Dicksonia* (*D. mollis Holtt.*) in forest on Mt Kinabalu at 5000-6500 ft; it has dense reddish hairs on its stipes, not scales, and sori in marginal pouches. Four species of *Cyathea* in Borneo have simply pinnate fronds and at most very short trunks; their indusia, if present, identify them generically, also their scales on stipe-bases which have minute oblique dark marginal setae.

Diagnostic characters for recognition of species

The most important characters for the main subdivision of the genus are found in the large scales at the bases of stipes. These are best seen on young fronds; old ones may lose most of them. When collecting herbarium specimens,

* The seventh, *C. brachyphylla* Holttum sp. nov. is described in the Addendum.

one can cut off a thin strip 5–10 cm long from the scale-bearing surface of the stipe; this is much more easily dried than a whole stipe. An additional character shown by the stipe is the distribution and shape of the areas, on each side of the stipe, where aerating tissue comes to the surface (called pneumathodes, or linear aerophores). These areas are almost white, and their surface is broken when old; they usually form a discontinuous line on each side of the stipe, or sometimes a double line. When whole stipes are dried, they shrivel along these lines, so that the shape and distribution of pneumathodes cannot be seen in most herbarium specimens, and in most cases information about them has not been recorded. A thin strip cut along the side of the stipe, to include several pneumathodes, is easily dried and provides permanent information in the herbarium.

The length of the stipe and size of the lowest pinnae may be important. In some species (e.g. *C. loheri*) the stipe is very short and the lower pinnae are gradually smaller, the lowest quite short. In two Bornean species there are very small pinnae at the base of the stipe, and then a long gap to the large pinnae; these basal pinnae should be looked for.

The other characters are best shown by the largest middle pinnae of a frond. Except in the simply pinnate fronds of a few species, these middle pinnae carry pinnules of almost uniform size for the greater part of their length; it is these pinnules which are described in the detailed descriptions of species, and their size, shape, depth of lobing and venation are important. On the upper surface of pinna-rachises and costae of pinnules there are always short curved hairs, but the occurrence and character of hairs and scales on the *lower* surface are much more varied and must be observed carefully; they may be seen in sufficient detail with a hand lens of 10 X magnification. These scales and hairs are in all cases mentioned in the present paper.

Sori are also important diagnostically, and have indusia of various shapes, or sometimes no indusia. Some indusia are very small and can only be seen by carefully removing the sporangia. The hairs which occur among the sporangia (paraphyses) are sometimes distinctive. In one Bornean species (*C. tripinnata*) there are false indusia formed by overlapping separate scales; these are not easy to see with a hand lens, but fortunately the species is easy to recognize from the fully tripinnate fronds which occur in no other species.

Classification

The classification here adopted is that of Flora Malesiana, with a change of subgeneric name which must be explained. In Flora Malesiana I divided the genus *Cyathea* into two subgenera, subg. *Cyathea* and subg. *Sphaeropteris*. The type species of *Cyathea, C. arborea* (L.) Sm., is native in the West Indies; I regarded the Malesian species placed in subg. *Cyathea* as closely related to it. But Dr R. M. Tryon subsequently made a new study of tropical American tree-ferns (Contr. Gray Herb. no. CC, 1970) and showed that *C. arborea* and some related species have stipe-scales of a distinct type not found in any species of the Old World. Dr Tryon also considered that subg. *Sphaeropteris* is sufficiently distinct to rank as a separate genus (there are a few species in tropical America). Thus he needed a new generic name for the Malesian species of *Cyathea* subg. *Cyathea* of my treatment, and the oldest available name is *Alsophila* R. Br. (type species *A. australis* R. Br. of Australia). He transferred all Malesian species of *Cyathea* subg. *Cyathea* to the genus *Alsophila,* and all in subg. *Sphaeropteris* to the genus *Sphaeropteris*. But in my view the differences are hardly of generic rank; this is supported by the fact that species of both subgenera have the peculiar chromosome number 69. Therefore I retain the genus *Cyathea* for Malesian species, substituting subg. *Alsophila* for subg. *Cyathea;* the name subg. *Cyathea* should then be restricted to the tropical American species related to *C. arborea.*

A further note on the generic name *Alsophila* is desirable because it was used in the past in a quite different sense. The type species *A. australis* has no indusia, and in the 19th century this was regarded as the prime distinguishing character of the genus, which thus was made to include all then known species of *Cyathea* (in the sense of the present paper) which had no indusia. But Copeland pointed out (Philip. Journ. Sci. 3C: 353; 1909) that such a definition brings together species which are not allied; in the classification of the present paper it will be seen that exindusiate species occur in both subg. *Alsophila* and in subg. *Sphaeropteris,* and in each case the exindusiate species certainly conform in all other characters to their own subgenus. The genus *Alsophila,* as defined by Tryon, includes species with and without indusia; thus it has a significance quite different from that given to it by 19th century pteridologists (e.g. Beddome in his Handbook to the Ferns of British India, 1883).

Prior to Flora Malesiana, the most important publication on the ferns of Mt Kinabalu was in Gardens Bulletin S. S. vol. 7 (1934) 191 — 324, in which Carl Christensen gave an annotated list, based on all known collections including those made by J. C. and M. S. Clemens in 1931-32 and my own of 1931, which together doubled the number of species known from the mountain, and included reference to a few from other parts of Borneo. The paper includes an account of my itinerary, with notes on ferns seen (pp. 185 — 206). The number of species of *Cyathea* in that paper was 18. In some cases the nomenclature of the present paper differs from that of Christensen of 1934; references are given to all such cases.

When preparing my account of *Cyathea* for Flora Malesiana I examined type specimens of all previously published species, few of which had been described in sufficient detail for clear recognition, with the result that all comparative taxonomic statements were in some measure confused. I found for example that no two accounts of the species of *Cyathea* in the Nature Reserve adjacent to the mountain garden at Tjibodas in Java agreed as to number of species and distinction between them, though this forest had been studied more carefully than any other area in Malesia. This was due to the fact that scales on pinnules, and indusia, had not been examined in sufficient detail. When re-describing type specimens I discovered that many Malesian species had received more than one name, so that many earlier names appear as synonyms in Flora Malesiana. I have not cited all these synonyms, except those used by Christensen in 1934, nor have I cited previous descriptions of the species, which are mostly inadequate where they are not also inaccurate; they are not reliable as indicators of distribution of species. I have also not included Dr Tryon's new names, which may all be found in his publication cited above. References to the account of *Cyathea* in Flora Malesiana, Series II, vol. 1 (1963), are given as F.M. with page number.

Key to the Subgenera and Sections

Stipe-scales usually dark and rigid, always with fragile edges which are eroded when old and may or may not bear irregular dark setae; hairs on lower surfaces, if present, crisped and appressed; indusia in some cases attached only on side of sorus remote from edge of pinnule-segment .... subg. **Alsophila**

Indusia present (sometimes very small, hidden by sorus); rachises usually green when fresh, never dark chocolate-brown; fertile and sterile pinnules of almost uniform size .... sect. *Alsophila*

Indusia absent; rachises dark chocolate-brown; fertile pinnules usually narrower, or with narrower lobes, than sterile .... Sect. *Gymnosphaera*

Stipe-scales usually thinner and paler, of uniform texture, with very short (usually darker) setae set obliquely on their edges; hairs on lower surface, if present, stiff and spreading erect from surface; indusia completely covering sorus and breaking at maturity, or lacking (in a few cases imperfect as an irregular ring round base of sorus), never attached on one side .... Subg. **Sphaeropteris**

Pinnules commonly 10–15 cm long, lobed almost to costa throughout or fully pinnate; costules not over 4 mm apart on pinnules 10 cm long; basal basiscopic vein of each group arising from costule above its base.. Sect. *Sphaeropteris*

Free tertiary leaflets few, sori indusiate or not, never covered by overlapping scales .... subsect. *Sphaeropteris*

Free tertiary leaflets present on all pinnules; sori covered by overlapping scales which simulate an indusium .... subsect. *Fourniera*

Pinnules rarely to 10 cm long, lobed less deeply, or pinnae undivided; costules usually 4 mm or more apart; basal basiscopic vein of each group arising from costa near base of costule .... Sect. *Schizocaena*

SUBG. *Alsophila* SECT. *Alsophila*

1. Stipe conspicuously spiny in basal part, spines 4–5 mm long:
   2. Pinnules all stalked except distal ones .... 1. *C. longipes*
   2. Pinnules not stalked, ± jointed to rachis .... 2. *C. acanthophora*
1. Stipe ± warty at base, lacking slender spines:
   3. Lower surface of costae densely and persistently scaly; indusium conspicuous, covering sorus to maturity:
      4. Pinnules commonly to $2\frac{1}{2}$ cm long; pinna-rachis densely scaly .... 3. *C. havilandii*
      4. Pinnules commonly to $7\frac{1}{2}$ cm or more long; pinna-rachis glabrescent:
         5.* Stipe 50 cm or more long; basal pinnae not greatly reduced .... 4. *C. oosora*
         5.* Stipe much shorter; lower pinnae gradually reduced, lowest c. 7 cm long .... 5. *C. loheri*
   3. Lower surface of costae not densely scaly; indusium small, at maturity reflexed against costule or covered by sorus:

6. Pinnules commonly more than 2 cm wide, with wide sinuses between lobes .... 6. *C. incisoserrata*
6. Pinnules less than 2 cm wide, sinuses between lobes narrow:

* See modification in Addendum, p. 181.

7. Indusium reflexed against costule and usually visible at maturity of sorus; paraphyses short .... 7. *C. borneensis*
7. Indusium very small, covered by mature sorus; paraphyses longer than sporangia, 2–4 cells wide at base .... 8. *C. latebrosa*.

1. **Cyathea longipes** Copel., Philip. Journ. Sci. 12C(1917) 54. Gard. Bull. S. S. 7(1934) 205, 222. F.M. 98.

Stipe slender, to 200 cm long, dark and copiously spiny near base, spines to 5 mm long; basal scales early caducous, rather broad (they need further examination). Pinnae to at least 70 cm long; pinnules all stalked except distal ones, stalks of lowest on lower pinnae 10 mm long, on smaller pinnae 3–6 mm; largest pinnules 10–13 × 2.0–3.2 cm, acuminate, 1–2 pairs basal segments free or connected by a narrow wing along costa; rest of pinnule lobed almost to costa, lobes crenate, costules 4½–6 mm apart; veins to 10 pairs. Sori near costules; indusium rather thin, covering young sori, breaking irregularly at maturity. Main rachis and pinna-rachises green, lacking scales beneath, with scattered short spines: scales on lower surface of costae ovate-acuminate, thin, entire, brown, distal ones shorter and ± bullate; bullate acuminate scales on costules.

Only known from Mt Kinabalu; formerly abundant in ridge forest on Penibukan and Marei-Parei ridge, at 4000–5500 ft.

2. **Cyathea acanthophora** Holtt., Kew Bull. 16(1962) 51. F.M. 93.

Sinilar to *C. longipes* in spines on stipe, and in scales and sori, differing as follows: stipe to 80 cm long; basal scales to 20 × 1 mm (only seen on a young frond); pinnules not stalked, more or less jointed to pinna-rachis, smaller (8½–10 cm × 1.5–1.8 cm), without free basal segments.

Only known from Mt Kinabalu, on the Kamborangah ridge, at 6000–7000 ft.

3. **Cyathea havilandii** Baker, Trans. Linn. Soc. II Bot. 4(1894) 249. Gard. Bull. S. S. 7(1934) 202, 221. F.M. 96.

Trunk short; fronds mostly almost erect, to 100 cm long, densely scaly throughout. Stipe 30–40 cm; scales near base to 15 × 1–2 mm, shining medium brown with very narrow fragile edges, scales on upper part of stipe smaller. Largest pinnae 10–16 cm long; pinnules to 2.5 cm × 7 mm, only a few free near bases of largest pinnae, rest connected by a narrow wing along pinna-rachis; largest pinnules, where fertile, lobed ½ way to costa, where sterile less deeply. Sori in a single row on each side of costae of pinnules; indusium firm and dark, breaking irregularly at maturity. Scales on costae bullate with flexuous hair-tips 1 mm or more long.

Only known from Mt Kinabalu, in Leptospermum — Dacrydium forest on ridges at 8000–10,000 feet.

4. **Cyathea oosora** Holtt., Kew Bull. 16(1962) 59. F.M. 101.

Stipe 50 cm or more long, warty near base; pneumathodes 14–20 mm long in an almost continuous line, scales not seen. Largest pinnae 60 cm long; pinnules to 9 × 2 cm, sessile or nearly so, lobed almost to costa, lobes rigid, crenate: costules 3½–4 mm apart, veins 9–10 pairs. Sori near costules; indusium firm, brown, at first ovoid with a small apical aperture, later breaking irregularly. Pinna-rachis bearing a few narrow brown scales 3–4 mm long; costae densely scaly, scales uniformly brown, lower ones elongate, grading to hair-pointed bullate scales distally and on costules.

Distribution: Mt Kinabalu at 7000–10,000 ft; also from Mt Rante Mario in S. W. Celebes at 10,000 ft. The Celebes specimens differ in having paler scales on costae.

5. **Cyathea loheri** Christ, Bull. Herb. Boiss. II, 6(1906) 1007. F.M. 104. — *C. korthalsii* sensu C. Chr., Gard. Bull. S. S. 7(1934) 222, non Mett.

Trunk to 10 m tall. Stipe short; scales to 25 × 1½–3 mm, pale, firm, their fragile edges bearing scattered long setae; pneumathodes to 11 mm long. Lower pinnae gradually smaller, lowest 7 cm long, longest 40 cm or more; largest pinnules 7½–9½ × 1½–2 cm, sessile, short-acuminate, lowest 1–4 segments ± contracted at base, rest of pinnule lobed almost to costa, segments deeply crenate where fertile; costules 3½–4 mm apart, veins 10–12 pairs. Sori near costules; indusium firm, shining brown, almost covering sorus to maturity but open on side remote from costule, breaking when old. Pinna-rachis at first densely scaly, larger scales pale with some dark setae; scales at base of costae light brown with marginal hairs or setae, grading to bullate scales distally and on costules.

Distribution: Mt Kinabalu, near streams in forest in deep valleys at 7000–9000 ft; Philippines (Luzon, Negros, Mindanao); Taiwan.

This species apparently occurs at lower altitudes in the Philippines than on Mt Kinabalu. Young plants found by me had long stipes, the lower pinnae not greatly reduced. The stipe-scales are distinctive.

6. **Cyathea incisoserrata** Copel., Philip. Journ. Sci. 6C(1911) 361. F.M. 113, fig. 18. — *Alsophila latebrosa* var. *ornata* Ridl., Journ. Mal. Br. R. Asiat. Soc. 4 (1926) 8.

Trunk to about 4 m tall; stipe to 85 cm, warty or with short conical spines at the base; scales sparse, to 10 × 1 mm, dark with narrow quickly abraded fragile edges; pneumathodes in a double row on each side of stipe, almost continuous. Lower pinnae slightly reduced, longest 70 cm long; pinnules commonly 10 × 2½ cm, to 12 × 3½ cm, sessile, deeply lobed, lobes crenate and separated by wide sinuses; costules 4½–5½ mm apart, veins 12–15 pairs. Sori near costules; indusium very small, on one side of base of sorus, covered by sporangia; paraphyses longer than sporangia, flat and 2–3 cells wide at base. Lower surface of pinna-rachis pale green, smooth; scales near bases of costae elongate, flat, entire, grading to bullate scales distally and on costules.

Distribution: lowland forest in Malaya and Sarawak. This is very near *C. latebrosa* (no. 8) but seems to be constantly distinct.

7. **Cyathea borneensis** Copel., Philip. Journ. Sci. 6C(1911) 135. F.M. 110, — *C. obtusata* Rosenst., Med. Rijksherb. no. 31(1917)1; Holttum, Rev. Fl. Mal. 2 (1955) 121.

Trunk to 2 m or more tall; stipes c. 25 cm, dark and warty at base, scales to 15 × 1 mm, dark, glossy, with narrow fragile edges; pneumathodes 12–18 mm long. Lower pinnae rather irregularly reduced, lowest c. 10 cm long, longest 60 cm; largest pinnules 8–10 × 1.7–2.2 cm, deeply lobed, lobes almost entire; costules 3½–5 mm apart, veins to 10 pairs. Sori near costules; indusium rather thin, on costular side, pressed against costule at maturity of sorus; paraphyses short. Pinna-rachis green, ± suffused with purple, bearing crisped hairs distally on lower surface; scales on costae dark, entire, flat or with bullate base, grading to dark bullate scales distally and on costules.

Distribution: Sarawak and Sabah, in lowland forest and to 3500 ft, but not recorded for Mt Kinabalu; Malaya and Peninsular Thailand.

8. **Cyathea latebrosa** (Hook.) Copel., Philip. Journ. Sci. 4C(1909) 52. Gard. Bull. S. S. 7(1934) 195, 198, 222. F.M. 115. — *Alsophila latebrosa* Hook., Spec. Fil. 1 (1844) 37.

Similar to *C. incisoserrata* (no. 6) but smaller, with smaller pinnules having costules 3–4 mm apart and narrow sinuses between the lobes; pneumathodes on stipe in a single row on each side.

Distribution: throughout Borneo; Sumatra, Malaya, Thailand to Hainan, in forest or on edges of forest, in low country and to 4500 ft.

SUBG. *Alsophila* SECT. *Gymnosphaera*

1. Base of stipe bearing reduced pinnae, widely separated from normal pinnae:
    2. Small basal pinnae with many narrow persistent segments, green when young, soon turning brown .... 9. *C. ramispina*
    2. Small basal pinnae stiffly spreading, with few slightly-lobed leaflets, spine-like when old .... 10. *C. recommutata*

.1. Base of stipe lacking reduced pinnae .... 11. *C. glabra*.

9. **Cyathea ramispina** (Hook.) Copel., Philip. Journ. Sci. 4C(1909) 36. Gard. Bull. S. S. 7(1934) 200, 222. F.M. 117. — *Alsophila ramispina* Hook., Syn. Fil. (1866) 42.

Trunk rather slender, to 2 m tall, persistently covered with the finely divided basal pinnae which remain attached to the old leaf-bases (the youngest ones green and covering the apex of the trunk). Stipe dark, almost covered with small scales, basal scales very dark, glossy, to 10 × 1½ mm with pale fragile edges. Normal pinnae to 45 cm long; pinnules slightly dimorphous (fertile smaller), lowest with stalks 2–3 mm long, largest 7–9 × 1½–2 cm, lobed to about 2 mm from costa, lobes slightly crenate; costules 4–4½ mm apart, veins to 8 pairs, usually all simple. Sori without indusia, distal ones close to costule, lower ones more distant from it. Scales on costae and costules narrow, dark, glossy with pale edges, grading to pale bullate scales.

Distribution: Sarawak and Sabah, in ridge forest at 6000–7000 ft on Mt Kinabalu; at 3000–4500 ft in Sarawak; also at 500 ft on a sandstone hillside in Tawao, Sabah.

10. **Cyathea recommutata** Copel., Philip. Journ. Sci. 4C(1909) 36. Gard. Bull. S. S. 7(1934) 198, 220. Holttum, Rev. Fl. Mal. 2 (1955) 125. F.M. 118, fig. 19a, b, 20d.

Habit of *C. ramispina* but basal small pinnae not so closely placed, rigidly spreading on each side of base of stipe, bearing few less deeply lobed leaflets which often become detached so that the reduced pinnae are like stout spines when old. Largest pinnae 40 cm long; pinnules rather strongly dimorphous, sterile to 1.6 cm wide with costules 4–4½ mm apart, fertile 6–12 mm wide with closer costules.

Distribution: Borneo, Malaya, central and southern Sumatra; in forest, usually at lower altitudes than *C. ramispina,* on Mt Kinabalu at 4500 ft; also occurring in several parts of Borneo in lowland swamp forest on sandy ground.

11. **Cyathea glabra** (Bl.) Copel., Philip. Journ. Sci. 4C(1909) 35. Holttum, Rev. Fl. Mal. 2(1955) 127. F.M. 120. — *Gymnosphaera glabra* Bl., Enum, Pl. Jav. (1828) 242. — *Alsophila vexans* Cesati, Atti Acad. Napol. 7, no. 8(1876) 4. — *Cyathea vexans* (Ces.) C. Chr., Gard. Bull. S. S. 7(1934) 218.

Trunk rather slender; stipes very dark; basal scales dark, glossy with pale fragile edges. Lower pinnae sometimes much reduced but not remote from rest; largest pinnae 45–55 cm long; largest pinnules 9–12 × 1½–2 cm, lowest on stalks 2–4 mm long, edges crenate to slightly lobed, not or little dimorphous; costules 4–5 mm apart; veins 3–5 pairs, simple. Sori without indusium. Scales on costae few, narrow, dark with pale edges which often bear a few dark setae; no bullate scales.

Distribution: West Java, Sumatra, Malaya, Borneo; in lowland swamp forest and in mountain forest to 5000 ft. There has been much confusion in the use of the specific name *glabra,* and there are other synonyms.

Subg. *Sphaeropteris* sect. *Sphaeropteris*

1. Free tertiary leaflets few:
    2. Stipe minutely warty at base; lower surfaces of costae copiously hairy throughout; indusia present .... 12. *C. leucotricha*
    2. Stipe strongly spiny at base; lower surface of costae bearing a few hairs distally; no indusia .... 13. *C. contaminans*
1. Free tertiary leaflets present on all pinnules .... 14. *C. tripinnata*

12. **Cyathea leucotricha** Christ, Ann. Jard. Bot. Btzg 20(1905) 135. F.M. 127.

Height of trunk not recorded. Stipe 50 cm, minutely warty; basal scales early caducous, dark brown with concolorous marginal setae. Largest pinnae 60 cm long; largest pinnules 9–12 × 1½–2 cm, 1–3 basal segments free or nearly so, rest of pinnule lobed almost to costa, lobes crenate; costules 4–5 mm apart, veins 10–12 pairs. Sori nearer to costule than to edge, indusiate; indusium pale, thin, breaking irregularly at maturity. Pinna-rachis glabrescent; costae and costules bearing many stiff spreading pale hairs on lower surface; a few narrow pale scales with dark setae near bases of costae.

Distribution: in lowland forest, recorded for several widely-spaced localities in Sarawak, Brunei and Kalimantan. This species is interesting because very few others in this section have indusia. More information about it would be welcome.

13. **Cyathea contaminans** (Hook.) Copel., Philip. Journ. Sci. 4C(1909) 60. Gard. Bull. 7(1934) 196, 222. Holttum, Rev. Fl. Mal. 2(1955) 119. F.M. 135. — *Alsophila contaminans* Hook., Spec. Fil. 1(1844) 52.

Trunk often very tall, much thickened by adventitious roots at base, when old showing leaf-scars on upper part. Stipe to 100 cm long, pale glaucous, purplish towards base which is strongly spiny and covered with pale brown scales varying in size up to 45 × 3 mm, very thin with short dark marginal setae; main rachis bearing many short spines throughout. Lowest pinnae somewhat reduced with stalks to 10 cm long; largest pinnae 60 cm; pinnules to 15 × 3 cm, often smaller, lowest distinctly stalked, largest with 1–2 pairs basal segments ± free, rest lobed almost to costa, lobes crenate, glaucous beneath; costules 4–4½ mm apart, veins commonly 12 pairs. Sori near costules, no indusia. Lower surface of costae bearing at first scattered narrow pale setiferous scales which soon fall; costular scales small, ovate, pale-fringed, soon caducous; a few hairs pairs present on lower surface of costae and costules near pinna-apex, variable in number; on Mt Kinabalu erect hairs may also be presented on lower surface of veins.

Distribution: throughout Malesia, in clearings and open places in forest, especially near streams, at 1000–5000 ft, often abundant. This is now by far the most conspicuous tree-fern at lower levels in Mt Kinabalu National Park.

14. **Cyathea tripinnata** Copel., Philip. Journ. Sci. IC, Suppl. 4 (1906) 251. Gard. Bull. S. S. 7(1934) 198, 222. Holttum, Rev. Fl. Mal. 2(1955) 120. F.M. 140.

Trunk 4–5 m tall; stipes to at least 40 cm, dark, bearing scattered sharp spines 1–3 mm long, covered almost throughout by a felt of very small setiferous scales, basal scales to 25 × 1 mm, thin and soft, matted together. Lowest pinnae 20–30 cm long, largest 60 cm; pinnules 9–14 × 1½–2½ cm, fully pinnate; tertiary leaflets to 15 × 3½ mm, largest deeply lobed at base, lower ones distinctly stalked; veins to 9 pairs, those in free basal lobes pinnate. Sori near midribs of tertiary leaflets, covered at maturity by overlapping thin pale scales. Lower surfaces of pinna-rachis, costae and costules bearing minute pale fringed scales.

Distribution: Pulau Tioman, Sabah, Philippines (Luzon to Mindanao), Amboina. The specimens from West Java which I formerly identified with this species appear to be distinct, matching recent collections from southern Sumatra; these will be described elsewhere as a new species of subsect. *Fourniera.*

SUBG. *Sphaeropteris* SECT. *Schizocaena*

1. Fronds sinply pinnate, pinnae entire or crenate-serrate:
   2. Apex of frond a deltoid deeply lobed lamina; pinnae sessile; basal veins anastomosing .... 15. *C. capitata*
   2. Apex of frond pinna-like; pinnae usually stalked; veins free:
      3. Pinnae not over 1.5 cm wide, stalks to 12 mm long; sori in 1–2 rows on each side of costa, fully indusiate .... 16. *C. angustipinna*
      3. Pinnae 2–4 cm wide, stalked or not; sori on fully fertile pinnae in more than 2 rows, indusiate or not:
         4. Pinnae not long-acuminate, upper usually sessile .... 17. *C. moluccana*
         4. Pinnae long-acuminate, all stalked .... 18. *C. arthropoda*
1. Fronds simply pinnate with deeply lobed pinnae, or bipinnate:
   5. Fronds simply pinnate with deeply lobed pinnae, or largest pinnae sometimes with free pinnules at their base:
      6. Pinnae commonly 25 cm long; no long pale hairs on lower surface of rachis .... 19. *C. alternans*
      6. Pinnae sometimes shorter; main rachis bearing long pale hairs on lower surface .... 20. *C. trichophora*

5. Fronds amply bipinnate:
   7. Sori indusiate (indusium sometimes reduced to a disc hidden by sorus):
      8. Basal pinnules of middle pinnae with stalks to at least 4 mm long:
         9. Pinnules lobed less than ½ way to costa; no free basal segments .... 21. *C. stipitipinnula*
         9. Pinnules lobed to 1–2 mm from costa; larger pinnules with 1–2 free basal segments .... 22. *C. assimilis*
      8. Basal pinnules sessile or nearly so;
         10. Indusium a disc hidden by sorus; basal pinna-lobes not free .... 23. *C. discophora*
         10. Indusium complete, covering sorus to maturity .... 24. *C. megalosora*
   7. Sori without indusia:
      11. Long spreading hairs abundant on lower surface of rachis and/or pinna-rachis, often also on costae:
         12. Costules and veins bearing hairs like those of costa on lower surface:
            13. Pinnules lobed ⅔ – ¾ towards costa; costules 4 mm or more apart .... 25. *C. trichodesma*
            13. Pinnules lobed to within 1 mm from costa; costules 3–3½ mm apart .... 26. *C. wallacei*
         12. Costules and veins lacking hairs on lower surface .... 20. *C. trichophora*
      11. Long spreading hairs lacking on lower surface of rachises:
         14. Largest pinnules with a free segment at base; pinnules on stalks to 4 mm or more long .... 27. *C. polypoda*
         14. Largest pinnae lacking free basal segment, almost sessile:
            15. Bullate scales lacking on costae and costules; pinnules lobed to less than 1 mm from costa .... 28. *C. agatheti*
            15. Bullate scales present on costae and costules; pinnules less deeply lobed ...... 29. *C. squamulata*

15. **Cyathea capitata** Copel., Philip. Journ. Sci. 12C(1917) 49. Gard. Bull. S. S. 7(1934) 201, 218. F.M. 142.

Trunk 1–3 m tall; stipe dark, to at least 40 cm long; basal scales brown, firm, to 25 × 3–4 mm, edges bearing concolorous setae. Apex of frond broadly deltoid and deeply lobed, grading into upper pinnae; pinnae to 40 pairs, jointed to rachis, largest 15–19 × 2–3 cm, edges entire except near apex, base truncate to cordate; veins in pinnate groups of c. 3 pairs, outer members of each group anastomosing with those of adjacent groups. Sori usually in 2 rows on each side of the costa of a pinna; indusium thin, completely covering young sorus, breaking when old.

Distribution: Sarawak (Mt Murud), Sabah (Mt Kinabalu), in wet ground near streams in forest at 4500–6000 ft.

16. **Cyathea angustipinna** Holtt., Kew Bull. 16(1962) 52. F.M. 143.

Trunk to at least 50 cm tall; stipe c. 30 cm, basal scales pale, firm, to 20 × $1\frac{1}{2}$ mm, marginal setae dark. Pinnae c. 18 pairs, to 12 cm long, sterile to 1.6 cm wide, fertile 1.0–1.2 cm, base narrowly cuneate, stalks to 12 mm long, edges entire except near apex; veins in groups of 3, basal one attached separately to costa, free. Sori in 2 rather uneven rows on each side of costa, indusiate as in *C. capitata.*

Distribution: known only from 2 collections on Mt Dulit, Sarawak, on sandy bank of stream near waterfall, in forest, at 4000 ft.

17. **Cyathea moluccana** R. Br. in Desv., Mem. Soc. Linn. Paris 6(1827) 322. F.M. 143. — *C. kinabaluensis* Copel., Philip. Journ. Sci. 12C(1917) 50. C. Chr., Gard. Bull. S. S. 7(1934) 218. — *C. brunonis* Hook., Gen. Fil. (1838) t.2. Holttum, Rev. Fl. Mal. 2(1955) 117.

Trunk to 50 cm tall; stipe 20–30 cm, basal scales medium brown, 15–30 x $\frac{1}{2}$–3 mm, edges with concolorous setae. Leafy part of frond to 150 cm or more long; apical lamina a pinna like the rest; pinnae jointed to rachis, stalked or the upper ones sessile, 12–28 × 2–4 cm, base broadly cuneate, edges entire except for short-acuminate crenate apex; veins as in *C. angustipinna,* but the middle vein of each group forked once or twice. Sori in 1–3 rows on each side of costa, commonly 4–6 on each vein-group, indusium as *C. capitata* or in some cases only forming a disc which is hidden by sorus.

Distribution: Central Sumatra, Malaya, Lingga, Borneo (excluding south and south-west), South & Central Celebes, Moluccas (Ceram, Amboina), in forest, low country to 3000 ft.

Copeland in 1917 described three exindusiate species from Mt Kinabalu, *C. kinabaluensis, C. pseudobrunonis* and *C. fuscopaleata,* distinguishing them by size and colour of stipe-scales, but I cannot see clear distinctions between them, and none are totally without indusia. See note under *C. alternans.*

18. **Cyathea arthropoda** Copel., Philip. Journ. Sci. 6C(1911) 134, t.13. F.M. 143.

Habit of *C. moluccana,* differing: all pinnae stalked, stalks of upper ones 5 mm, of lower ones 12–15 mm; shape of pinnae narrowly elliptical (sides not parallel as in *C. moluccana*) with a caudate apex to 4 cm long; indusium a narrow irregular ring hidden by sorus.

Distribution: Sarawak, Bongo Range. The shape of pinnae appear to distinguish this from *C. moluccana,* but the latter is variable and needs more study in Borneo.

19. **Cyathea alternans** (Hook.) Presl, Abh. K. Böhm. Ges. Wiss. V, 5(1848) 347. Gard. Bull. S. S. 7(1934) 219. F.M. 145 — *Hemitelia alternans* Hook., Ic. Pl. 7(1844) t. 622.

Trunk usually less than 2 m tall; stipe to 60 cm, dark, basal scales to 30 × 2 mm. Pinnae jointed to rachis, lowest sometimes reduced, largest commonly 25 × 4–5 cm, in some cases to 40 × 9 cm, deeply lobed throughout (lobes entire, rounded at apex) or with few to many of the lobes acute at apex and separately joined by their contracted bases to axis of pinna, rarely 1–2 basal ones as quite free pinnules; veins varying in number according to size of pinna-lobes. Sori usually in one row on each side of costules of a pinna-lobe; indusium sometimes completely covering sorus to maturity, more often forming an irregular disc round base of sorus. Scales on lower surface of pinna-midrib and costules of lobes usually sparse, narrow, setiferous; bullate scales sometimes present on costules, sometimes also thick pale hairs.

Distribution: Sumatra, Malaya, Borneo, in forest, 1000–4000 ft.

The variable plants here included are always found growing in association with *C. moluccana,* and are in several respects intermediate between *C. moluccana* and *C. squamulata* (no. 29). The latter is fully bipinnate and quite exindusiate. If *C. alternans* does in fact represent a series of hybrids, the existence of plants otherwise almost indistinguishable from *C. moluccana* could represent extreme cases of introgressive hybridization. Experimental study of these plants is desirable.

20. **Cyathea trichophora** Copel., Philip. Journ. Sci. 6C(1911) 363. F.M. 151. — *C. elliptica* Copel., Philip. Journ. Sci. 12C(1917) 51. F.M. 146.

Trunk to 50 cm tall. Stipe 25–50 cm, ± persistently scaly throughout, scales to 20 × 3 mm, light brown, glossy; main rachis bearing narrow setiferous scales and also hairs 2 mm long on lower surface. Lowest pinnae sometimes deflexed, largest 30–45 cm long; largest pinnules 3–6½ × 1.2–1.4 cm, lobed ½ way to costa; costules 3½–4 mm apart; veins 3–5 pairs. Sori medial, exindusiate. Hairs sometimes present on lower surface of pinna-rachis and costae, not on veins; bullate scales on costules.

