# The Gardens' Bulletin

## Singapore

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SINGAPORE BOTANIC GARDENS

**NATIONAL PARKS BOARD**

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# THE GARDENS' BULLETIN

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*Sterculia acuminatissima* Merr., Philip. J. Sci. 21 (1922) 524.

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# On The Agaric Genera *Hohenbuehelia* and *Oudemansiella* Part I: *Hohenbuehelia*

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## Abstract

The construction of the fruit-body and the affinity of the genus are discussed. It is considered that it comes between *Pleurotus* and *Oudemansiella*, having the basidia of the former and the pleurocystidia of the latter. Eighteen species are described for Malesia, of which 15 are new. Notes are given on several extra-Malesian species. New taxa: *H. concentrica, H. griseipendens, H. incarnata, H. lanceifera, H. malesiana, H. mellea, H. minutissima, H. pachyhyphata, H. pahangensis, H. perstriata, H. quadruplex, H. singaporensis, H. suppapillosa, H. vermiculata. H. bullulifera* Singer v. *brasiliensis.* New combinations: *H. cystidioides* (C.G.Lloyd), *H. subtorulosa* (Cke).

## Contents



## General Account

A fruit-body with lateral pileus, an upper gelatinous layer to the flesh, and a farinaceous smell of meal is a sign of *Hohenbuehelia.* It is checked microscopically for the thick-walled pleurocystidia. However, there are specific variations in most features and what seems to be a uniform genus has ragged fringes.

*Fruit-body.* Two European species have mesopodal fruit-bodies, namely *H. longipes* (among moss in woodland) and *H. culmicola* (on remains of the coastal dune-grass *Elymus*). At the other extreme, there are fruit-bodies which are dorsifixed, more or less sessile, and at first cyphelliform, as *H. bullulifera, H. chevalieri, H. griseipendens, H. nigra,* and *H. singaporensis.* Such species resemble *Resupinatus* which lacks the thick-walled pleurocystidia.

*Flesh.* The upper gelatinous layer is usually thinner than the firm layer of the flesh but it may be as thick or thicker. In a few species the flesh is almost completely gelatinous. In contrast, the gelatinous layer is said to be poorly developed or little differentiated in the South American *H. roigii* and *H. spegazzinii.* Concerning the absolute thickness of the gelatinous layer, there must be some caution in comparing descriptions. I measure its maximum thickness at the base of the lateral pileus, as I do for the flesh, and this may be the customary procedure, but Singer measures it towards the margin of the pileus. In this case, it is necessary to state whether it is an old or young pileus because the old pilei become marginally attenuate and may give a narrower measure than the young. The gelatinous layer swells abnormally in material preserved in alchohol-formalin and, also, in sections mounted in dilute potash. Sections of dried material mounted in water give a more or less normal thickness.

*Spores.* Most species have smooth and thin-walled spores as seen under the light microscope but there is one exception with verruculose to echinulate and thick-walled spores, namely *H. bursaeformis.* For this, Singer (1969) made the subgenus *Reidia* and Horak (1981) has treated it as the distinct genus *Conchomyces* v. Overeem, while remarking oddly that *Hohenbuehelia* is characterised by allantoid cylindric spores. Singer added a second species, *H. dimorphocystis*, which Horak reduced to his *C. bursaeformis.* However, there are difficulties in accepting this genus. Donoso (1981) showed that the spores of some species of the genus have a thin mucilage sheath beneath which the endospore, under SEM, is subverrucose, e.g. *H. geogenia, H. heterosporica, H. petaloides* and *H. rickenii*: in the case of *H. bursaeformis*, the spines penetrate this sheath. Then, according to Donoso, *H. heterosporica* has both smooth and subverrucose spores (as seen under SEM), even on the same basidium. I find with Malesian material of *H. bursaeformis* that the spores under the light microscope vary from echinulate to merely asperulate and that these spines or warts contract in Melzer's iodine and disappear in dilute potash, thus unlike typical spines. In other words, there is a gradation from echinulate spores (of a sort) to truly smooth spores, which nullifies the main idea of a separate *Conchomyces.*

The spores of the genus are often said to be 1-guttate but, in my experience, fresh spores are usually aguttate and, on drying, the contents contract into a sort of gutta, though a few species have fresh spores with 1-2 minute guttulae.

*Cheilocystidia.* These make a sterile gill-edge and are nearly always thin-walled. They vary in different species from clavate to cylindric-moniliform and lecythiform, or ventricose. They would seem to supply useful specific features but they may vary considerably even in the same fruit-body.

*Pleurocystidia.* These are usually called metuloids because the thick wall is encrusted distally with granules or crystals. In most species they are not dextrinoid but Stevenson (1964) has described several species from New Zealand with dextrinoid walls. In *H. bursaeformis* the wall is scarcely thickened and not or slightly encrusted. In two species, namely *H. horrida* and *H. incarnata*, the pleurocystidia are extremely abundant. The wall thickens from apex to base, young pleurocystidia being thin-walled. They are the first hymenial elements to develop and have, in consequence, a deep tramal origin in the mature gill. Their length may vary because the first to be formed are at the base of the gills and between them and are the longest, and they shorten towards the gill-edge where they may be almost hymenial and, even, mixed with the cheilocystidia.

*Hyphae.* These are short-celled and, usually, with little inflation though strongly inflated in the flesh of some species. In others they develop thickened walls and may become almost solid, as in *H. pachyhyphata*; this species has ampulliform swellings on some hypae which resemble the inflated cells in *Chaetocalathus* (Corner, in ed.). The gelatinous layer begins to form almost as soon as the pileus. It separates a narrow superficial layer, one or two to ten hyphae thick in different species, from the tissue of the flesh (Fig. 12). The superficial layer develops a loose sterile hymenium with variously formed cells and, in most species, narrow hyphae grow slowly out to project vertically to form the villous surface; thus it is more evident in the proximal part of the pileus. In *H. quadruplex* (Fig. 9) the gelatinous layer is double. In a few species, such as *H. suppapillosa* (Fig. 11,12), there are many inflated cells in the gelatinous layer as well as the usual uninflated hyphae. The gill-trama is constructed from descending hyphae but in *H. angustata* there seems to be a vestige of the radial construction seen in *Panus* s.str.

*Surface of pileus.* The loose sterile hymenium on the surface may develop cells like cheilocystidia or pleurocystidia but in some species, especially those with the fruit-bodies at first cyphelliform, there is a more or less close hymenioderm of clavate cells, e.g. *H. bullulifera, H. griseipendens, H. nigra, H. singaporensis* and *H. subbarbatus* (Dennis, 1953). Such a hymenioderm is used in modern mycology to distinguish genera but has not aroused that attention in *Hohenbuehelia.*

*Nematode-catching.* This habit has been explained in detail by Thorn and Barron (1986). They associate 9 species of the mycelial genus *Nematoctonus* Drechsler, which has clamp-connections, with some 14 species of temperate *Hohenbuehelia.* The nematodes are caught by a viscous excretion from short hyphal processes, often lecythiform, and the mycelia may form solitary conidia or chlamydospores. Tropical species remain to be tested.

## Classification of the Species

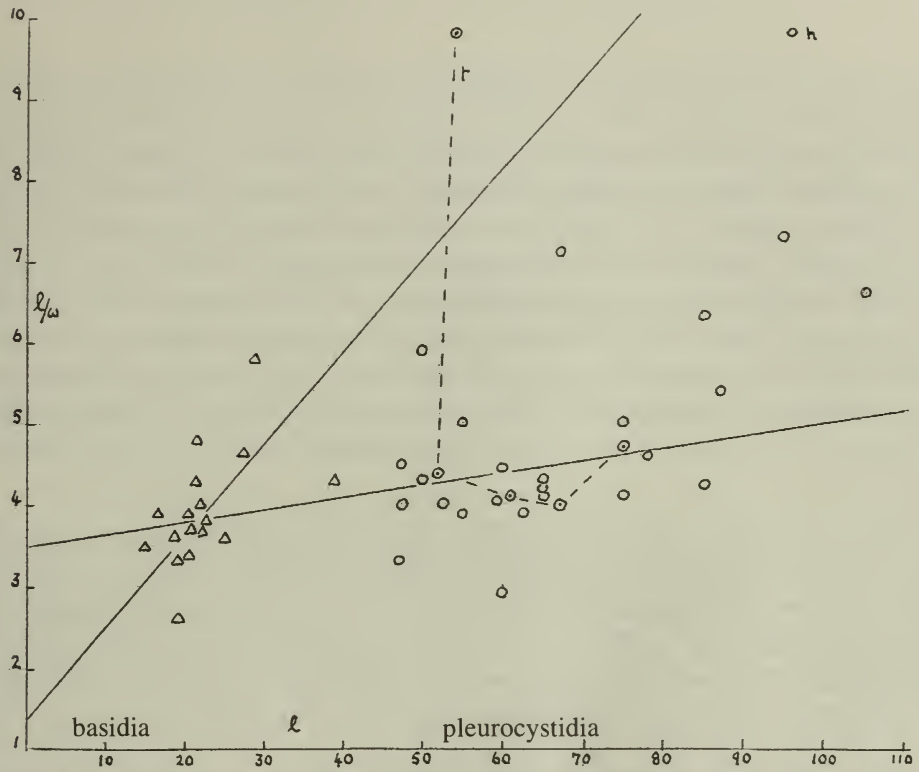
Several ways have been proposed to arrange or to ally the species, but none seems, as yet, to be satisfactory. Huijsman (1961) employed the relative thickness of the gelatinous and firm layers of the flesh and the direction of the hyphae in the gelatinous layer, whether it was ascending more or less vertically to the surface, longitudinal (radiating) parallel with the hyphae of the firm layer, or interwoven, His conclusions were drawn from rather few temperate species and, as Singer has remarked, need extension to those of the world. Singer (1975) distinguished subgen. *Reidia* with ornamented spores from subgen. *Hohenbuehelia* with smooth spores but, as Donoso (1981a,b) has shown, the distinction breaks down with SEM examination. For the Malesian species I have used primarily the presence or absence of thick-walled cystidia like pleurocystidia on the surface of the pileus because I find that it is a constant character. However, though I have perused descriptions of other species, there remain numerous doubts about its universal applicability.