Distribution: Sarawak, Sabah, Philippines, in forest, lowlands to 4000 ft.

The type of *C. trichophora* was found in Luzon, that of *C. elliptica* on Mt Kinabalu. Specimens on which Copeland based six other names are also here included. The differences between them are slight. Small plants may have few free pinnules.

21. **Cyathea stipitipinnula** Holtt., Kew Bull. 16(1962) 62. F.M. 147.

Stipe to more than 30 cm long, persistently scaly; scales to 25 × 3 mm, glossy brown with paler edge bearing dark setae; minute scales also present; main rachis glabrescent on lower surface. Pinnae to 45 cm long; pinnules to 6.5 × 1.2 cm, lobed less than ½ way to costa, coriaceous, lowest pinnules with cordate bases and stalks to 4 mm long; costules 3½–4 mm apart; veins 3–4 pairs, thick. Sori usually 3 to each pinnule-lobe, medial; indusium pale, firm, covering sorus to maturity. Scales near bases of costae light brown, ovate-acute, flat, with crisped marginal hairs or short setae, grading to light brown bullate scales on costules and veins.

Distribution: Mt Kinabalu, Marei Parei ridge, in open places, 4000–5000 ft.

22. **Cyathea assimilis** Hook., Syn. Fil. (1865) 24. F.M. 150.

Stipes to 65 cm long, finely warty, persistently scaly near base; scales firm, 15–20 × 1–2 mm. Lamina to almost 200 cm long; pinnae ± jointed to rachis, lower ones with stalks to 4 cm, largest 55 cm long; largest pinnules 8–9 × 2½ cm, lowest with stalks 4–8 mm, basal 1–2 segments of larger pinnules free, rest lobed to 1–2 mm from costa, lobes firm, crenate; costules 5–7 mm apart, veins 8–10 pairs. Sori medial; indusium pale, thin, covering sorus to maturity. Pinna-rachis glabrous beneath; costa with narrow setiferous scales at base grading to bullate scales distally and on costules; no hairs on lower surfaces of axes of frond.

Distribution: Southern Sumatra, Sarawak, at 1000–7000 ft. Plants of ridge forest on sandstone (Mt Dulit) have darker and more rigid fronds, sometimes smaller than above described.

23. **Cyathea discophora** Holtt., Kew Bull. 16(1962) 54. F.M. 148.

Stipe persistently scaly near base; scales pale, to 25 × 2 mm, edges with short dark setae; rachis glabrescent, finely and sparsely warty beneath. Pinnae to 50 cm long, pinnules rather widely spaced, sessile; largest pinnules 8 × 1½ cm, rather thin, lobed ⅔ towards costa except at base, lowest segment not free; costules 4–4½ mm apart; veins 6–7 pairs. Sori medial; indusium a thin brown disc of irregular shape covered by ripe sorus. Costae rather densely scaly, basal scales pale, flat, elongate with stiff pale marginal hairs, grading to rather large pale acuminate bullate scales distally and on costules; a few long hairs on costa near apex of pinnule and on costules.

Distribution: only known from the type, at 8000 ft on Mt Kinabalu, in open place in forest. This is intermediate between *C. megalosora* and *C. squamulata.*

24. **Cyathea megalosora** Copel., Philip. Journ. Sci. 12C(1917) 54. Gard. Bull. S. S. 7(1934) 221. F.M. 148.

Trunk to at least 2 m tall. Stipe c. 30 cm long, densely scaly; scales thin, pale, somewhat crisped, to 25 × 1½ mm, edges sparsely setose. Lowest pinna 20 cm, largest 35 cm long; pinnules to 6 × 1.2 cm, almost sessile, lowest 1–2 segments free, rest of pinnule lobed almost to costa; costules 4–5 mm apart, veins 5–7 pairs; lamina-segments very firm, crenate. Sori medial; indusium firm, covering sorus to maturity. Pinna-rachis persistently densely scaly on lower surface, scales long, pale, bases of smaller ones bullate; costae densely scaly, scales elongate, not setiferous; many long hairs towards apex of costa; similar hairs on costules and a few on veins; long pale hairs also on upper surface of costules and veins.

Distribution: Mt Kinabalu, in mossy forest on ridges at 7000–10000 ft; plants at highest altitudes have smaller fronds, with pinnae to 10½ × 2½ cm, free pinnules c. 5 pairs, lobed only ½ way to costa.

25. **Cyathea trichodesma** (Scort.) Copel., Philip. Journ. Sci. 4C(1909) 55. F.M. 150. — *Alsophila trichodesma* Scort. in Bedd., Journ. Bot. 25(1887) 321. — *C. burbidgei* sensu C. Chr., Gard. Bull. S. S. 7(1934) 222; sensu Holttum, Rev. Fl. Mal. 2(1955) 124, non (Bak.) Copel.

Trunk to 4½ m tall. Stipe densely scaly near base; scales medium to light brown, firm, to 25 × 2 mm, closely setose. Pinnae to 60 cm long; pinnules in Malaya 9–11 × 1½–2 cm, on Mt Kinabalu to 7 × 1½ cm, nearly sessile, lobed to 2 mm from costa, no free basal segments; costules 4½–5 mm apart; veins 6–8 pairs. Sori medial, often confluent at maturity, no indusia. Pinna-rachis, costae, costules and veins bearing many pale erect hairs 1–2 mm long on lower surface; scales on costae and costules sparse, pale, some bullate, most with dark setae; in Malaya hairs present on upper surface of costules and veins.

Distribution: Malaya, Sarawak, Sabah, in lowland forest; to 5000 ft on Mt Kinabalu. The Kinabalu specimens are perhaps smaller than those in Malaya owing to altitude.

26. **Cyathea wallacei** (Kuhn) Copel., Philip. Journ. Sci. 4C(1909) 48. F.M. 151. — *Alsophila wallacei* Kuhn, Linnaea 36 (1869) 153. — *A. burbidgei* Bak., Journ. Bot. 17(1879) 38; not *Cyathea burbidgei* sensu. C. Chr., Gard. Bull. S. S. 7 (1934) 222, which is *C. trichodesma.*

Stipe 30 cm or more long, pale and smooth above base; basal scales to 15 × 2 mm, pale brown; main rachis finely hairy on distal part of lower surface. Largest pinnae 38 cm long; pinnules to 6.5 × 1.3 cm, sessile, lobed to within 1 mm from costa; costules 3–3½ mm apart; veins 4–6 pairs, mostly simple. Sori medial, no indusia. Lower surface of pinna-rachis, costae, costules and veins bearing pale hairs 1 mm long; pale bullate scales on costae and costules; long hairs present on upper surface of costae and costules.

Distribution: Sarawak, Sabah, in lowland forest (including Bako National Park, near Kuching). This differs from *C. trichodesma* in more deeply lobed pinnules and closer costules. It has the aspect of a stunted member of sect. *Sphaeropteris* but has the venation of sect. *Schizocaena.*

27. **Cyathea polypoda** Bak., Trans. Linn. Soc. II Bot. 4(1894) 250. F.M. 151. — *C. kemberangana* Copel., Philip. Journ. Sci. 12C(1917) 52. Gard. Bull. S. S. 7(1934) 200, 219. — *C. ampla* sensu Holtt., Rev. Fl. Mal. 2(1955) 125, non Copel.

Trunk to 3 m tall; small branches frequent on its lower part. Stipe to 80 cm, green; basal scales medium brown, firm, to 30 c 2 mm, setae concolorous; rachis glabrescent on lower surface. Pinnae to 60 cm long; lower ones long-stalked; largest pinnules 8½–11 × 2.0–2.7 cm, thick and rigid when dry, all stalked, stalks of lowest 9 mm; basal 1–2 segments of largest pinnules free, rest of pinnule lobed to 1–2 mm from costa; costules 4½–5½ mm apart; veins 7–9 pairs. Sori inframedial, no indusia. Small dark or brown setiferous scales near bases of costae; bullate scales, often setiferous, on costules, all early caducous.

Distribution: Malaya, Borneo, Philippines (Panay, Mindanao); in open places on ridge-crests and summits, 2000–7000 ft; specimens from the higher altitudes very tough. Baker described the type of this species as indusiate; the "indusia" which he saw were bullate scales partly covering young sori.

28. **Cyathea agatheti** Holtt., Kew Bull. 16(1962) 51. F.M. 152.

Trunk hardly 5 cm tall. Stipe 35–75 cm long, dark towards base, rest smooth, green; basal scales 10 × 2–2½ mm, light brown with dark setae on pale edge. Lamina of frond 50–60 cm long; pinnae jointed to rachis, largest 18–25 cm long; pinnules to 3½ × 1 cm, lobed to within 1 mm from costa, lowest with stalks 1 mm long; costules 3 mm apart; veins 4–5 pairs, simple. Sori medial, no indusia. Lower surface of costae bearing scattered pale hairs, few hairs on costules; scales few, not bullate; upper surface of costae, costules and veins bearing long hairs.

Distribution: only known from original collection, W. Kutai, Kalimantan, in Agathis forest on water-logged white sand, at 2000 ft.

29. **Cyathea squamulata** (Bl.) Copel., Philip. Journ. Sci. 4C(1909) 37. C. Chr. in Gard. Bull. S. S. 7(1934) 219 excl. syn. *C. elliptica* Copel. Holtt., Rev. Fl. Mal. 2(1955) 122, fig. 49. F.M. 152.

Trunk to 2 m tall. Stipe 40–60 cm, persistently scaly throughout (main rachis sometimes also); scales firm, medium brown with dark setae, to 30 × 2–3 mm. Lowest pinnae somewhat reduced, variable, largest 50 cm long; largest pinnules 8–10 × 1½–2 cm, rather thin with almost entire lobes, lobed ½–⅔ towards costa (more deeply only in largest); costules 3½–4½ mm apart; veins 6–9 pairs, simple in smaller pinnules, forked in larger. Sori a little inframedial, no indusia; pale paraphyses longer than sporangia. Pinna-rachis glabrescent beneath, finely warty; costae with flat brown setiferous scales at base, grading to bullate distally and on costules; no hairs on lower surface of costules, a few on upper surface.

Distribution: Sumatra, Java, Malaya, Borneo, Sulu Archipelago, in lowland forest; in Malaya rarely above 3500 ft; specimens from higher altitudes (to 7000 ft) on Mt Kinabalu are small, with densely scaly rachis.

Addendum: A new species from Mt Kinabalu

In 1966 Mr E. F. Allen collected a small plant of a tree fern at an altitude of 10,000 feet on Mt Kinabalu, and brought it to his home, near Ipswich in England, where he successfully cultivated it. It flourishes in the open air in summer, but in the winter needs the protection of a cool greenhouse. This plant has now produced a fertile frond, and proves to be distinct from any previously known species.

The key to the species of subg. *Alsophila* sect. *Alsophila* needs to be modified at indentation 5 as follows, to accommodate the new species and to indicate its distinctive characters.

Young sorus completely covered by indusium which breaks at maturity, leaving the exposed sporangia surrounded by an irregular cup .... *C. oosora*

Indusium hood-shaped, attached only on the side towards the costule, not quite covering sorus at maturity:

> Basal scales on stipe firm, pale, to 25 × 3 mm; stipe short, its pneumatodes to 11 mm long; several pairs of lower pinnae gradually reduced, lowest 7 cm long; pinnules to 9½ cm long, less than 2 cm wide; costules 3½–4 mm apart; small scales mostly lacking rigid marginal setae, bullate scales abundant on costae and costules .... *C. loheri*
>
> Basal scales of stipe light brown, thin, to 10 × 1½ mm; stipe to 50 cm long its pneumatodes 3 mm long, well spaced; lower pinnae little reduced; fertile pinnules 7 × 2.2 cm, costules 4½–5 mm apart; nearly all small scales bearing several rigid setae; bullate scales few, often setiferous .... *C. brachyphylla*

Cyathea brachyphylla Holttum, **sp. nov.**

C. loheri affinis, differt: frondibus minoribus; stipite 50 cm longo, basi paleis tenuibus usque 10 × 1½ mm vestita, sursum paleis minutis plerisque copiose setiferis praedito; pneumatodiis 3 mm longis, valde dissitis; pinnis inferioribus paulo reductis; pinnis maximis 33 cm longis; pinnulis usque 7 × 2.2 cm; costulis 4½–5 mm inter se distantibus; paleis rhachidum costarumque fere omnibus setiferis, paleis bullatis paucis distalibus etiam plerisque setiferis.

Type: cult. E. F. Allen, Ipswich, England, origin Mt Kinabalu, alt. 10,000 ft (holotype K; isotype SING).

Mr Allen reports that he saw plants with trunks up to 8 feet (240 cm) tall. They were growing in deep soil in a sheltered place, not on the crest of the ridge where *Cyathea havilandii* is abundant at about the same altitude.

As indicated in the revised part of the key, the new species is related to *C. loheri* in the form of its sori, but differs in its smaller size with fronds of a different shape, and in the scales of all parts of the frond. The other two species of Cyathea which have previously been found near 10,000 feet altitude (*C. havilandii* and *C. oosora*) have sori of a different structure; careful examination with a hand lens is necessary to distinguish the difference.

Morphological studies on some inland Rhizophoraceae

by

GEH SIEW YIN[1] ET HSUAN KENG[2]

I. Introduction

The family Rhizophoraceae (as Ordo Rhizophoreae) was first established by R. Brown in 1814, and includes *Rhizophora* L., *Bruguiera* Lamk., and *Carallia* Roxb. Other genera were subsequently added by Bentham and Hooker and others and the Rhizophoraceae has since been expanded to comprise 16 genera and approximately 120 species of trees and shrubs (Hou, 1958) which are pan-tropical in distribution.

The best known representatives of the family are four mangrove genera, viz. *Rhizophora, Bruguiera, Ceriops,* and *Kandelia,* which are characterized by their peculiar adaptive features of viviparous fruits, in which the seeds undergo germination on the parent plant, and by their various special roots (pneumatophores and knee roots), which enable the plants to thrive in a muddy, littoral habitat. These mangrove genera have been extensively studied by many authors. The majority of the Rhizophoraceous genera are, however, inland plants which exhibit none of these special adaptive characters and are relatively less investigated. It is because of this that the classification of the family has been subjected to much revision and rearrangement.

The present investigation is mainly confined to the species of the following 5 inland Rhizophoraceous genera, viz., *Anisophyllea, Carallia, Combretocarpus, Gynotroches* and *Pellacalyx*, found in Singapore and Malaysia.

Members of the inland Rhizophoraceae are usually sun-loving, gregarious, and generally found in secondary forests. Because they are normally small trees, their timbers, except for construction, possess little or no commercial value, yet from the ecological point of view they are among the important pioneer trees which prepare a suitable environment for other superior trees such as dipterocarps and others to grow.

The specimens of 8 species belonging to 5 different genera examined were partly fresh material collected in Singapore, and partly from herbarium or wood collections of the Botanic Gardens, Singapore, from Dr. T. C. Whitmore, formerly of the Forest Research Institute, Kepong, and from Dr. J. A. R. Anderson, former Conservator of Forests, Sarawak. The nomenclature of the material used follows a recent taxonomic treatment by Hou (1958).

Fresh material including leaves, stems, flowers, fruits and seedlings were preserved in formalin-acetic acid-alcohol (F.A.A.). Infiltration of the fluid was facilitated by the use of the suction pump. Material taken from the herbarium collections were first softened in a dilute solution of sodium hydroxide (5%) then thoroughly rinsed in water and stored in 70% alcohol. Wood specimens were cut into

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small cubes and boiled for 1 ~ 2 hours to remove the air, transferred to 30%–40% hydroflouric acid for periods of one month or longer, washed overnight in running water and then stored in glycerin-alcohol.

Serial sections of twigs, petioles, leaves, flower buds and mature flowers were obtained by the paraffin method. Dehydration and embedding were carried out by the tertiary butyl alcohol series in accordance with the method described by Johansen (1940). Sections of 8–15 μ were obtained by means of the rotary microtome, and these were then stained with a safranin and fast-green combination.

Semi-permanent preparations of pollen grains were obtained by scraping pollen grains from recently dehisced anthers into lactophenol, and sealing the mounted slides with nail polish.

Cleared leaves and floral parts were prepared according to a modification of Foster's (1949) and Arnott's (1959) methods.

Transverse, tangential, and radial longitudinal sections of wood material were obtained with a sliding microtome. The sections were stained in safranin, dehydrated through the xylene-alcohol or tertiary-butyl-alcohol series and mounted in euparol. Fragments of wood were macerated in Jeffrey's nitric-chromic acid mixture.

II. External Morphological Observations

External morphological observations on fruits, seeds and seedlings of various genera and species were made during the course of this study.

Fruits of *Anisophyllea disticha, Carallia brachiata, Gynotroches axillaris, Pellacalyx axillaris* and *P. saccardianus* were collected and the following observations recorded. Attempts to germinate the seeds from these fruits proved to be unsuccessful, although several batches of seeds (8 for *Anisophyllea disticha*; 30–40 for the other species) in different media (soil, sand, filter paper) and under light and dark conditions were experimented with. Consequently only the seedling stages of two species, *Anisophyllea disticha* and *Gynotroches axillaris,* found in the field are described below. Fruits of *Combretocarpus rotundatus* are described from herbarium and pickled material obtained from Kuching, Sarawak and from the Forest Research Institute, Kepong, Malaysia.

a. FRUIT

Genera of the Rhizophoraceae appear to differ considerably in fruit structure. Baccate fruits are present in *Carallia* (Fig. 3 C), *Gynotroches* (Fig. 5 C) and *Pellacalyx* (Fig. 6 C), while *Anisophyllea* (Fig. 2 C) produces drupaceous fruits and *Combretocarpus* (Fig. 4 D) dry, indehiscent, winged fruits. Plants of the mangrove genera, *Rhizophora, Bruguiera, Ceriops* and *Kandelia,* are well-known for their peculiar one-seeded, vivaparous fruits.

The fruits of the Gynotrocheae vary in size from small and globular in *Carallia brachiata* (2.5–3.5 mm across) and *Gynotroches axillaris,* to large and turbinate in *Pellacalyx axillaris* and *P. saccardianus* (1–1.5 cm across). The fruits of these plants are further differentiated by the glabrous character of the former two species and the puberulous exterior of the *Pellacalyx* fruits.

The fruits of *Carallia brachiata* are many-seeded with the light-brown seeds embedded in an axile placenta. The pericarp changes from green, through translucent pink to red as the fruit matures. *Gynotroches axillaris* produces similar fruits which ripen to a shiny black on maturity. The fruits borne by *Pellacalyx axillaris* and *P. saccardianus* are approximately four to five times the size of the other two genera, and are very similar to one another in size; *P. saccardianus* can, however, be distinguished by its four-shouldered berries which are situated on longer stalks and are less densely puberulous than those of *P. axillaris*. Mature fruits of *Pellacalyx* are yellowish-green in colour.

The fertilised ovary of *Anisophyllea disticha* develops into a succulent drupe which ripens from pale pink to bright red. These fruits are often found in pairs or singly, on the underside of the pendent branches. The succulent mesocarp encloses a yellowish-brown stone which is acute at both ends and ridged longitudinally; these ridges are obvious in dried specimens of the fruits. *Combretocarpus rotundatus* produces a winged fruit in contrast to the other members of the family. There are usually three, less often four, membranous extensions of the pericarp which are delicately transversely veined. The single enclosed seed is spindle-shaped and very slender.

The fruits of all the species examined possess persistent calyx lobes. These lobes are situated above the pomaceous fruits which are formed by inferior or half-inferior ovaries except in *Gynotroches axillaris* where it is found below the berry. Very often, remains of stamens and style are also persistent on the fruit but the petals of all species are caducous. The persistence of the calyx is also notable in the fruits of the mangrove genera where they often become accrescent. There is hardly any other common feature between the fruits of the tidal and inland species than this.

b. SEED

Plants of the Gynotrocheae are characterized by comparatively small but several to numerous seeds embedded in pulpy placentae of baccate fruits. Each locule of the ovary in *Carallia brachiata* houses two ovules, while in the other two genera, there are several to many ovules per locule. The ovules of *Pellacalyx* species are arranged in fascicles of 8–25 attached to an axile placenta while those of *Gynotroches axillaris* are found embedded in a mass of placental and endocarpic tissue.

The seeds of these species are light yellowish-brown to dark brown in colour, and the testa is often crustaceous or sometimes coriaceous. Endosperm is always present surrounding the embryo which is axile, linear and practically extending from one end of the seed to the other.

Both *Combretocarpus rotundatus* and *Anisophyllea disticha* have fairly large single-seeded fruits. In *C. rotundatus* the pendulous seed lies in the centre of the fruit attached to the apex of the locule and is enclosed by a thin dry pericarp which is extended externally into 3–4 wings. The embryo is linear and cylindrical, and sections of the fruit reveal the presence of two distinct cotyledons and a fairly long hypocotyl; the plumule within the cotyledons is rudimentary. Surrounding the embryo is a structurally differentiated endosperm which is composed of densely cytoplasmic and more darkly stained cells. There is a clear demarcation between the embryo and its surrounding tissue, contrary to Hou's observation (1958) that the embryo and endosperm form a solid whole and are not differentiable under the microscope.

Freehand and microtome sections of the fruit and seed of *Anisophyllea disticha* at different stages show that the embryo is yellowish-white, axile, linear and embedded in a tissue which is endospermous in nature (Fig. 2 C 1 to C 5).

Hou (1958), possibly from dried material, has decribed the embryo and its enveloping tissue as forming a solid unity. This was not found to be so in the fresh specimens examined, as in all cases the embryo proper was quite naturally separable from its surrounding tissues. In the young seed, the endosperm takes up most of the space with the embryo confined to the apical portion, but as the seed matures, the embryo gradually occupies the entire central region, at the expense of the endosperm. Thus in longitudinal sections of a mature seed, it reveals the embryo as a terete structure extending almost the entire length of the seed. At the apical portion of the embryo two protuberances are observed which can be interpreted as cotyledons*. The rest of the embryo is a solid cylindrical structure with a sheath of small-celled vascular tissue separating the cortical from the central region. Between the cotyledons is the plumule which elongates into a young shoot and later bears the scale-like cataphylls of the seedling.

The seeds of the mangrove members of the Rhizophoraceae are distinguished by their conspicuous hypocotyls which develop while the fruit is still attached to the parent plant. In *Rhizophora* and *Bruguiera* the two cotyledons are connate into a sheath and surround the plumule, serving to assimilate nutrients from the endosperm for the developing embryo. This form of cotyledons is not confronted in the inland genera and is absent in *Anisophyllea disticha* where the entire, undifferentiated embryo is embedded in endospermous tissue.

c. SEEDLING

Although usually abundant fruits and seeds are produced by individual plants belonging to the inland Rhizophoraceous genera, the number of seeds which actually germinate appears to be very small indeed. Therefore, seedlings of these species are not commonly found on forest floor. Fresh seeds of several species (including *Carallia, Gynotroches, Pellacalyx, Anisophyllea*) collected in the field mostly failed to germinate in the laboratory and consequently only seedlings of the following two species are described.

Germination in *Anisophyllea disticha* seed is distinctly hypogeal (Fig. 7). The seed lies prostrate on the ground at first, then is carried downwards together with the radicle as the latter penetrates the soil, and soon produces lateral roots. Roots are formed from both ends of the seed, with the plumular end producing a less developed root system. The cotyledons and hypocotyl do not emerge outside the seed, but the plumule elongates into a strong cylindrical stem portion bearing small scale-like cataphylls before the first whorl of lateral branches is produced.

Gynotroches axillaris seed germinates into a seedling which does not produce cataphylls. Cotyledons have not been found on any of the seedlings observed, thus it is not possible to determine if germination was epigeal or hypogeal (Fig. 8). However, since in the mangrove genera the first green leaves are not cotyledonary, and the germination of *Anisophyllea* is hypogeal, it is perhaps reasonable to presume that the germination in *Gynotroches* and other inland plants may also be hypogeal. Seedling leaves of *G. axillaris* resemble very closely the mature leaves in their general shape, colour, texture and especially in venation. Another prominent feature

* The seed structure of *Barringtonia* as observed by Payens (1967), in general, is very similar to that of *Anisophyllea disticha*; in both cases, the embryos are not clearly differentiated into plumule, cotyledons and hypocotyl. The two protuberances at the apical end of the embryo of *Barringtonia* are considered by Payens to be scales, not cotyledons, on account of their spiral arrangement and the presence of axillary meristems. Those at the apical end of the embryo of *Anisophyllea disticha,* however, are strictly oppositely arranged, therefore can be reasonably interpreted as cotyledons.

is the conical interpetiolar stipules which cover the apical developing buds of the plants; the stipules in the Rhizophoraceae overlap one another leaving one free margin on each side, except in the case of *Pellacalyx* where the stipules are flat as in most Rubiaceae. The presence of such overlapping stipules may hence be used as a guide for identifying Rhizophoraceous seedlings, except in *Anisophyllea* and *Combretocarpus* which are exstipulate.

III. Anatomical Studies

Serial sections were made of fresh specimens of the stem, wood, leaf, petiole and flowers of *Anisophyllea disticha, Carallia brachiata, Gynotroches axillaris, Pellacalyx axillaris* and *P. saccardianus* collected in Singapore, and of herbarium collections of the flowers of *Combretocarpus rotundatus* and the wood of *Anisophyllea corneri, Carallia eugenioidea* and *C. rotundatus* obtained from Dr. J. A. R. Anderson, Sarawak and from Dr. T. C. Whitmore, Kepong, Malaysia.

A brief summary of the anatomical details of the leaf-blades, petioles, stems, woods, flowers and pollen-grains of the species investigated is presented below.

a. LEAF-BLADE (Table 1; Fig. 15)

(1) *Stomata.* The stomata in the species of the Rhizophoraceae investigated belong to the ranunculaceous or anomocytic type (Metcalfe & Chalk, 1950), i.e. the epidermal cells surrounding the two guard cells are indistinguishable from the other epidermal cells; sometimes, however, the cells around the stomata are more oblong than their neighbouring cells. Stomata are confined to the lower leaf surface only.

(2) *Epidermis.* The upper epidermis varies from the uniseriate in *Anisophyllea disticha* and *Carallia brachiata,* to 2–5 layered in *Gynotroches axillaris, Pellacalyx axillaris* and *P. saccardianus.* The outermost layer of a multiple epidermis resembles the ordinary uniseriate epidermis in having a cuticle (absent in *P. axillaris*), while the inner layer or layers (or the hypoderm) are composed of larger cells which do not contain chloroplasts, and commonly serve as a water storage tissue. Among the hypodermal cells are frequently large mucilage producing cells which are especially conspicuous in *P. axillaris.* The thickest hypoderm, of 3–4 layers, is found in *P. saccardianus.*

The lower epidermis in all the species examined is single-layered. It is covered by a thin cuticle except in *Carallia brachiata* and *Pellacalyx axillaris* where it is nearly absent.

Cork-like warts occur as small black dots on the lower surface of *Carallia brachiata,* while tufted trichomes are present especially on the abaxial surfaces of *Pellacalyx* species. Crystalliferous inclusions in the form of druses are usually present in the upper epidermal cells of *C. brachiata.*

In contrast to the thin cuticle present in the inland genera, the mangrove species are generally covered by a thick cuticle which may be composed of two distinct layers. Multiple epidermis is also common among the mangrove genera although species of *Bruguiera* may have a uniseriate epidermis. The number of layers in the hypodermis has been directly correlated to the concentration of salt in the water where the plants are growing, in the case of *Rhizophora mangle* Linn. (Bowman, cited in Metcalfe & Chalk, 1950).

(3) *Mesophyll.* The mesophyll is differentiated into palisade and spongy tissues. In *A. disticha* the leaf is isobilateral, and the single-layered palisade is distinguished from the spongy parenchyma only by nature of its more longitudinally elongated axis. *C. brachiata* also shows a one-layered palisade tissue which is distinct from the spongy mesophyll and separated from it by 1–2 layers of parenchyma cells with tanniferous inclusions. The other species investigated have 2–4 palisade layers which are closely packed in the first layer but become more loosely arranged, and scarcely distinguishable from the spongy mesophyll in the case of *P. saccardianus.* Palisade cells of *P. axillaris* are very much narrower and anticlinally elongated than the other cells of the mesophyll.

The number of cells in the spongy mesophyll ranges from 6–17 rows in the species examined. *A. disticha* and *P. axillaris* both have approximately 6 rows of cells which are more compactly arranged in the former, but include extensive air-spaces in the latter. In *G. axillaris* the spongy mesophyll cells are small in size and loosely arranged. The lower 3–5 layers of cells are larger and more compact in arrangement forming a pseudo-hypodermis, which as defined by Metcalfe and Chalk (1950) is formed of cells not aligned with the epidermal cells and ontogenetically not derived from them. Mucilage cells are also observed in the pseudo-hypodermis.

Cells of the spongy mesophyll in *C. brachiata, G. axillaris* and *P. saccardianus* contain darkly stained, probably tanniferous substances. These are found in the first 2–3 layers of the spongy mesophyll in *C. brachiata,* in the last 2–3 layers beneath the lower epidermis in *P. saccardianus,* and scattered all over the mesophyll in the case of *G. axillaris.* Druses are also found occasionally in the parenchyma cells of all the species examined.

The proportion of spongy mesophyll in relation to the total leaf thickness, in average, is found as follows: — *A. disticha* 72%; *C. brachiata* 75%; *G. axillaris* 69%; *P. axillaris* 63%; *P. saccardianus* 57%. Thus, a well-developed spongy mesophyll is present in these species.

(4) *Vascular Bundles.* The mid-rib bundle is identical to and a smaller version of the median petiolar bundle in all the species under observation. The vascular bundles of the leaf blades are of the collateral type with xylem on the adaxial side and phloem below it, facing the lower epidermis. The larger veins extend from the upper epidermis or hypodermis to the spongy mesophyll, while the smaller veins are present only in the spongy tissue.

The larger vascular bundles are completely encircled by two types of bundle sheaths. The inner sheath is composed of thick-walled sclerenchymatous cells and this is overlaid by a single layer of parenchymatous tissue. Sclerenchyma frequently encloses the smaller veins of the leaf lamina which may be composed only of xylem elements. Phloem cells are absent from vein endings which are composed mainly of elongated tracheids surrounded by a parenchymatous bundle sheath.

Bundle sheath extensions are not well-developed in the inland species examined, and this is probably due to the increase of the thickness of the spongy parenchyma as suggested by Wylie (1943).

(5) *Sclereids.* Sclerenchymatous idioblasts are notably absent in the species investigated in contrast to the well-developed H-shaped sclereids in the palisade and variously branched idioblasts in the spongy mesophyll of *Rhizophora* species. Solitary sclerenchymatous cells have also been recorded in the spongy mesophyll of *Poga oleosa* by Schimper (1898).

TABLE 1

COMPARISON OF THE COMPOSITION AND RELATIVE AMOUNT OF THE DIFFERENT TISSUES IN THE LEAVES OF INLAND RHIZOPHORACEAE

Species	Total leaf thickness (μ)	Cuticle	Epidermis		Palisade		Spongy	
		Thickness (μ)	No. of layers	Thickness (μ)	No. of layers	Thickness (μ)	No. of layers	Thickness (μ)
Anisophyllea disticha	145～160	2	1	16.5	1	33～35	5～7	84～106
Carallia brachiata	520～560	2～4	2	65～73	1～2	33～42	11～14	315～350
Gynotroches axillaris	398～420	1～2	2～4	120～132	1～2	33～37	8～12	250～280
Pellacalyx axillaris	280～420	0	2～4	45～60	2～3	40～60	6～9	140～175
Pellacalyx saccardianus	420～510	2～3	3～5	65～80	2～5	60～75	9～15	210～280

b. PETIOLE (Fig. 16)

Serial sections made through the distal end of the petiole, immediately below the lamina, show that the main vascular strand in this region is mostly U-shaped. The two margins of the median bundle have a tendency to curve inward in *C. brachiata* and in *Pellacalyx* species. The median strand of *G. axillaris* is a shallow crescent-shaped structure with another small strand fitting into the hollow of the crescent. There is no sclerenchymatous tissue surrounding the vascular strands, and 1–3 accessory bundles may be found on either side of the main trace.

The petiole of *P. axillaris* is characterized by the presence of large mucilaginous cells in the peripheral region of the cortex. Darkly stained amorphous inclusions and, occasionally, druses are present in the parenchymatous tissue of the cortical region of the four other species.

c. STEM (Fig. 17)

The young branches are oblong or elliptical in transverse section. The outer surfaces of the stems are glabrous in *C. brachiata* and *G. axillaris,* but possess trichomes in the case of *A. disticha, P. axillaris* and *P. saccardianus*. The epidermal cells are covered by a thin cuticle and the cortex is composed of closely arranged ground tissue. Many of the cortical cells in the species investigated contain darkly stained inclusions. A continuous ring of sclerenchyma forming the pericycle surrounds the vascular cylinder in *A. disticha,* and is absent in the other species. The vascular bundles are collateral, with phloem surrounding the xylem cylinder. The pith is very wide in all cases and is composed of thin-walled cells which are larger in the central region. In the older branches of *Gynotroches* and *Pellacalyx* species, the central pith cells disintegrate leaving a characteristic hollow, which is one of the field characters utilized in identifying these two genera. Cork formation is sub-epidermal in origin.

The nodal structure in this family is trilacunar and many-traced, and agrees with the observations by Sinnott (1914). The Rhizophoraceae has been included customarily under the Myrtales which, however, is characterized by unilacunar nodes.

d. WOOD ANATOMY (Tables 2 & 3; Figs. 18 & 19; Plate 2)

The wood structure of the five genera examined fall in harmoniously with one another in most features. Except that *Pellacalyx* exhibits vessels with opposite pitting to the ray cells and has the tendency for the pore clusters to be tangentially arranged, and the occurrence of scalariform pitting in *G. axillaris,* there is no sharp demarcation in the wood anatomy of the species investigated.