*Conchomyces* was considered by Horak (1981) to be unrelated to any other agaric genus on account of the echinulate, subglobose and rather thick-walled spores, the large cheilocystidia, the rather thin-walled pleurocystidia and the inflated hyphae of the firm tissue of the flesh. It is difficult to follow this argument because all the points have their gradations in other species of *Hohenbuehelia* with which it agrees in colour and gelatinous upper layer to the pileus. The one species, *H. bursaeformis*, has been regarded as peculiar to the southern hemisphere of Australasia and Chile, but its occurrence in Malaya and north Borneo does not accord. Maybe it has traces of the stouter fruit-body of *Oudemansiella.*

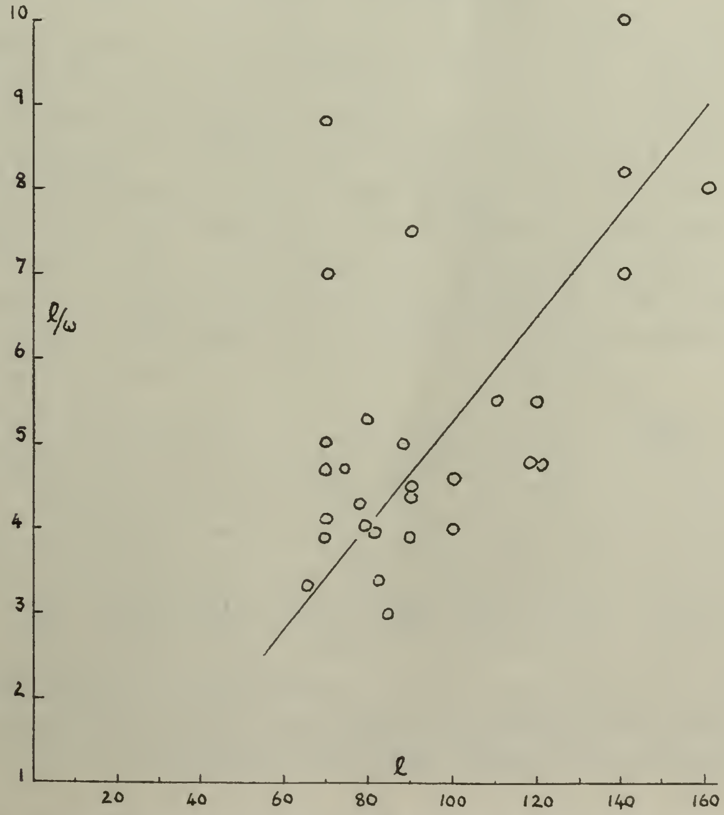
## Basidiograph and Pleurocystidiograph

In Graphs 1 and 2, the ratio $l/w$ for basidia and pleurocystidia is plotted against $l$, where $l$ is the length and $w$ the width of these structures as given in the following descriptions for their mean values. The result is peculiar. The basidia conform to a steep locus as drawn, roughly, by the line through the triangles, and the pleurocystidia conform to a more gradual locus shown, roughly, by the line drawn through the circles. However, there are two outstanding exceptions, for the pleurocystidia of *H. horrida* (point h) and for one of the measures for *H. testudo.*

In the equation to these loci $l/w = a + bl$, $b$ is 0.112 for the basidium and 0.015 for the pleurocystidium; the reciprocal of $b$ gives the maximum width as 8.9 µm for the basidium and 66.7 µm for the pleurocystidium. These values are based on mean measures; the widest basidium that I have recorded was 10 µm for *H. concentrica* (mean 9 µm); the widest pleurocystidium was 28 µm in *H. angustata*. Thus, the basidia of *Hohenbuehelia* are extremely narrow, even narrower that the clavarioid basidium with $b = 0.08$ ($1/b = 12.5$ µm). The pleurocystidia, however, conform to the wider basidium seen in *Amauroderma* and *Ganoderma* with $b = 0.013$ (Corner 1983). The hymenium of *Hohenbuehelia* seems to be influenced in two ways; one is primitive and retains the wide or massive expression and the other is far advanced towards the minimal narrowness of the uninflated hypha.



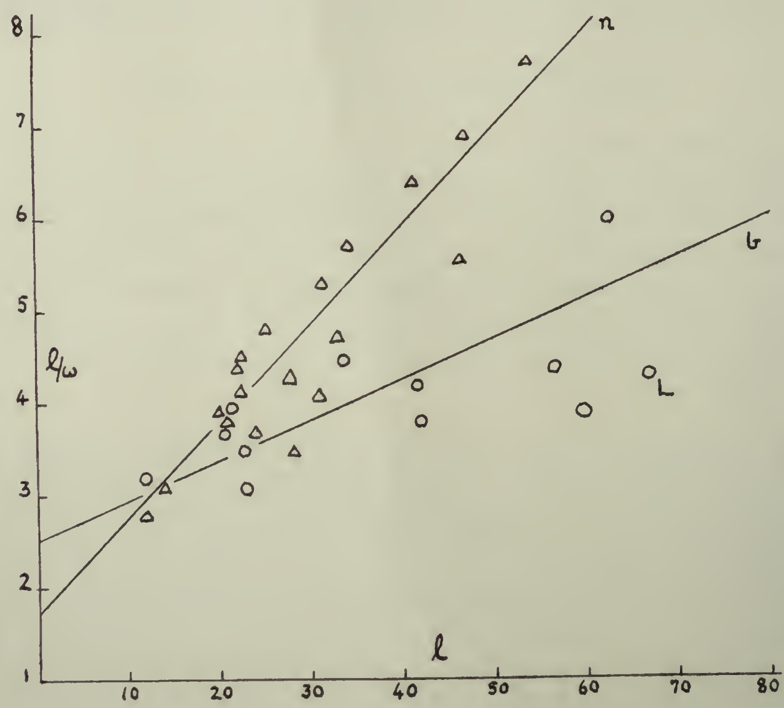

Graph 1. *Hohenbuehelia,* basidiograph (triangles) and pleurocystidiograph (circles); h, *H. horrida;* t, *H. testudo.* (Constructed from the data in this article).




Graph 2. *Hohenbuehelia,* pleurocystidiograph for the longest pleurocystidia.

The situation in *Pleurotus* is instructive. In dealing with the Malesian species, I distinguished species with narrowly ellipsoid to cylindric spores from those with broadly ellipsoid to subglobose spores (Corner 1981). Graph 3 gives the basidiographs of these two groups. That with narrow spores has the steeper slope for which, roughly, $b$ = 0.105 (1/$b$ = 9.5 µm) which is comparable with *Hohenbuehelia*; and that with broad spores has, roughly, $b$ = 0.045 (1/$b$ = 22.2 µm) which is intermediate to the large basidium of *Oudemansiella* with $b$ = 0.02 (1/$b$ = 50 µm). That is to say, in comparision with *Hohenbuehelia, Pleurotus* is progressing to the narrowness of the basidium with little tendency to retain the pleurocystidium as the larger unit. The basidiograph of both genera corresponds with that of the developing basidia of *Oudemansiella* with $b$ = 0.11 (Corner, 1947).

These conclusions are tentative because they are based on mean measures and not on true averages of many individual basidia. Moreover, in the case of the pleurocystidium of *Hohenbuehelia* it is not always clear that the width refers to that between the outer walls or to the overall width including the incrustation. Nevertheless, it seems that the pleurocystidia of *H. horrida* conform with both loci. The genus is less advanced in this respect than *Pleurotus.*




Graph 3. *Pleurotus,* basidiograph. Species with narrow spores as triangles with locus n. Species with broad spores as circles with locus b. L, *Lampteromyces japonicus.* (Constructed from the data in Corner 1981).

## Affinity

Modern taxonony places *Hohenbuehelia* along with *Resupinatus* (without thick-walled pleurocystidia) in Tricholomataceae tr. Resupinateae. This classification emphasizes the gelatinous texture of the flesh. As regards *Resupinatus*, I have given reason to suppose that it is a mixture of marasmioid fungi with subacerose basidioles and pleurotoid fungi without them (Corner, in ed.). Concerning *Hohenbuehelia*, there are several species which fail in one way or other the dual test of a gelatinous layer in the flesh and thick-walled pleurocystidia. That its species are mostly pleurotoid seems not to matter because *H. culmicola* and *H. longipes* are mesopodal.

Both diagnostic characters emphasize the difference from *Pleurotus*. An analogy, however, seems to dispose of a family distinction. *Polyporus* s. str. and *Echinochaete* have the same peculiar hyphal construction but *Echinochaete* has an upper gelatinous layer to the pileus and thick-walled pleurocystidia, both features lacking in *Polyporus* s. str. (Corner, 1984). *Echinochaete* has been regarded as a synonym of *Polyporus* subgen. *Asterochaete* by Singer (1975). Thus, the affinity of *Hohenbuehelia* may well concern *Pleurotus*, some species of which have thin-walled pleurocystidia (Corner, 1981); moreover, *Hohenbuehelia* has been regarded as a subgenus of *Pleurotus* by several authors. The faculty of nematode-catching has been found, also, in several species of *Pleurotus* (Thorn and Barron, 1986), but not reported for *Resupinatus*.

Another genus, in this connection, is *Agaricochaete* which has been re-established with a third species by Pegler (1977). The fruit-bodies are mesopodal and clitocyboid without gelatinous flesh but with the thick-walled pleurocystidia of *Hohenbuehelia*. Emphasizing these pleurocystidia, Peglem placed the genus in Resupinateae, and here enter two other species of South America, *H. roigii* and *H. spegazzinii*. Their fruit-bodies have no distinctly gelatinous flesh but they have the thick-walled pleurocystidia, and they are pleuropodal or sessile. If emphasis is laid on pleurocystidia, then it is difficult to see how these two can be separated from *Agaricochaete*, which would then become practically synonymous with *Hohenbuehelia*.

The contrast is shown by *H. bursaeformis* with the gelatinous upper layer to the flesh but with thin or but slightly thick-walled pleurocystidia. One is led to think of *Oudemansiella* with mesopodal fruit-bodies and large spores, as if antecedent, and it has a species with echinulate spores. *Agaricochaete* is evidently rare and, maybe, there are other tropical species of this general alliance to be discovered. The fourth species attributed to the genus, *A. indica* Natarajan et Raman (1986), without clamp-connections, is excluded by Thorn and Barron who think that it may be *Lactocollybia*.

Another alliance has been suggested with *Geopetalum* Pat. or *Faerberia*, as it seems it must now be called (Pouzar, 1981), but I use the old name as that of past literature. The fruit-body of *G. carbonarium* has the stature and colour of mesopodal *Hohenbuehelia* and the thick-walled pleurocystidia, but it lacks the gelatinous layer to the flesh. It is dimitic in the manner of several species of *Pleurotus* and has cantharelloid gill-folds with thickening hymenium (Corner, 1966, 1968); moreover, it is not nematode-catching. A minor distinction may be that, instead of the prevailing farinaceous smell of *Hohenbuehelia*, it disengages HCN. Nevertheless, if the cantharelloid gill-fold preceded the agaric, *Geopetalum* could have led to *Pleurotus* and, so via *Agaricochaete* to *Hohenbuehelia.* Whereas *Cantharellus* is excluded from Agaricales by modern taxonomy, it consistently admits the cantharelloid *Geopetalum.* It has been ranked with *Hohenbuehelia* in Geopetalaceae, to the exclusion of *Resupinatus*, by Jülich (1981). The common character is the thick-walled pleurocystidium, not the gelatinous layer in the flesh; the other characters, given by Jülich, such as multiguttulate basidia and spores, do not occur in my experience in *Hohenbuehelia.*

Three other pleurotoid genera have, at least in some of their species, thick-walled pleurocystidia. Of these, *Chaetocalathus* and *Panus* lack the gelatinous upper layer to the flesh but it is present in some species of *Panellus.* This genus and *Chaetocalathus*, however, are marasmioid with subacerose basidioles. *Panus* has, in the main, radiate gill-construction which may be a relic of the cantharelloid.

If one attempts to relate these genera, dispersed in various tribes or families, in a phylogenetic tree, it becomes obvious how much must have disappeared in the long course of evloution. I am forced to conclude that modern taxonomy still needs modernising.

## *Hohenbuehelia* Schulzer (1866) - Generic Character

Fruit-bodies pileate, mesopodal, pleuropodal or sessile to dorsifixed and at first cyphelliform, gymnocarpic. Gills decurrent or radiating from the point of attachment, thin, sometimes dichotomous. Flesh with an upper gelatinous layer and a firm lower layer, in a few species almost wholly gelatinous. Smell often farinaceous. Spores white, mostly smooth but varying verrucose to echinulate, inamyloid. Hymenium not thickening, without subacerose basidioles; gill-edge sterile with thin-walled cheilocystidia. Pleurocystidia typically thick-walled and encrusted, usually not dextrinoid. Hyphae clamped, monomitic, short-celled, inflating or not, inamyloid. Surface of pileus often villosulous with excrescent, often faciculate, hyphae; pileocystidia thick-walled, present or not; in some species hymenioderm with clavate cell. Colour of pileus usually fuscous brown, grey or pallid subochraceous to whitish, either in the walls of the superficial hyphae or in the sap of the upper hyphae of the firm layer of the flesh. Lignicolous or on plant-remains, a few terricolous, associated (? always) with nematode-catching. Worldwide.

## Keys to the Species of *Hohenbuehelia* in Malesia

1. Surface of pileus with thick-walled cystidia .................................... **Group 1**
1. Surface of pileus without such cystidia ............................................ **Group 2**

### Group 1

1. Flesh almost wholly gelatinous. Pileus -14 mm wide, with subdiscoid base. Spores 4.5-6 x 3.3-4.3 μm. Cheilocystidia mostly clavate. Solomon Islands ................................................................ *H. subdiscipes*

1. Flesh with a distinct firm layer below the gelatinous layer. Cheilocystidia mostly ventricose with short, often capitate appendage.

    2. Gills distant, -3.5mm wide. Pileus -22mm in radius, subsessile, striate. Flesh -2mm thick. Spores 5-6 x 3.5-4 μm. Solomon Islands ......................................................................... *H. perstriata*

    2. Gills crowded. Pileus sessile or pleuropodal.

        3. Pileus -7mm wide, greyish buff. Gills -0.7mm wide. Flesh with the gelatinous layer thicker than the firm layer. Spores 4-6.5 x 3-4 μm. Pileocystidia very heavily encrusted. Solomon Islands. .................................................................................................................... *H. vermiculata*

        3. Pileus larger. Gills wider. Gelatinous layer thinner than the firm layer.

            4. Cheilocystidia clavate to obtusely ventricose. Spores 3.5-4.3 x 3-3.5 μm. Malaya ............. ................................................................................................................ *H. pahangensis*

            4. Cheilocystidia often ventricose with capitate apex. Spores 5-7 x 2.5-3.5 μm. S.E.Asia ........ ................................................................................................................ *H. testudo*

            (Spores 3.5-5 μm wide. Malesia ........................................................................ var. *glabra*)

### Group 2

1. Hyphae of the firm layer of the flesh and of the gill-trama with walls 1-3  thick or more. Spores smooth.

    2. Firm layer of the pileus much thinner than the gelatinous.

        3. Pileus -3mm wide, grey. Spores 5-7 x 2.7-3.5 μm. New Guinea ....................... *H. minutissima*

        3. Pileus -45mm wide, greyish to brownish bistre, occasionally white. Gills waxy gelatinous. Spore 7-9 x 3-4 μm. Malesia ..................................................................................... *H. malesiana*

    2. Firm layer of flesh thicker than the gelatinous layer (at least in the proximal part of the pileus).

            4. Pileus -30mm wide, white to dingy yellowish or fuscous vinaceous. Stem short, thick. Smell farinaceous. Spores 6-7.5 x 3-3.5μm. Hyphae of firm layer of flesh with ampulliform swellings. Borneo, Queensland ................................................................. *H. pachyhyphata*

            4. Pileus - 13mm wide, white to greyish umber. Spores 4-5.5(-6) x 3.3-3.7 μm. No ampulliform swellings. Borneo ........................................................................................... var. *minor*

1. Hyphae with thin or scarcely thickened walls.

    5. Spores echinulate, subglobose. Pileus white to pale ochraceous. Malesia .................. *H. bursaeformis*

    5. Spores smooth.

        6. Pileus dorsifixed, at first cyphelliform, expanding to 25mm wide or less, fuliginous grey. Flesh 1-2mm thick, gills -1.5mm, crowded. Cheilocystidia 15-30 x 6 -10(-15) μm, clavate. Surface of pileus more or less hymeniiform.

            7. Spores 6-7 x 4-4.5 μm. Pleurocystidia 12-25 μm wide. Clavate cells on pileus 8-20 μm wide, compact. Singapore ........................................................................ *H. singaporensis*

7. Spores 4-5 x 3.5-3.7 µm. Pleurocystidia 7-14 µm wide. Clavate cells -7 µm wide, some lobulates scattered on pileus. Borneo ........................................................ *H. griseipendens*

6. Pileus pleuropodal or laterally sessile from the first.

8. Pleurocystidia exceedingly numerous, lanceolate, 5-12(-14) µm wide. Gills more or less distant, 4-6mm wide. Pileus - 7cm wide, shortly pleuropodal.

9. Wholly pinkish buff. Gelatinous layer of flesh - 150 µm thick. Spores 4-7 x 4.5-6 µm, subglobose, smell slight, of fenugreek. Solomon Islands ............ *H. incarnata*

9. White to brownish ochrceous or greyish. Gelatinous layer 250-600 µm thick. Spores 5-6.5 x 3-4 µm, ellipsoid. Smell farinaceous. Malesia ....................... *H. horrida*

8. Pleurocystidia numberous but not crowded, ventricose-fusiform. Gills 1.5-3mm wide or -4mm.

10. Pleurocystidia with long attenuate apex, 40-160 x 12-20 µm . Flesh almost wholly gelatinous, firm layer 100-200 µm thick. Gills pale ochraceous to brownish. Pileus -20mm wide. Inodorous.

11. Gills crowded. Pileus white to pallid ochraceous. Spores 4-5.5 x 3.7-4.5 µm. Borneo ........................................................... *H. lanceifera*

11. Gills distant. Pileus honey yellow to brownish, not villous. Spores ? 5-6.5 x 2.3-3 µm. Singapore ................................................................ *H.mellea*

10. Pleurocystidia not long attenuate, shorter. Gills crowded.

12. Gills - 4mm wide. Pileus -8cm wide, ochraceous to orange. Flesh more than 1mm thick

13. Gills white. Pileus white to ochraceous and brownish, shortly stipitate. Flesh 1.5-4mm thick, gelatinous layer - 1mm thick. Spores 6-7 x 4-5 µm. Inodorous. Malaya, Sarawak ...... *H. suppapillosa*

13. Gills pale ochraceous buff. Pileus light orange to brownish ochraceous, with concentric ridges. Flesh 3-5mm thick, gelatinous layer 1-2mm thick. Spores 8-8.5 x 6-6.7 µm. Smell farinaceous. Singapore ............................................................. *H. concentrica*

12. Gills -1mm wide, white to pale ochraceous buff. Spores 4-6.5 x 3-4 µm.

14. Pileus -8mm wide, greyish, sessile. Firm layer of flesh 50-100 µm thick, gelatinous layer much thicker. Solomon Islands ... ......................................................................... *H. vermiculata*

14. Pileus -30mm wide, pleuropodal, fuscous fawn, smooth. Flesh with two gelatinous layers. Solomon Islands .. *H. quadruples*

## **Hohenbuehelia bursaeformis** (Berk.) Reid — Figure 1

**Kew Bull. 17 (1963) 304; Singer, Nova Hedwigia Beih. 29 (1969) 62.**

***Conchomyces bursaeformis*** **(Berk.) Horak, Ann. Mycol. ser. II. 34 (1981) 109; New Zeal. J. Bot. 9 (1971) 458.**

Pileus -6cm in radius, -8cm wide, sessile or with a short and more or less lateral stem, at first convex or cucullate, generally descending, then applanate, smooth except the shortly villous base, white to pale ochraceous bistre or drab fawn buff, striate towards the incurved, minutely scurfy margin. Stem 0-5 x 1-3 mm, lateral or nearly so, villous. Gills decurrent, very crowded and thin, very narrow, almost contiguous, 13-30 primaries 1-2mm wide, 5-7(-8) ranks, rarely dichotomous, shining white, edge entire. Flesh 2-4mm thick at the base of the pileus, fibrous firm then rather spongy, with a thin gelatinous layer 200-500 µm thick (100 µm near the margin of the pileus). Smell sour or of fresh mushrooms (*RSS 1799*), or none (*RSS 844*).

On fallen branches and trunks of various trees, and on dead palm-trunks, in the forest. Malaya, Java, Borneo, New Guinea, Solomon Islands, New Caledonia, Australia, New Zealand, Chile.