Growth rings are indistinct in members of the Rhizophoraceae and the wood is commonly diffuse porous. The pores are solitary (especially in *Anisophyllea*), or arranged in pairs, or in clusters (tangentially arranged in *Pellacalyx*). Pores are usually scanty in *Anisophyllea* and *Combretocarpus* (3–6/mm^2) but more abundant in *Gynotroches* where they may number up to 25–30/mm^2. The pores are mostly spherical in outline and the walls are rather thin and evenly thickened. The largest pores (up to 350 μ) are found in *Anisophyllea* and *Combretocarpus,* while in the other genera they are small to medium-sized. The length of the vessel members range from medium-sized to very long in *C. brachiata* (to 1400 μ).

Pits to ray cells are generally oval and alternate in arrangement, but in *G. axillaris* they are exclusively scalariform and elongate, while in *Pellacalyx* they are opposite and angular.

TABLE 2

SUMMARY OF WOOD ANATOMY CHARACTERS OF THE INLAND GENERA OF RHIZOPHORACEAE

Character	*Anisophyllea*	*Carallia*	*Combretocarpus*	*Gynotroches*	*Pellacalyx*
Vessel member					
1. Arrangement	Solitary or paired	Solitary or paired	Mostly solitary	Solitary or 3–5	Clusters of 2–5
2. Abundance	6 per mm^2	6–10 per mm^2	3 per mm^2	18–25 per mm^2	15–18 per mm^2
3. Pore outline	Ovate-angular	Round or spherical	Spherical	Angular	Angular
4. Diameter and length	(D.) (L.)	(D.) (L.)	(D.) (L.)	(D.) (L.)	(D.) (L.)
lowest average	135 μ 395 μ	105 μ 620 μ	180 μ 350 μ	140 μ 450 μ	230 μ 615 μ
mean of averages	248 μ 465 μ	160 μ 680 μ	380 μ 520 μ	150 μ 630 μ	145 μ 683 μ
highest average	310 μ 718 μ	230 μ 1,155 μ	420 μ 780 μ	200 μ 750 μ	193 μ 795 μ
5. Pits to ray cells	Alternate; oval	Alternate; oval	Alternate; oval	Scalariform	Opposite; angular
6. Perforation plate	Simple or multiple	Simple	Simple	Simple	Simple
7. End-wall	Oblique-long caudate	Oblique	Oblique	Oblique	Oblique
Wood fibre					
8. Wall thickness	Thick-walled	Thick-walled	Thick-walled	Thick-walled	Thick-walled
9. Length					
lowest average	1,285 μ	395 μ	1,500 μ	980 μ	1,155 μ
mean of averages	1,840 μ	908 μ	1,760 μ	1,350 μ	1,880 μ
highest average	2,425 μ	1,105 μ	2,800 μ	1,850 μ	2,315 μ
Wood ray					
10. Krib's Type	Heterogeneous IIa	Heterogeneous IIa	Heterogeneous IIa	Heterogeneous IIa	Heterogeneous IIa
11. Uniseriate rays (av. height)	10–12 cells	8–10 cells	12 cells	4–10 cells	10 cells
12. Multiseriate rays (av. width)	6–8 cells	12–14 cells	5 cells	28–30 cells	8 cells
Wood parenchyma					
13. Distribution	Paratracheal confluent or vasicentic and metatracheal.	Paratracheal confluent and metatracheal banded.	Paratracheal confluent and metatracheal banded.	Paratracheal confluent or aliform.	Paratracheal confluent.

TABLE 3

SUMMARY OF WOOD ANATOMY CHARACTERS OF THE TRIBES OF RHIZOPHORACEAE

Character	Anisophylleeae	Gynotrocheae	Rhizophoreae
Vessel member			
1. Arrangement ..	Often solitary, sometimes paired.	Solitary or more often in pore multiples of 2–5.	Solitary or in multiples of 2–14.
2. Abundance ..	2–5 per mm^2	7.25 per mm^2	5–35 per mm^2
3. Diameter and length	(D.) (L.)	(D.) (L.)	(D.) (L.)
lowest average ..	150 μ 380 μ	116 μ 584 μ	
mean of averages ..	292 μ 483 μ	152 μ 671 μ	
highest average ..	347 μ 738 μ	209 μ 720 μ	
4. Pits to ray cells ..	Alternate; oval	Alternate oval or scalariform or opposite angular.	Scalariform.
5. End wall type ..	Oblique-long caudate	Oblique	steeply inclined tapering ends.
Wood fibre			
6. Wall thickness ..	Thick	Thick	Thick
7. Length			
lowest average ..	1,350 μ	1,014 μ	
mean of averages ..	1,813 μ	1,385 μ	
highest average ..	2,550 μ	1,740 μ	
Wood ray			
8. Krib's Type ..	Heterogeneous IIa	Heterogeneous IIa	Heterogeneous Type IIa or Homogeneous (*Rhizophora*)
9. av. length of uniseriate rays	13 cells	9 cells	
10. av. width of uniseriate rays	6 cells	10(–26) cells	3–6 cells
Wood parenchyma			
11. Distribution ..	Apotracheal or paratracheal	Paratracheal confluent	Scanty vasicentric

Perforation plates are simple, or rarely, multiple in *Anisophyllea*. End walls are oblique and long caudate in *Anisophyllea* or oblique with less pronounced prolongations in others.

Wood fibres are thick-walled in all species examined, with a range in length of extremely short (320 μ in *C. brachiata*) to very long (2,800 μ in *Combretocarpus*).

Wood rays are consistently heterogeneous of Krib's Heterogeneous Type IIa. Uniseriate rays may be present as 2–3 cells or 28 cells (in *Gynotroches*) but are more often 4–10 cells high in *Gynotroches*. Multiseriate rays are commonly 100 or more cells high, to over 400 cells in *Carallia*. Cells of the rays may contain amorphous depositions in species of all the genera, and are most abundant in *Carallia*, but rarely found in *Pellacalyx*.

Wood parenchyma is often paratracheal confluent in *Anisophyllea, Combretocarpus, Carallia* and *Pellacalyx,* and metatracheal bands are in addition, present in the former three genera. *G. axillaris* shows a tendency towards aliform arrangement of the axial parenchyma as well as the characteristic paratracheal confluent distribution of *Anisophyllea, Combretocarpus* and *Gynotroches.*

Among the wood specimens of the various species examined, those of the following three are investigated for the first time.

(1) *Anisophyllea corneri* D. Hou
(2) *Carallia eugenioidea* King
(3) *Pellacalyx saccardianus* Scort.

The main evolutionary trends of wood anatomy characters (pertinent to the wood anatomical characters of the Rhizophoraceae) are summarised in Table 4.

TABLE 4

SUMMARY OF EVOLUTIONARY TRENDS OF WOOD ANATOMY CHARACTERS

Character	Primitive	Intermediate	Advanced
1. Wood porosity ..	diffuse-porous	semidiffuse-porous	ring-porous
2. Vessel elements			
(*a*) Arrangement ..	solitary	paired	clustered in pore multiple
(*b*) Outline in t.s. ..	angular		oval or rounded
(*c*) Diameter ..	very small		very large
(*d*) Length ..	very long		very short
(*e*) Perforation plate ..	Scalariform with many bars	reticulate	simple
(*f*) End-wall ..	very oblique, long caudate	oblique, short caudate	horizontal
(*g*) Pits to ray cells ..	Scalariform, elongated	opposite; transitional; oval	alternate; rounded.
3. Wood fibres			
(*a*) wall thickness ..	very thin		very thick
(*b*) length ..	very long		very short
4. Wood rays			
(*a*) Krib's Type ..	Heterogeneous Type I	Heterogeneous Type IIa	Heterogeneous Type III
(*b*) Length of uniseriate rays	very long		very short
(*c*) Width of multiseriate rays	very broad		very narrow
5. Wood parenchyma			
(*a*) Distribution ..	diffuse-scanty	paratracheal	apotracheally banded

Following the putative phylogenetic trends (Carlquist 1961), the vessel members of the Rhizophoraceae may be considered advanced in the possession of simple perforation plates. Although the lengths and widths of the vessels in the genera investigated do not differ greatly, it is evident that *Carallia* possesses the longest vessel element length and the narrowest pore diameter, while *Anisophyllea* and *Combretocarpus* show more advanced, broader and shorter vessel members. A further advanced feature lies with the occurrence of alternately arranged pits to contiguous ray cells, but this character is not common to all five genera; *Gynotroches* shows a primitive scalariform pattern, while *Pellacalyx* possesses opposite pits, which condition is considered intermediate between those found in

Gynotroches on the one hand, and *Anisophyllea, Combretocarpus* and *Carallia* on the other. In the arrangement of the pores, the solitary condition, often found in *Anisophyllea* is a less evolved condition which apparently progresses through that found in *Carallia* and *Gynotroches* to the pore clusters of 2–5 found in *Pellacalyx*.

The longest wood fibre lengths are found in *Combretocarpus* (2800 μ), whereas the shortest in *Carallia* (395 μ). In this instance therefore, the wood of *Carallia* shows a more advanced character in contrast to its other more primitive vessel elements.

Wood rays of the genera studied are uniformly heterogeneous of Krib's Type IIa. The multiseriate rays are broad to very broad (28–30 cells) in *Gynotroches* and generally over 100 cells high. The highest multiseriate rays are found in *Carallia* (up to 500 cells). Uniseriate rays are shortest on the average in *Gynotroches* and longest in *Anisophyllea* in contrast to the heights of multiseriate rays found in the respective genera.

All members of the five genera show a tendency towards a paratracheal confluent arrangement of wood parenchyma, which is considered an intermediate condition in wood parenchyma phylogeny. Metatracheal bands also occur in *Anisophyllea, Combretocarpus* and *Carallia.*

From the data obtained, it is difficult to consider any one genus as more advanced than the other. *Anisophyllea* and *Combretocarpus* probably show a slight advantage in the number of advanced features than the other genera, but on the other hand, these features alone appear to be insufficient to consider that these two genera are phylogenetically more evolved.

According to the observations of Marco (1935) and Metcalfe and Chalk (1950), the members of the mangrove Rhizophoraceae, likewise, show a mixture of advanced and primitive wood anatomy features, but in this group, the primitive characters are more in preponderance, e.g. scalariform pitting on the lateral walls, very oblique end walls, and scanty wood parenchyma. The genus *Rhizophora* seems more advanced than the other three genera of the mangrove Rhizophoraceae in the possession of homogeneous wood rays.

Considering the wood anatomical features of the family Rhizophoraceae as a whole, the mangrove members which constitute the tribe Rhizophoreae may be regarded as the most primitive, and the inland members, especially *Anisophyllea* and *Combretocarpus* which constitute the tribe Anisophylleeae, the most advanced.

e. FLOWER AND POLLEN GRAINS

The inland Rhizophoraceae produce axillary flowers either in condensed clusters (in *Gynotroches* (Fig. 5), *Carallia* (Fig. 3; Plate 1) & *Pellacalyx* (Fig. 6; Plate 1)) or in fascicles or racemose inflorescences (in *Anisophyllea* (Figs. 1 & 2) & *Combretocarpus* (Fig. 4)). In contrast, genera of the mangrove Rhizophoreae exhibit paired or cymose arrangement of the flowers. The basic inflorescence structures of the family, nevertheless, are probably cymose in nature.

The accessory floral parts are always valvate in aestivation and vary in number from 3–4 (in *Anisophyllea, Combretocarpus*) to 4–15 (in *Rhizophora, Bruguiera*). The sepals are always connate at the base into a calyx-tube with triangulate or linear calyx-lobes, each of which receives a constant supply of a single vascular trace. The petals are often clawed in *Gynotroches, Carallia* and *Pellacalyx*, and apically fringed in various degrees. In *Anisophyllea* and *Combretocarpus* the petals are deeply and evenly 3–5 lobed, or entire, while in the mangrove Rhizophoreae the petals are entire or bi-lobed and often associated with special appendages. The stamens are twice the number of the petals in the inland Rhizophoraceae, and may be arranged in a single whorl around a crenulate or lobed disc, or be attached to a calyx tube as in *Pellacalyx* species. The filaments are unequal in length in *Carallia brachiata* and *Pellacalyx* species (the anti-sepalous ones being shorter in *C. brachiata* and longer in *P. axillaris* and *P. saccardianus*). Among the mangrove genera, the filaments of *Rhizophora* species are extremely short, and those of *Bruguiera* are arranged in unequal pairs which are embraced by the petals. The filaments of stamens in the other Malayan genera of Rhizophoraceae are more or less equal in length. The anthers are generally small, 4-locular, dorsifixed and dehiscing longitudinally and introrse. Anthers of *Rhizophora* deserve special mention as they are large and multiloculate, producing clouds of pollen at anthesis.

The microspore mother cells in a developing anther are enveloped by 5 layers: an inner tapetum, an outer epidermis and three intermediate layers. The layer immediately underlying the epidermis produces 'fibrous' thickenings of the wall which is so characteristic of the endothecial layer, and which presumably facilitates pollen dispersal (Eames, 1961).

Following meiosis of the microsporocytes the tapetal and middle layers disintegrate and are absorbed by the developing pollen grains so that at maturity, only a spirally thickened endothecium and epidermis remain. In all the six species the septum between the locules of each half-anther usually ruptures before the pollen is released by a longitudinal line of dehiscence. The cells around the region of dehiscence are smaller, isodiametric, and thin-walled, and the epidermal cells are inconspicuous above this region.

According to Erdtman (1952) the pollen grains of Rhizophoraceae are 3(–4)-colporoidate, colporate, oblate-spheroidal to subprolate, and with finely reticulate or indistinct exine pattern. Table 5 shows the specific pollen type in the listed species. The pollen grains of the species listed are more or less similar in appearance. There is no pronounced difference between the pollen structure of the species of the three genera, and pollen morphology in this case does not seem to assist in the identification of the members of the family.

TABLE 5

POLLEN GRAINS OF THE RHIZOPHORACEAE

Species	Size	Shape	Exine pattern
Anisophyllea disticha ..	19.8 μ x 16.5 μ	Subprolate	Indistinct
Combretocarpus rotundatus	24 μ x 10.6 μ	Subprolate	Indistinct
Carallia brachiata ..	16.5 μ x 15 μ	Prolate-spheroidal	Finely reticulate
Gynotroches axillaris ..	10.5 μ x 8.6 μ	Subprolate	Finely reticulate
Pellacalyx axillaris ..	12 μ x 10.5 μ	Subprolate	Indistinct
Pellacalyx saccardianus ..	13.2 μ x 9.9 μ	Subprolate	Indistinct
Bruguiera ..	21 μ x 17 μ	Subprolate	Finely reticulate
Ceriops candolleana ..	15 μ x 15.5 μ	Oblate-spheroidal	Finely reticulate
Rhizophora mucronata ..	25 μ x 21 μ	Subprolate	Finely reticulate

The compound gynoecium is generally 2–12-loculate. The floral vasculature of the plants show the presence of two series of traces, an outer series which supplies the calyx, corolla and androecium, and an inner series which comprises the gynoecial vasculature. Traces supplying the carpels diverge into the ovules as well as ramify in the carpellary walls before supplying the style or styles of the various species.

The ovary is usually inferior (Figs. 9, 11, 12, 14), rarely superior (e.g. in *Gynotroches* (Fig. 13)). Internally the gynoecium is divided by septa into as many locules as the number of carpels. The ovules, varying from 1–2 to numerous per locule, are pendulous and attached to an axile placenta.

The placentation in the Rhizophoraceae is generally described as axile, but serial sections of flower buds show that the uppermost portions of the syncarpous ovary of *Combretocarpus* (Fig. 12) and *Gynotroches* (Fig. 13) are unilocular, indicating the parietal condition.

In *Combretocarpus* the carpels are fused by their ovarian regions but the styles and stigmas are separate. Each style is grooved longitudinally on its ventral (inner) surface, and as sections are taken down the lengths of the styles, there is evidence of lateral concrescence of the adjacent margins of the styles. This condition finds its equivalent in the corresponding junction of the margins of a whorl of open conduplicate carpels. As a result, the lower part of the style and the upper one-third of the inferior ovary are unilocular, while sections lower down show the typical plurilocular syncarpous ovary with axile placentation.

In *Gynotroches* the style is simple and hollow in its lower half. This hollow cavity leads down to the upper part of the superior ovary, and sections taken at this point reveal a single locule deeply subdivided by projecting partitions of the conjunct margins of each carpel, which do not meet in the centre. The lower part of the ovary is by contrast, divided into 4–5 chambers as a result of the union of the partitions. In the older flowers the axile condition is more pronounced and the parietal arrangement becomes somewhat obscure.

Attempts to draw any conclusion about phylogenetic relationships of axile and parietal placentation require great caution (Puri, 1952). The two conditions may have arisen independently from marginal placentation or one condition may have arisen from the other. The situation occurring in *Combretocarpus* and *Gynotroches,* nevertheless, seems to suggest that there is possibly a general trend from parietal to the commonly axile placentation (see Gundersen, 1939) in the Rhizophoraceae.

Each ovule has two integuments. In *Gynotroches, Carallia,* and *Pellacalyx,* the outer integument develops thick walls and becomes crustaceous while the inner integument is membranous. In *Anisophyllea disticha,* the outer is also composed of thick-walled cells which is lined by a thin-walled, 1–2-layered, inner integument. In *Combretocarpus rotundatus* however, the outer integument is composed of 3–4 layers of cells with less conspicuously thickened walls in contrast to the single-layered inner integument.

In the mangrove and in some inland Rhizophoreae, a simple style is found which is connected to a simple or lobed stigmatic crest. In *Anisophyllea* and *Combretocarpus* however, as described before, 3–4 styles are present each of which shows a ventral groove running from the apical stigmatic surface to the ovary. The styles of *Carallia brachiata, Gynotroches axillaris,* and *Pellacalyx* spp. have a stylar canal running from stigma or upper stylar region to the ovary.

IV. Taxonomic Considerations

The subdivision of the family Rhizophoraceae has been a subject of controversy ever since it was established by R. Brown in 1814. Four major systems of classification of the family have so far been proposed. They were by Hooker (in Bentham and Hooker f., 1862–67), Schimper (1898), Ridley (1922), and Melchior (1964).

Following Hooker's system, the family includes 3 tribes, namely:

(1) the *Rhizophoreae*, members of the mangrove genera (*Rhizophora*, *Bruguiera*, *Kandelia*, etc.), which exhibit inferior ovary, single style, exalbuminous macropodous embryo, viviparous germination, and opposite, entire, glabrous, stipulate leaves.

(2) the *Legnotidae* which includes *Carallia*, *Gynotroches* and *Pellacalyx* as well as other members with inferior or half-inferior ovary, small embryo embedded in fleshy albumen of the seed and opposite stipulate leaves.

(3) the *Anisophylleeae*, including *Anisophyllea* and *Combretocarpus* with inferior ovary, 3–4 styles, exalbuminous macropodous embryo, and alternate stipulate leaves.

Schimper's proposed classification is altogether different; an outline of it follows:

(1) *Rhizophoroideae* — includes genera with perigynous or epigynous flowers, simple styles, baccate or rarely capsular fruits, opposite, stipulate leaves.

  (*a*) *Gynotrocheae* — comprising two sub-tribes.

    (i) *Gynotrochinae* — consisting of *Crossostylis*, *Gynotroches*, *Ceriops*, *Kandelia* and *Rhizophora*.

    (ii) *Carallinae* — composed of *Carallia*, *Pellacalyx* and *Bruguiera*.

  (*b*) *Macarisieae* — comprising *Blepharistemma*, *Cassipourea*, *Dactylopetalum*, *Macarisia* and *Weihea*.

(2) *Anisophylloideae* — including genera with epigynous flowers, 3–4 styles, drupaceous or dry indehiscent fruits, alternate, exstipulate leaves. Only two genera, *Anisophyllea* and *Combretocarpus* are included in this sub-family.

Among the genera belonging to Hooker's Legnotidae, Schimper found that certain members, namely, *Weihea*, *Cassipourea*, *Blepharistemma*, *Dactylopetalum* and *Macarisia*, are so distinctly related that he placed them in a tribe of their own, Macariseae, to which he later assigned *Anopyxis* and *Sterigmapetalum*. The remaining genera he placed with the mangrove species.

According to Hooker, the mangrove genera are placed in a group of their own because of the several distinctive characters they exhibit, the majority of which are no doubt of adaptive significance and origin. On this very point Schimper (1898) voices his dissent, and considers it erroneous to separate a group of plants on the strength of their response to environmental conditions. He favours a 'natural' classification which gives a more realistic indication of the relationships of the plants within the family. The outcome of his proposal is the dispersion of the mangrove genera into two different sub-tribes of Gynotrocheae, each of which includes some of the inland genera.

Hooker's proposal of a third tribe Anisophylleeae was accepted, but relegated to a sub-family by Schimper.

Ridley agreed with Hooker's arrangement of the Rhizophoraceous genera, but raised all the three tribes to family rank. In his investigation he found that the inland genera *Carallia, Gynotroches* and *Pellacalyx* are closely related and warrant a group of their own. Other members of Hooker's Legnotidae were not investigated as his study was confined to the Malayan flora, and hence Schimper's suggestion of the Macarisieae as a distinct tribe was not discussed.

He also assigned *Anisophyllea* to a separate family Anisophylleaceae (as Anisophylleae), and this was later taken up by Corner (1952).

In the latest (12th) edition of Engler's Syllabus as revised by Melchior (in Melchior 1964), the family Rhizophoraceae is divided into four co-ordinated tribes as follows: Macarisieae, Gynotrocheae, Anisophylleeae and Rhizophoreae.

In the present investigation of hte Rhizophoraceous genera found in Johore, Malaysia, and in Singapore, some morphological data have been assembled and tabulated (see Table 6) in the three tribes proposed by Hooker (1898) but revised by Melchior (1964). On the strength of the morphological features it appears that these three tribes resemble one another very closely in many ways but yet have their distinct differences. The mangrove tribe differs from the inland counterparts not exclusively but manifestly in their ecological adaptive features.

TABLE 6

COMPARISON OF SOME MORPHOLOGICAL CHARACTERS OF THE 3 TRIBES OF RHIZOPHORACEAE

Rhizophoreae (*Rhizophora, Bruguiera, Ceriops*)	*Gynotrocheae* [Legnotideae] (*Carallia, Gynotroches Pellacalyx*)	*Anisophylleeae* (*Anisophyllea, Combretocarpus*)
1. Trees of littoral habitats.	1. Trees of inland forests.	1. Trees of inland forests.
2. Leaves opposite, entire, glabrous.	2. Leaves opposite, entire or serrate, glabrous or densely puberulous.	2. Leaves alternate, entire, glabrous to pubescent.
3. Stomata anomocytic.	3. Stomata anomocytic.	3. Stomata anomocytic.
4. Stipules present.	4. Stipules present.	4. Stipules absent.
5. Phellogen subepidermal in origin.	5. Phellogen subepidermal in origin.	5. Phellogen subepidermal in origin.
6. Flowers medium-sized to large (0.5–4 cm.)	6. Flowers small to medium-sized (0.25–1.5 cm.)	6. Flowers minute (0.15–0.5 cm.)
7. Calyx lobes persistent; 4–15 in number.	7. Calyx lobes persistent; 4–8 in number.	7. Calyx lobes persistent; 3–4 in number.
8. Petals entire or lobed, with or without appendages.	8. Petals clawed, fringed at the apex in various degrees.	8. Petals laciniate or entire.
9. Stamens twice the number of petals or numerous, equal or unequal in length.	9. Stamens twice the number of petals, usually unequal in length.	9. Stamens twice the number of petals, equal or unequal in length.

TABLE 6—*continued*

COMPARISON OF SOME MORPHOLOGICAL CHARACTERS OF THE 3 TRIBES OF RHIZOPHORACEAE

Rhizophoreae (*Rhizophora, Bruguiera, Ceriops*)	*Gynotrocheae* [Legnotideae] (*Carallia, Gynotroches Pellacalyx*)	*Anisophylleeae* (*Anisophyllea, Combretocarpus*)
10. Anthers basifixed, multi-loculate or 4-locular.	10. Anthers basifixed, 4-locular.	10. Anthers basifixed 4-locular.
11. Filaments shorter or longer than anthers.	11. Filaments several times longer than anthers.	11. Filaments several times longer than anthers.
12. Disc present or absent.	12. Disc present.	12. Disc present.
13. Pollen grains 24 μ – 26 μ in longest axis.	13. Pollen grains 12 μ – 15 μ in longest axis.	13. Pollen grains 20 μ – 24 μ in longest axis.
14. Carpels 1–4; ovary half-inferior or inferior, syncarpous.	14. Carpels 3–12; ovary superior or inferior, syncarpous.	14. Carpels 3–5; ovary inferior, syncarpous.
15. Ovules 2–6 per locule.	15. Ovules 2–several per locule, fasciculate or not.	15. Ovules 1–2 per locule.
16. Fruit a specialized structure with seed which germinates while still attached to parent plant.	16. Fruit a berry, usually globose or pyriform.	16. Fruit a drupe or dry and indehiscent with winged or woody pericarp.
17. Pericarp hard and tough.	17. Pericarp succulent.	17. Pericarp succulent or dry.
18. Seeds one per fruit.	18. Seeds numerous, embedded in pulpy placentae in fruit.	18. Seeds one per fruit.
19. Endosperm absent.	19. Endosperm present.	19. Endosperm present.
20. Embryo macropodous; cotyledons connate or free.	20. Embryo minute, embedded in fleshy endosperm; cotyledons free.	20. Embryo macropodous. cotyledons rudimentary or not.

The following discussions are centrated on the three tribes as proposed by Hooker but revised by Melchior.

(A) *On the tribe Rhizophoreae*

The Rhizophoraceae may be conveniently divided into mangrove and inland groups on ecological grounds. Members of the former group belong to the tribe Rhizophoreae, those of the latter, to the tribes Gynotrocheae (or Legnotidae) and Anisophylleeae. In spite of Schimper's (1898) strong objection to the adoption of this scheme, the mangrove genera (namely, *Rhizophora, Bruguiera, Ceriops* and *Kandelia*) in many aspects, do form a closely related unit. The development of such characters as xerophytic leaves, prop roots, pneumatophores, in mangrove plants are undoubtedly brought about as a result of ecological adaption. However, there are many other features such as persistent and accrescent sepals, ex-endospermous seed and wood anatomical characters which set this tribe apart.

The unique method of viviparous germination of seeds in the Rhizophoreae seems to be another adaptive feature. However, as van Steenis (in Hou, 1958) pointed out, it is not universal or even common in other equally successful mangrove plants such as *Sonneratia* (Sonneratiaceae) or *Barringtonia* (Barringtoniaceae), thus the general assumption that this character is a special adaption to the environment may be disputable.

(B) *On the tribe Gynotrocheae*

In the tribe Gynotrocheae (= Legnotidae, in part) only 3 genera, namely, *Carallia, Gynotroches* and *Pellacalyx* were studied. They appear to fit into a natural group. However, according to Marco (1935), this tribe is heterogeneous, and therefore should be further divided into 3 groups: (1) Group I including *Carallia, Combretocarpus, Anisophyllea, Gynotroches* and *Crossostylis,* (2) Group II including *Macarisia* and four other genera which are not present in this part of the world, (3) Group III including *Pellacalyx* and *Poga.* Unfortunately most of this material are not available for the present study.

It is noted that Marco's Groups I and II correspond closely to Schimper's tribes Gynotrocheae and Macariseae. Marco (1935) also considered *Pellacalyx* to be wood anatomically unclassifiable with the others. Although this genus differs in its tangential arrangement of 2–5 vessels in pore clusters, and in the possession of opposite, angular pits to ray cells, yet with regard to the other wood anatomical characters, it seems to fit in homogeneously with the rest of the Gynotrocheae. Therefore it would appear to be unwarranted to separate *Pellacalyx* out solely on these points of difference.

(C) *On the tribe Anisophylleeae*

Anisophyllea and *Combretocarpus,* which constitute the Anisophylleeae, are conspicuous by the alternate arrangement of their leaves as contrasted to the paired condition found in the other tribes, and by their lack of the characteristic interpetiolar stipules of the family. The flowers of these two genera are very tiny by comparison, their 3–4 styles are free, yet the fruits produced are relatively large to very large (for example, 8–12 × 5–7 cm in *Anisophyllea grandis* Burk.). Anatomically, *Anisophyllea* shows a tendency towards formation of isolateral leaves without a hypoderm, and has less palisade tissues than the other inland genera. Transverse sections of the young stem show the presence of a sheath of sclerenchymatous cells surrounding the vascular cylinder, which is not found in the other genera examined. These features are probably among the deciding factors for the separation of the two genera, *Anisophyllea* and *Combretocarpus,* into a tribe or even into a family as advocated by Ridley (1922) and Corner (1952).

The embryos in the seeds of the Anisophylleeae resemble those of the Rhizophoreae in being macropodous. Other common features between these two tribes include the deeply bi-lobed petals and the comparatively larger size of the pollen grains. The wood anatomical characters of the Anisophylleeae on the other hand, in general, agree very well with those of the Gynotrocheae, but appear to be more advanced. For example, they possess shorter, broader vessel elements than *Carallia, Gynotroches* and *Pellacalyx* (of Gynotrocheae), and the pores are larger, often solitary and fewer in number. Therefore, on morphological grounds it would hardly seem justifiable to establish a separate family to accommodate these two genera.

To summarize, after due consideration of the data available, it appears to be most appropriate that the Malayan members of the family Rhizophoraceae should be accommodated in three tribes: namely Rhizophoreae, Gynotrocheae and Anisophylleeae, as suggested by Hooker (1865) and revised by Melchior (1964).

Acknowledgements

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Bibliography

1. Arnott, H. J.
   1959. Leaf clearings. Turtox News, *37*: 192–194.
2. Bentham, G. & J. D. Hooker
   1862–67. Genera Plantarum. Vol. 1. London.
3. Carlquist, S.
   1961. Comparative Plant Anatomy. Holt, Rinehart and Winston, N.Y.
4. Corner, E. J. H.
   1952. Wayside trees of Malaya. 2 vols. 2nd edition. Govt. Printing Office, Singapore.
5. Eames, A. J.
   1961. Morphology of the Angiosperms. New York: McGraw-Hill.
6. Erdtman, G.
   1952. Pollen morphology and plant taxonomy. Angiosperms. Stockholm: Almgvist and Wiksell.
7. Foster, A. S.
   1949. Practical plant anatomy. 2nd ed.; van Nostrand. New York.
8. Gundersen, A.
   1939. Flower buds and phylogeny of dicotyledons. Bull. Torrey Bot. Club *66*: 287–295.
9. Hou, Ding
   1958. Rhizophoraceae in Flora Malesiana Ser. I. *5*: 429–493.
10. Johansen, D. A.
    1940. Plant microtechnique. McGraw-Hill. New York.
11. Marco, H. F.
    1935. Systematic anatomy of the woods of the Rhizophoraceae. Trop. Woods. *44*: 1–21.

12. Melchior, H.

1964. A. Engler's Syllabus der Pflanzenfamilien. Band II Gebrueder Borntraeger, Berlin.

13. Metcalfe, C. R. and R. Chalk.

1950. Anatomy of the dicotyledons; leaves stem and wood in relation to taxonomy, with notes on economic uses. 2 vols. Clarendon Press. Oxford.

14. Payens, J. P. D. W.

1967. A monograph of the genus *Barringtonia* (Lecythidaceae). Blumea *15*: 157–263.

15. Puri, V.

1952. Placentation in Angiosperms. Bot. Rev. *18*: 603–651.

16. Ridley, H. N.

1922. Flora of the Malay Peninsula. Vol. 1. L. Reeve and Co. London.

17. Schimper, A. F. W.

1898. In Engler & Prantl, Die Nat. Pflanzenfamilien *3*, 7. 42–50. Leipzig.

18. Sinnott, E. W.

1914. Investigations on the phylogeny of the Angiosperms I. The anatomy of the node as an aid in the identification of angiosperms. Amer. J. Bot. *1*: 303–322.

19. ————— and I. W. Bailey.

1914. Investigations on the phylogeny of the Angiosperms III. Nodal anatomy and morphology of stipules. Amer. J. Bot. *1*: 441–453.