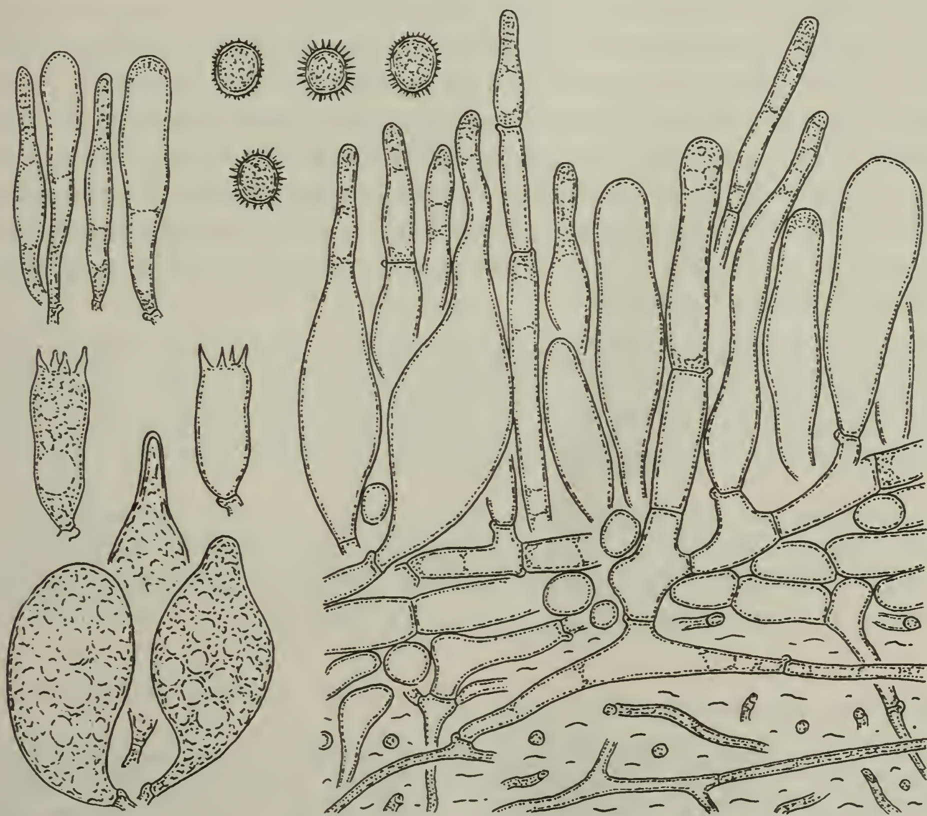


Figure 1. *Hohenbuehelia bursaeformis.* Spores, basidia, cheilocystidia and pleurocystidia, x 1000. Surface of pileus, x 500.

Spores 5-6.7 x 4.5-6 µm, 6-6.7 x 5-5.7 µm (*RSS 844, 1799*), 6-8 x 5-5.6 µm (*RSNB 5168, 8039*), white, broadly ellipsoid to subglobose, closely and finely echinulate with spines -1 µm long, or with shorter spines -0.7 µm (*RSNB 5168, 8039*), -0.5 µm (Tembeling), or -03 µm (*RSS 1799*), or merely asperulate (*RSS 844*), inamyloid, the spines often contracting in Melzer's iodine and dissolving in dilute potash. Basidia 17-22 x 7-8 µm; sterigmata 4, 5 µm long; no acerose basidioles; subhymenium narrow, interwoven subgelatinous. Cheilocystidia 30-60 x 6-20 µm, subcylindric, clavate or ventricose, obtuse, not capitate, thin-walled, smooth, as a sterille gill-edge but becoming disrupted or collapsing. Pleurocystidia -65 x 9-20 µm, clavate to ventricose with a short obtuse appendage -16 x 3-6 µm, thin-walled or the apex of the appendage with slightly thickened wall -0.5 µm, smooth, drying with reddish brown vitreous-vacuolate contents (dissolving and becoming colourless in KOH and Melzer's iodine, or persistently reddish brown in Melzer's iodine). Hyphae monomitic, with minute clamps (easily overlooked), inflating, with cylindric cells 16-105 (-140) x 3-23 µm, not or scarely constricted at the septa, branching rather loosely at a wide angle, longitudinal and intewoven but more compact and 3-6 µm wide and strictly longitudinal in a thin layer 40-50 µm thick over the gills and below the gelatinous layer, the walls firm or thickened -0.5 µm; in the gill-trama descending, short-celled, inflated; in the gelatinous layer of the pileus longitudinal and interwoven. Surface of pileus developing a villous layer -400 µm thick and composed of much entangled hyphae 3-8 µm wide, separate, sparingly branched, with smooth wall -0.5 µm thick, in the middle part of the pileus with clavate to subventricose thin-walled cells 30-80 x 7-30 µm (? as a palisade in the young pileus, collapsing in the villous part of old pilei).

Collections.- Malaya, Pahang, Tembeling, *Corner s.n.* 4 Nov. 1930.- Borneo, Mt. Kinabalu, 1100-1700m alt., on rotten wood, *RSNB 607, 5167, 5167A 5167C, 8039*.- Solomon Islands, Guadalcanal, Tsuva, on a rotten trunk of *Areca*, *RSS 1799*; San Cristobal, Warahito River, *RSS 844*, on a dead branch.

This is my description from Malesian material. It agrees well with that of other authors. Horak gives the pleurocystidia as merely 20-35 x 7-16 µm with the wall -1 µm thick in the distal part, and covered with resinous incrustation or, rather rarely, with crystals. *Conchomyces* is discussed on p. 2.

### **Hohenbuehelia concentrica** sp. nov.

**Pileus -6cm in radio, -8cm latus, sessilis flabelliformis convexo-planus, rugis concentris zonatus, aurantiocervinus vel pallide cervino-ochraceus, sicco albivillosulus. Lamellae confertae subtenaces, 11-19 primariae 2.5-3.5mm latae, ordinibus 6-8, pallide ochracei-alutaceae. Caro 3-5mm crassa, strato gelatinoso 1-2mm crasso, strato villoso 0.3mm crasso, albida vel alutacea. Odor farinaceus fortis. Sporae 8-8.5 x 6-6.7 µm, laeves ovoidease, intus granuloso-opalescentes. Cheilocystidia vix evoluta, lamellae acie hyphis -70 x 1.5-3 µm haud vel laxe ramosis instructa. Pleurocystidia 30-80 x 7-15 µm, ventricosa, tunicis -5 µm crassis, haud incrustata, solum apicibus acutis breviter projicientibus, sparsa sed lamellae aciem versus numerosa. Subhymenium 15-20 µm crassum, cellulis3-7 µm latae. Superficies pilei sine cystidiis. Ad truncum putridum *Lophopetalum* (Celastraceae) in silva. Singapore, Selitar, *Corner s.n.* 4 Feb. 1944; typus, herb. Corner.**

Pileus -6cm in radius, -8cm wide, sessile, convexo-plane, with narrow raised concentric zones, wholly light orange fawn to pale fawn ochraceous, drying white villous with the raised zones as narrow concentric ridges closely developed towards the incurved margin. Stem practically none, as a finely villous pulvinus. Gills crowded, rather tough, thin, not gelatinous, 11-19 primaries 2.5-3.5mm wide, 6-8 ranks, entirely pale ochraceous buff. Flesh with the firm whitish to pallid buff layer 2-3.5mm thick at the base of the pileus, the brownish gelatinous upper layer 1-2mm thick, the villous layer 0.3mm thick. Smell strong, of meal.

On rotten wood of *Lophopetalum* (Celastraceae) in the forest. Singapore, Seletar.

Spores 8-8.5 x 6-6.7 µm, white, smooth, ovoid, wholly finely opalescent granular. Basidia 35-43 x 8-10 µm, clavate, finely opalescent granular, 3-3.5 µm wide at the base; sterigmata (2-3-)4, 6-6.5 x 2.5-3 µm. Subhymenium 15-20 µm thick, composed of short-celled, rather regularly divergent hyphae 3-6 µm wide, at right angles to the descending hyphae of the gill-trama, distinctly corticate. Cheilocystidia not formed, the gill-edge with many narrow emergent hyphae -70 x 1.5-3 µm, not or sparsely branched, septate or not. Pleurocystidia 30-80 x 7-15 µm, ventricose with a short acute process, wall -5 µm thick, smooth, rather sparse but more abundant towards the gill-edge, the tip shortly projecting. Hyphae monomitic, clamped; in the firm layer of the flesh 3-7 µm wide with rather firm walls, longitudinal and interwoven, compact, 1.5-4.5 µm wide and ascending in the gelatinous layer; in the gill-trama 2-10 µm wide, descending with thin or scarcely thickened walls, not gelatinous. Surface of pileus with an often ill-defined layer c. 20 µm thick, composed of longitudinal hyphae 2-6 µm wide, overlain by a layer 20-40 µm thick, composed of laxly interwoven hyphae 1.5-3 µm wide, with excrescent and slightly thick-walled hyphae forming discrete or anastomosing subagglutinated fascicles -350 µm high at the base of the pileus; no pileocystidia.

This species is very distinct in the orange-tinted and zoned pileus, the large ovoid spores, the absence of cheilocystidia and the distinctly corticate subhymenium.

**Hohenbuehelia griseipendens** sp. nov. Figure 2

**Receptacula -20mm lata, sessilia cyphelliformia pendentia, pallide grisea. Lamellae confertae, 9-11 primariae -1.5mm latae, ordinibus 4-6. Caro 1-2mm crassa, ex integra gelatinosa firma. Odor nullus. Sporae 4-5 x 3.5-3.7 µm, laeves, late ellopsoideae. Cheilocystidia 15-30 x 6-10 µm, clavata sed nonnulla ut pleurocystidia intermedia. Pleurocystidia 25-70 x 7-14 µm, ventricosa breviter appendiculata, tunicis -2.5 µm crassis, vel clavata tunicis haud vel vix incrassatis, etiam hymenialia ut cheilocystidia. Hyphae in carne 1.5-3.5 µm latae, gelatinosae. Superficies pilei sine cystidiis et cellulis clavatis, aut cum cellulis clavatis paucis et saepe sublobatis. Ad lignum putridum in silva montana. Borneo, Mt Kinabalu, fl. Liwagu, 1300m alt., *RSNB 2562*, 29 Aug. 1961; typus, herb. Corner.**

var. **nonsatisfacta** var. nov.