20. Wylie, R. B.

1943. The role of the epidermis in foliar organisation and its relation to minor venation. Amer. J. Bot. *30*: 273–280.

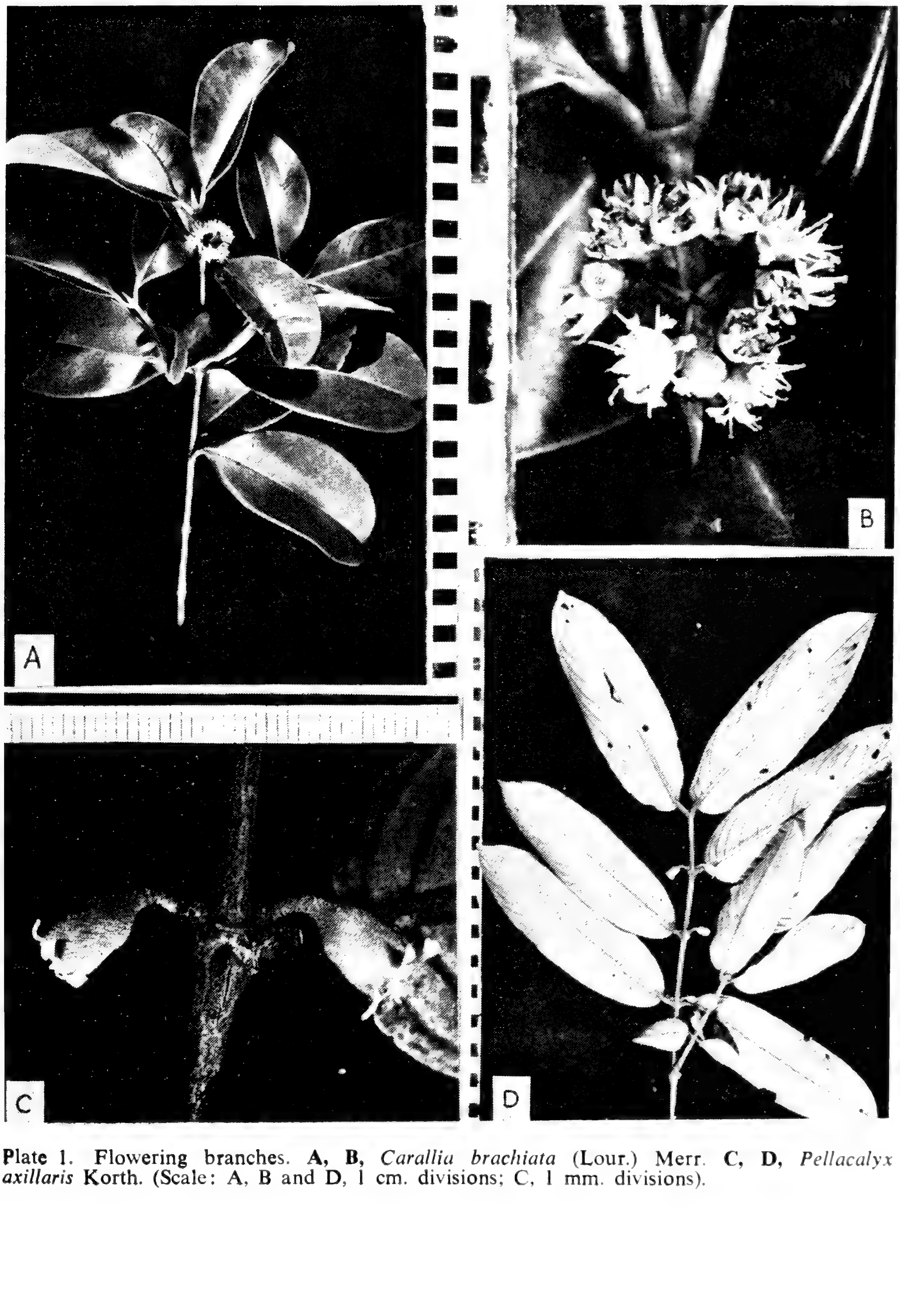

Plate 1. Flowering branches. **A, B,** *Carallia brachiata* (Lour.) Merr. **C, D,** *Pellacalyx axillaris* Korth. (Scale: A, B and D, 1 cm. divisions; C, 1 mm. divisions).

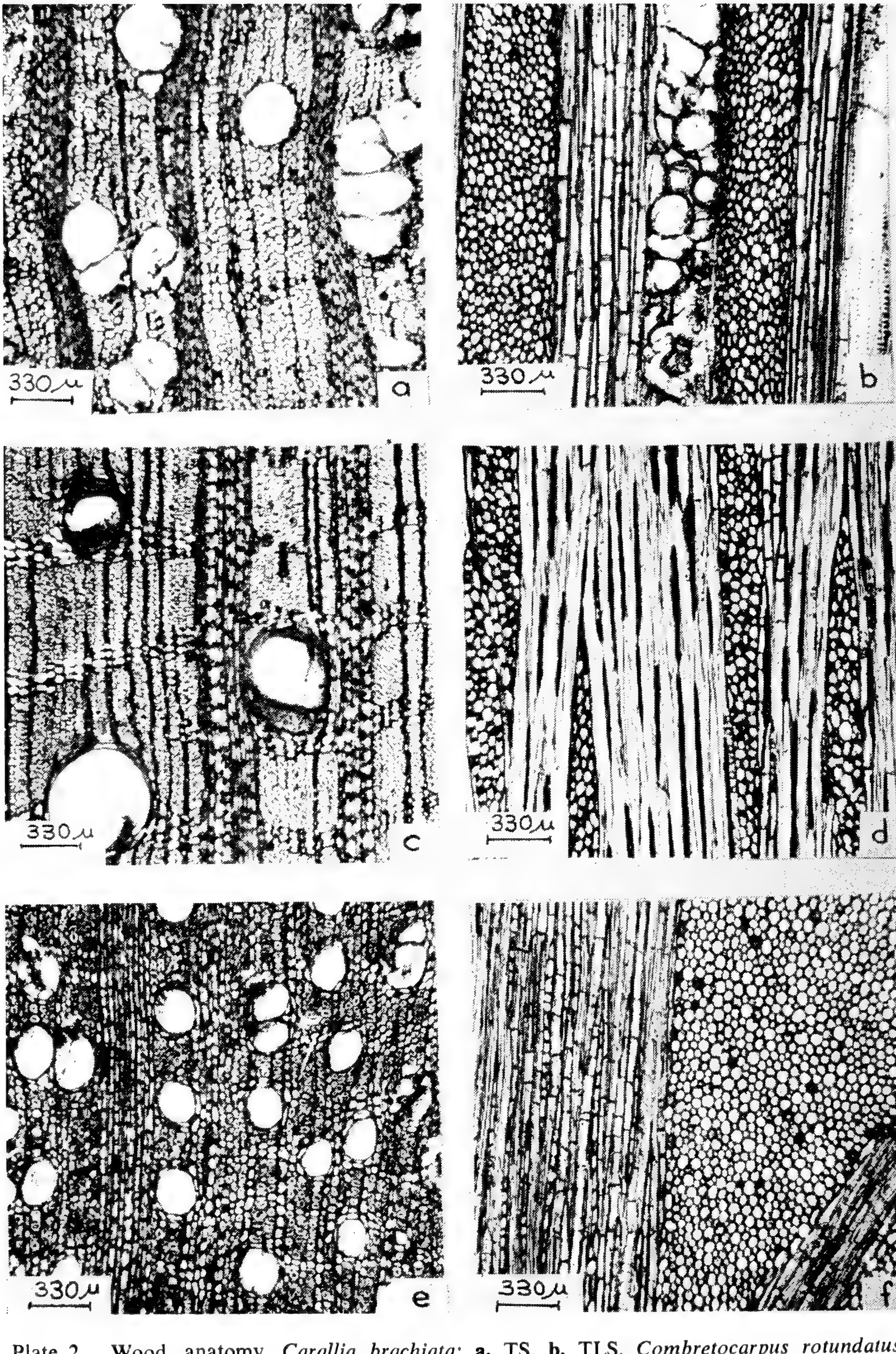

Plate 2. Wood anatomy. *Carallia brachiata:* **a,** TS. **b,** TLS. *Combretocarpus rotundatus:* **c,** TS. **d,** TLS. *Gynotroches axillaris:* **e,** TS. **f,** TLS.

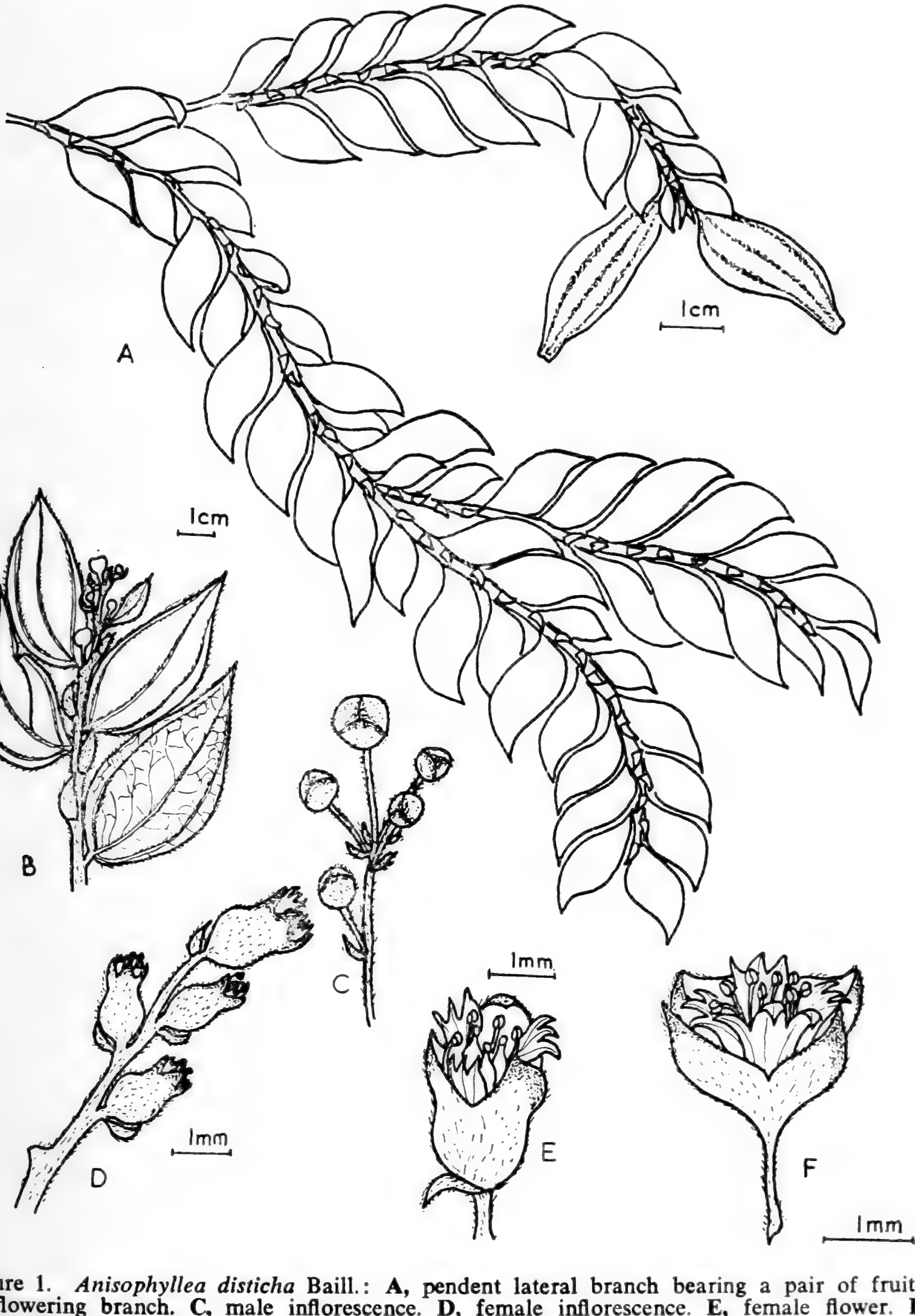

Figure 1. *Anisophyllea disticha* Baill.: **A,** pendent lateral branch bearing a pair of fruits. **B,** flowering branch. **C,** male inflorescence. **D,** female inflorescence. **E,** female flower. **F,** male flower.

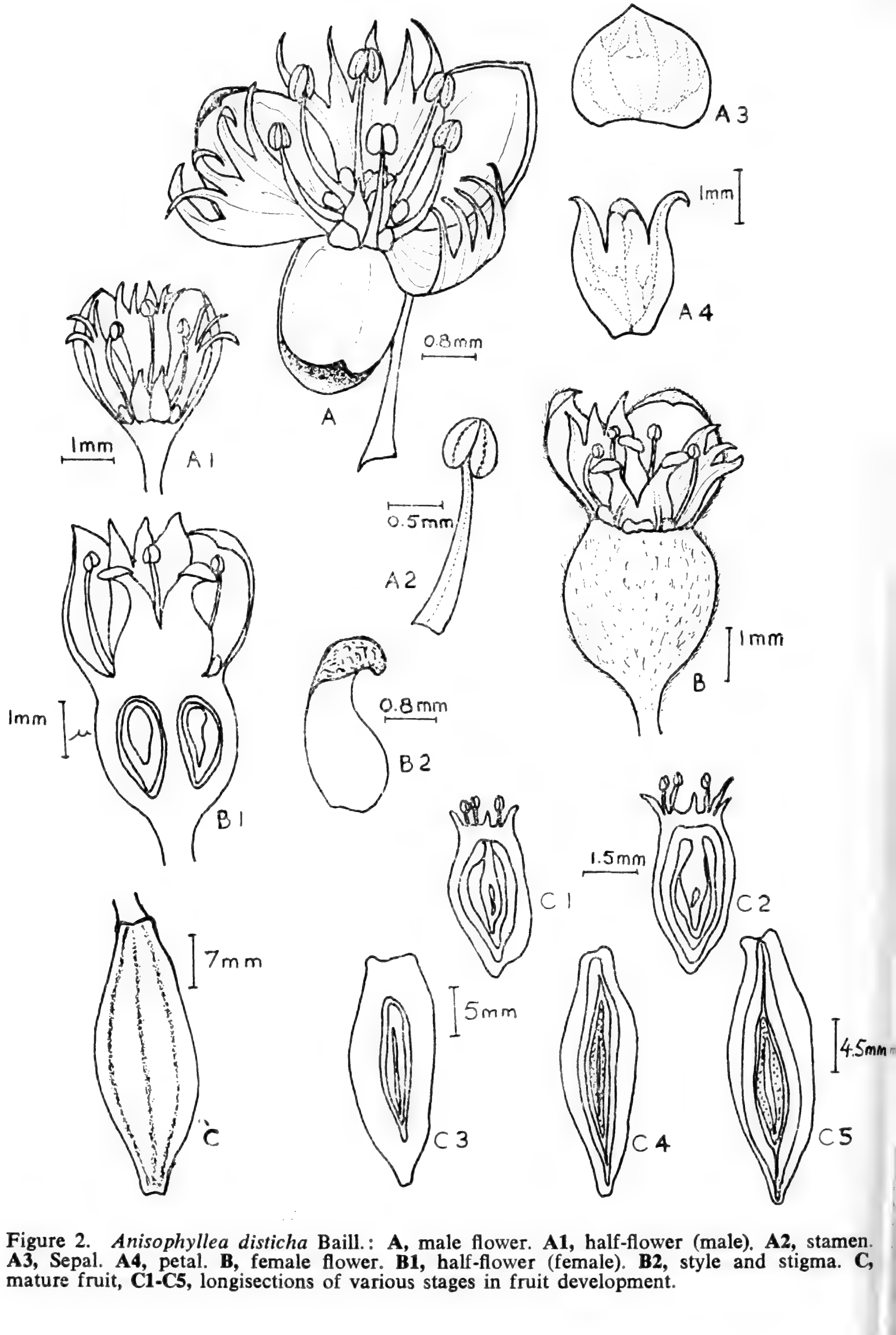

Figure 2. *Anisophyllea disticha* Baill.: **A,** male flower. **A1,** half-flower (male). **A2,** stamen. **A3,** Sepal. **A4,** petal. **B,** female flower. **B1,** half-flower (female). **B2,** style and stigma. **C,** mature fruit, **C1-C5,** longisections of various stages in fruit development.

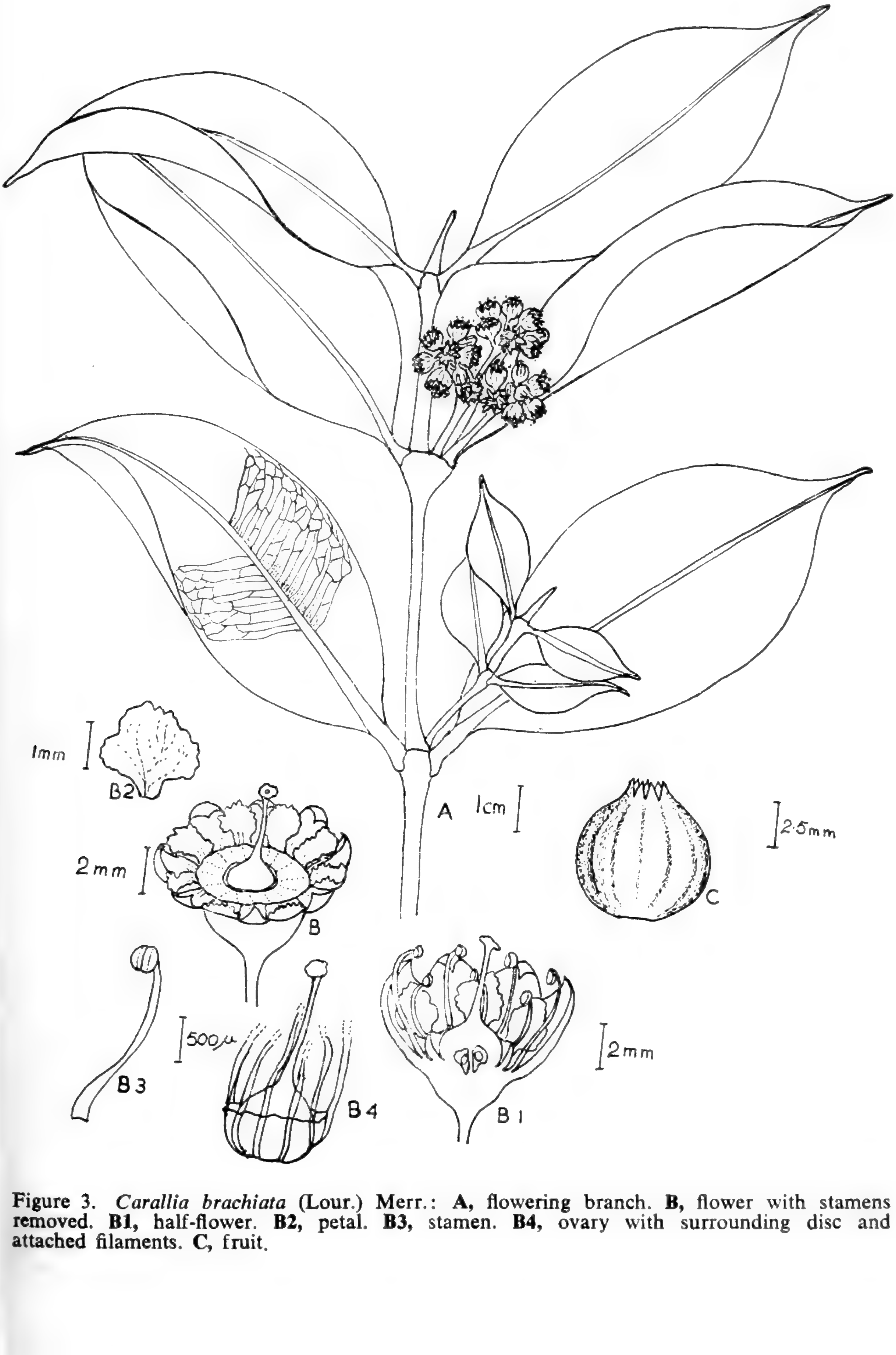

Figure 3. *Carallia brachiata* (Lour.) Merr.: **A,** flowering branch. **B,** flower with stamens removed. **B1,** half-flower. **B2,** petal. **B3,** stamen. **B4,** ovary with surrounding disc and attached filaments. **C,** fruit.

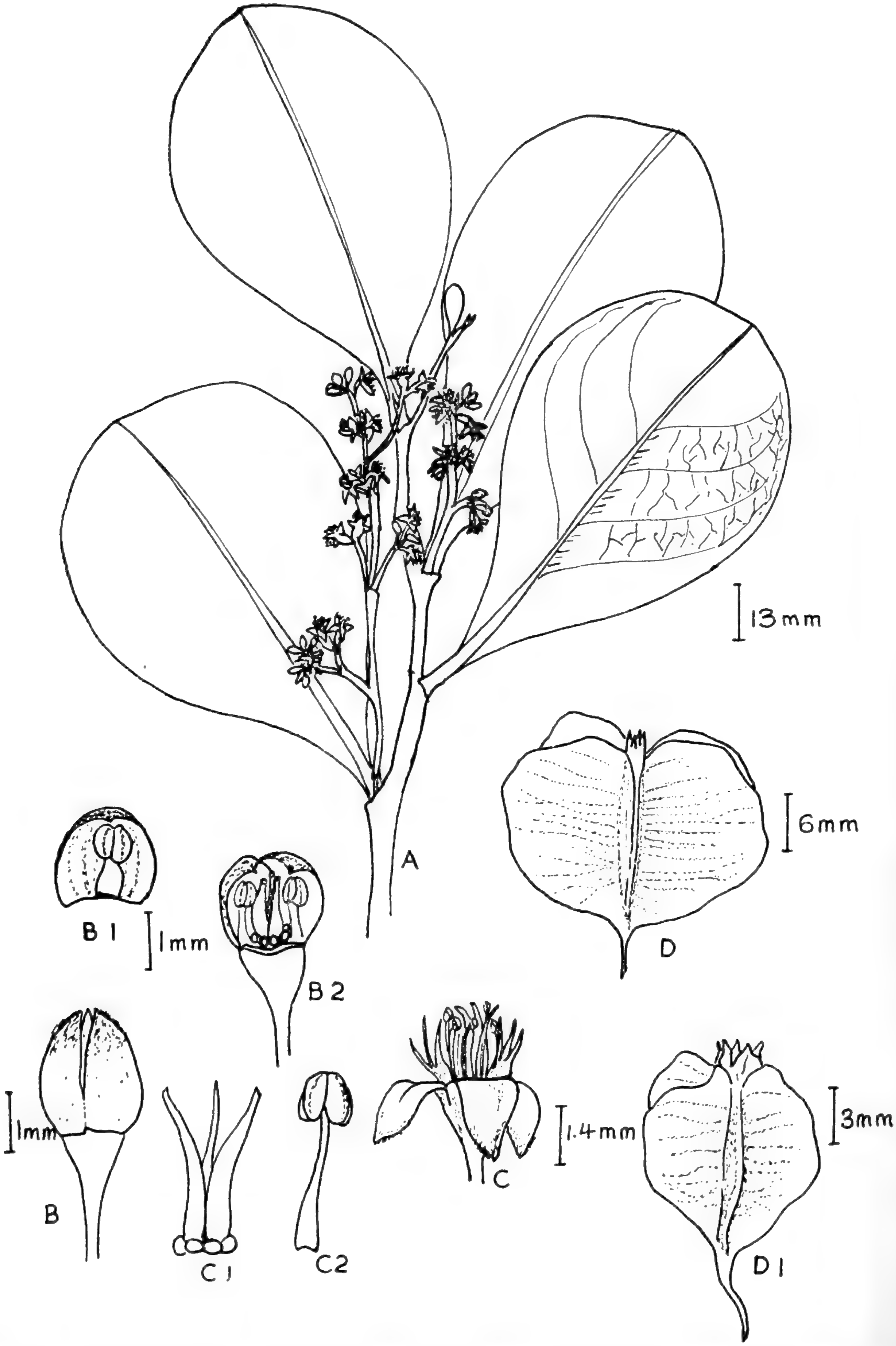

Figure 4. *Combretocarpus rotundatus* (Miq.) Danser: **A,** flowering branch. **B,** flower bud. **B1,** sepal and antisepalous stamen. **B2,** flower bud with petals and one sepal removed to show stamens, lobed disc and styles. **C,** mature flower. **C1,** style and stigma with surrounding, deeply lobed disc. **C2,** stamen. **D,** mature fruit. **D1,** younger fruit.

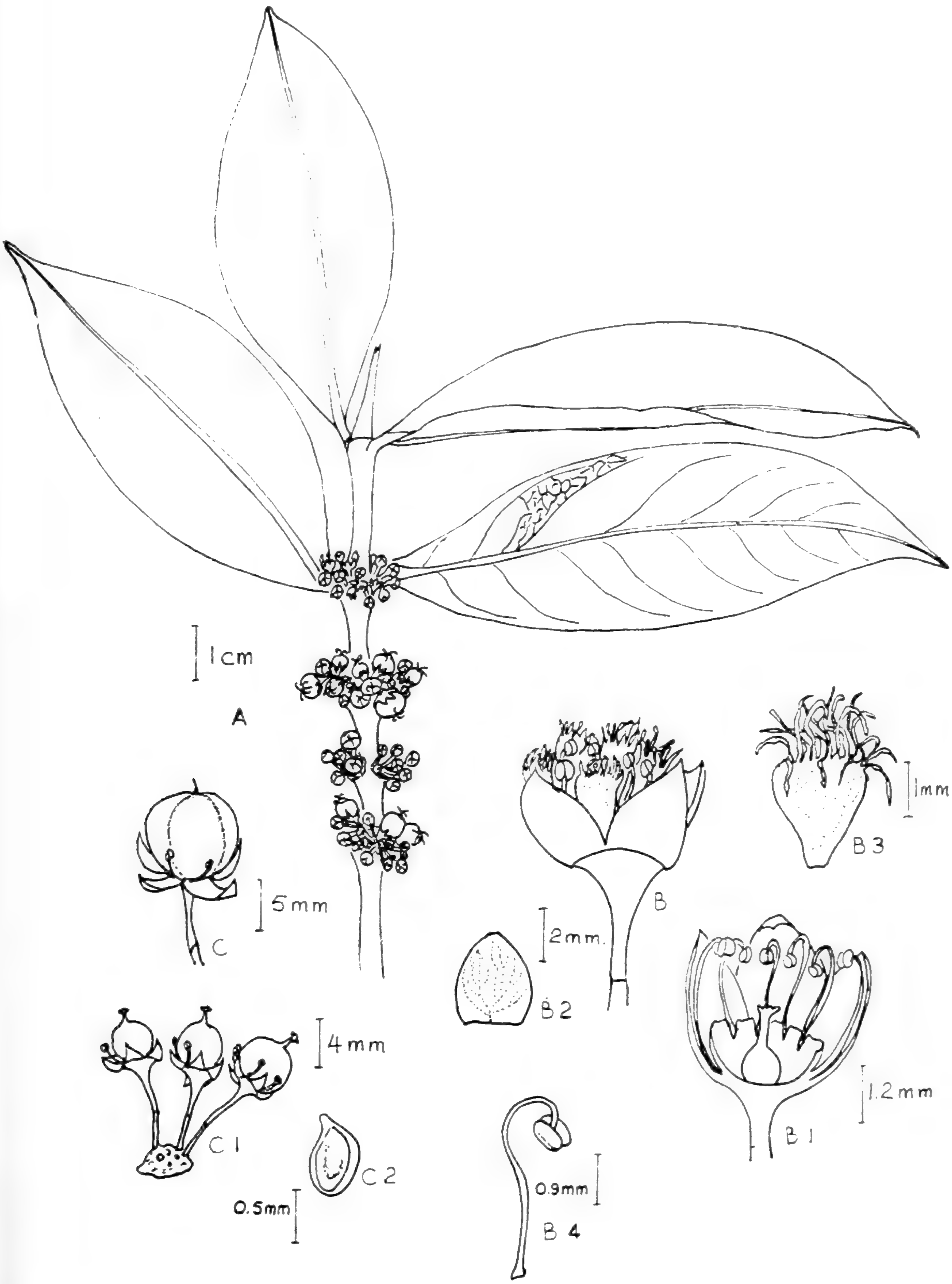

Figure 5. *Gynotroches axillaris* Bl.: **A,** flowering and fruiting branch. **B,** flower. **B1,** half-flower. **B2,** sepal. **B3,** petal with apical appendages. **B4,** stamen. **C,** fruit with basal persistent calyx. **C1,** cluster of fruits. **C2,** seed.

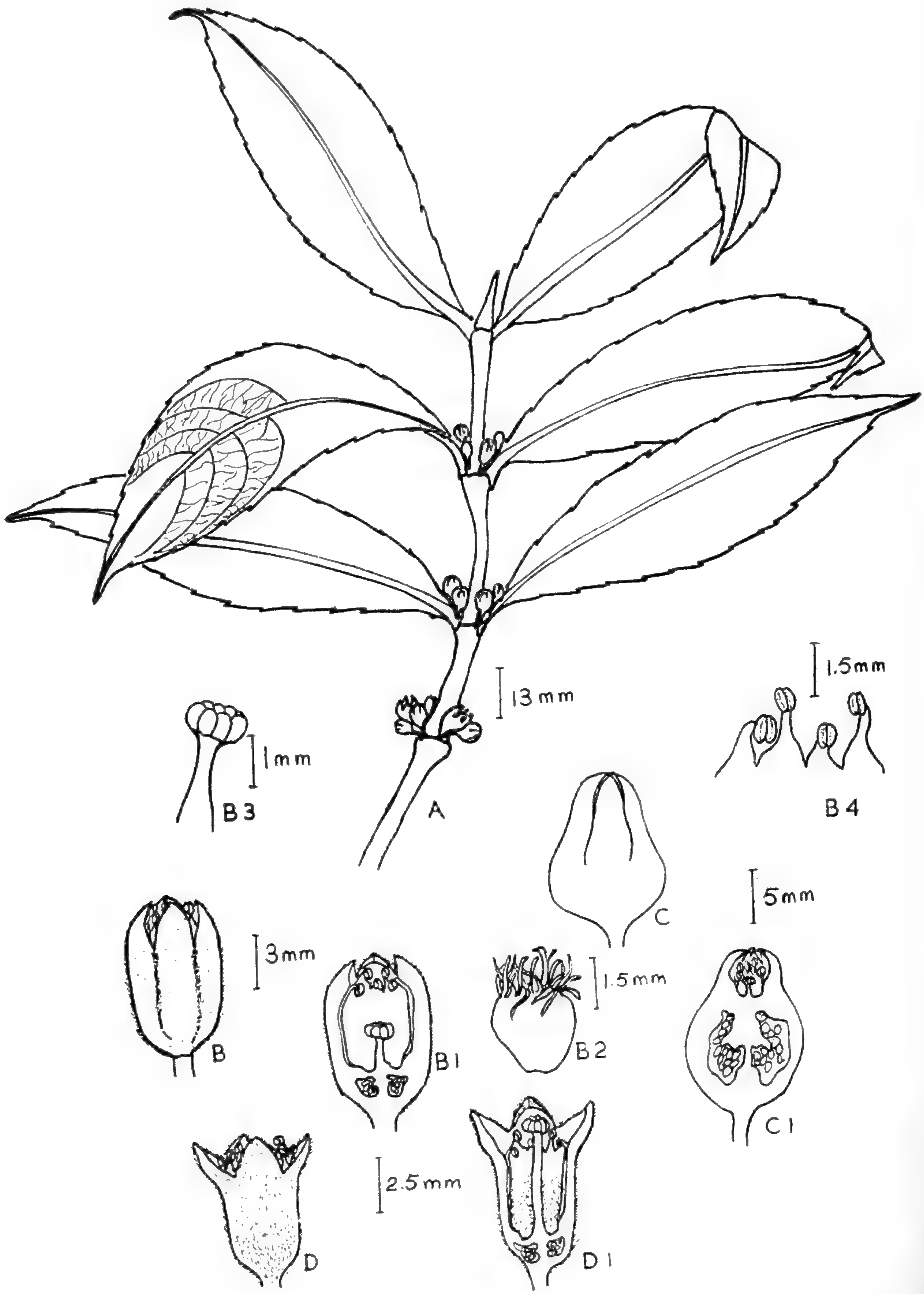

Figure 6. *Pellacalyx saccardianus* Scort.: **A,** flowering branch; **B,** flower, **B1,** half-flower, **B2,** petal, **B3,** style and lobed stigma, **B4,** stamen, **C,** fruit, **C1,** longitudinal section of fruit. *P. axillaris* Korth.: **D,** flower, **D1,** half-flower.

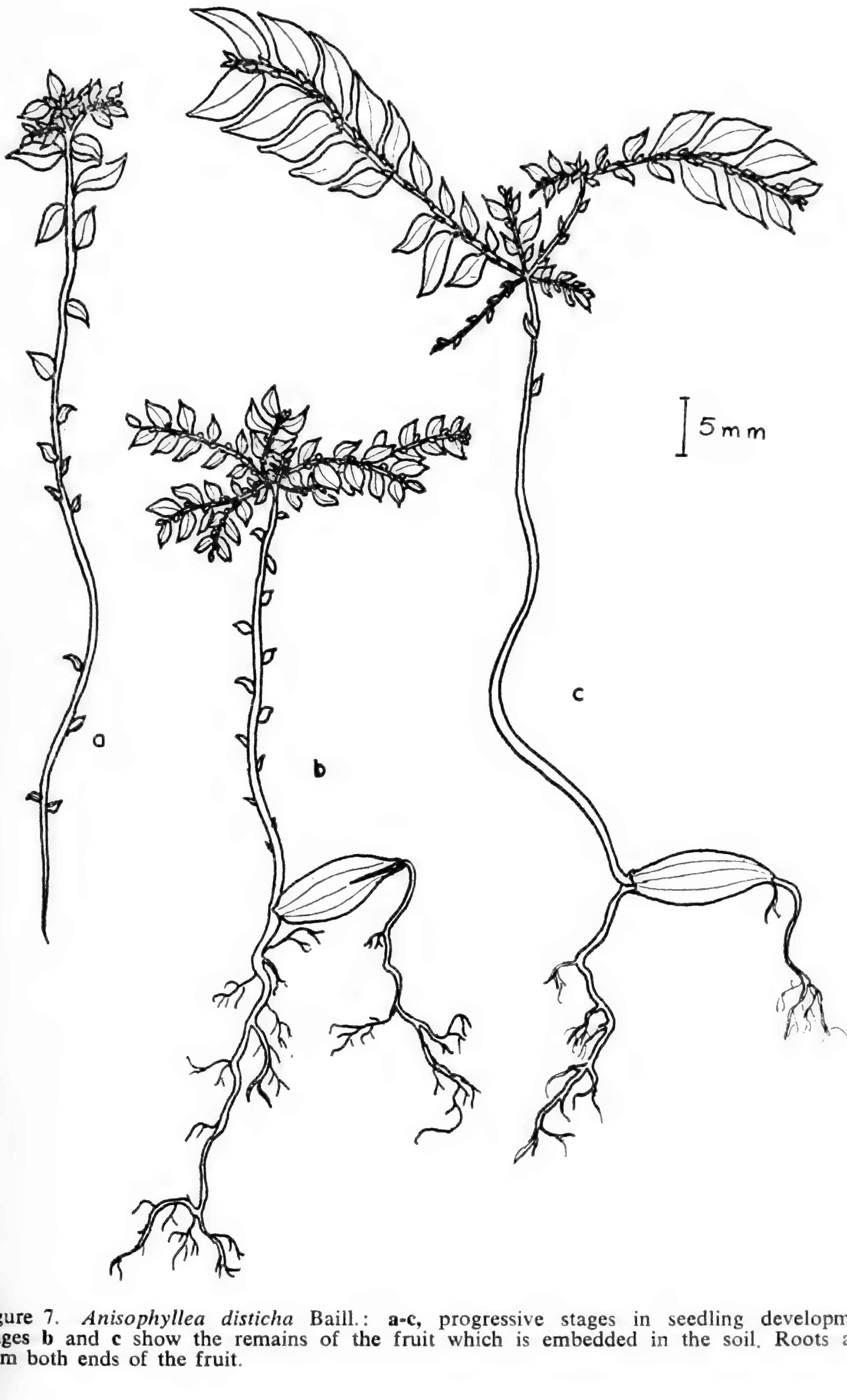

Figure 7. *Anisophyllea disticha* Baill.: **a-c**, progressive stages in seedling development. Stages **b** and **c** show the remains of the fruit which is embedded in the soil. Roots arise from both ends of the fruit.