**Differt sporis angustioribus 4-5 x 2-2.3 µm, pleurocystidiis tunicis vix incrassatis -0.5 µm, pilei superficie acystidiata. Ad lignum putridum in silva. Insulae Solomonenses, Guadalcanal, *RSS 511*; typus, herb. Corner**

Fruit-bodies -20mm wide, sessile, cyphelliform pendent, pale grey, the upperside drying finely white villous. Gills diverging from the central point, crowded, thin, narrow, 9-11 primaries 1-1.5mm wide, 4-6 ranks, grey edge entire. Flesh 1-2mm thick at the base, wholly gelatinous-firm. Smell none.

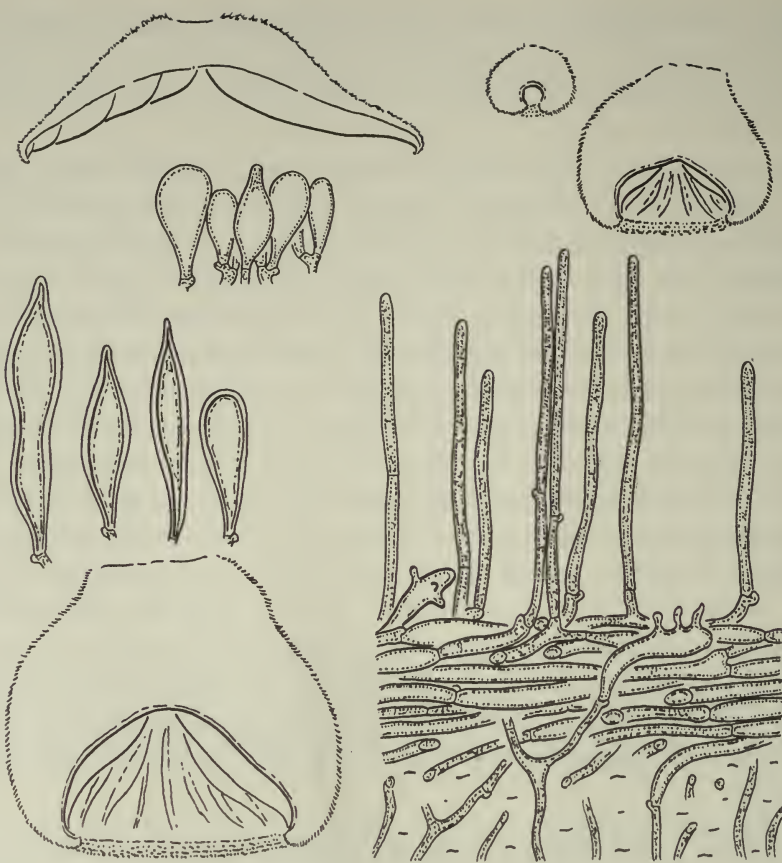


Figure 2. *Hohenbuehelia griseipendens.* Developing fruit-bodies in section, x 10. Mature fruit-body in section, x 2. Cheilocystidia, pleurocystidia and surface of pileus, x 500.

On rotten wood in montane forest. Borneo, Mt Kinabalu, Liwagu river 1300m alt.

Spores 4-5 x 3.5-3.7 mm, white, smooth, broadly ellipsoid, thin-walled, inamyloid, (1-2 guttulate in material in alcohol-formalin). Basidia 5 μm wide, 4-spored. Cheilocystidia 15-30 x 6-10 μm, mostly clavate, thin-walled, as a sterile gill-edge, but with transitions to the pleurocstidia. Pleurocystidia 25-70 x 7-14 μm, ventricose and rather shortly appendaged to clavate, walls 0.5-2.5 μm thick in the ventricose cells, not encrusted or slightly in the distal part, abundant, with many smaller cystidia at the gill-surface like the cheilocystidia. Hyphae monomitic, clamped, 1.5-3.5 μm wide, gelatinous; in the gill-trama 3-5 μm wide with firmly gelatinous walls, descending. Surface of pileus with a layer 25-35 μm thick, composed of radiating and interwoven hyphae 2-5 μm wide with firm (not gelatinous) walls, some ending in a short subclavate cell -7 μm wide and often with shortly lobed apex, but not as a hymenioderm and without thick-walled cystida; this layer giving rise with excrescent hyphae 2-4 μm wide, often fasciculate, with slightly thickened walls, not or sparsely septate with clamps as the villous layer -300 μm thick.

var. **nonsatisfacta**

Pileus -9 mm wide, sessile, dorsifixed, unilaterally expanded and flabelliform resupinate, striate , fuliginous grey, drying white villous over the centre. Gills radiating from the excentric attachment, crowded, 8-10 primaries 1mm wide, 4-5 ranks, fuliginous grey. Flesh 1mm thick at the base, wholly gelatinous.

On rotten wood in the forest. Solomon Islands, Guadalcanal, Gallego, Monitor Creek, 2 July 1965, *RSS 511.*

Spores 4-5 x 2.2-3 μm, white, smooth, ellipsoid, inamyloid. Basidia 13-17 x 4-4.5 μm, 4-spored; no subacerose basidioles; subhymenium 15-25 μm thick, composed of 1.5-3 μm intewoven hyphae. Cheilocystidia 12-25 x 4-8 μm, clavate to ventricose, occasionally with a short appendage, not capitate, thin-walled, smooth, as a sterile gill-edge. Pleurocystidia 30-55 x 7-9.5 μm, base 3-4 μm wide, fusiform, acute, wall slightly thickened -0.5 μm, thinly encrusted distally, not dextrinoid, abundant, varying more or less immersed to subhymenial and projecting -18 μm. Hyphae monomitic, clamped; in the flesh 1.5-3 μm wide with gelatinous walls in the gill-trama 2-4 μm wide a discontinous layer, 1-2 hyphae thick, of 2-4 μm hyphae with firm walls, developing the thinly villous layer at the base of the pileus, without cystidia or clavate cells.

This is close to *H. singaporensis* but it lacks the hymenioderm and the pleurocystidia are not so thick-walled or so wide.

**Hohenbuehelia horrida** (Boedijn) comb. nov.

***Acanthocystis horrida*** **Boedijn, Bull. Jard. bot. Buitenz. ser. 3, 16 (1940) 400, f. 9.**

Pileus -7 cm in radius, -6cm wide, shortly pleuropodal to laterally sessile, spathulate to flabelliform and reniform, faintly striate, white then pale yellowish drab or greyish bistre, drying white to greyish and radially sulcate and closely white villous towards the base; margin becoming lobed and undulate in large specimens. Stem -18 x 3-12mm, lateral varying rudimentary or subdiscoid, occasionally absent, white villous. Gills decurrent, distant, rather thick, wide interstices smooth, 11-25 primaries 4-6mm wide, 4-7 ranks, pale cream buff then dingy pallid ochraceous, finally pinkish rufous (pale grey to greyish brown, Boedijn). Flesh 1-2.5mm thick at the base of the pileus, 0.5-1mm halfway to the margin, firm, subcoriaceous, with a gelatinous layer 250-600 μm thick, watery concolorous. Smell farinaceous, rather slight, or none (*RSS 1044*).

On fallen or standing dead trunks and rotten wood in lowland primary and secondary forest. Malesia.

Spores 5-6 x 3-4 µm, white in the mass, smooth, aguttate, inamyloid. Basidia 18-25 x 4-5 µm; sterigmata 4, 4-5 µm long; subhymenium 20-30 µm thick, with compactly interwoven hyphae 2.5-8 µm wide, not gelatinous. Cheilocystidia unformed, as clusters of small sterile basidia, some with a slender process ending in an excreted globule -7 µm wide, scattered among emergent hyphae 1.5-3 µm wide, often fasciculate in flattened clusters, the gill-edge sterile. Pleurocystidia -140 x 12.5 µm with pale yellowish walls -5.5 µm thick, ventricose-lanceolate, acute, lumen becoming linear, not or thinly encrusted, the larger subhymenial or tramal and embedded or projecting -55 µm, the smaller 35-55 x 6-8 µm with thin to slightly thickened wall hymenial, smooth or little encrusted, with all intermediates, extremely abundant. Hyphae monomitic, clamped; in the firm tissue of the flesh 3-11 µm wide, with thin or slightly thickened walls, longitudinal; in the gelatinous layer 1.5-3 (-5) µm, ascending; in the gill-trama 4-22 µm wide, often unevenly inflated, with firm to slightly thickened walls, loosely interwoven and descending. Surface of pileus with a thin compact layer of longitudinal hyphae 3-8(-15) µm wide above the gelatinous layer and giving rise to a vague outer layer c. 20 µm thick of interwoven hyphae 1.5-3 µm wide, variously excrescent, septate, clamped, becoming aggregated or agglutinated into fascicles -300 µm long as the villous layer; pileocystidia absent.

Collections.- Malaya, Pahang, Tembeling, *Corner s.n.* Nov. 1930, common; Johore, Sedili River, *Corner s.n.* 22 Oct. 1939.- Krakatau, leg. Boedijn.- Solomon Islands, San Cristobal, Warahito river, 28 July 1965, *RSS 855*; Kolombangara, 24 Aug. 1965, *RSS 1044*.

This is my description of this striking and widespread species. It agrees with that of Boedijn except in the colour of the gills. The structure of the gill-edge without distinct cheilocystidia suggests nematode-catching. *H. incarnata* is allied and, perhaps, also the East African *H. aurantiocystis* Peglear (1977) though it has crowded narrow gills and pleurocystidia often with reddish incrustation at the apex.