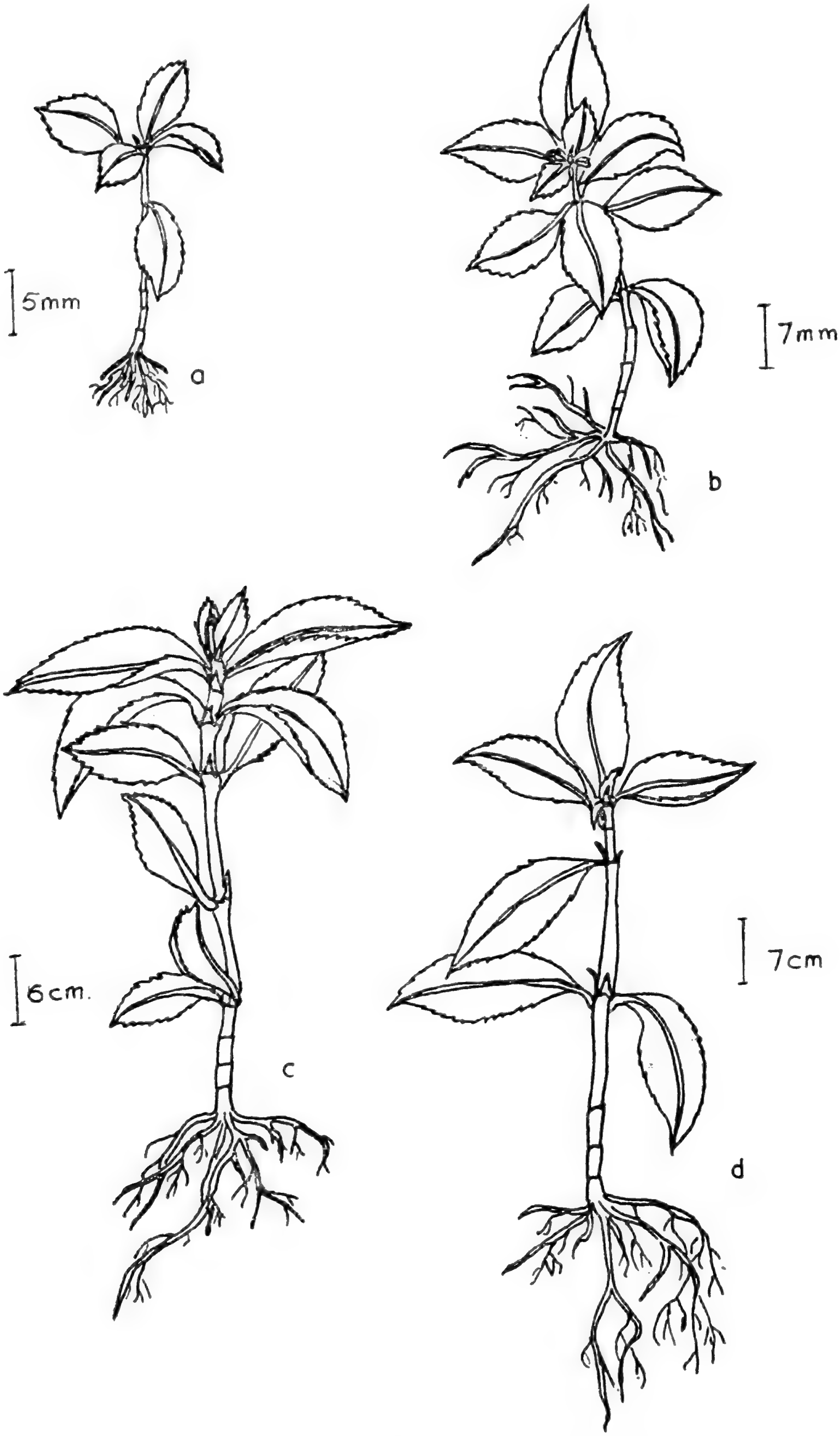

Figure 8. *Gynotroches axillaris* Bl.: **a-d,** stages in seedling development.

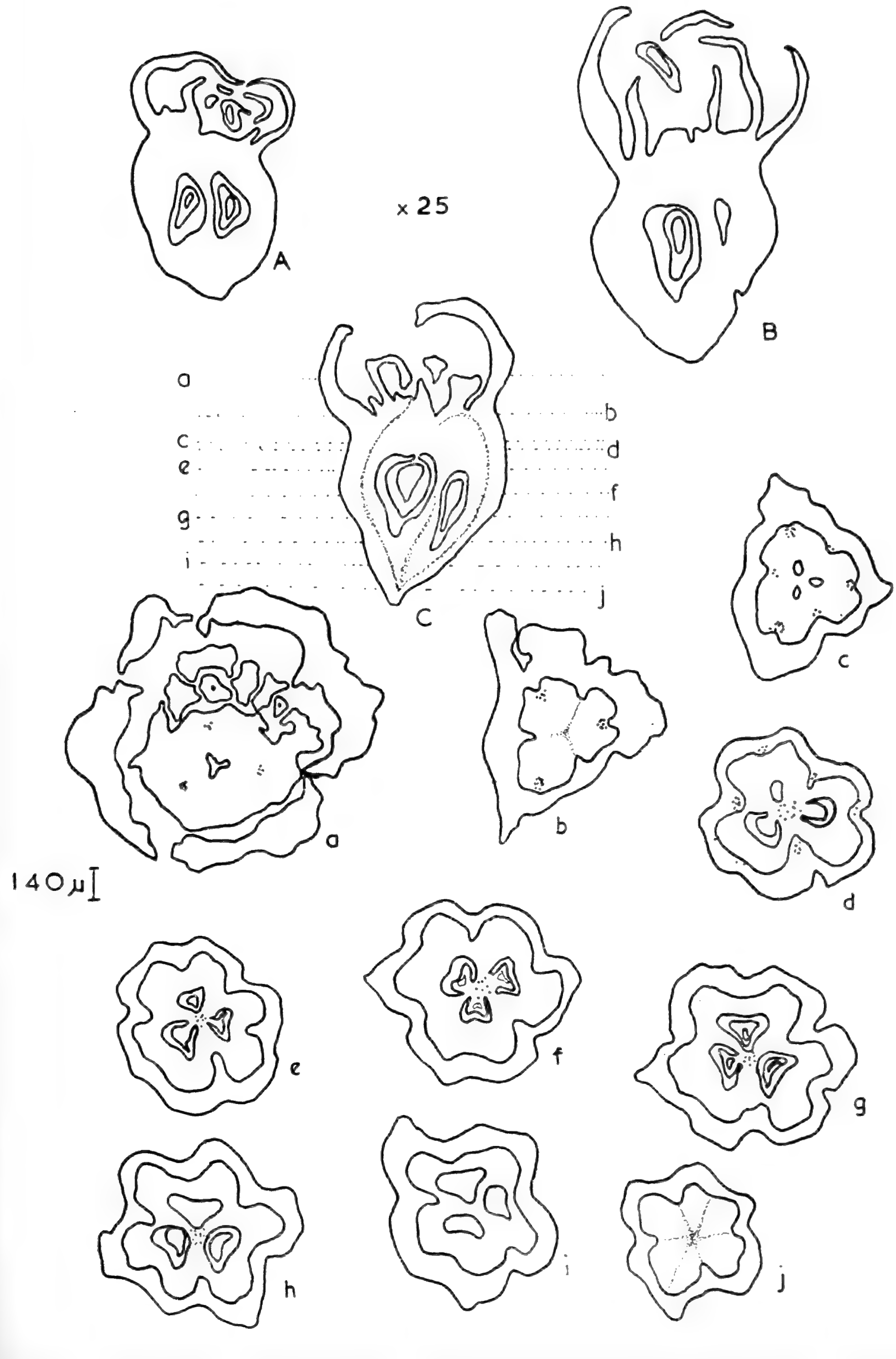

Figure 9. *Anisophyllea disticha* Baill.: **A, B & C,** different longitudinal sections of female flower. **a-j,** transections at different levels as indicated in **C.**

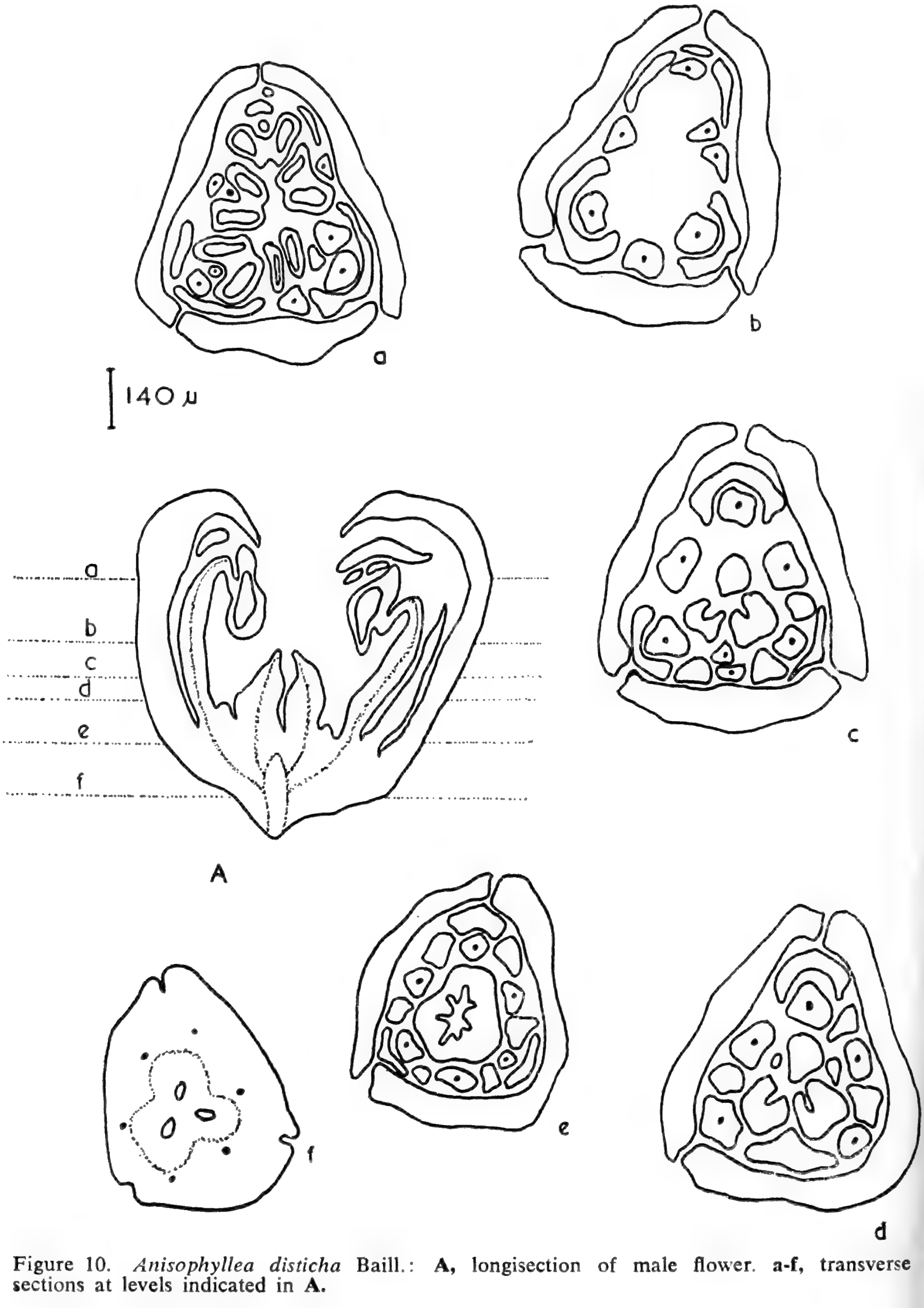

Figure 10. *Anisophyllea disticha* Baill.: **A,** longisection of male flower. **a-f,** transverse sections at levels indicated in **A.**

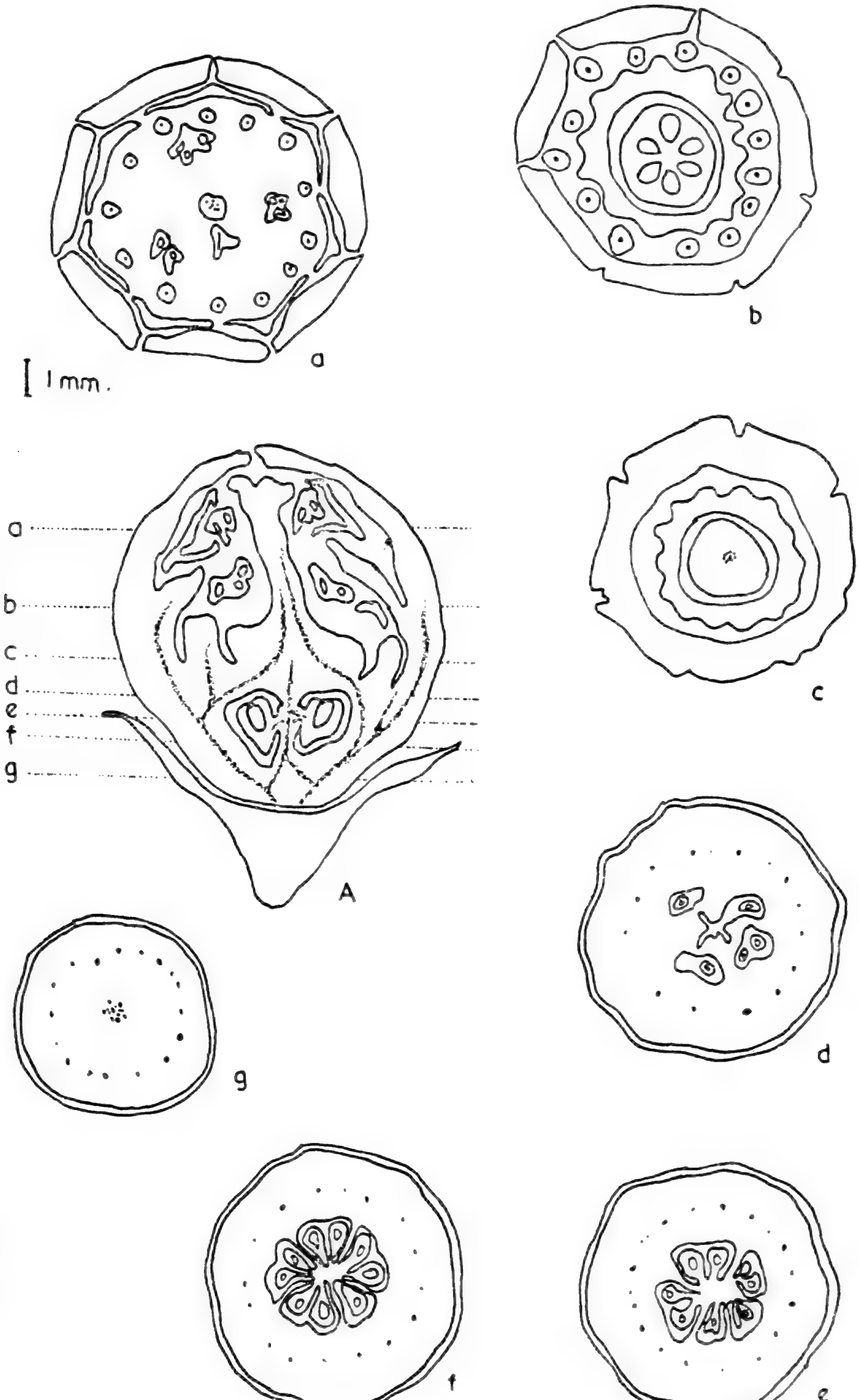

Figure 11. *Carallia brachiata* (Lour.) Merr.: **A**, longitudinal section of flower. **a-g**, transections at levels corresponding to those shown in **A**.

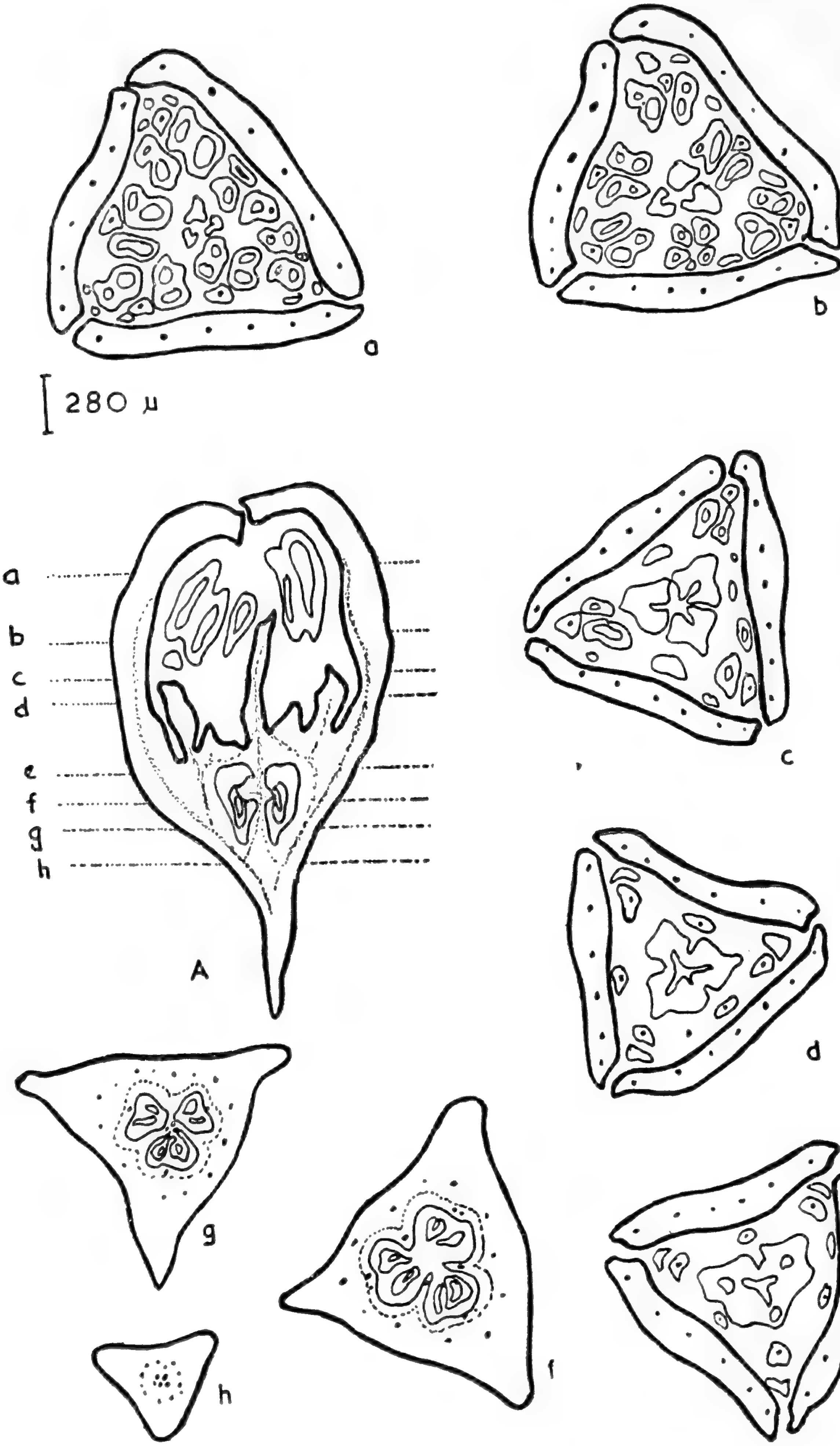

Figure 12. *Combretocarpus rotundatus* (Miq.) Danser: **A**, longisection of flower, **a-h**, transverse sections at levels shown in **A**.

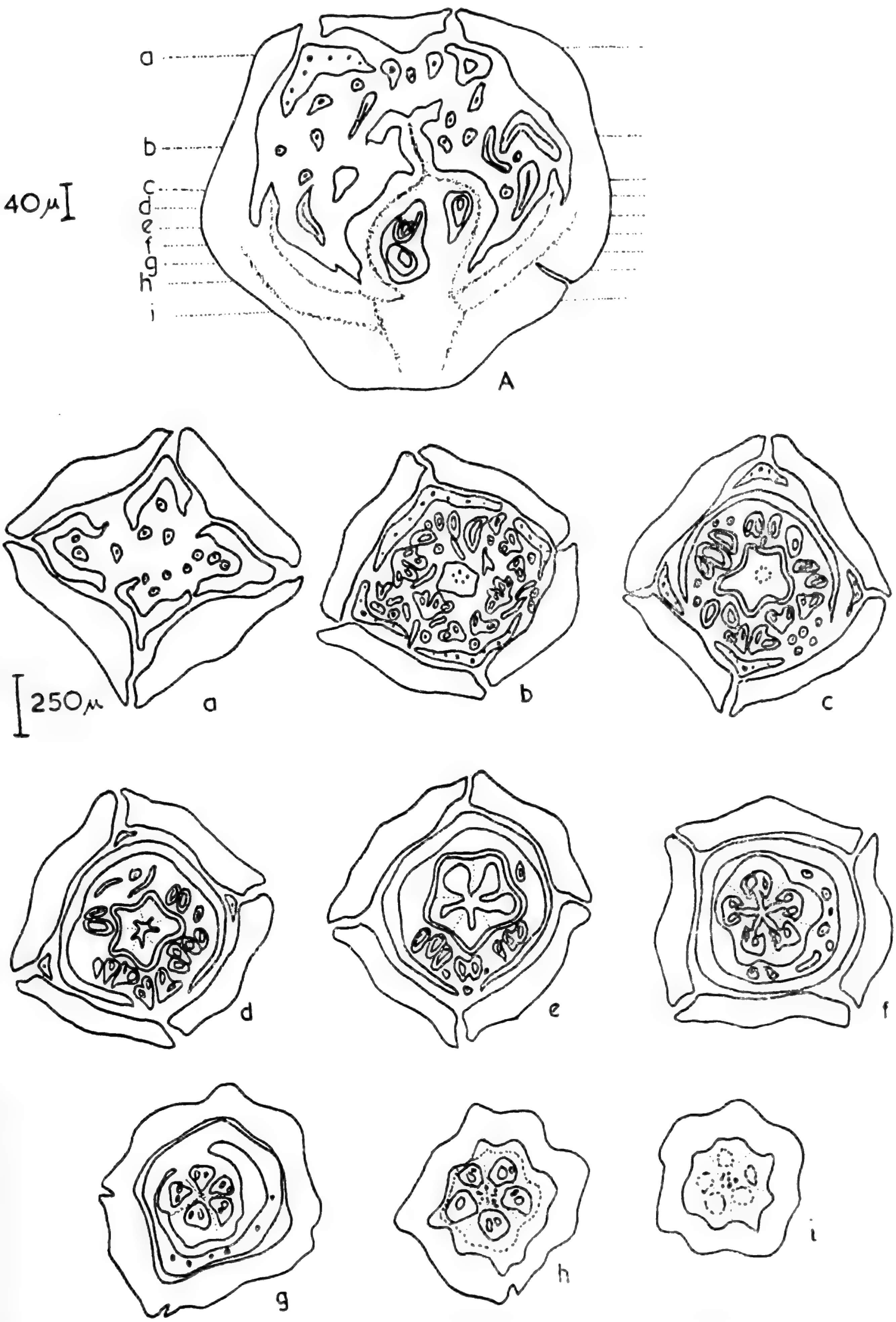

Figure 13. *Gynotroches axillaris* Bl.: **A**, longitudinal section of flower, **a-i**, transverse sections at different levels.

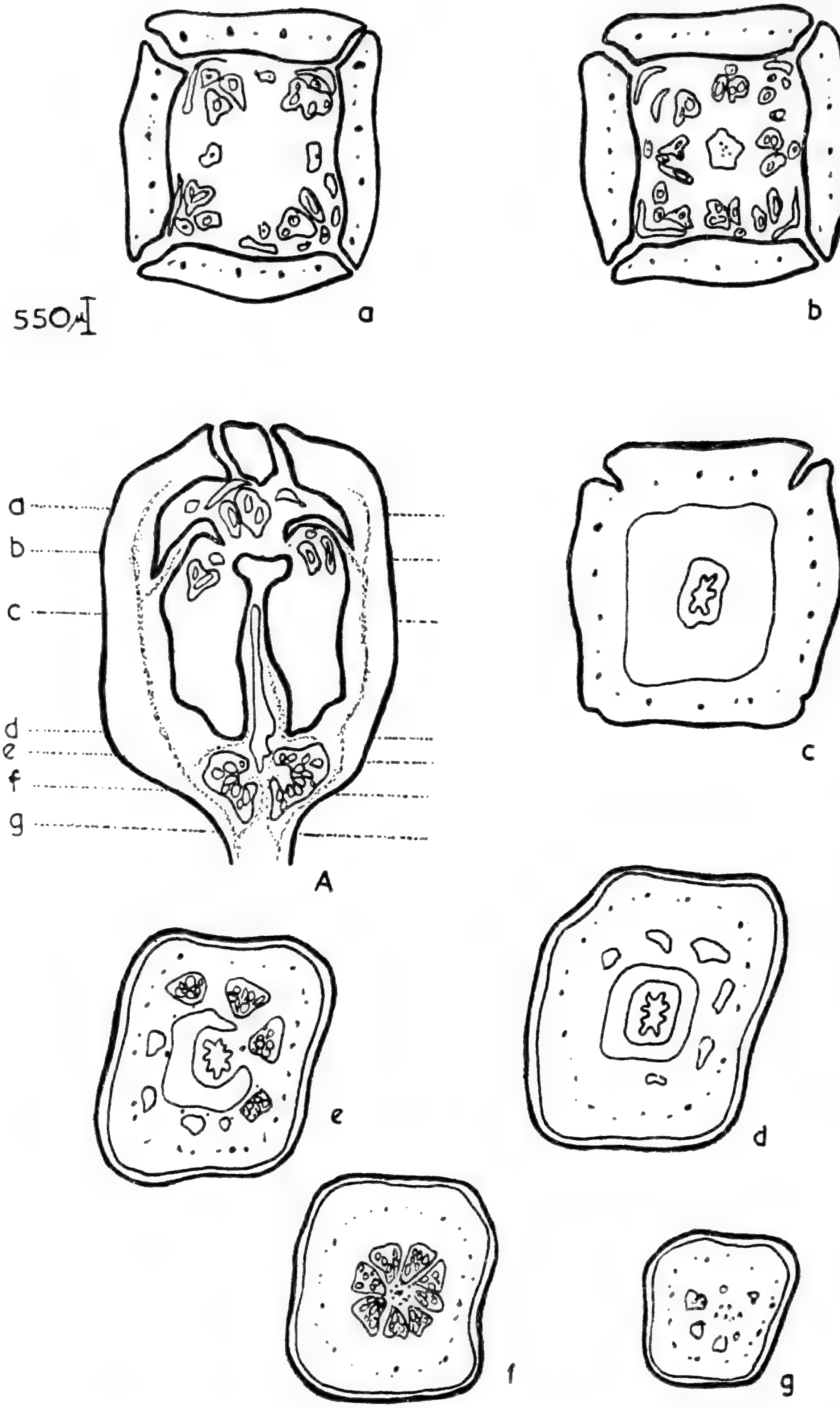

Figure 14. *Pellacalyx saccardianus* Scort.: **A,** longitudinal section of flower. **a-g,** transections of flower at levels indicated in **A.**

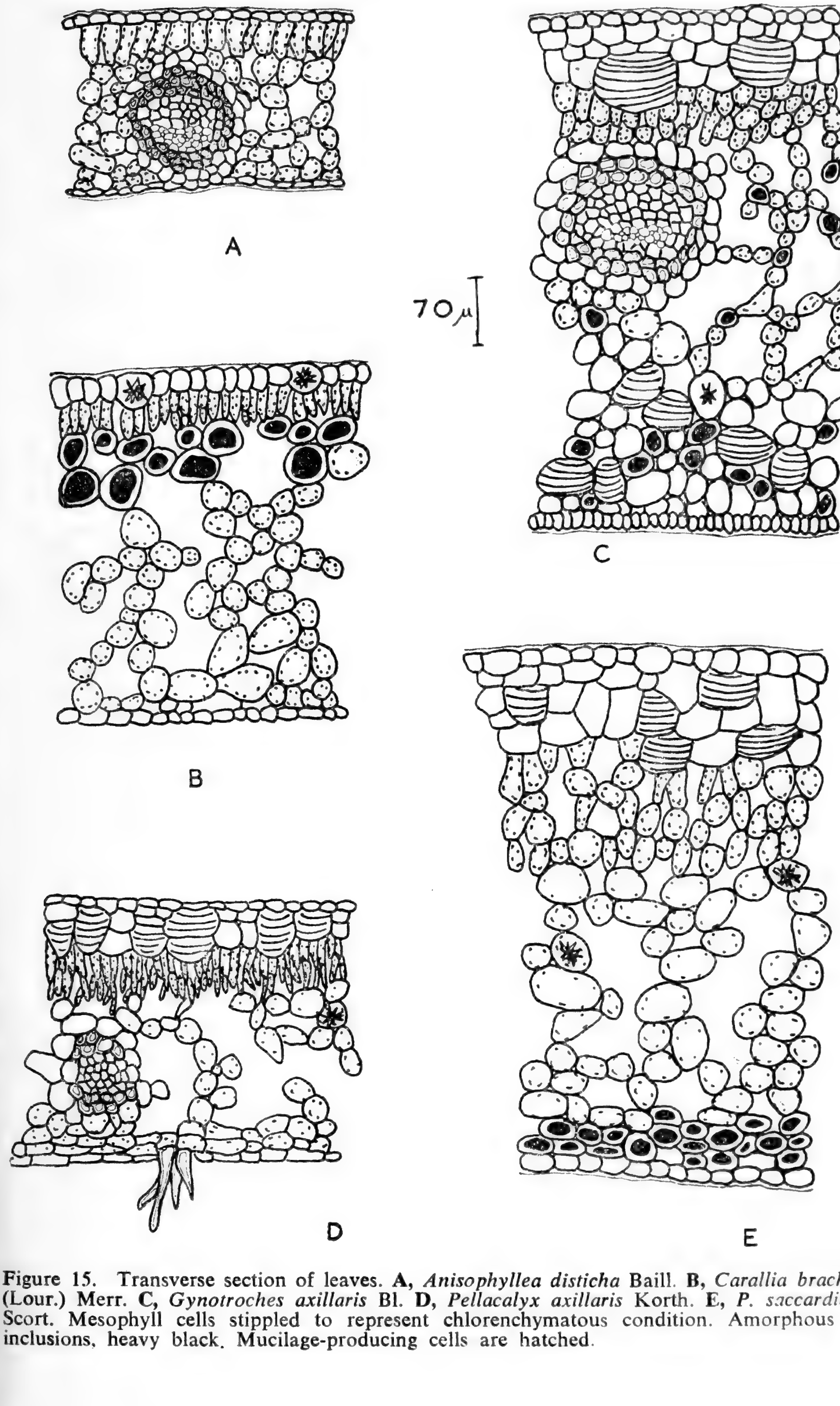

Figure 15. Transverse section of leaves. **A,** *Anisophyllea disticha* Baill. **B,** *Carallia brachiata* (Lour.) Merr. **C,** *Gynotroches axillaris* Bl. **D,** *Pellacalyx axillaris* Korth. **E,** *P. saccardianus* Scort. Mesophyll cells stippled to represent chlorenchymatous condition. Amorphous cell inclusions, heavy black. Mucilage-producing cells are hatched.