### **Hohenbuehelia incarnata** sp. nov.

**Receptacula pallide incarnata-alutacea sessilia vel breviter pleuropadalia. Pileus -6 cm latus, spathulatus dein flabelliformis, substriatus, sicco tenuiter albidi-villosus vel subspiculosus. Lamellae subdistantes, 7-13 primariae -5 mm latae, ordinibus 4(-5), raro connexae. Caro -2 mm crassa, strato gelatinoso 100-150 µm crasso. Odor subaromaticus. Sporae 5-7 x 4.5-6 µm, laeves, subglobosae. Cheilocystidia 16-33 x 2-5 µm, subcylindrica vel submoniliformia. Pleurocystidia 45-90 x 7-12 µm, lanceolata attenuata, apicibus acutis vel aciculiforminus, tunicis, -3 µm crassis, apicem versus subincrustata, copiosa conferta. Hyphae in carne firma 2-8 µm latae. Superficies pilei sine cystidiis. Ad lignum putridissimum, mycelio albo lignum infestanti. Insulae Solomonenses, Guadalcanal, 3 Jul. 1965, *RSS 529*; typus, herb, Corner.**

Fruit-bodies wholly pale pinkish buff, sessile to shortly pleuropodal. Pileus -6 cm wide, spathulate to flabelliform, ascending then horizontal, flexuous, substriate, thinly white villous or spiculose on drying; margin incurved at first. Stem very short or none, white villous. Gills deeply decurrent, arising almost from the base of the fruit-body, subdistant, with smooth interstices, 7-13 primaries -5 mm wide, 4(-5) ranks, occasionally joined. Flesh -2 mm thick at the base of the fruit-body, rather firm, with a very thin gelatinous layer below the surface. Smell rather of fenugreek.

On very rotten wood, the spongy white mycelium incorporating the wood. Solomon Islands, Guadalcanal, Mt Gallego, frequent, *RSS 529* and *529a.*

Spores 5-7 x 4.5-6 μm, white, smooth, subglobose. Cheilocystidia 16-33 x 2-5 μm, subcylindric to submoniliform with slightly subcapitate apex. Pleurocystidia 45-90 x 7-12 μm, lanceolate with long tapered acute to almost acicular apex, wall -3 μm thick, thinly encrusted near the apex or smooth, very abundant and closely set. Hyphae monomitic, clamped; in the firm layer comprising most of the flesh 2-8 μm, thin-walled, longitudinal, compact; in the gelatinous layer 100-150 μm thick 1.5-3 μm wide; in the gill-trama as in the firm tissue of the pileus. Surface of pileus with more or less fasciculate cylindric hyphae 2-4 μm wide, septate, some with subclavate tips 3-5 μm wide, the fascicles -250 μm long, arising from a layer 20-70 μm thick of similar, more or less radiating, appressed hyphae; no pileocystidia.

This is close to *H. horrida* but with different colour and smell, thinner gelatinous layer and distinct cheilocystidia.

**Hohenbuehelia lanceifera** sp. nov. Figure 3

**Pileus -20 mm radio, sessilis lateralis spathulato-flabelliformis, rhizomorphis albis gracilibus affixus vel ad basim discoideum subvillosum 3-7 latum, albus dein pallide ochraceus, opacus, basim versus subvillosus. Lamellae confertae, 6-15 primariae -2.5 mm latae, ordinibus 4-5, albae dein pallide subochraceae, aetate brunneolae vel subincarnatae. Caro -1.5 mm crassa, fere ex integra aquosi-gelatinosa, subochracea. Inodora. Sporae 4-5.5 x 3.7-4.5 μm, laeves subglobosae vel late ellipsoideae. Cheilocystidia ut pleurocystidia parva vel ut basidia sterilia. Pleurocystidia 30-90 vel -140 x 7-20 μm ad lamellarum basi, lamellae sciem versus 20-30 x 5-7 μm, ventricoso-lanceolata, tunicis incrassatis, apicem versus incrustata, copiosa. Caro strato firmo 150-200 μm crasso, ex hyphis 3-7 μm latis instructo. Superficies pilei sine cystidiis. Ad ramos dejectos truncosque emortuos in silva montana. Borneo, Mt. Kinabalu, 1700m alt. *RSNB 2891*; typus, herb. Corner**

Pileus -20 mm radius, lateral, sessile, spathulate to flabelliform, attached with white mycelial fibrils or with a discoid subvillous base 3-7 mm wide, thinly villous towards the base, minutely cottony over the limb, white then dingy watery ochraceous; margin opaque, minutely fimbriate. Gills radiating from the base, crowded, thin, 6-15 primaries 2-2.5 mm wide, 4-5 ranks, white then pallid dingy ochraceous, finally brownish or pinkish. Flesh -1.5 mm thick at the base of the pileus, more or less wholly watery gelatinous, subochraceous. Smell none.

On fallen rotten branches and dead standing trunks in montane forest. Borneo, Mt Kinabalu 1700m alt.

Spores 4-5.5 x 3.7-4.5 μm, white, smooth, subglobose to broadly ellipsoid. Basidia 5-6 μm wide; aterigmata 4(-5), 3 μm long. Cheilocystidia small to fairly large, somewhat thick-walled as if immature pleurocystidia, with scattered sterile basidia, thinly enveloped in mucilage, as a sterile gill-edge. Pleurocystidia -140 x

Figure 3. *Hohebuehelia lanceifera.* Surface of pileus and (below) firm layer of flesh, and pleurocystidia, x 500.

20 µm at the base of the gills, 30-90 x 7-14 µm over the surface, 20-30 x 5-7 µm near the gill-edge, ventricose-lanceolate with long attenuate apex, thick-walled, encrusted distally with crystals and towards the apex with granules, base more or less tramal, abundant. Hyphae monomitic, clamped; in a firm layer 150-200 µm thick over the gills 3-7 µm wide, compact, longitudinal; in the thick gelatinous layer 1.5-3 µm wide, longitudinal and ascending; in the gill-trama 3-10 µm wide, descending, short-celled, not gelatinous; oleiferous hyphae 3-7(-10) µm wide, sparse in the tissue below the surface of the pileus. Surface of pileus with a layer 20-50 µm thick composed of longitudinal, compact, rather short-celled hyphae 3-7 µm wide with firm walls, giving off fascicles 200 x 20-60 µm of similar hyphae forming the villous layer.

Collections.- Borneo, Mt Kinabalu, Tenompok, 8 Sept. 1961, *RSNB 2891*; Mesilau, 22 April 1964, *RSNB 8408.*

This is near *H. concentrica* which has larger spores and fruit-bodies.

**Hohenbuehelia malesiana** sp. nov. Plate 1, Figure 4

**Pileus -3 cm radio, -4.5 cm latus, lateralis, sessilis vel substipitatus, spathulatus dein flabelliformis, ultimo lobatus, substriatus, sordide alutaceus vel albus, sicco albivillosus. Stipes vix evolutus. Lamellae confertae vel subdistantes, nonnullae furcatae, ceracei-gelatinosae, 5-11 primariae 0.5-2 mm latae, ordinibus 3-7, albidae vel concolores. Caro 0.3-1.5 mm crassa, fere ex integra gelatinosa. Inodora. Sporae 7-9 x 3.5-4 µm, laeves subcylindricae, aguttatae vel 1-2 guttulatae (vivae). Cheilocystidia 15-25 x 5-10 µm, clavata vel ventricosa, saepe capitulo 2-3.5 µm lato substipitato praedita. Pleurocystidia 30-100 x 7-25 µm, ventricoso-fusiformia, tunicis flavidulis crassis, apices versus tenuiter incrustata. Hyphae in strato firmo tenuissimo 3-8(-10) µm latae. Superficies pilei sine cystidiis. Ad lignum emortuum ramulosque in silva. Peninsula Malayana, Borneo, Insulae Solomonenses. Typus Singapore *Corner s.n.* 17 March 1940: herb. Corner.**

Pileus -3 cm in radius, -4.5 cm wide, sessile, lateral, spathulate then flabelliform, finally lobate, smooth, translucent, faintly striate, watery greyish to pallid dingy bistre, occasionally white, drying more or less wholly white villous and faintly sulcate-striate. Stem very slight, generally none. Gills decurrent, subdistant to

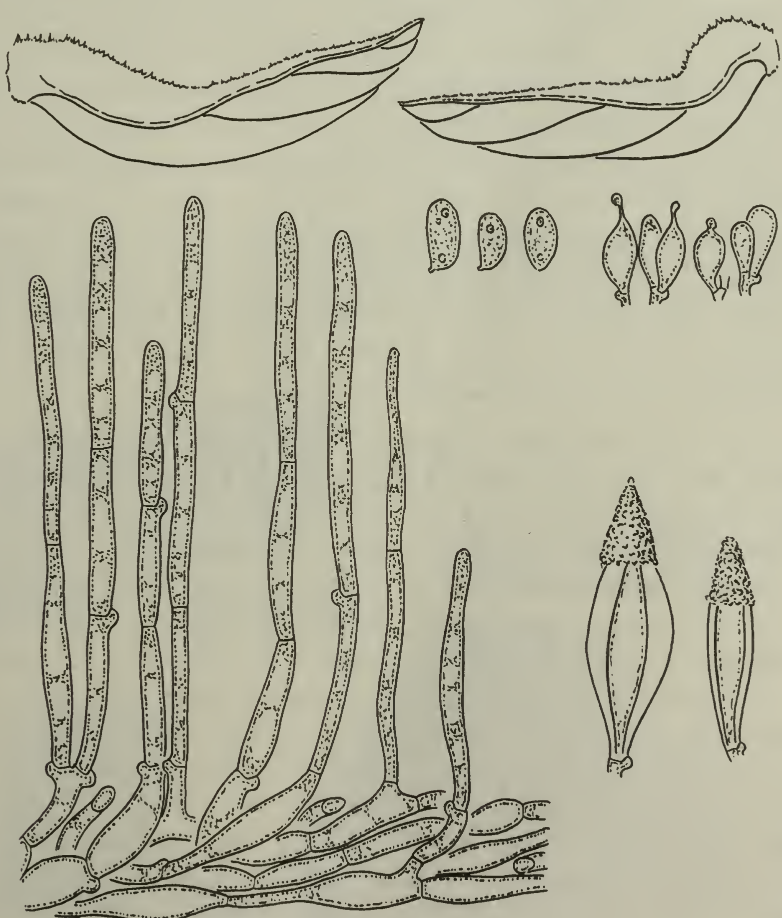


Figure 4. *Hohenbuehelia malesiana.* Fruit-body in section, x 10. Spores, x 1000. Cheilocystidia, pleurocystidia and surface of pileus, x 500.

crowded, sometimes dichotomous, 5-11 primaries 0.5-2 mm wide, 3-7 ranks, waxy gelatinous, watery white to pale concolorous. Flesh 0.3-1.5 mm thick at the base of the pileus, wholly and rather firmly gelatinous except a very thin layer over the gills. Smell none.

On sticks and dead wood in the forest. Malay Peninsula to the Solomon Islands.

Spores 7-9 x 3.5-4 µm, white, smooth, subcylindric, often slightly curved, aguttate or with 1-2 minute guttulae at the ends of the spore (living), inamyloid. Basidia 20-30 x 6-8 µm; sterigmata 4, 2.5 µm long. Cheilocystidia 15-25 x 5-10 µm, clavate or ventricose with a short apical stalk -2 µm long and a globose head 2-3.5 µm wide, thin-walled, hyaline, as a sterile gill-edge. Pleurocystidia 30-100 x 7-25 µm, ventricose fusiform, walls thick and yellowish, roughened and minutely encrusted over the distal third or smooth, acute to subacute. Hyphae monomitic, clamped, not or scarcely inflated; firm layer of the flesh thinner than the gelatinous layer, composed of hyphae 3-8(-10) µm wide, 2-3 µm in the gelatinous layer; gill-trama as the firm layer of the flesh. Surface of pileus with a thin interrupted layer of longitudinal hyphae 1.5-6(-10) µm wide, developing excrescent, short-celled, cylindric hyphae -300 µm long at the base of the pileus, -50 µm near the margin, 3-6 µm wide, with firm walls, mostly unbranched, not or rarely fasciculate; no thick-walled cystidia.

Collections.- Malaya, Perlis, Bukit Chupeng, *Corner s.n.* 29 Nov. 1929; Johore, Mawai, *Corner s.n.* 21 Sept. 1934.- Singapore, Botanic Garden, *Corner s.n.* March 1935; Bukit Timah, *Corner s.n.* 17 Sept. 1939, 17 March 1940.- Borneo, Mt Kinabalu, 1700m alt., *RSNB 5625* 3 March 1964.- Solomon Islands, Kolombangara, *RSS 1162*, 30 Aug. 1965.

This may be the commonest species in South East Asia. In 1934 and 1935 I managed to raise some fruit-bodies from the log on which I had found them in Johore. Many primordia started but merely three developed satisfactorily. Measurements were begun when the primordial pileus was 2 mm in radius. In 6 days the largest reached its full size of 22 mm in radius, 25 mm wide, and then lasted for 9 days before collapsing. During the first four days of observation, the pileus increased in radius by 2, 3, 5 and 6 mm when it slowly declined in the next 2 days. The smallest pileus reached 8 mm in radius, 9 mm wide, in 3 days from the same initial state and lasted for a further 7 days. The third fruit-body of intermediate size, reaching 15 mm in radius, 20 mm wide, developed in much the same manner as the first and reached full size in 7 days; it collapsed 8 days later. I reckoned the primordium of this third fruit-body was 48 hours old because it developed near the other two but 2 days later. Thus the total life of the largest fruit-body was about 16 days, of which the last 8-9 days were at full size. The fruit-bodies eventually collapsed because they became sodden with water and failed under their own weight.

**Hohenbuehelia mellea** sp. nov. Plate 1

**Pileus -15 mm latus, sessilis spathulatus dein semiorbicularis, melleiflavus vel ochraceibrunneus, squamulis flavidulis ornatus, striatus. Lamellae subdistantes, 6-8 primariae 1.5-2 mm latae, ordinibus 3-4, ceraceimolles, pallide ochraceae dein pallide cinnamomei-ochraceae. Caro 1-2 mm crassa, fere ex integra gelatinosa, concolor. Inodora. Sporae 5-6.5 x 2.5-3 µm, laeves ellipsoideae, paucis visis. Cheilocystidia 30-50 x 8-18 µm, ventricosa, processu simplici vel 1-ramoso etiam subcapitato, tenuiter tunicata. Pleurocystidia 50-160 x 11-20 µm, ventricoso-fusiformia, longe attenuate acuta, tunicis -5 µm crassis flavidis, incrustata. Stratum carnis firmum 100-150 µm crassum, ex hyphis 4-15 µm latis instructum; in lamellae trama 5-18 µm latae. Superficies pilei strato fere pseudoparenchymatico 15-20 µm crasso obtecta, haud villosa, hinc inde cystidiis ut cheilocystidiis. Ad lignum emortuum in silva. Singapore, Bukit Timah, *Corner s.n.* 24 Dec. 1940; typus, herb. Corner.**

Pileus -15 mm wide, sessile, broadly spathulate to semicircular, slightly convex becoming plane, honey yellow or ochraceous brownish, striate, with minute yellowish fleck-like scales, drying radially rugulose. Gills radiating from the base, subdistant, 6-8 primaries 1.5-2 mm wide, 3-4 ranks, waxy-soft, pale ochraceous then pale cinnamon ochraceous. Flesh 1-2 mm thick at the base, wholly gelatinous, waxy in the gills, concolorous. Smell none.

On dead wood in the forest. Singapore, Bukit Timah.

Spores 5-6.5 x 2.5-3 µm, white, smooth ellipsoid, (few seen). Cheilocystidia 30-50 x 8-18 µm, more or less ventricose with a simple or once branched, cylindric or subcapitate appendage 2-3.5 µm wide, some with an excretory blob, rather irregular, thin-walled, colourless, as a narrow sterile gill-edge. Pleurocystidia 50-160 x 12-20 µm, ventricose fusiform, long tapered, subacute to acute, the pale yellow walls 2-5 µm thick, heavily granular encrusted over the greater part, abundant. Hyphae monomitic, clamped; in the very thin firm layer of the flesh,


Plate 1. 1, *Hohenbuehelia mellea.* 2, *H. malesiana.*
3, *H. suppapillosa.*

100-150 µm thick, longitudinal 4-15 µm wide; in the gelatinous tissue composing most of the flesh, longitudinal and interwoven 3-5 µm wide; in the gill-trama 5-18 µm wide with firm yellowish walls. Surface of pileus with an almost pseudoparenchymatous layer 15-20 µm thick, composed of longitudinal hyphae with cells 20-45 x 4-16 µm, with scattered narrow hyphal ends shortly projecting and scattered cystidia like the cheilocystidia; no villous layer, no thick-walled cystidia, but at the base of the pileus numerous, shortly excrescent, slightly thick-walled hyphae -200 x 2-4.5 µm.

Superficially, this suggests *Crepidotus*. A sterile collection from Sarawak seems intermediate between this and *H. lanceifera*. It had the pale colour of *H. lanceifera* and the same structure to the pileus but the more distant gills and cheilocystidia of *H. mellea*. Thus:- Pileus -30 mm wide, drab white tinged pale ochraceous, thinly villous at the base. Gills distant, 7-9 primaries 2-3 mm wide, 4-5 ranks, pale ochraceous drab. Pleurocystidia -140 x 8-14 µm at the base of the gills, fusiform, long attenuate, thick-walled, heavily encrusted with granules between the swollen central part and the attenuate apex. Sarawak, Bako National Park, *Corner s.n.* 31 Jan. 1959.

**Hohenbuehelia minutissima** sp. nov.

**Pileus -3 mm latus subsessilis lateralis spathulatus griseus. Stipes -0.5 mm longus vel nullus. Lamellae confertae, 7-9 primariae -0.5 mm latae, ordinibus 3-4, albae. Caro tenuissima, tenaciter gelantinosa. Sporae 5-7 x 2.7-3.5 µm, laeves subcylindricae. Cheilocystidia ut basidia sterilia clavata subventricosa, saepe capitulata, vel ut pleurocystidia. Pleurocystidia 40-80 x 9-20 µm, ventricosa subacuta, tunicis flavidulis, apices versus tenuiter incrustata. Hyphae in strato firmo angusto et in lamellis 2-5 µm latae, tunicis 1-2 µm crassis, lumine lineari, subgelatinosae. Superficies pilei sine cystidia. Ad rami delapsi corticem in silva. Nova Guinea, prope Lae, *Corner s.n.* 7 Sept. 1960; typus, herb. Corner.**

Fruit-bodies very small, sessile or with a slight lateral stem. Pileus -3 mm in radius and wide, spathulate, smooth, grey. Stem -0.5 mm long, white, pruinose, or none. Gills crowded, narrow, acute, 7-9 primaries -0.5 mm wide, 3-4 ranks, white. Flesh very thin, toughly gelatinous.

On the bark of a fallen branch in forest. New Guinea, near Lae.

Spores 5-7 x 2.7-3.5 µm, white, smooth, subcylindric, thin-walled, aguttate. Basidia 5.5-6 µm wide, 4-spored. Cheilocystidia either as sterile basidia clavate to subventricose and then often shortly apiculate and capitate, or as thick-walled, thinly encrusted, obtuse to subacute cystidia, as a sterile gill-edge. Pleurocystidia 40-80 x 9-20 µm, ventricose, subacute, with thick yellowish walls, thinly encrusted distally with granular matter soluble in KOH. Hyphae monomitic, clamped, not inflated; in the narrow firm layer of the flesh over the gills and in the gills 2-5 µm wide with walls 1-2 µm thick and linear lumen, possibly subgelatinous; in the gelatinous tissue, forming most of the flesh, 1.5-4 µm wide, thin-walled. Surface of pileus with a layer, 1-2 hyphae thick, of longitudinal hyphae 1.5-3 µm wide, thin-walled; no villous layer, no cystidia.

This is distinguished by the very small size of the fruit-body and the thick-walled hyphae of the firm tissue.