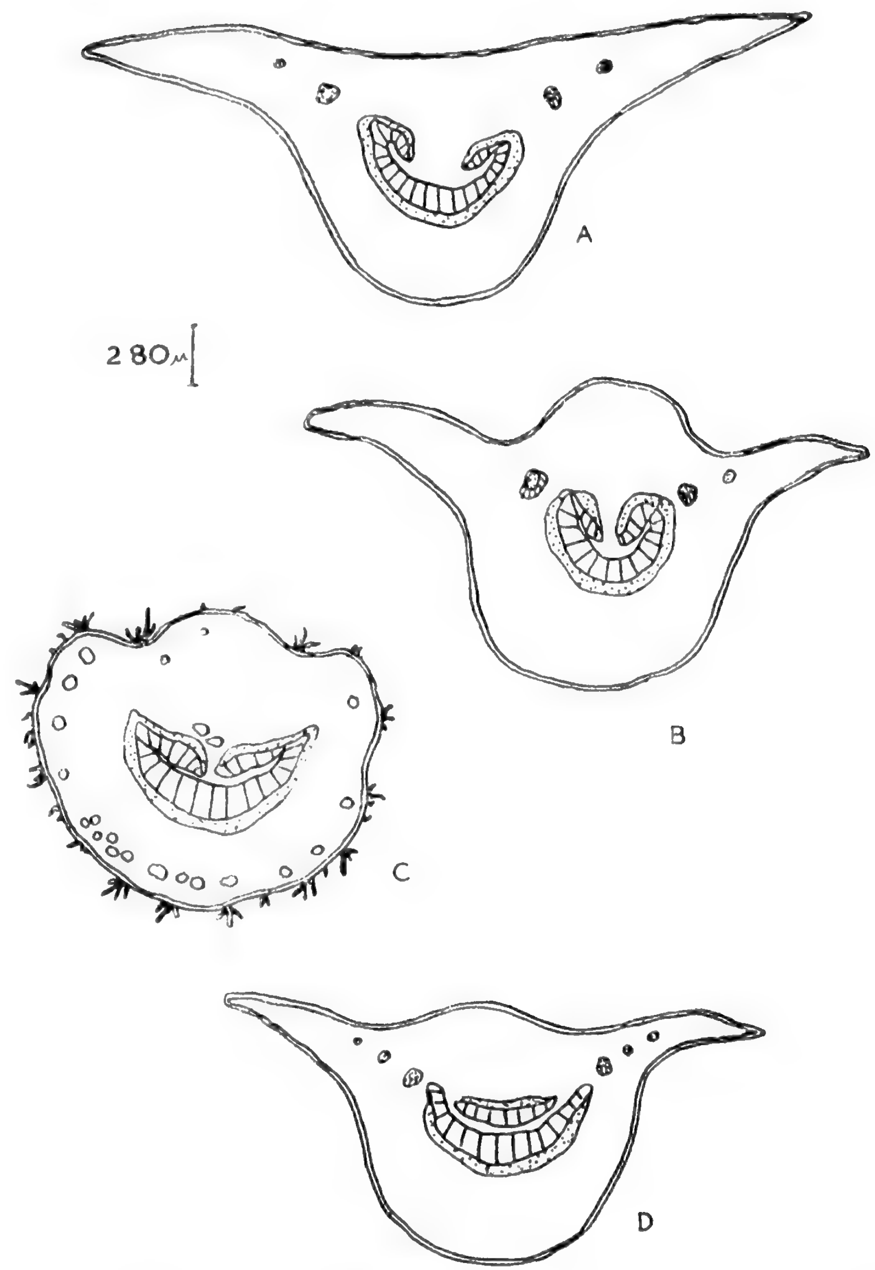

Figure 16. Diagrammatic representation of transections of petioles. **A,** *Carallia brachiata* (Lour.) Merr. **B,** *Pellacalyx saccardianus* Scort. **C,** *P. axillaris* Korth. **D,** *Gynotroches axillaris* Bl. Mucilage-producing cells present around peripheral region of petiole of *P. axillaris* Korth. (stippled = xylem, hatched = phloem).

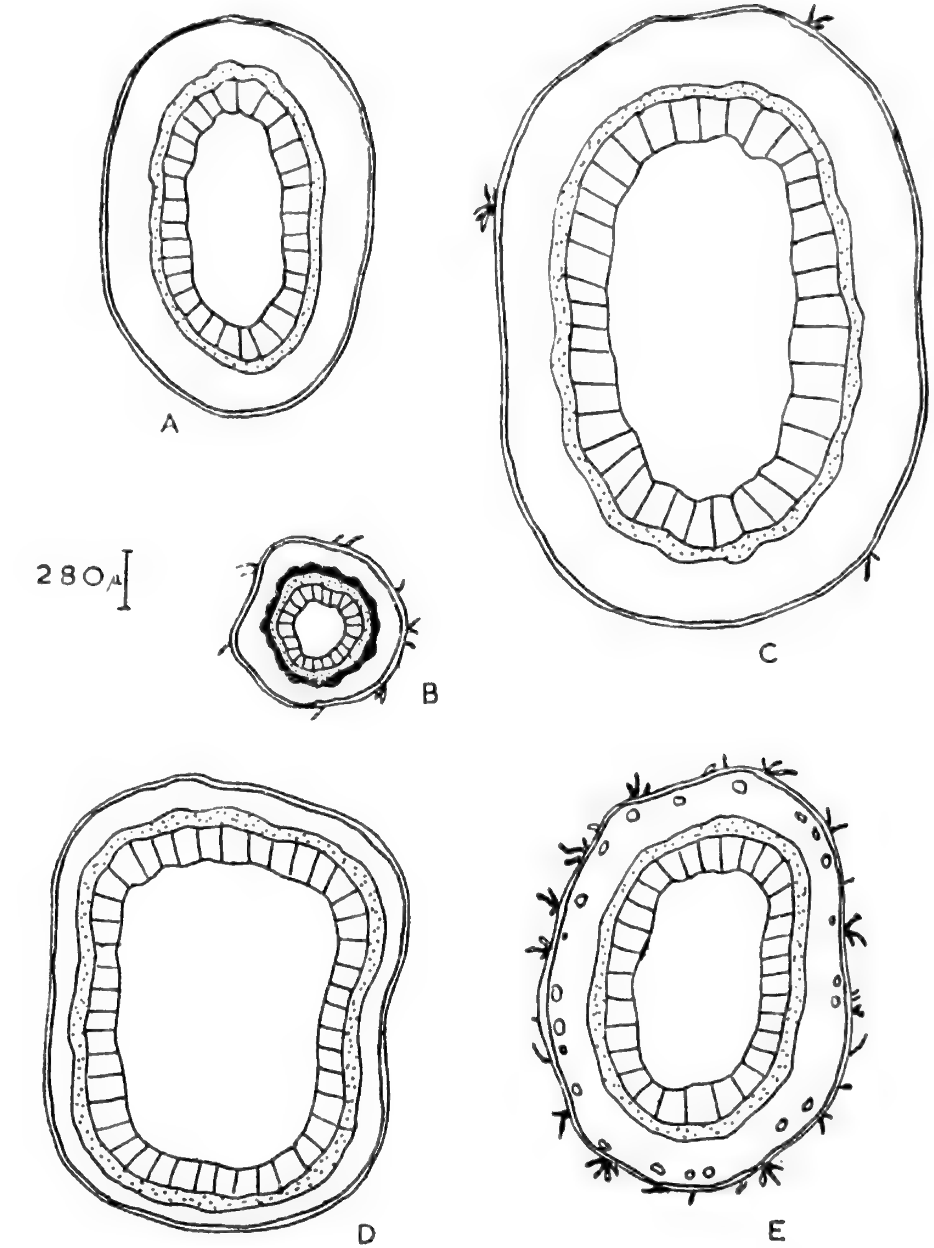

Figure 17. Diagrammatic representation of transections of young stems. **A,** *Carallia brachiata* (Lour.) Merr. **B,** *Anisophyllea disticha* Baill. **C,** *Pellacalyx saccardianus* Scort. **D,** *Gynotroches axillaris* Bl. **E,** *P. axillaris* Korth. with mucilage-producing cells in peripheral region. (hatched = xylem, stippled = phloem, heavy black = sclerenchyma).

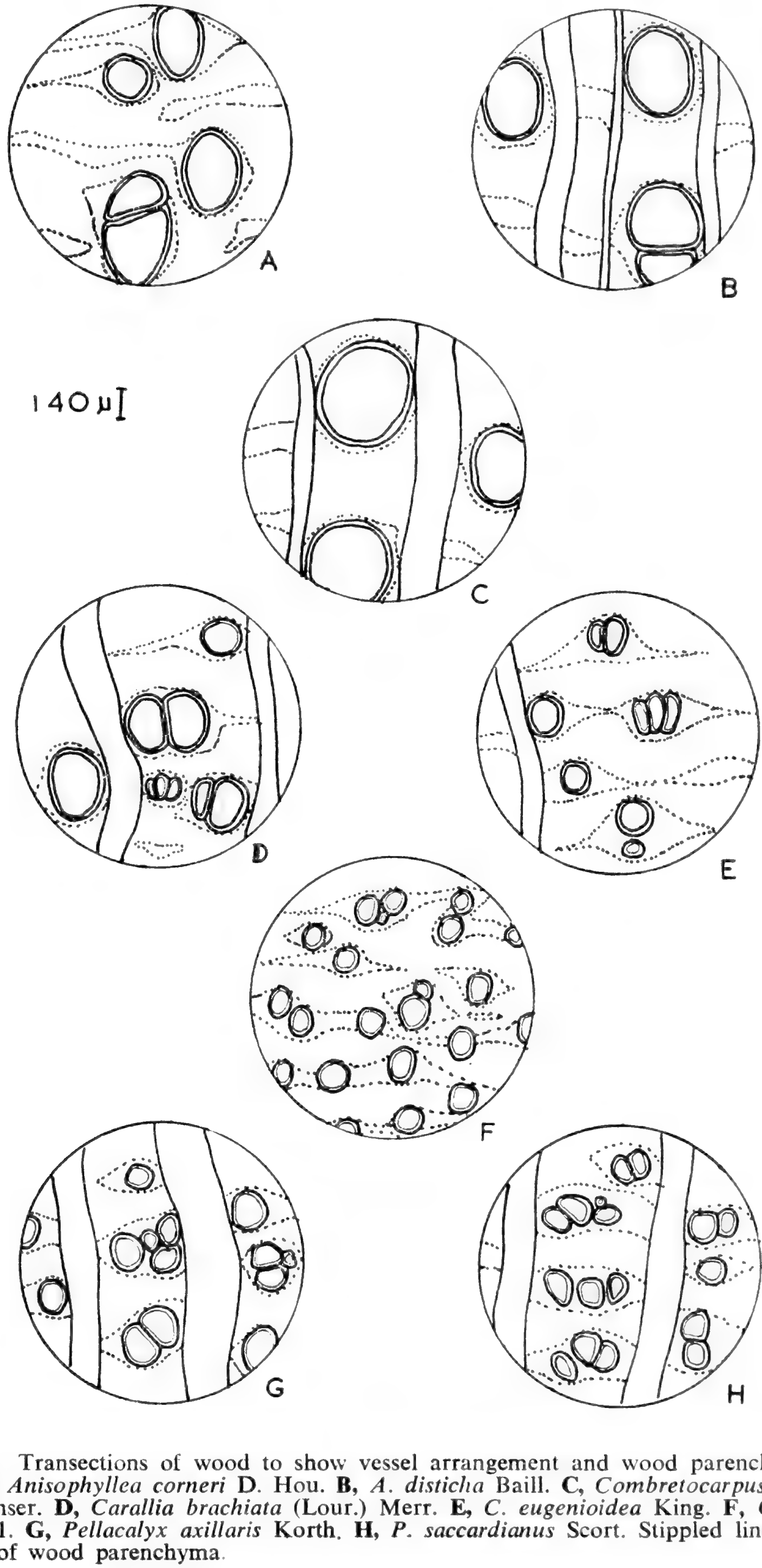

Figure 18. Transections of wood to show vessel arrangement and wood parenchyma distribution. **A,** *Anisophyllea corneri* D. Hou. **B,** *A. disticha* Baill. **C,** *Combretocarpus rotundatus* (Miq.) Danser. **D,** *Carallia brachiata* (Lour.) Merr. **E,** *C. eugenioidea* King. **F,** *Gynotroches axillaris* Bl. **G,** *Pellacalyx axillaris* Korth. **H,** *P. saccardianus* Scort. Stippled lines represent boundary of wood parenchyma.

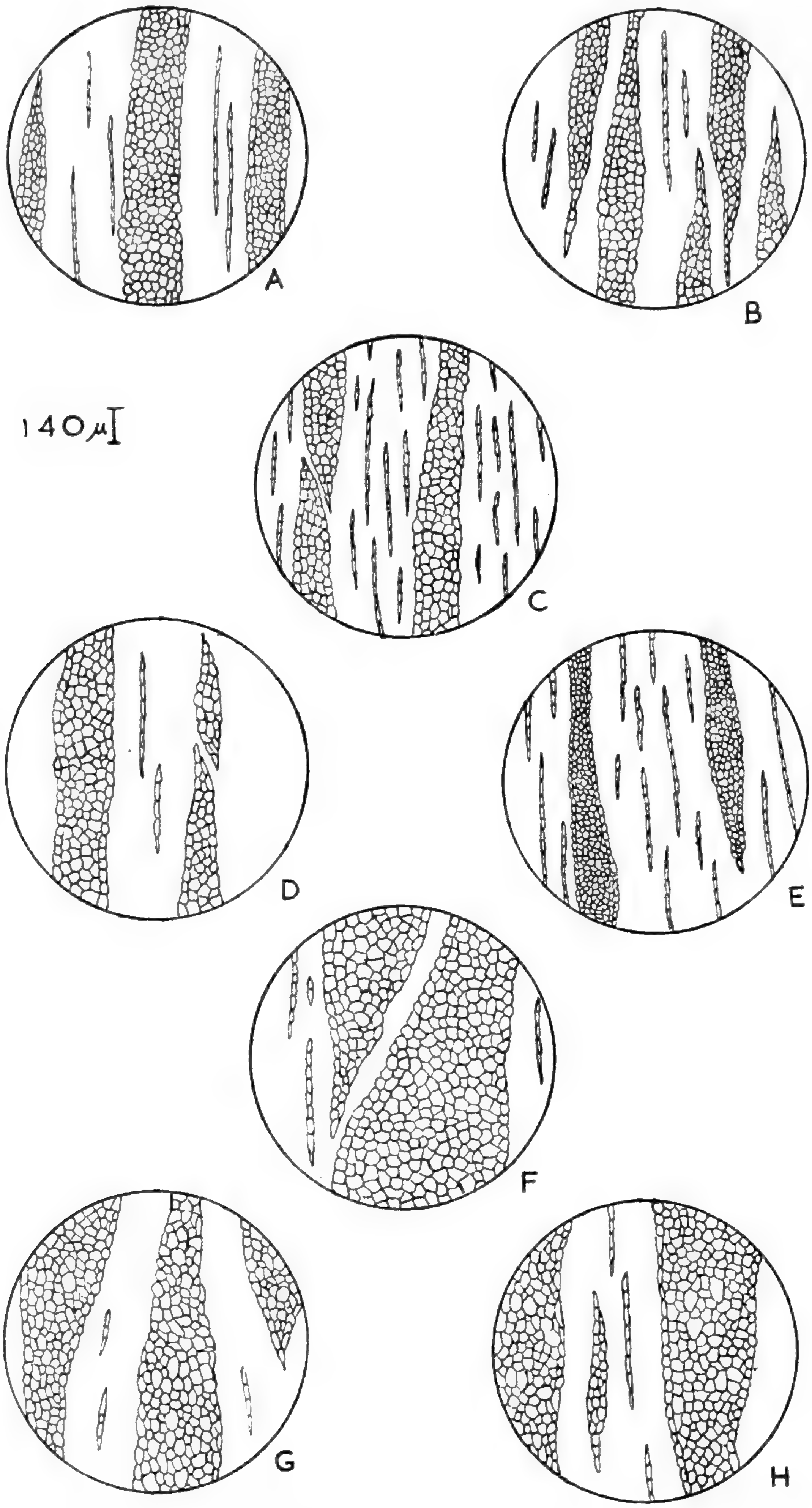

Figure 19. Uniseriate and multiseriate wood rays as seen in tangential longitudinal section. **A,** *Anisophyllea corneri* D. Hou. **B,** *A. disticha* Baill. **C,** *Combretocarpus rotundatus* (Miq.) Danser. **D,** *Carallia brachiata* (Lour.) Merr. **E,** *C. eugenioidea* King. **F,** *Gynotroches axillaris* Bl. **G,** *Pellacalyx axillaris* Korth. **H,** *P. saccardianus* Scort.

Report of the Botanic Gardens for the year 1973

1. ADMINISTRATION

The Botanic Gardens and the Parks & Trees Branch, PWD, were integrated to form the Parks & Recreation Division, PWD as of 1.7.73. Mr A. G. Alphonso, acting Director of the Botanic Gardens was appointed acting Deputy Commissioner of the Parks & Recreation Division with effect from 2.7.73. A number of posts were redesignated as shown below.

	Redesignated Post
Botanist	Curator
Horticultural Assistant	Assistant Curator
Junior Horticultural Assistant	Horticultural Assistant

Mr Quek Wai Yan, Assistant Curator, who was granted 3 years' no-pay leave to pursue a Diploma in Horticulture course at the Royal Botanic Gardens, Kew, resumed duty on 21.6.73.

2. GARDENS' MAINTENANCE

The Gardens' lawns were well-maintained throughout the year. Several areas were landscaped with flowering and foliage plants and many old plants were replaced by more vigorous specimens.

Additional road lights and spot lights were installed in the earlier part of the year to further improve the lighting facilities, however all spot-lights were switched off from November, in an effort to conserve electricity during the current energy crisis.

Over 110 offenders of the Environmental Public Health Act 1968 were summoned during the year.

3. HERBARIUM

The Herbarium facilities were fully made use of throughout the year by visiting botanists. About 202 specimens were identified for the public, and 1,878 specimens were sent out on loan to various institutions. 1,232 duplicates were sent out in exchange for 4,310 received from other herbaria.

During the year, 7,650 specimens were mounted, 1,028 old specimens were repaired, and 10,170 sheets were indexed. About 5,646 specimens were incorporated in the herbarium.

Several collecting trips were made in the year, details of which are given in Appendix II.

4. ORCHIDS

Twenty-five new orchid hybrids were described in 1973. Two of these, Dendrobium Dzemal Bijedic (D. Tumphal x *D. ostrinoglossum*) and Dendrobium Rahah (D. Noor Aishah x D. Peggy Shaw) were named in honour of the Prime

Minister of Yugoslavia and Toh Puan Rahah, wife of the Prime Minister of Malaysia, respectively, during their visit to the Gardens.

Three orchid hybrids were awarded prizes at the Orchid Show organised by the Orchid Society of South East Asia. They are:

Aranda Majula (Arachnis Maggie Oei x *Vanda insignis*)	1st Prize
Paphiopedilum Shireen (*Paphiopedilum glaucophyllum* x *Paph. philippinense*)	1st Prize
Vanda Kinloch Smith (Vanda Josephine x *Vanda coerulea*)	2nd Prize

During the year 106 hybrid pods were harvested from the Gardens' nursery, 13 pods were received from local growers and 33 pods were received from the Royal Botanic Gardens, Sydney, for germination. 99 of these 152 pods produced viable seeds. A total of 1,141 flasks of orchid seedlings were transplanted into pots and 2,794 seedlings were removed from the seedling houses and grown into bigger pots.

260 plants were received from various institutions and private individuals in exchange for 10 seed pods, 4 flasks of seedlings and 189 orchid cuttings and plants.

A total of 31,875 orchid sprays were supplied to various organisations, government departments and statutory bodies.

5. NURSERIES

a. *Pot Plant Nursery*

For the period January to September 1973, 191 requests were received for the loan of 7,635 potted plants for decoration purposes. Loan of potted plants were handled by the Logistics and Maintenance section from October 1973.

Production figures of plants at the Pot Plant Nursery are shown in Appendix I.

b. *Plant Introduction Nursery*

A total of 662 species of plants were introduced through collections, gifts, exchanges, and purchases from various institutions, nurseries and private individuals. Several of the more promising species were sent to the Primary Production Department and to the Logistics and Maintenance section for future experimentation and propagation. Altogether, 289 plants of 70 species and varieties were distributed. Seeds of 11 species of plants were also supplied to the Logistics and Maintenance section. The plants included new varieties of roses and pot Chrysanthemums as well as seedlings of a fruit tree (*Artocarpus odoratissima*) well-known in the Philippines and Sabah, and which should become popular in Singapore.

6. DECORATIONS AND FLORAL ARRANGEMENTS

The Gardens assisted in decorations with orchids, flowering and foliage plants for the following: —

1. National Day Parade Float of "The Garden City".
3. National Day State Banquet.

3. The 50th Birthday Dinner for the Prime Minister organised by the National Trade Union Congress.
4. Meeting of the 4th ASEAN Permanent Committee on Commerce and Industry.
5. Orchid Show organised by the Orchid Society of South East Asia.

7. Tree Planting Day

Tree Planting Day is an annual national event which serves to remind the public of the importance of growing trees.

This year's Tree Planting Day was held on Sunday, 4th November 1973. Tree-planting activities were organised in various constituencies. A total of 6,850 ornamental trees, 5,291 fruit trees and 8,450 shrubs and climbers were planted this year.

8. School of Ornamental Horticulture

There is a total enrolment of 26 students in the School. Twelve of them are in their second year and 14 are in their first academic year.

A first year examination was conducted for the senior students in August.

The School prospectus was revised by a School Board Sub-Committee at the end of the year.

The School Board comprises of: —

Mr Lim Leong Geok — Chairman
Mr A. G. Alphonso
Mr Kee Chin Hin
Mr Wong Yew Kwan
Mr K. C. Chung
Miss Kwok Mei Yong
Mr Hardial Singh — Secretary

9. Educational Assistance and Training Schemes

Mr Djunaedi G. Widjaja of Indonesia, ASEAN Scholar in Botanic Studies underwent a two-month practical training course in the Gardens.

Four students from the University of Singapore and Nanyang University were given six weeks' practical experience in the Gardens as part of the Industrial and Business Orientation programme organised by the Science Council of Singapore.

Miss Artis Djusar of Indonesia was awarded a Colombo Plan Scholarship to pursue a six-month course in orchid culture in the Gardens.

Two students participating in the Youth Week in Commerce and Industry programme were attached to the Gardens for two days.

10. Library and Publications

The Library, which maintains a valuable collection of botanical and horticultural publications is referred to by staff members, botanists and research workers preparing taxonomic revisions and floristic studies of this region. Interested members of the public may obtain permission from the Deputy Commissioner of Parks and Recreation to make use of the Library during normal office hours.

At the close of the year, the accessioned book collection totalled 9,878. There were 384 current titles of serial publications obtained from subscriptions and exchanges. Gifts received during the year numbered 8 periodical titles, 76 reprints and 18 books.

Volume 26, part II of the Gardens' Bulletin was published on 15 September 1973. There were 178 exchanges for the Gardens' Bulletin and the Botanic Gardens' Annual Report 1972.

11. Sale of Publications and Plants

Revenue collected from the sale of botanical and horticultural publications amounted to $2,039.20.

1,401 orchid seedlings and 1,257 orchid plants and cuttings were sold for a total sum of $7,874.00.

12. Visitors

H E Mr Dzemal Bijedic, Prime Minister of Yugoslavia and Madame Razija Bijedic visited the Gardens on 18.3.73. An orchid, Dendrobium Dzemal Bijedic was named in honour of the Prime Minister.

Mr R. J. Tizard, Minister of State for Health Services, New Zealand, presented and planted a Pohutukawa tree in the Gardens. He was accompanied by Mrs Tizard.

Toh Puan Rahah, wife of the Prime Minister of Malaysia was welcomed at the Gardens on 15.11.73. She chose an orchid, Dendrobium Rahah, to be named after her.

Other eminent visitors included: —

Mr George Avery, Director Emeritus, Brooklyn Botanic Gardens and Mrs Avery.

Mr J. J. Aves, Director of Parks, Pretoria, South Africa.

Mr Ian D. Galloway, Director of Parks, Wellington, New Zealand.

Professor H. Kamemoto, University of Hawaii, Honolulu, U.S.A.

Professor Charles H. Lamoureux, University of Hawaii, Honolulu, U.S.A.

13. Nature Reserves

The present Nature Reserves constitute the Bukit Timah Reserve, the Catchment Area, and Labrador Reserve. Kranji Reserve was deleted late in the year.

The Bukit Timah Nature Reserve comes under the supervision of the Botanic Gardens. The Labour force concentrated on maintenance and repair work during the year. Over 400 steps along the footpaths were repaired and a fence was installed along a precipitous boundary aligning one granite quarry. Danger signs were posted to alert the public of dynamite blasting at specified times by the quarries. A new set of benches and 18 litter bins were installed. The Reserve is closed to public vehicles at the following times: —

7 a.m. — 8 p.m. on Sundays and Public Holidays.

4 p.m. — 8 p.m. on weekdays.

2 p.m. — 8 p.m. on Saturdays.

Earlier in the year, paths and bridges in Kranji Reserve were repaired when they were damaged during high tides.

A new Board of Trustees for the Nature Reserves was set up under the Nature Reserves (Amendment) Act of 1973.

The Board members are: —

Mr Quek Kiah Huat (Chairman).

Mr Lim Leong Geok.

Mr A. G. Alphonso.

Dr Hsuan Keng.

Mr Chan Chor Cheung.

Mr Sie Chu Hua.

Mr Wong Yew Kwan.

Mr Kee Chin Hin.

Mr Christopher Giles Roche.

Dr Tay Kah Seng.

Dr Chang Kiaw Lan was nominated Honorary Secretary by the Board.

14. Meteorological Records

Temperature, rainfall and humidity records for the years 1969-1973 are given in Appendix III. The figures were recorded at the Botanic Gardens and at the Bukit Timah Nature Reserve.

APPENDIX I

PRODUCTION FIGURES OF POTTED PLANTS AT THE POT PLANT NURSERY FOR 1973

Month	Botanic Gardens Nursery	Ulu Pandan Nursery	Total
January	1,090	1,295	2,385
February	895	850	1,745
March	965	1,015	1,980
April	785	1,032	1,817
May	885	508	1,393
June	1,060	1,590	2,650
July	1,075	1,166	2,241
August	2,230	1,170	3,400
September	2,836	1,913	4,749
October	1,400	880	2,280
November	1,250	740	1,990
December	520	887	1,409
Total ..			28,037

APPENDIX II

Personnel	Date	Locality	Collection
Mohd Shah, Sanusi bin Sarih, A. Mookya and Ali bin A. Rahim	29th January 1973 to 4th February 1973	Gua Musang, Ulu Sg. Ketil, Sg. Kundor, Bertam, Gunong Brong, Batu Bang, Ulu Kelantan	85 nos. for herbarium, 309 orchid plants, 148 other living plants.
Miss Lee Wai Chin, Sanusi bin Sarih, A. Mookya and Ahmad bin Shukor	21st February 1973 to 1st March 1973	Penang, Kedah and Perak	202 orchid plants, 224 other living plants.
Mr. Hardial Singh and Samsuri bin Ahmad	2nd March 1973 to 6th March 1973	Mersing, Endau, Jemaluang, Pahang	103 nos. for herbarium.
Mr. Ng Kok Wah, Sanusi bin Sarih and Ahmad bin Shukor	7th March 1973 to 10th March 1973	Pahang, Trengganu	423 orchid plants, 41 other living plants.
Mohd Shah, Samsuri bin Ahmad with Dr. E.A. Heaslett	11th March 1973	Gunong Panti East, Johore	12 nos. for herbarium, 38 orchid plants.
Mohd. Shah, Mohd Ali with Dr. R.D. Hill (University of Singapore)	10th June 1973 to 15th June 1973	Gunong Ulu Kali, Genting Highlands, Anak Takun, Templer Park, Ulu Gombak	154 nos. for herbarium, 63 orchid plants.
Mr. A. G. Alphonso and Sanusi bin Sarih	5th November 1973 to 17th November 1973	Perak, Penang, Kedah and Perlis	772 orchid plants, 244 other living plants.
Mohd Shah, Sanusi bin Sarih, Ahmad bin Shukor and Said bin Jailani	21st November 1973 to 1st December 1973	Gunong Lesong, Sg. Sawak and Sg. Rompin, Pahang	75 nos. for herbarium, 546 orchid plants, 55 other living plants.

Total: 429 nos. for herbarium
2,353 orchid plants
712 other living plants.

APPENDIX IIIa

1969

METEOROLOGICAL REPORT

Reading daily at 9.30 a.m. Local Time at **Botanic Gardens Office** from 1-1-69 to 31-12-69

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January ..	8.02	2.64	13	87.8	92.0	73.9	71.5	81.4	76.9	89.0
February	8.33	1.64	11	89.7	93.0	74.4	72.0	81.7	77.2	80.8
March	5.71	1.97	12	89.5	92.5	75.1	72.5	82.4	78.0	82.0
April	5.67	1.72	16	86.3	93.0	76.2	73.5	82.9	79.0	84.0
May	10.94	2.31	21	89.6	92.5	76.7	74.5	82.8	79.6	86.5
June	5.99	1.86	14	88.2	91.0	76.4	73.0	76.4	74.7	86.9
July	7.43	2.15	14	85.9	90.0	75.8	72.5	81.0	77.4	84.6
August	4.11	0.91	17	85.9	95.2	75.2	72.5	80.5	76.6	83.2
September	6.84	1.65	18	87.4	90.2	76.0	73.5	82.0	77.3	80.4
October	3.92	1.19	13	87.5	90.2	75.3	73.0	81.7	76.8	79.7
November	8.77	1.71	18	86.0	90.0	74.7	73.0	80.1	76.4	83.9
December	23.23	9.15	18	84.8	90.0	73.4	70.0	78.8	75.5	85.2
Total ..	98.96	28.90	185	..	..	..	..	..	..	..
Mean ..	..	..	..	87.4	91.6	75.3	72.6	81.0	77.1	83.9

APPENDIX IIIb

1970

METEOROLOGICAL REPORT

Reading daily at 9.30 a.m. Local Time at **Botanic Gardens Office** from 1–1–70 to 31–12–70

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	9.54	2.16	14	86.3	89.5	73.9	70.5	78.8	75.5	80.9
February	2.81	1.54	7	87.2	91.0	74.0	71.5	79.9	75.4	80.1
March	9.63	2.66	12	88.6	92.2	75.5	73.0	82.6	76.4	85.5
April	5.47	1.40	20	86.7	91.5	75.2	72.0	82.6	78.4	83.1
May	9.68	3.00	16	88.8	92.5	76.0	74.0	82.5	79.1	85.2
June	6.66	1.62	15	88.5	91.0	75.5	72.0	81.5	77.3	86.6
July	5.34	2.31	11	87.3	91.0	75.8	71.5	81.1	77.2	83.6
August	4.29	1.42	13	87.8	91.0	75.8	73.0	81.1	77.3	82.5
September	6.46	1.58	14	87.0	91.0	75.0	72.5	80.7	76.8	83.3
October	12.66	2.50	18	86.6	89.0	71.7	73.0	79.9	77.0	87.0
November	10.18	2.85	17	85.7	88.5	74.7	73.0	79.7	76.5	85.9
December	9.79	2.87	18	86.1	90.5	75.3	71.0	79.6	76.2	84.8
Total ..	92.51	25.91	175	..	..	..	..	..	..	..
Mean ..	..	..	..	87.2	90.7	74.9	72.3	80.8	76.9	84.0

APPENDIX IIIc

1971

METEOROLOGICAL REPORT

Reading daily at 9.30 a.m. Local Time at **Botanic Gardens Office** from 1–1–71 to 31–12–71

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	2.28	0.45	13	83.8	90.5	79.7	69.5	75.1	74.1	83.7
February	4.03	1.14	11	86.4	89.0	73.3	71.0	78.6	75.0	84.9
March	5.33	1.90	10	88.1	91.0	74.2	70.0	77.7	75.9	80.4
April	2.36	0.84	8	89.7	92.0	75.1	74.0	83.0	77.4	80.8
May	5.73	0.93	13	88.6	93.0	75.8	73.0	82.4	78.6	82.0
June	4.53	1.38	12	88.2	90.5	74.8	71.0	81.2	77.8	84.9
July	7.21	1.64	13	87.9	90.5	74.7	72.0	81.2	77.4	82.9
August	7.43	1.10	22	85.7	91.0	74.1	72.0	79.9	75.1	83.0
September	6.04	3.40	10	86.7	90.0	75.2	71.5	81.0	77.3	80.3
October	5.67	1.47	18	87.3	91.5	74.7	71.0	80.8	77.0	83.5
November	7.06	1.19	17	86.5	89.0	74.1	72.0	79.1	75.8	84.6
December	12.95	4.50	23	83.9	88.0	73.5	70.5	77.3	75.0	89.8
Total ..	70.62	19.94	170	..	..	..	..	..	..	..
Mean ..	..	..	..	86.9	90.5	74.9	71.5	79.8	76.4	83.4

APPENDIX IIId

1972

METEOROLOGICAL REPORT

Reading daily at 9.30 a.m. Local Time at **Botanic Gardens Office** from 1–1–72 to 31–12–72

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	2.55	1.61	8	86.4	88.0	72.5	69.0	78.2	74.6	84.1
February	8.15	2.86	12	88.6	95.0	74.0	71.0	80.3	76.2	82.1
March	5.97	2.00	12	88.7	92.5	74.0	71.0	80.5	76.3	82.5
April	14.27	1.69	22	87.4	90.5	74.5	72.5	80.1	78.1	88.8
May	5.13	3.00	11	88.2	91.0	76.0	74.0	82.7	79.0	84.8
June	5.28	1.65	10	87.2	91.5	76.8	72.0	82.3	78.5	84.3
July	0.54	0.26	4	88.2	93.0	78.3	73.5	83.4	78.3	79.0
August	7.30	1.22	13	87.1	92.0	76.5	70.5	81.7	77.8	83.4
September	12.65	2.34	13	83.4	89.0	57.6	72.0	81.0	77.4	82.1
October	3.09	1.64	10	88.3	90.0	75.8	74.0	83.3	78.7	80.8
November	6.83	1.32	17	86.2	90.0	75.1	72.5	80.0	77.7	83.3
December	10.47	3.11	22	84.7	90.0	74.5	71.5	79.2	76.6	88.9
Total ..	82.23	22.70	151	..	..	..	..	..	..	..
Mean ..	..	..	..	87.0	91.0	75.3	72.0	81.1	77.4	83.7

APPENDIX IIIe

1973

METEOROLOGICAL REPORT

Reading daily at 9.30 a.m. Local Time at **Botanic Gardens Office** from **1–1**–73 to 31–12–73

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	7.10	1.87	11	85.5	89.5	74.6	71.0	79.4	76.2	85.4
February ..	8.13	2.12	17	86.5	90.0	75.4	72.5	80.8	77.5	85.6
March	10.56	3.93	12	87.5	90.5	75.6	74.0	81.0	78.1	86.9
April	9.97	3.15	15	87.5	92.0	73.9	74.5	81.0	78.3	88.0
May	8.21	1.90	14	87.1	92.0	76.1	73.5	82.0	78.4	84.5
June	3.90	0.88	14	87.3	92.0	77.1	73.5	81.7	78.7	85.8
July	7.11	2.72	10	87.7	92.0	76.8	72.5	82.2	78.4	83.8
August	9.13	2.41	20	85.9	90.0	75.0	72.5	80.2	76.8	85.9
September	8.89	1.42	20	84.9	89.5	75.0	72.0	79.7	77.1	84.9
October	6.80	2.70	15	86.0	89.5	77.9	72.0	80.6	77.6	86.0
November	11.22	3.20	18	82.7	91.0	74.9	73.0	79.8	77.3	89.2
December	6.83	1.36	15	82.6	87.0	73.4	71.0	77.3	75.5	91.6
Total ..	97.85	27.66	181	..	..	..	..	..	..	..
Mean ..	..	..	..	85.9	90.4	75.5	72.7	80.5	77.5	86.5

APPENDIX IIIf

1969

METEOROLOGICAL REPORT

Reading daily at 8.00 a.m. Local Time at **'Orchid Enclosure'** from 1–1–69 to 31–12–69

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	7.54	2.66	14	90.1	93.5	75.5	70.5	75.0	74.2	96.2
February	8.47	2.22	11	90.2	93.2	73.2	72.0	75.4	74.0	95.6
March	5.95	2.08	13	90.8	94.5	74.3	70.0	76.3	75.4	95.6
April	6.30	1.72	16	90.2	94.0	75.1	72.5	77.9	77.0	95.8
May	9.80	2.46	20	90.4	93.5	76.0	73.8	78.6	77.7	95.8
June	6.28	1.98	15	89.7	94.0	75.8	73.5	78.2	77.2	95.4
July	7.83	2.19	14	87.3	94.5	73.7	69.0	76.7	76.0	96.4
August	4.63	0.78	19	86.9	92.0	84.1	71.5	76.2	75.5	96.9
September	7.32	1.66	18	88.0	90.5	74.9	72.5	77.8	76.7	95.4
October	4.27	1.26	11	88.7	92.5	74.3	72.5	76.8	75.9	95.8
November	8.51	1.40	19	87.8	92.5	73.9	73.3	76.9	75.5	96.4
December	25.53	8.98	19	86.7	90.2	72.4	69.5	75.0	74.4	97.0
Total ..	102.43	29.39	189	..	..	..	..	..	..	..
Mean ..	..	..	..	88.9	92.9	74.5	71.7	76.7	75.8	96.0

APPENDIX IIIg

1970

METEOROLOGICAL REPORT

Reading daily at 8.00 a.m. Local Time at **'Orchid Enclosure'** from 1–1–70 to 31–12–70

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	9.91	2.34	14	88.6	92.0	72.5	69.5	74.7	74.2	96.5
February	2.56	1.61	7	89.4	93.0	72.3	68.0	74.5	73.7	96.9
March	9.88	2.70	13	90.2	94.5	74.3	72.0	76.2	75.2	95.0
April	9.31	1.58	21	89.9	93.0	74.4	71.2	84.6	76.7	96.5
May	8.03	2.51	16	89.2	93.0	77.4	73.0	78.6	77.2	96.4
June	7.31	1.76	15	88.8	93.0	74.0	71.5	81.1	77.1	92.2
July	4.70	2.29	9	85.2	91.5	74.3	71.0	77.6	76.3	94.4
August	4.94	1.13	12	87.5	93.0	74.2	66.5	77.4	76.5	94.9
September	6.55	1.58	12	87.7	90.5	74.9	72.0	77.3	76.2	94.6
October	11.67	2.45	18	86.6	90.0	74.6	73.0	78.4	73.7	94.6
November	9.32	2.79	18	87.4	91.5	74.0	72.5	76.7	75.8	96.0
December	9.66	2.65	18	87.9	92.0	73.4	70.0	75.5	74.9	97.2
Total ..	93.84	25.39	173	..	..	..	..	..	..	..
Mean ..	..	..	..	88.2	92.3	74.2	70.9	77.7	75.6	95.4

APPENDIX IIIh

1971

METEOROLOGICAL REPORT

Reading daily at 8.00 a.m. Local Time at **'Orchid Enclosure'** from 1–1–71 to 31–12–71

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	2.34	0.48	13	85.5	92.5	69.3	69.0	73.7	72.5	95.8
February	3.88	1.19	11	87.8	91.0	72.4	70.5	73.7	73.2	96.5
March	5.19	1.68	11	89.2	93.0	72.7	68.0	75.0	74.2	96.2
April	3.26	1.20	10	90.7	93.5	74.2	73.0	76.4	75.8	97.0
May	5.92	0.93	13	89.5	94.5	75.4	73.0	77.8	76.8	96.0
June	4.87	1.69	11	88.6	92.0	74.6	70.5	76.7	75.8	95.7
July	6.61	1.44	13	88.3	91.5	73.9	71.0	76.0	75.3	97.0
August	6.97	1.54	22	86.4	91.5	73.7	71.5	75.3	74.6	96.7
September	6.39	2.36	8	87.8	92.5	73.5	71.0	76.9	76.2	96.6
October	5.31	1.44	21	88.5	94.0	72.7	69.9	76.1	75.5	95.5
November	6.19	1.21	19	88.4	91.5	71.9	70.0	75.4	74.3	95.0
December	12.98	3.78	22	85.8	90.5	71.4	69.8	74.3	73.7	97.0
Total . .	69.91	18.94	174	. .	. .	. .	. .	. .	. .	. .
Mean . .	. .	. .	. .	88.0	92.3	73.0	70.6	75.6	74.8	96.3

APPENDIX IIIi

1972

METEOROLOGICAL REPORT

Reading daily at 8.00 a.m. Local Time at **'Orchid Enclosure'** from 1–1–72 to 31–12–72

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	2.58	1.63	8	85.0	92.0	71.0	68.5	72.9	71.9	95.5
February	6.36	2.70	12	82.8	93.0	71.8	68.5	74.3	73.7	96.9
March	6.31	2.08	12	91.0	94.0	72.8	68.0	74.4	73.7	96.7
April	12.27	1.42	22	88.3	92.0	71.9	69.5	76.7	76.0	96.8
May	4.26	2.51	11	90.0	93.0	73.5	71.5	78.7	77.9	96.7
June	5.39	1.52	9	89.8	92.5	74.1	70.0	79.1	78.0	95.2
July	0.48	0.24	3	90.7	93.0	75.6	72.0	80.1	78.4	92.3
August	4.74	1.42	12	89.4	92.5	74.1	70.0	78.0	77.5	93.5
September ..	11.54	2.32	15	88.3	92.0	71.9	71.0	78.7	77.5	94.4
October	3.16	1.46	11	90.7	93.0	74.6	72.5	79.0	77.8	94.7
November	7.31	1.37	18	89.2	94.0	73.2	71.0	77.9	76.9	95.8
December	10.10	2.88	22	86.6	90.5	72.7	70.5	76.5	75.8	96.8
Total ..	74.50	21.55	155	..	..	..	..	..	..	..
Mean ..	..	..	..	88.5	92.6	73.1	70.3	77.2	76.3	95.4

APPENDIX IIIj

1973

METEOROLOGICAL REPORT

Reading daily at 8.00 a.m. Local Time at **School of Ornamental Horticulture** from 1–1–73 to 31–12–73

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	7.15	1.84	11	84.9	92.0	72.7	70.0	76.6	75.7	95.9
February	7.37	1.86	18	89.0	92.0	73.5	71.0	76.9	76.2	97.2
March	9.61	3.92	12	89.9	93.0	73.3	71.5	77.3	76.5	96.2
April	9.59	2.72	15	89.2	92.5	73.3	71.5	78.7	77.9	96.3
May	7.72	1.78	14	89.0	93.0	73.5	71.0	79.1	78.3	96.5
June	4.27	0.63	12	89.3	93.5	74.8	71.0	79.7	78.6	94.7
July	7.15	2.43	10	90.1	93.5	74.5	71.0	79.6	78.3	93.6
August	9.46	3.01	18	87.5	92.0	73.2	70.0	77.8	76.9	95.7
September	8.62	1.21	21	86.8	92.0	73.0	70.0	77.4	76.5	95.8
October	7.36	2.48	15	88.5	93.0	73.5	70.5	77.9	76.9	95.2
November	11.79	3.36	18	88.3	93.0	73.2	71.5	77.2	76.5	97.2
December	6.03	1.26	16	85.2	90.0	71.6	70.0	75.3	74.4	96.2
Total ..	96.12	29.50	180	..	..	..	..	..	..	..
Mean ..	..	..	..	88.1	92.5	73.3	70.8	77.8	76.9	95.8

APPENDIX IIIk

1969

METEOROLOGICAL REPORT

Reading daily at 8.00 a.m. Local Time at **Bukit Timah** from 1–1–69 to 31–12–69

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	8.70	3.20	15	85.2	89.0	75.5	69.5	77.0	75.0	90.4
February	7.29	1.96	12	86.2	89.5	75.6	70.7	76.3	74.0	88.7
March	13.43	3.47	13	86.8	90.4	73.4	69.0	76.7	74.4	80.1
April	12.96	3.47	15	87.0	91.0	74.8	71.8	78.7	76.4	90.6
May	18.65	3.47	19	88.2	91.6	74.4	70.2	80.4	77.3	86.2
June	10.06	3.20	10	87.2	90.0	75.2	71.0	78.9	76.6	89.9
July	12.87	3.20	14	85.5	89.3	73.0	68.0	77.5	75.6	91.2
August	10.52	1.52	18	89.0	89.0	73.5	68.0	77.6	75.4	90.3
September	13.62	3.20	12	87.1	89.5	75.0	70.5	78.5	75.8	89.3
October	10.22	3.20	13	86.9	90.0	74.1	69.6	77.8	75.4	89.6
November	13.88	2.40	18	86.9	90.1	73.9	70.2	76.7	74.5	87.7
December	25.50	7.85	17	85.0	89.5	72.4	67.5	76.6	74.4	89.6
Total ..	157.70	40.14	176	..	..	..	..	..	..	..
Mean ..	..	..	..	86.5	89.9	74.0	69.7	77.7	75.4	88.6

APPENDIX IIII

1970

METEOROLOGICAL REPORT

Reading daily at 8.00 a.m. Local Time at **Bukit Timah** from 1–1–70 to 31–12–70

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	11.81	3.20	10	85.4	89.0	73.0	69.8	77.0	74.9	91.0
February	4.07	3.47	3	85.5	89.8	72.8	69.9	76.6	74.6	90.3
March	11.23	2.50	11	87.7	90.7	73.6	68.5	77.3	75.1	90.1
April	7.37	1.03	19	87.1	89.8	74.2	71.0	78.7	76.1	88.1
May	12.63	1.72	18	87.6	90.9	75.3	72.0	80.2	76.5	83.9
June	11.55	2.22	13	86.5	89.0	75.1	70.0	79.8	76.6	86.3
July	4.49	1.46	11	86.3	88.5	75.5	71.5	76.4	75.2	87.8
August	6.94	2.35	10	86.3	88.5	75.4	71.0	77.3	75.8	90.2
September	9.85	2.27	14	86.8	89.0	75.1	71.0	78.3	75.8	89.4
October	7.84	1.55	19	83.7	90.5	77.0	71.0	77.5	75.3	88.5
November	10.18	2.50	16	86.4	89.0	75.0	72.5	77.7	75.3	89.5
December	13.73	2.50	15	86.0	89.5	73.7	60.5	76.8	74.8	86.0
Total ..	111.69	26.77	159	..	..	..	..	..	..	..
Mean ..	..	..	..	86.3	89.5	74.6	69.9	77.8	75.5	88.4

APPENDIX IIIm

1971

METEOROLOGICAL REPORT

Reading daily at 8.00 a.m. Local Time at **Bukit Timah** from 1–1–71 to 31–12–71

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	3.11	0.70	10	82.0	88.0	71.4	68.0	74.1	72.1	90.4
February	4.26	1.22	10	84.8	90.0	71.4	70.0	74.0	72.2	91.6
March	10.06	3.75	10	85.9	90.0	70.0	70.0	75.4	73.4	90.7
April	4.93	1.46	7	87.9	90.5	71.3	71.0	78.2	75.7	88.7
May	4.56	1.37	15	87.6	91.5	74.6	70.0	79.6	76.1	86.1
June	3.88	1.28	14	86.2	89.5	73.5	70.0	78.8	75.7	85.5
July	5.96	1.80	12	86.4	89.0	73.9	70.5	78.7	76.0	87.5
August	7.98	1.60	17	85.1	90.0	73.5	70.0	77.6	75.2	89.0
September	5.03	2.96	8	86.3	89.7	74.7	70.6	78.4	76.1	89.8
October	4.85	0.79	19	87.0	92.0	73.7	69.0	77.6	74.8	87.9
November	5.85	1.15	18	85.2	90.0	72.4	70.5	75.7	73.6	90.0
December	9.44	2.00	17	82.5	89.0	72.1	70.0	74.9	73.3	92.6
Total ..	69.91	20.08	157	..	..	..	..	..	..	..
Mean ..	..	..	..	85.6	89.9	72.7	70.0	76.9	74.5	89.2

APPENDIX IIIn

1972

METEOROLOGICAL REPORT

Reading daily at 8.00 a.m. Local Time at **Bukit Timah** from 1–1–72 to 31–12–72

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	2.49	1.10	5	83.7	88.0	71.3	69.0	74.0	71.8	89.3
February	8.38	2.04	12	86.0	90.9	72.5	70.0	75.7	73.7	90.7
March	6.75	2.02	8	86.2	90.1	72.7	70.0	75.9	73.5	88.9
April	11.72	1.89	19	86.6	91.0	73.3	70.0	79.0	76.1	87.5
May	3.52	0.69	10	87.2	91.0	75.8	71.0	81.0	77.5	81.5
June	4.31	1.18	10	86.6	88.5	75.7	71.0	80.1	77.1	86.7
July	1.79	0.99	5	87.5	89.3	77.0	73.2	80.0	76.9	85.8
August	6.93	2.55	13	87.2	90.5	74.8	68.8	79.5	76.9	87.3
September	13.12	4.10	9	86.4	89.0	74.4	71.0	78.9	76.3	87.9
October	4.65	0.80	14	88.4	90.4	75.2	72.0	79.0	76.5	85.0
November	8.18	2.10	18	86.2	90.0	71.4	71.0	80.8	75.9	84.7
December	12.51	3.33	20	84.1	90.0	72.5	69.0	77.2	74.8	89.1
Total ..	84.35	22.79	143	..	..	..	..	..	..	..
Mean ..	..	..	..	86.3	89.9	73.9	70.5	78.4	75.6	87.0

APPENDIX IIIo

1973

METEOROLOGICAL REPORT

Reading daily at 8.00 a.m. Local Time at **Bukit Timah** from 1–1–73 to 31–12–73

Month	Total Rainfall	Highest fall in 24 hours	No. of Days Rainfall	Mean Maximum Temp.	Highest Maximum Temp.	Mean Minimum Temp.	Lowest Minimum Temp.	Mean Temp. Dry Bulb	Mean Temp. Wet Bulb	R.H.
	inches	inches		°F	°F	°F	°F	°F	°F	%
January	8.38	1.80	14	84.3	89.5	72.3	69.5	75.8	73.6	89.7
February	10.09	3.47	16	85.6	90.5	73.0	70.5	76.5	74.6	91.2
March	6.40	2.63	12	87.3	90.0	73.7	72.0	78.0	75.3	87.6
April	8.15	1.46	20	87.6	90.0	74.8	72.5	79.4	76.8	88.7
May	11.67	2.40	16	87.8	91.5	75.3	72.0	80.0	77.4	85.0
June	3.18	0.92	11	86.7	90.0	75.7	68.0	80.0	77.0	86.7
July	5.76	1.60	12	87.1	90.5	76.2	70.0	80.1	77.2	87.2
August	9.11	3.00	19	85.5	90.0	74.1	71.0	78.1	75.7	88.9
September	10.78	2.36	21	84.0	90.0	73.1	70.0	77.0	74.8	89.4
October	13.60	4.00	16	86.7	90.0	74.1	69.0	78.5	75.6	87.1
November	8.86	3.10	18	85.6	91.0	72.1	70.0	77.1	74.5	88.3
December	6.55	2.29	16	82.2	89.0	71.8	70.0	75.1	73.0	90.3
Total ..	102.53	29.03	191	..	..	..	..	..	..	..
Mean ..	..	..	..	85.9	90.2	73.9	70.4	78.0	75.5	88.3

APPENDIX IIIp

1969

METEOROLOGICAL REPORT

KRANJI WAR GRAVES CEMETERY

Recorded daily at 8.00 a.m. from
1-1-69 to 31-12-69

Month	Total Rainfall	No. of days with rain	Highest fall in 24 hours
	inches		inches
January	7.35	7	2.05
February	9.35	9	3.10
March	6.95	10	2.35
April	7.65	10	2.35
May	9.47	11	2.80
June	6.33	8	2.00
July	4.37	7	1.50
August	4.25	9	0.80
September	6.45	7	1.75
October	8.10	5	4.35
November	5.40	9	0.90
December	26.35	15	12.15
Total ..	102.02	107	36.10

1970

METEOROLOGICAL REPORT

KRANJI WAR GRAVES CEMETERY

Recorded daily at 8.00 a.m. from
1-1-70 to 31-12-70

Month	Total Rainfall	No. of days with rain	Highest fall in 24 hours
	inches		inches
January	5.58	10	2.45
February	4.93	5	1.75
March	11.20	10	3.05
April	6.65	10	1.50
May	11.48	17	2.00
June	10.78	13	2.10
July	10.40	9	2.90
August	4.28	9	1.05
September	4.25	7	0.85
October	8.45	13	1.20
November	13.47	12	5.06
December	11.83	15	2.00
Total ..	104.70	130	25.90

APPENDIX IIIq

1971

METEOROLOGICAL REPORT

KRANJI WAR GRAVES CEMETERY

Recorded daily at 8.00 a.m. from
1–1–71 to 31–12–71

Month	Total Rainfall	No. of days with rain	Highest fall in 24 hours
	inches		inches
January	3.55	7	0.75
February	5.49	6	1.95
March	3.73	6	1.65
April	0.48	3	0.18
May	2.47	7	1.50
June	6.65	10	1.78
July	7.48	7	3.00
August	10.10	18	1.94
September	5.06	9	1.15
October	8.25	17	1.69
November	8.65	16	1.43
December	7.26	14	3.65
Total ..	69.17	120	20.67

1972

METEOROLOGICAL REPORT

KRANJI WAR GRAVES CEMETERY

Recorded daily at 8.00 a.m. from
1–1–72 to 31–12–72

Month	Total Rainfall	No. of days with rain	Highest fall in 24 hours
	inches		inches
January	1.40	4	0.81
February	8.93	12	2.30
March	2.33	8	0.66
April	9.73	16	2.08
May	4.50	10	1.29
June	4.19	8	1.07
July	0.94	3	0.68
August	5.22	13	0.80
September	9.73	13	2.18
October	0.83	12	1.16
November	8.19	15	1.72
December	8.65	19	2.01
Total ..	70.64	133	16.76

APPENDIX IIIr

1973

METEOROLOGICAL REPORT

KRANJI WAR GRAVES CEMETERY

Recorded daily at 8.00 a.m. from
1-1-73 to 31-12-73

Month	Total Rainfall	No. of days with rain	Highest fall in 24 hours
	inches		inches
January	7.91	13	1.91
February	8.02	16	1.56
March	8.98	9	1.32
April	11.77	16	2.33
May	8.16	15	2.30
June	5.20	11	1.51
July	5.87	9	2.60
August	10.01	17	2.66
September	9.26	17	2.30
October	9.81	11	2.90
November	8.43	15	2.50
December	6.23	14	2.40
Total ..	99.65	163	26.29

Annotated list of seed plants of Singapore (III)*

by

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Department of Botany
University of Singapore

II. Angiosperms-Dicotyledons (continued)

19. CAPPARIDACEAE

Key to the genera

A. Leaves simple; scandent shrub; fruit a many-seeded berry ... *Capparis*

A. Leaves palmately divided or compound.
- B. Herbs; fruit cylindric, dry ... *Cleome*
- B. Erect trees; fruit globose, fleshy ... *Crataeva*

Capparis micracantha DC.

Shrub, scandent; consisting of two forms: the wild form, ssp. *korthalsiana* (Miq.) Jacobs, with 60–100 stamens per flower was once collected from Changi (*Ridley 4418*) and Bukit Timah, called *C. finlaysoniana* Wall. in Ridley's Flora; the cultivated form, ssp. *micracantha*, with 20–35 stamens per flower, is occasionally planted in gardens. Vern. *Jambol merah*.

Cleome aculeata Linn.

Herb, often with stipular thorns; flowers white to cream; stamens 6; ovary on a short stalk; weed, of tropical American origin.

Cl. gynandra Linn.

Tall herb, often cultivated in gardens; flowers white; stamens and ovary both elevated by a long stalk (androgynophore); also called *Gynandropsis pentaphylla* DC. Native of Tropical America.

Cl. rutidosperma DC.

Herb; flowers violet-blue to pink; stamens 6; seeds with an open cleft; weed, of African origin.

Cl. speciosa Rafin.

Tall herb, often growing in gardens as an ornament; flowers pink; stamens and ovary both elevated by a long stalk; native of trop. America. 醉蝶花。

Cl. viscosa Linn.

Herb; flowers bright yellow; stamens 10–20; ovary sessile; weed, pantropical.

Crataeva religiosa Forst. f.

Small tree, occasionally planted in gardens; leaves 3-foliolate; flowers creamy yellow; native of Malaya and Tropical Asia. Vern. *Cadat*. 魚木。

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* continued from *Gdns' Bull. Sing.* 27:83.

20. CRUCIFERAE

Key to the genera

A. Flowers white or purplish.
- B. Erect herbs; petals 1.5–2 cm long ... *Raphanus*
- B. Creeping or floating herbs; petals less than 7 mm long ... *Nasturtium*

A. Flowers brightly yellow.
- C. Garden vegetables; petals over 0.5 cm long; disc-glands 4 ... *Brassica*
- C. Weeds; petals less than 0.5 cm long; disc-glands 6 ... *Rorippa*

*Brassica** *alboglabra* Bailey

Kai Lan or Chinese kale; native of S. China; growing locally from the imported seeds. 芥藍。

Bras. chinensis Jusl.

Pak Choy or Chinese white cabbage; prob. native of S. China; one of the commonest vegetables in markets; growing locally and also imported; many varieties, including; Pak Choy (var. *chinensis* 白菜), Choy Sam (var. *para-chinensis* 菜心), etc.

Bras. juncea Czern. & Coss.

Kai Choy or mustard cabbages; native of subtropical Asia; mostly imported; several varieties, including the crisp leaved (var. *crispa*) and the broad-leaved (var. *rugosa*) and others. 芥菜。

Bras. oleracea L.

The cabbages; native of S. Europe; almost all imported; several varieties, including cabbages (var. *capitata* 椰菜，包心菜), cauliflower (var. *botrytis* 花椰菜), kohl-rabi (var. *gongylodes* 芥蘭頭) etc.

Bras. pekinensis Rupr.

The celery cabbage or the pale and soft-leaved cabbage; native of China; mostly imported; common varieties including the compact-headed Shangtung cabbage (var. *cylindrica* 黄椰白菜), the loose headed celery cabbage (var. *laxa* 黄金白菜), etc.

Nasturtium officinale R. Br.

Water cress, a native of Europe; aquatic herb, creeping or floating, growing locally as a vegetable. 西洋菜。

Raphanus sativus L.

Radish, prob. a native of temperate Asia or the near East; annual or perennial herb, the fleshy tap root is a common vegetable, mostly imported. 蘿蔔。

Rorippa indica Hiern

Annual weed, occasionally found in waste land; flowers very small, bright yellow; formerly called *Nasturtium indicum* DC.

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*For the nomenclature of the *Brassica* species, G.A.C. Herklot's *Vegetables in South-East Asia* (1972) is followed.

21. MORINGACEAE

Moringa pterygosperma Gaertn.

Horse radish tree, native of India; small tree; leaves 3 or 4 times pinnately compound; flowers pale yellow, in large panicles; fruit a long cylindric capsule often cultivated near villages for its edible leaves and fruits. Vern. Lembugai, 辣木。

22. CRASSULACEAE

Kalanchoe laciniata (L.) DC.

Succulent herb; flowers yellow or orange; cultivated, native of continental Asia.

Kalan. pinnata (Lamk.) Pers.

Flowers purple; detached leaves producing young plants from leaf margins or midrib; also called *Bryophyllum calycinum* Salisb.; native of Africa.

23. SAXIFRAGACEAE

Key to the genera

A. Herbs; leaves rounded — *Saxifraga*

A. Shrubs or trees; leaves ovate or oblong.
- B. Flowers 4-merous, functional, in terminal racemes — *Polyosma*
- B. Flowers 5-merous, all sterile, in dense terminal corymbs — *Hydrangea*

Hydrangea macrophylla (Thunb.) Ser. ex DC.

Shrub or subshrub; flowers all sterile, in large corymbs, pink or blue; garden plant, propagated by cutting; native of China. 繡球花。

Polyosma conocarpa Ridl.

Small tree; petals linear, white; specimens not available.

Poly. fragrans Benn.

Small tree; once collected by Wallich (*No. 8472*), Not Seen.

Poly. ridleyi King.

Tree; flowers white; recorded from Seletar.

Saxifraga stolonifera Meerb.

Small herb, with long thin runners; leaves rounded, lobed, hairy; occasionally cultivated in pots, never flowering; native to China, often called *Saxif. sarmentosa* Linn. f. 虎耳草。

24. PITTOSPORACEAE

Pittosporum ferrugineum Ait

Shrub or small tree; leaves crowded at twig tips, in false whorls; flowers yellowish white; capsule orange, 2-valved; Kranji, (*Mat 5912*) Changi, Seletar, often along sea-shores. Vern. *Giramong.*

25. DICHAPETALACEAE

Dichapetalum sordidum (Ridl.) Leenh.

Shrub or small tree; infl. axillary; petals oblong, yellow, bifid at apex; Bajau, (*Mat 6752*). Called *Chailletia sordida* Ridl. in Ridley's Flora.

26. ROSACEAE

Key to the genera

A. Herbs or shrubs, creeping, scandent or climbing.	
B. Tiny herb with creeping stolons; leaves 3-foliate	*Duchesnea*
B. Shrubby with prickly stems.	
C. Leaves pinnate; carpels on a concave receptacle	*Rosa*
C. Leaves simple, entire or shallowly lobed; carpels on a convex receptacle	*Rubus*
A. Trees or shrubs, erect.	
D. Style terminal; carpel 1, 2-ovulate	*Prunus*
D. Style basal.	
E. Ovary 1-loculate.	
F. Stamens 5–10	*Licaria*
F. Stamens 2	*Parastemon*
E. Ovary 2-loculate	*Parinari*

Duchesnea indica Focke

Tiny herb with slender stolons; aggregate fruits red, spheroid, a miniature of the strawberry; also called *Fragaria indica* Andr. A weed, occasionally found in shade and wet places.

Licaria splendens (Korth.) Prance

Small tree; leaves alternate; flowers small, white; fruit a small red drupe; common in secondary forests in Water Catchment area (*Cantley 2592*). Called *Coccomelia nitida* Ridl. and *Angelesia splendens* Korth. in Malayan literature.

Parastemon urophyllus A. DC.

Large tree; flowers very small, in racemes; fruit oblong, yellowish or pink; in open places often near the sea; formerly found in Jurong (*Ridley 6066*), Changi, Chua Chu Kang.

Parinari corymbosa (Bl.) Miq.

Large tree; Changi (*Ridley 4792*) and Fort Canning. Called *Parinarium griffithianum* Benth. in Ridley's Flora, and *Maranthes corymbosa* Bl. in Whitmore's Tree Flora.*

Pari. excelsa (Jack) Kosterm.

Large tree; flowers white, in racemes or panicles; fruit rounded, slightly compressed; formerly found in Chua Chu Kang. Called *Parinarium asperulum* Miq. in Ridley's Flora, and *Atuna excelsa* Kosterm. in Whitmore's Tree Flora.

*Tree Flora of Malaya **2** (1973)

Pari. oblongifolia Hook. f.

Large tree; leaves glaucous beneath; fruit ellipsoid (6 × 3 cm); in dense forests, Bukit Timah and Mandai (*Kiah* s.n. in 1940); one of the valuable timber trees in Malaya. Vern. *Balau*.

Pari. sumatranum (Jack) Benth.

Large tree, buttressed; flowers white; fruit ellipsoid, hard, brown with white dots; in forests, Chua Chu Kang (*Ridley 3901*), Seletar. Called *Parinarium costatum* Bl. in Ridley's Flora.

Prunus arborea (Bl.) Kalkman

Large or small tree; in forests, Kranji, Tanglin, Cluny Road (*Ridley 4452*): called *Pygeum parviflorum* Hook. f. and *Pyg. persimile* Kurz in Ridley's Flora.

Prun. grisea (C. Muell.) Kalkm. var. **tomentosa** Kalkm.

Shrub; Seletar (*Sinclair 40272*). Called *Pygeum lanceolata* Hoff. in Ridley's Flora.

Prun. polystachya (Hook. f.) Kalkman

Tree; leaf-blades with 2 conspicuous glands at the base; fruit rounded, 2-lobed; common in forests, Gardens jungle, Catchment forests, etc.

Rosa chinensis Jacq.

Native of China, called *R. indica* L. in Burkill's Dictionary; including: var. *semperflorens* or the crimson China rose, var. *minima* the dwarf fairy rose, etc. Several other garden species and hybrids are introduced and cultivated. 月季花。

Rubus glomeratus Bl.

Climbing shrub; leaves ovate deltoid, obscurely 3-lobed; petals white; fruit orange, of few drupes; Jurong (*Ridley* s.n. in 1880). Vern. *Akar balan adap*.

Rubus moluccanus L.

Shrub, armed with small hooked prickles; leaves ovate or rounded, cordate, 3–8 shallowly lobed; fruit red, of many small drupes; Bukit Timah (*Sinclair 37800*), Tanglin, Jurong. Called *R. angulosus* Focke in Ridley's Flora. Vern. *Tempu rengat*.

27. CONNARACEAE

Key to the genera

A. Carpels 4 to 5 in a flower, usually more than 1 carpel developing into fruit (except *Rourea*); calyx usually enlarged in fruiting stage. (except *Cnestis*).

- B. Leaves 3-foliolate; fruit warty — *Agelaea*
- B. Leaves pinnately compound; fruit glabrous — *Cnestis, Rourea*

A. Carpel 1 per flower; calyx not enlarged.

- C. Leaves 1-foliolate; flowers small, in axillary clusters — *Ellipanthus*
- C. Leaves mostly pinnate; flowers in large terminal panicles — *Connarus*

Agelaea borneensis Merr.

Climber; leaves 3-foliolate, leaflets elliptic to oblong; flowers small, pinkish red; fruit papillose; common in forests; Tanglin, Sembawang, Bukit Timah (*Ridley 5585*), Changi; called *Agel. vestita* in Ridley's Flora. Vern. *Akar kachang kachang.*

Agel. macrophylla (Zoll.) Leenh.

Lateral leaflets ± symmetric; Changi (*Hullett 426*); called *Agel. hullettii* in Ridley's Flora.

Agel. trinervis Merr.

Lateral leaflets very oblique; fruit warty; Changi (*Ridley* s.n. in 1893); called *Agel. wallichii* in *Ridley's* Flora. Vern. *Akar kachang jantan.*

Cnestis platantha Griff.

Climber, sometimes a shrub; leaves odd-pinnate, leaflets 21–31; flowers white; fruit 1 or 2 per flower, pear-shaped; common in dry woods and open places; Bukit Timah (*Ridley* s.n. in 1894), Tanglin, Changi.

Connarus ferrugineus Jack

Climber, sometimes a shrub; leaves odd-pinnate, leaflets 7–11; branches densely ferruginous-tomentose; fruit ellipsoid; Bukit Timah (*Md. Shah 744*), Bukit Mandai.

Conn. grandis Jack

Leaflets 3–5, lanceolate to oblong-ovate; fruit obovoid; Changi, Nee Soon (*Sinclair 40321*).

Conn. monocarpus L. ssp. **malayensis** Leenh.

Leaflets 5–9; fruit obliquely spindle-shaped; formerly found at Bukit Mandai, Changi and Chua Chu Kang (*Ridley* s.n. in 1894); called *Conn. oliogophyllus* in Ridley's Flora.

Conn. semidecandrus Jack

Leaflets 3–7, elliptic to lanceolate; fruit pear-shaped, compressed; Bukit Mandai, Cluny Road, Seletar (*Mohd. Noor 26*).

Ellipanthus tomentosus Kurz.

Large tree; leaves 1-foliolate; flowers small, white; Bukit Timah (*Corner 34639*), Gardens jungle; called *Ellip. griffithii* in Ridley's Flora.

Rourea fulgens Planch.

Large climber or shrub; leaves odd-pinnate; leaflets 13–51, very oblique at base; young leaves pink; flowers white or pink; fruit ovoid to ellipsoid, curved; formerly collected at Kranji (*Goodenough 2027*), and at Gardens jungle.

Rour. minor (Gaertn.) Leenh.

Leaflets 1–19; Bukit Timah, Changi (*Ridley 3981*); called *Rour. acuminata* in Ridley's Flora.

Rour. mimosoides Planch.

Leaflets 5–51, the base slightly oblique; fruit narrowly ellipsoid. curved; Changi (*Goodenough 2020*) and also very common in reservoir woods; Vern. *Semilat*.

Rour. rugosa Planch.

Leaflets 15–41; fruit oblong-ovoid, curved; Changi, Seletar (*Hullett 594*); Vern. *Semilat puteh.*

28. LEGUMINOSAE

Key to the subfamilies.

A. Flowers regular; calyx and corolla mostly valvate in bud	I. Mimosoideae
A. Flowers irregular; perianth segments conspicuously imbricate in bud	
B. Corolla caesalpinaceous, namely petals 5, free, with the uppermost (posterior) petal innermost	II. Caesalpinoideae
B. Corolla papilionaceous, namely petals 5, with the uppermost petal outermost, and the two lower (anterior) petals often basally connate	III. Papilionoideae

(I) Mimosoideae — Conspectus of tribes*

A. Calyx-lobes valvate.

B. Stamens more than 10.

1. Ingeae (Filaments united into a tube): *Serianthes, Samanea, Pithecellobium, Albizia, Calliandra.*
2. Acacieae (Stamens free or nearly so): *Acacia.*

B. Stamens as many or twice as many as petals.

3. Mimoseae (Anthers glandless): *Leucaena, Mimosa.*
4. Adenanthereae (Anthers crowned by a gland; seeds albuminous): *Neptunia, Adenanthera.*
5. Piptadenieae (Anthers usually glandulate; seeds exalbuminous): *Entada.*

A. Calyx-lobes imbricate.

6. Parkieae: *Parkia.*

(II) Caesalpinoideae — Conspectus of tribes

A. Leaves pinnate, or sometimes simple or 1-foliolate.

B. Sepals free to the base.

1. Cynometreae (Anthers dorsifixed, dehiscing by slits; leaves simple pinnate or simple; bracteoles small or large, not enclosing the flower buds): *Cynometra, Sindora.*
2. Amherstieae (Anthers and leaves as above; bracteoles well developed, enclosing the flower buds, valvate, persistent): *Saraca, Trachylobium, Hymenaea, Tamarindus, Intsia, Amherstia, Brownea.*
3. Cassieae (Anthers firm in texture, usu. dehiscing by pores; leaves usu. simple pinnate): *Dialium, Koompassia, Cassia.*

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*Adapted and modified from J. C. Willis' Dictionary (7th ed. 1972).

B. Sepals joined below.

4. Cercideae (Leaves usu. simple, bilobed; stamens 10 or fewer): *Bauhinia.*

A. Leaves bipinnate.

5. Caesalpinieae (Flowers in racemes or panicles): *Caesalpinia, Peltophorum, Delonix.*

(III) Papilionoideae — Conspectus of tribes

A. Stamens free or almost so.

1. Sophorieae (Trees, shrubs or rarely woody herbs or lianes; leaves pinnate or 1-foliolate with a joint between petiole and lamina): *Ormosia, Sophora.*

A. Stamens mon- or di- adelphous (i.e. filaments joined into one or two groups).

B. Herbs or shrubs (or trees or lianes in tribes 3 & 7); pods dehiscent unless short and 1–2 seeded, or inflated.

C. Pods not transversely jointed.

2. Genisteae (Usually shrub; leaves simple or digitately 3- or more foliolate, leaflets entire; stamens usually monadelphous, anthers often of 2 sizes): *Crotalaria.*

3. Astragaleae (Galegeae) (Leaves pinnately 5-many or rarely 3- or 1-foliolate; leaflets usually entire; rachis not ending in a tendril; stamens usually diadelphous): *Indigofera, Psoralea, Tephrosia, Milletia, Giliricidia, Sesbania.*

4. Fabeae (Vicieae) (Herbs, leaves even-pinnate, without stipels, rachis ending in a point or tendril; stamens 10, diadelphous): *Vicia, Pisum.*

5. Abreae (Shrubs or twiners woody at the base; leaves even-pinnate, rachis ending in a point, usually stipellate; stamens 9, united): *Abrus.*

6. Phaseoleae (Often twining; leaves pinnately 3-foliolate, usually stipellate, rarely 1 or 5–7 foliolate; leaflets entire or lobed; stamens di- or monadelphous): *Clitoria, Centrosema, Glycine, Erythrina, Mucuna, Canavalia, Cajanus, Maughania, Phaseolus, Vigna, Pachyrrhizus, Dolichos, Psophocarpous.*

C. Pods transversely jointed.

7. Coronilleae (Hedysareae) (Shrubs or twiners; leaves pinnately 3- to many-foliolate, stipellate or not): *Aeschynomene, Arachis, Zornia, Desmodium, Alysicarpus; Uraria.*

B. Trees, shrubs or lianes; pods indehiscent.

8. Dalbergieae (Leaves pinnately 5-many-foliolate, rarely 1–3-foliolate, stipellate or not): *Dalbergia, Pterocarpus, Pongamia, Derris, Andira.*

Abrus precatorius L.

Twining subshrubs; leaves even-pinnate, leaflets 8–17 pairs; seeds hard, scarlet with a black spot; in hedges and on sea-shores (Changi. *Ridley* s.n. in 1891). Probably of African origin, naturalized. Vern. *Akar saga*, 相思子。

Acacia auriculiformis A. Cunn. ex Benth.

Tree; phyllodes (seemingly leaves) dull green; flowers small in yellow clusters; pods curling up into a ring when ripe, dark brown. Native of New Guinea and Australia (or Thursday Island in the Torrey Strait); extremely common all over the island.

Acac. farnesiana Willd.

Shrub or small tree, thorny; leaves bipinnate; flower heads bright yellow, fragrant. Probably of American origin. Vern. *Lasana*, 金合歡。

Acac. cincinnata F. Muell.

Shrub or small tree; phyllodes silvery-coloured ("Silver Wattle"); native of tropical Queensland. Sometimes called *Acac. mangium* Willd. (from Moluccas) which may prove to be conspecific with this species.

Acac. pseudo-intsia Miq.

Big climber; leaves bipinnate; pinnae 4–10 pairs; leaflets 10–30 pairs on each side stalk; in forests, Bukit Mandai, Changi (*Hullett 458*). Tuas, Chua Chu Kang. Vern. *Akar kapok.*

Adenanthera bicolor Moon

Tree; pods curved in a ring; seeds one third black and two thirds scarlet; in lowland forests, Bukit Mandai (*Ridley 3636a*), Pasir Panjang, etc.

Ad. pavonina L.

Large tree; leaves bipinnate; leaflets 9–15 on each side stalk; pod curved; seeds scarlet. Native of tropical Asia; commonly planted. Vern. *Saga* 孔雀豆。

Aeschynomene indica L.

Herb; leaves pinnate, with 20–30 pairs of leaflets; flowers yellow; pods jointed, breaking into 8–10 prickly parts; in open wet places; Galang (*Ridley 10355*).

Albizzia falcataria (L.) Fosberg

Tall tree, very fast-growing; native of Moluccas, planted and wild in Singapore, common in waste places. Also called *A. falcata* Back. or *A. moluccana* Miq.

Alb. retusa Benth.

Tree; leaves bipinnate; pinnae 1–4 pairs; leaflets 3–10 pairs on each side stalk; flower heads pink; rare, once collected at Pulau Ubin (*Ridley 4752*). Called *A. littoralis* T. & B. in Ridley's Flora.

Alb. pedicellata Baker

Tall tree; leaves bipinnate; leaflets 12–16 pairs on each side stalk; pods flat (30-45 cm long) and thin; in forests, Kranji (*Ridley 6297*).

Alysicarpus vaginalis DC.

Ascending herb; uni-foliolate, variable; flowers white or dark red; pods cylindric, jointed, of 4–9 1-seeded pieces; in open places, Changi (*Ridley 2080a*), Telok Kurau.

Amherstia nobilis Wall.

Small tree; leaves pinnate; leaflets 4–7 pairs, opposite; flowers in hanging racemes from branches. Native of Burma, a well-known garden ornamental.

Andira inermis (Wright) H.B.K.

Tree; leaves odd-pinnate, with 4–8 pairs of leaflets; flowers dark purple; pods pear-shaped, indehiscent. Native of Surinam in trop. America.

Arachis hypogaea L.

Ascending herb, rooting at the base; leaves even-pinnate, with 2 pairs of leaflets; flowers bright yellow; after pollination, the ovary on a lengthening stalk is forced into the ground, where the pod develops "ground-nut". Native of Brazil, occasionally cultivated. Vern. Kachang tanah, 花生，落花生。

Bauhinia acuminata L.

Shrub; leaves simple, 2-lobed, the lobes pointed; flowers white; stamens 10. Native of S.E. Asia, cultivated.

Bauh. flammifera Ridl.

Large climber; flowers in large panicles, yellow, orange then red. Called *Phanera flammifera* (Ridl.) de Wit. Native of Malaya.

Bauh. griffithiana Prain

Large climber; petals white; stamens 6; in thickets. Also called *Phanera griffithiana* (Prain) de Wit.

Bauh. monandra Kurz

Tree; petals yellow then pale red; perfect stamen 1. Native of America, cultivated.

Bauh. purpurea L.

Bush or small tree; flowers pink; stamens 3 with pink filaments. Continental Asia, cultivated.

Bauh. semibifida Roxb.

Large climber; flowers white then greenish yellow; stamens 3, white; in secondary jungle, Bukit Mandai, Bukit Timah (*Burkill 323*), Gardens jungle. Also called *Phanera semibifida* (Roxb.) Benth.

Bauh. tomentosa L.

Shrub or tree; flowers solitary or in pairs; petals pale yellow; stamens 10. Trop. Africa and continental Asia, cultivated.

Bauh. variegata Bl.

Bush or small tree; leaves simple, 2-lobed; flowers in short racemes, pink to violet; perfect stamens 5. Native of continental Asia, cultivated. A natural hybrid between this species and *Bauh. purpurea* is called *Bauh. blackeana* Dunn which also has 5 stamens but remains sterile, commonly cultivated in gardens.

Brownea ariza Benth.

Shrub or small tree, branches drooping; new leaves pink, developing in tassels; flowers red, in a crowded head. Native of Colombia, occasionally cultivated in gardens.

Caesalpinia bonduc Roxb. emend. Dandy & Exell

Prickly shrub; leaves bipinnate; pinnae 6–10 pairs; leaflets 12–24; stipules pinnate; petals yellow; near the sea.

Caes. crista L.

Prickly black-stemmed climber; leaves bipinnate; flowers bright yellow; on sandy beaches and mangroves, Kranji, Jurong. Called *C. nuga* in Ridley's Flora.

Caes. globulorum Bakh. f. & Van Royen

Leaves and leaflets larger than those of *Caes. bonduc;* stipules subulate; near the sea.

Caes. pulcherrima (L.) Swartz

Shrub; flowers yellow or red; known as Peacock flower, native of S. America. Also called *Poinciana pulcherrima*, 金鳳花。

Caes. sappan L.

Prickly shrub or tree; flowers bright yellow. Native of Continental Asia, occasionally cultivated. Vern. *Sappan tree*, 蘇木。

Cajanus cajan (L.) Huth.

Shrub, white hairy; leaves 3-foliolate. Vern. *Kachang kayu*, pigeon pea, 木豆。

Calliandra brevipes Benth.

Erect shrub; leaves bipinnate; pinnae in one pair; leaflets 20–40 pairs; free part of the filaments pinkish above and white below. Native of Tropical America.

Call. haematocephala Benth.

Like the above species, but leaflets 6–10 pairs, and free part of the filaments entirely blood red. Native of Trop. America.

Canavalia catharica Thou.

Twiner; leaves 3-foliolate; flowers rose-pink to dark purple; pod linear oblong (7–12.5 × 4–6 cm), strongly 3-keeled; beans poisonous; common on sandy shore. Also called *C. turgida, C. obtusifolia.*

Cana. ensiformis DC.

Jack bean; native of the New World tropics; pod 20–30 × 2–3 cm. Vern. *Kachang parang puteh.*

Cana. gladiata DC.

Sword bean; native of the old world tropics; pod 30–60 × 3–4.5 cm, edible. Vern. *Kachang parang.*

Cana. maritima Piper

Twiner; flowers pink, sweet scented; pod 6–15 × 1.5–3; beans edible; common on seashores; Changi. Also called *C. turgida* Grah. ex Gray.

Cassia alata L.

Shrub; leaves simple pinnate; leaflets 8–20 pairs; flowers orange, in racemes, at first covered with large dark orange bracts; pod black, with 2 broad wings along its length; native of tropical America. Vern. *Gelenggang*. In addition to those listed below, there are a number of others species planted. All the *Cassia* species in Singapore are introduced; 2 of them, *C. nodusa* and *C. siamea* are native to the Malayan mountains, the rest are from various parts of the World.

Cas. fistula L.

Tree; leaflets 3–8 pairs; hanging racemes with yellow flowers (hence "Golden shower"); pod woody, cylindric. Native of India and Ceylon.

Cas. fruticosa Mill.

Shrub; leaflets 2-pairs; flowers pale yellow, in loose terminal clusters. Native of Tropical America.

Cas. hirsuta L.

Hairy herb; leaflets 3–6 pairs; flowers 1–3, axillary, yellow; pod linear, rounded. Tropical America.

Cas. mimosoides L.

Subshrub; flowers 1–3, axillary. A weed, native of S.E. Asia.

Cas. nodusa Buch.-Ham. ex Roxb.

Tree; leaflets 5–12 pairs; flowers in pink clusters ("pink Cassia"), often behind leaves. Native of the Malayan mountains.

Cas. obtusifolia L.

Herb, resembling *C. tora* but not foetid; flowers yellow. Weed, American origin.

Cas. occidentalis L.

Herb or subshrub; flowers orange-yellow. Weed. native of S. America.

Cas. siamea Lam.

Tree; flowers bright yellow. Ornamental and timber tree; native of Malaya and Thailand.

Cas. tora L.

Herb or subshrub; leaflets 3 pairs; flowers pale yellow; pod narrow and curved, 4-angled.

Centrosema plumieri Benth.

Twining subshrub; leaves 3-foliolate; flowers white with 2 large reddish violet blotches. "Butterfly pea", native of America.

Clitoria laurifolia Poir.

Erect herb; leaves 3-foliolate; flowers white to pale blue. Native of Brazil.

Clit. ternatea L.

Slender twiner; leaves 5–7 foliolate; flowers blue (often in double form). Native home unknown (either S. America or the Malay Islands).

Crotalaria bialata Schrank

Subshrub; leaves 1-foliolate; stems winged; flowers pale yellow; in sandy places or on waste ground, Jurong, Changi (*Ridley 4671*). Vern. *Kachang hantu darat*. Called *C. alata* Buch.-Ham. ex D. Don in Ridley's Flora.

Crot. mucronata Desv.

Shrubby; leaves 3-foliolate; flowers yellow with reddish or purplish stripes; in open places, Changi, Geylang. Called *Crot. saltiana* Andr. in Ridley's Flora.

Crot. quinquefolia L.

Herb; leaves 5–(3–7–) foliolate; flowers bright yellow; in open waste ground, rare, Kranji (*Ridley 575*).

Crot. retusa L.

Shrubby; leaves 1-foliolate; stems not winged; flowers yellow; on sea-shores, Changi, (*Ridley 2087*).

Cynometra cauliflora L.

Tree; leaves of 1 pair of leaflets; flowers white, small, in clusters on trunk; pod kidney-shaped, can be eaten raw or cooked. Prob. a native of E. Malesia. vern. *Nam nam, Num num.*

Cyn. ramiflora L.

Leaflets 1–2 pairs; pod thick, ovoid, wrinkled, not edible; in tidal rivers and mangroves, Jurong, Kranji (*Sinclair SFN 40957*).

Dalbergia candenatensis Prain

Climber; leaflets usually 5; panicles axillary; flowers white; pods thick, flat, 1- or 2-seeded rounded; in littoral scrubs, Kranji, P. Ubin (*Ridley 4678*), P. Damar. Called *D. torta* Grah. in Ridley's Flora.

Dalb. hullettii Prain

Shrub; flowers white, produced when the leaves are fallen; rare, in open swampy ground, Seletar (*Ridley* s.n. in 1896).

Dalb. junghuhnii Benth.

Woody climber; flowers small, greenish white; in secondary woods, Changi, Sembawang, P. Ubin, Tanglin (*Hullett 161*). Called *D. scortechinii* Benth. in Ridley's Flora.

Dalb. parviflora Roxb.

Large climber, spiny. Bukit Timah (*Ngadiman 358*).

Dalb. rostrata Grah.

Woody climber; flowers white; Gardens jungle, Changi (*Ridley 6090*), Bukit Mandai.

Dalb. velutina Benth.

Woody climber; Tempinis, Changi, Seletar (*Sinclair 39617*).

Delonix regia Rafin.

A large deciduous tree with umbrella-shaped crown; leaves bipinnate; flowers scarlet (hence "flame of the forest"); pods woody, very large, with 20–40 seeds inside, splitting open on the tree. Native of Madagascar, widely planted. Vern. *Gul mohm,* 鳳凰木。

Derris amoena Benth.

Large climber; leaves pinnate, leaflets about 7; flowers pink, in panicles; pods flattened, 2-seeded; once found in Siglap (*Ridley 10380*).

Der. elliptica Benth.

Native of continental Asia, often planted for the roots which are used for killing insects on vegetables and for catching fish. Vern. *Tuba,* 毒魚藤。

Der. heptaphylla (L.) Merr.

Woody climber; flowers greenish; tidal river, Yeo Chu Kang, P. Ubin (*Hullett 6194*). Called *D. sinuata* Thw. in Ridley's Flora.

Der. heterophylla (Willd.) Backer

Scandent shrub; leaflets 3–5; flowers pink; pods thin, flat, 1-seeded; common on sea coast and by tidal rivers, Changi, P. Ubin, Kranji (*Ridley s.n. in 1893*), etc. Called *D. uliginosa* Benth. in Ridley's Flora. Vern. *Akar ketuil.*

Der. scandens Benth.

Scandent bush; flowers white; Pulau Merambong (*Ridley 9492*).

Der. thyrsiflora Benth.

Scandent bush; flowers in dense erect panicles, white; pods long and thin, reddish; common in open places, Bukit Timah, Tanglin, Changi (*Ridley 2092*).

Desmodium heterocarpon (L.) DC.

Shrub; leaves 3-foliolate; flowers white or deep crimson; pods of several 1-seeded joints; in open places, Changi (*Ridley* s.n. in 1890), Tanglin, Seletar. Called *D. polycarpum* DC. in Ridley's Flora. A variety (var. *ovalifolium* Prain) with creeping habit, round silky leaflets and pale lavender flowers was recorded at Ang Mo Kio. Vern. *Kalumbar.*

Desm. heterophyllum DC.

Creeping herb; flowers pink; common in the grassland all over the island; pod 3–4 mm wide. Singapore (*Hullett 418*).

Desm. triflorum DC.

Like the above species, pods narrower (2–2.5 mm wide). Roadsides and grassland; Tanglin, Changi (*Ridley 2079*), Bukit Timah.

Desm. umbellatum DC.

Large shrub; flowers white; on sea coasts around the island; Pulau Senang (*Sidek 87*).

Dialium laurinum Baker

Large tree; leaves pinnate, leaflets 5–7; pods ovoid, velvetely dark brown, each containing one seed surrounded by sweet edible pulp; the hard, heavy wood is well-known; Kranji, MacRitchie Reservoir (*Sinclair 8921*). Vern. *Kranji.*

Dial. maingayi Baker

Like the above, with 7–9 leaflets; Catchment Area, Bukit Timah (*Ngadiman 34621*).

Dial. wallichii Prain

Like the above, with 9–11 leaflets; Garden's jungle, Bukit Timah (*Sinclair 39568*).

Dolichos lablab L.

Also called *Lablab niger* Medik.; prob. native of India, cultivated for its edible pods and beans ("hyacinth bean"). Vern. *Kachang kara, Karkaras,* 扁豆。

Entada spiralis Ridl.

Woody climber; leaves bipinnate, pinnae 4, leaflets usually 4 pairs in a pinna; flowers small, in dense racemes; pods curled with 5–11 very large seeds (3 × 5 cm); in secondary forests, formerly at Tanglin (*Ridley 2102*), Chua Chu Kang, now survives in Catchment Area.

Erythrina fusca Lour.

Tree; leaves 3-foliolate, terminal leaflets much longer than broad, tapering to base; flowers dark purple. A widely distributed species from India to the Pacific Islands, cultivated.

Ery. orientalis Murr.

Tree; terminal leaflets broader than long, truncate at base; flowers dark scarlet. Also called *Ery. indica* Lam., from India to the Pacific Islands, but cultivated here. Vern. Indian coral tree, 刺桐。

Ery. parcelli Hort.

Leaflets with a broad yellow midrib and several yellow stripes along the side-veins, the base truncate; flowers bright orange red; cultivated in gardens or as a roadside tree. Native of Trop. Asia.

Ery. subumbrans Merr.

Like *Ery. orientalis,* but terminal leaflets nearly as long as broad; and flowers comparatively smaller (3–5 cm long); native of Malesia. cultivated.

Gliricida sepium Walp.

Small tree; leaves pinnate; leaflets 13–17; flowers pinkish native of Mexico (hence "Mexican lilac"); cultivated in gardens or along roadside.

Hymenaea courbaril L.

Tall, fast-growing tree with a spreading crown; leaves consisting of a pair of oblique leaflets; flowers white; pods oblong with 2 or few seeds inside, stinking. The resin (collected by cutting the bark) is called "copal" of the trade. "Locust tree", native of the West Indies.

Indigofera tinctoria L.

Shrubby, much-branched; leaves pinnate; leaflets 5–13; flowers greenish yellow. Indigo, a deep blue dye, is obtained by allowing plants to soak and ferment in water. Native of India and Ceylon. Vern. *Nila, tarum,* 藍靛。

Indig. hirsuta L.

Herb, stems, leaf rachis, calyx and pods covered with long brown hairs; leaflets 5–9; a weed, found on sandy seashores.

Intsia bijuga (Colebr.) O. Ktze.

Small tree; leaflets in 1 (or less commonly in 2) pair; pods woody, large, oblong, slightly flat; common along sea coast, Bajau (*Ridley 4675*), Changi, Kranji. Called *Afzelia bijuga* A. Gray and *A. retusa* Kurz in Ridley's Flora. Vern. *Merbau ayer.*

Koompassia malaccensis Maing. ex Benth.

Gigantic tree with bug buttresses; leaflets 5–9; pods 1-seeded, flat, oblong. Formerly very common all over the island, now restricted to Bukit Timah and Catchment Area (*Ridley 6403*). Vern. *Kempas.*

Kunstleria ridleyi Prain

Large climber; leaflets 5; flowers small, dark purple, in large panicles; pods golden pubescent; in woods, Gardens jungle, Mandai (*Corner 37735*), Seletar. Endemic to Singapore.

Leucaena leucocephala (Lamk.) De Wit

Shrub; leaves bipinnate; flowers white, crowded in globular heads; pods thin flat, 2-valved; seeds many. "Lead tree", native of trop. America; occurs near villages. Called *L. glauca* Benth. in literature. Vern. *Petai Jawa.*

Mezoneuron sumatranum W. & A. ex Benth.

Prickly climber; leaves bipinnate; flowers flame-coloured; pods bright red; in edge of woods and open places, not common; Bukit Timah, Kranji, Jurong. Vern. *Akar Darah Blut* (Eel's blood).

Millettia atropurpurea Benth.

Tree; crown large dome-shaped; leaflets 9–11; flowers large, dark purple; pods thick leathery, 1–2-seeded. Native of the Malayan mountains, planted; fine specimens in MacRitchie Reservoir. Vern. *Tulang daing.*

Mill. eriantha Benth.

Woody climber, covered with golden hairs; leaflets 2–3 pairs; flowers coppery red; pods woody, 1-seeded; found from Gardens' jungle, Bukit Mandai, Tanjong Gul (Sinclair 10750). Called *Adinobotrys erianthus* Dunn in Ridley's Flora. Vern. *Akar pua.*

Mill. maingayi Baker

Big climber with hanging panicles of scented pink flowers; leaflets 11–17; pods 1-seeded; recorded from Reservoir woods, Chua Chu Kang and Tanglin (*Hullet 145*). Called *Padebruggea maingayi* (Baker) Dunn in Ridley's Flora.

Mimosa invisa Mart. ex Colla

Subshrub or herb, scandent at base, erect above; pinnae 5–9 pairs; flower-heads reddish purple; in open places; native of trop. America.

Mim. pudica L.

The sensitive plant; subshrub, spreading; stems prickly; leaves bipinnate, pinnae in two pairs, arranged at the top of a long stalk; flower-heads pink; pods jointed, the edges covered with bristles; native of trop. America, naturalized in waste places. Vern. *Rumput si-malu,* 含羞草。

Mim. sepiaria Benth.

Shrub; pinnae 5–9 pairs; flower-heads white or pale yellow; native of trop. America.

Maughania strobilifera St. Hil. ex O. Kuntze

Shrub, leaves 1-foliolate; on seashores, uncommon; recorded from Changi (*Ridley 2076*) and Blakang Mati. Formerly called *Flemingia strobilifera* Br.

Mucuna bennetti F. Muell.

Climber; leaves trifoliolate; flowers large, scarlet, in racemes. Introduced from New Guinea. Seeds obtained only through hand-pollination.

Muc. gigantea (Willd.) DC.

Climber; leaves large, trifoliolate; flowers greenish white; recorded from Blakang Mati and Telok Paku (*Sinclair 9972*).

Neptunia natans (Linn. f.) Druce

A water-sensitive plant; floating; leaves bipinnate; leaflets numerous; flowers bright yellow; perhaps a native of S.E. Asia; in ditches, formerly very abundant, now very rarely cultivated as a vegetable. Also called *N. oleracea* Lour.

Ormosia bancana (Miq.) Merr.

Tree; leaflets 7–13, small, deep green; flowers white; pods round; seeds 1–3, red; Catchment Area, Changi, Pasir Panjang (*Ridley 8096*). Formerly called *O. parvifolia* Baker.

Ormos. macrodisca Bak.

A big tree; flowers pink; pods flat and round, with a large scarlet and black seed; a timber tree, very rare, once recorded in Dalvey Road (*Ridley 2103*).

Ormos. sumatrana (Miq.) Prain

Tree; flowers white; rare, recorded from Tanglin and Seletar (*Ridley 5574*).

Pachyrhizus erosus (L.) Urb

Twining herb, spreading, with a tuberous tap root; leaves 3-foliolate. Native of America; leaves, beans and seeds poisonous but the tuberous roots ("yam bean") are edible. Also called *P. tuberosus* Spreng. Vern. *Bengkuang*, 豆薯。

Parkia speciosa Hassk.

Tall tree, buttressed; leaves bipinnate; leaflets 20–35 pairs on side stalks; flowers very small, crowded on pear-shaped heads; pods large, flattened and twisted, with onion-smell, edible; scattered in forests, Bukit Timah, Catchment Area. Vern. *Petai*.

Peltophorum pterocarpum Backer ex Heyne

Tree, with dome-shaped crown; leaves bipinnate; flowers showy, yellow (hence "yellow flame"); pods flat, thin, with a wing around; formerly a native tree at Changi coast (*Ridley 4676*), now extinct, but widely planted as ornamental or as roadside trees. Also called *Pelt, ferrugineum* Benth. Vern. *Balai*, 盾柱木。

Phaseolus lunatus Linn.

Lima bean, native of S. America, occasionally cultivated for its edible beans.

Phas. vulgaris Linn.

French bean or kidney bean, native of trop. America, commonly cultivated for its edible beans. Vern. *Kachang pendek,* 四季豆，菜豆。(several other species of *Phaseolus* (or *Vigna*) of which the dried beans are selling in stores including: *Phas. aureus* Roxb., the green gram, 綠豆，native of India, and *Phas. angularis* F. W. Wright, the adzuki bean, 赤豆，native of the Orient).

Pithecellobium clypearia Benth.

Small tree; leaves bipinnate; pinnae 2–9 pairs; leaflets 4–14 pairs, rhombic, asymmateric; flowers in large panicles; pods flattish, lobed, twisted and loosely curled; common in secondary forests, Seletar, (*Goodenough 2097*), Chua Chu Kang. Vern. *Petai belalang.*

Pith. contortum Mart.

Small tree, like *P. clypearia* but twigs rounded (not angled as in the latter); common, Tanglin, Changi, Seletar, Bukit Mandai (*Ridley 4755*).

Pith. dulce Benth.

Tree, with a bushy crown; pods pale greenish, seeds black covered by thick white pulp. A native of trop. America, erroneously called "Madras Thorn".

Pith. ellipticum Hassk.

Tree; pods flat, 3 cm wide, twisted into a ring; Seletar, P. Merambong (*Corner 29963*), P. Ubin. Vern. *Jering hutan.*

Pith. globosum (Bl.) Kosterm.

Small tree. Tanjong Bunga (*Ridley 6408*). Called *P. affine* Baker in Ridley's Flora.

Pith. jiringa (Jack) Prain

Tree, pods large, 5–6 cm wide, strongly swollen at each seed, curled and twisted, garlic smelled, can be cooked and consumed as a vegetable, wild in secondary forests, commonly cultivated for the edible pods. Called *P. lobatum,* Gardens jungle (*Ridley* s.n. in 1897). Vern. *Jering.*

Pith. microcarpum Benth.

Small tree, flowers white; pods curly, bright orange; in secondary woods, Tanglin, Changi (*Ridley 188*) Chua Chu Kang, Bukit Timah.

Pith. splendens Corner

Large tree; pods flat, swollen at the seeds, slightly curved; rare, Bedok (*Ridley 8446*), Seletar. Called *P. confertum* Benth in Ridley's Flora.

Pongamia pinnata (L.) Pierre

Small tree; leaflets 5–7; flowers pink; formerly common on the coast, Changi, Siglap, Jurong, P. Ubin (*Ridley*) s.n. 1891), now occasionally found in mangrove, sometimes cultivated. Vern. Mempari, 水黃皮。

Psophocarpus tetragonolobus DC.

Perennial twinner, with a tuberous root; leaves 3-foliolate; flowers pale blue-violet; pods cylindric with 4 wings ("four angled bean"). Prob. native to Madagascar, cultivated for its edible beans. Vern. *Kachang botor,* 四翼豆。

Psoralea corylifolia Linn.

Annual herb; leaves simple. Native of India, grown on several occasions in Botanic Gardens; the seeds are used medicinally. 補骨脂。

Pterocarpus indicus Willd.

Large tree, leaves pinnate, flowers yellow, fragrant; pods 1–2-seed, wood valuable. Native of the continental Asia and Malaya; extensively planted as roadside trees, easily propagated by large cuttings. Vern. *Angsana, Sena,* 印度紫檀。

Samanea saman (Jacq.) Merr.

Large tree, trunk usually branched; crown broadly dome-shaped; leaves bipinnate. "Rain tree", a native of Tropical America, often planted as a shade tree in large gardens or on roadsides. Also called *Enterolobium saman* Prain.

Saraca indica Linn.

Small tree; leaves pinnate; leaflets 4–6 pairs; flowers orange-yellow, in large clusters on trunk or branches; pods large, flat, purple. Native of Malaya and the continental Asia, Cultivated. Vern. Gapis, *Talan.*

Sar. thaipingensis Cantley ex Prain

Like above species, but leaves larger and leaflets with a conspicuous stalk. Native of Malaya, sometimes cultivated in gardens.

Serianthes dilmyi Fosberg

Tree; leaves bipinnate; pods woody, thick; once collected from Bukit Timah (*Wallich 5285*). Recently collected from Pulau Pawai (*Sinclair 38902*). Called *Seri. grandiflora* Benth. in Ridley's Flora.

Sesbania grandiflora Pers.

Shrub or small tree, with showy white or blue flowers. Native country unknown, cultivated as an ornamental plant for its edible leaves. Vern. *Turi,* 大花田菁。

Sindora wallichii Grah. ex Benth.

Large tree with a massive crown; leaves with 3–4 pairs of leaflets; pods oval to oblong, flat, 1-seeded, covered with close, stout hard spines; Gardens' jungle, Changi (*Bakar s.n. in 1893*). Vern. *Sepetir daun tebal.*

Spatholobus ferrugineus Benth.

Large climber, sometimes to the tops of the tallest trees; leaves 3-foliolate; flowers dark purple; pods flat, thin, with 1 seed near the tip, indehiscent; Gardens' jungle, Tanglin, Changi (*Ridley 3609a*) Bukit Timah. Vern. *Ajar Sejangat.*

Spath. maingayi Prain

Flowers white or pinkish white; Gardens' jungle, Bukit Timah Road (*Ridley 6397*).

Spath. ridleyi Prain

Flowers white or yellow; Botanic Gardens (*Ridley 6401*), Chua Chu Kang.

Strongylodon macrobotrys A. Gray

"Jade vine", from the Philippines, sometimes cultivated for its large, hanging, blue-green flowers.

Tamarindus indica Linn.

Large tree, with a dense, rounded crown; leaves pinnate; leaflets 10–20 pairs; flowers pale yellowish; pods brown. The pulp of the ripe pods is edible, also employed in the native medicine; timber valuable. Native of tropical E. Africa and W. Asia. Vern. *Asam jawa, Tamarind,* 羅望子。

Tephrosia noctiflora Bojer ex Baker

Bushy herb; leaflets 13–19; flowers white or pinkish; on waste grounds. Native of Africa.

Uraria crinita Desv. ex DC.

Shrubby; leaflets 5–7; flowers lavender, in dense racemes, to 30 cm long; in open waste places. Native of Tropical Asia.

Vigna marima Merr.

Small twiner; leaves 3-foliolate; flowers yellow ("yellow vetch"); on sandy seashores, Changi (*Ridley* s.n. in 1890), Blakang Mati. Called *V. retusa* Walp. in Ridley's Flora.

Vigna unquiculata (L.) Walp.

Twining herbs; leaves 3-foliolate; prob. native of India; two forms are cultivated: ssp. *sinensis* Fruw. (pods up to 30 cm long, vern. *Kachang bol,* 豇豆) and ssp. *sesquipedalis* Fruw. (pods 30–90 cm long, vern. *Kachang perut ayam,* 長豇豆); pods of both forms are served as vegetables.

Zornia diphylla Pers.

Creeping herb; leaves of a pair of narrow leaflets; flowers yellow; pods spiny; in open sandy places. A pantropical weed.

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