## **Hohenbuehelia pachyhyphata** sp. nov. Figure 5

**Receptacula ex integro alba dein alutacea vel pallide fuscivinacea. Pileus 2-3 cm latus, breviter pleuropodalis, flabelliformis, ultimo revolutus, opacus, sicco villosulus. Stipes -3 x 4 mm, sursum dilatatus. Lamellae confertae, saepe furcatae vel prope stipitem reticulatae, 11-26 primariae 1-2 mm latae, ordinibus 4-7. Caro 2-4 mm crassa, strato gelatinoso 1 mm crasso. Odor farinaceus, fortis. Sporae 6-7.5 x 3-3.5 µm, laeves, subcylindricae. Cheilocystidia -20 x 7 µm, clavata vel ventricosa, saepe breviter capitulata, etiam ut pleurocystidia. Pleurocystidia 30-80 x 8-20 µm, ventricosa, breviter acuta, tunicis crassis, apicem versus tenuiter incrustata, copiosa. Hyphae in carnis strato firmo et in lamellis 3-10 µm latae, tunicis valde incrassatis, lumine quasi occluso, et ampullis -20 µm latis (-50 µm in stipite). Superficies pilei sine cystidiis crasse tunicatis. Ad lignum emortuum in silva. Borneo, Queensland. Typus, Borneo, *Corner s.n.* 22 Jun. 1961; herb. Corner**

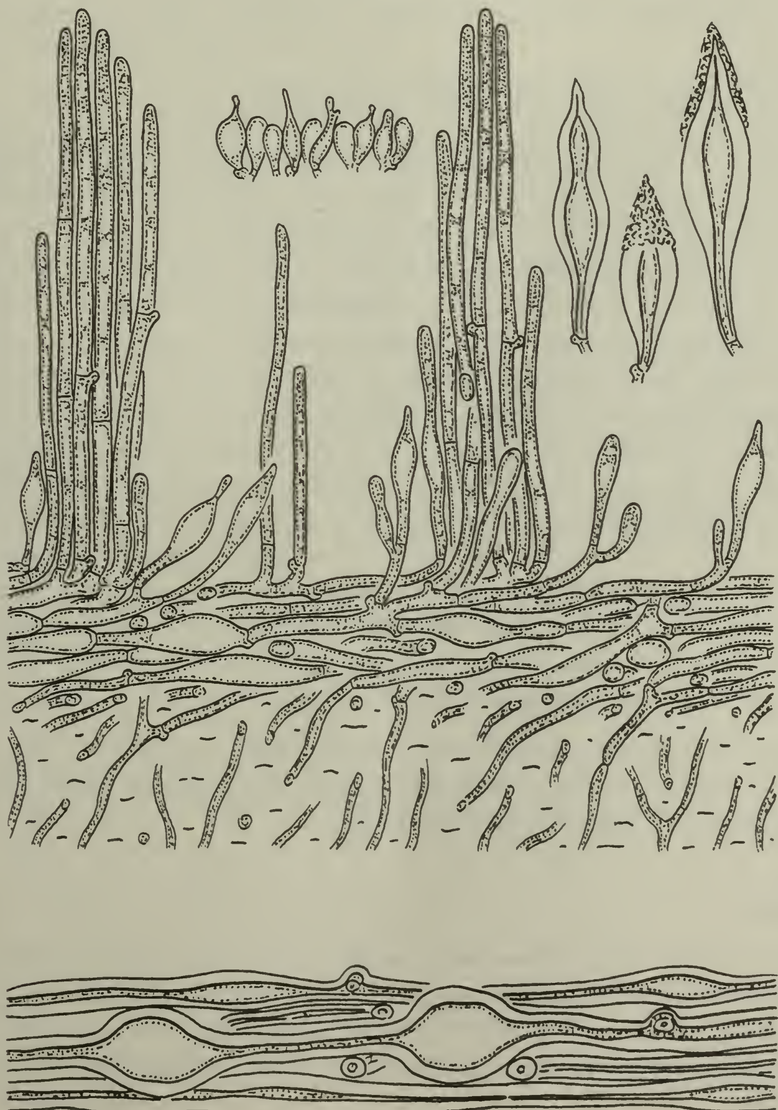


Figure 5. *Hohenbuehelia pachyhyphata.* Cheilocystidia, pleurocystidia, surface of pileus and hyphae of the firm layer of the flesh, x 500.

var. **minor** var. nov.

**Differt pileo -13 mm lato, albo dein griseo-umbrino, strato gelatinoso 0.5 mm crasso, sporis 4.5-5.5(-6) x 3.3-3.7 μm ellipsoideis, hyphis haud ampulliformibus. Ad truncum delapsum in silva. Borneo, Mt. Kinabalu, Mesilau 1700m alt., 26 Jan. 1964, *RSNB 5141*; herb. Corner.**

Fruit-bodies wholly white, then pale yellowish buff to pale livid bistre or pale fuscous vinaceous (*RSNB 8691*). Pileus 2-3 cm wide, lateral, convex then plane to revolute, flabelliform, opaque, drying minutely villous or cottony flocculose; margin incurved. Stem -3 x 4 mm, lateral, short, stout, widened upwards, pruinoso-villosulous. Gills decurrent, crowded, thin, often forked or reticulate near the stem, 11-26 primaries 1-2 mm wide, 4-7 ranks, edge entire. Flesh 2-4 mm thick at the base of the pileus, the gelatinous layer 1 mm thick. Smell farinaceous, strong on cutting.

On dead wood in the forest. Borneo, Queensland.

Spores 6-7.5 x 3-3.5 μm, white, smooth, subcylindric, inamyloid. Basidia 18-25 x 5 μm, 4-spored. Cheilocystidia -20 x 7 μm, clavate to subventricose, often with a short capitate process, thin-walled, also mixed with some thick-walled cystidia, as a sterile gill-edge. Pleurocystidia 30-80 x 8-20 μm, ventricose with rather short acute apex, thick-walled, arising deeply from the trama, immersed or shortly projecting, the free part with thin incrustation (soluble in KOH), very abundant. Hyphae monomitic, clamped; in the firm layer of the flesh 3-10 μm wide, becoming very thick-walled and nearly solid, but with ampulliform swellings -20 μm wide, -50 μm in the stem, longitudinal, compact; in the gelatinous layer 1.5-3.5 μm wide, walls thin or slightly thickened, ascending, also with a few thick-walled hyphae; in the gill-trama as in the firm layer of the flesh, descending. Surface of pileus with a layer 15-40 μm thick of rather closely interwoven hyphae 2-4 μm wide, in places -10 μm, with firm thin walls, producing fascicles -300 μm long of hyphae 2.5-5 μm wide with firm, often slightly thick-walled, often subagglutinated, 0-2 septate and clamped, with scattered ill-formed and thin-walled cystidia 4-8 μm wide like the cheilocystidia, but no thick-walled cystidia.

Collections.- Borneo, Mt Kinabalu, 1100-1700 alt., east ridge, *Corner s.n.* 22 June 1961; Mesilau, 6 May 1964, *RSNB 8691*.- Queensland, Mary Cairncross Reserve, Maleng, *Corner s.n.* 20 June 1964.

var. **minor**

Pileus -13 mm wide, pleuropodal, flabelliform, white then clouded greyish umber towards the minutely villous base. Stem very short. Gills very crowded, narrow, 13-17 primaries 1-1.5 mm wide, 5-6 ranks, white. Flesh 1-1.5 mm thick at the base, the gelatinous layer 0.5 mm thick and generally thinner than the firm layer. Smell ?

On a fallen trunk in the forest. Borneo, Mt Kinabalu, Mesilau 1700m alt., 26 Jan. 1964.

Spores 4.5-5.5(-6) x 3.3-3.7 µm, white, smooth, ellipsoid, aguttate. Cheilocystidia 12-23 x 5-9 µm, clavate to ventricose with a short capitate process. Pleurocystidia 30-90 x 7-20 µm, ventricose-conical, acute, sometimes curved or waisted, with thick yellowish walls thinly encrusted distally. Hyphae of the firm layer of the flesh 2-8 µm wide, cylindric, clamped, with walls 1-3 µm thick, without ampulliform swellings. Surface of pileus as in var. *pachyhyphata* but the excrescent hyphae often fasciculate.

The pale colour, farinaceous smell and very thick-walled hyphae of the firm tissue distinguish this species.

**Hohenbuehelia pahangensis** sp. nov. Figure 6

**Pileus -4 cm radio, -7 cm latus, sessilis vel breviter pleuropodalis, ascendens, spathulatus flabelliformis opacus villosulus, fuscus dein pallide isabellinus. Stipes -5 x 2.5-4 mm, villosulus albidus. Lamellae alte decurrentes, confertissimae, 12-16 primariae 2 mm latae, ordinibus 6-7, albae, acie serrulata. Caro 2-2.5 mm crassa, strato gelatinoso c. 300 µm crasso. Odor farinaceus fortis. Sporae 3.5-4.3 x 3-3.5 µm, laeves, late ellipsoideae. Cheilocystidia 35-60 x 5-7 µm, clavata vel obtuse subventricosa. Pleurocystidia 55-120 x 10.5-22 µm, ventricosa, breviter acuminata, tunicis flavidulis 2-7 µm crassis, laevia vel apicem versus tenuiter incrustata. Hyphae in carnis strato firmo lamellisque 4-23 µm latae. Superficies pilei cystidiis 40-90 x 6-8 µm ut pleurocystidia praedita, etiam minoribus ut cheilocystidia. Ad terram muscosam in silva montana. Malaya, Pahang, Cameron Highland, *Corner s.n.* 1 Aug. 1934; typus, herb. Corner.**

Pileus -4 cm in radius, -7 cm wide, sessile or very shortly pleuropodal, steeply ascending, spathulate-flabelliform, opaque, minutely villous from the base outwards, fuscous, paler drab bistre with age. Stem -5 x 2.5-4 mm, thinly villous, pallid white. Gills deeply decurrent, almost from the base of the fruit-body, very crowded, 12-16 primaries 2 mm wide, 6-7 ranks, shining white, edge serrulate. Flesh 2-2.5 mm thick at the base of the pileus, the gelatinous layer c. 300 µm thick. Smell farinaceous, strong.

On the ground among moss in montane forest, solitary, Malaya, Pahang, Cameron Highlands, 1 Aug. 1934.

Spores 3.5-4.3 x 3-3.5 µm, white, smooth, broadly ellipsoid, inamyloid. Basidia 14-19 x 4-4.5 µm; sterigmata 4, 3 µm long. Cheilocystidia 35-60 x 5-7 µm, clavate or obtusely subventricose, thin-walled, smooth, as a broad sterile gill-edge. Pleurocystidia 55-120 x 10.5-22 µm, ventricose, shortly acuminate, walls 2-7 µm thick yellowish, smooth or thinly encrusted distally, smaller towards the gill-edge. Hyphae monomitic, clamped; in the firm layer of the flesh longitudinal with cells 40-120 x 4-23 µm, often rather constricted at the septa, thin-walled, in the gelatinous layer 2-4 µm wide and ascending; in the gill-trama as in the firm layer of the flesh, descending. Surface of pileus with a discontinuous pellicle, 1-2 hyphae thick, of 1.5-3 µm hyphae developing fascicles of the hyphae as the villous layer; pileocystidia either as thick-walled pleurocystidia 40-90 x 6-8 µm or as the cheilocystidia.

This is close to the American *H. angustata* (p. 39) and differs in the larger pileus, wider gills, thicker gelatinous layer in the pileus, the form of the cheilocystidia, the strongly inflated hyphae in the firm layer of the flesh, the descending hyphae in the gill-trama, and the smaller spores. The terricolous habit, the fairly large fruit-body and the shining white gills are distinctive among the Malesian species.

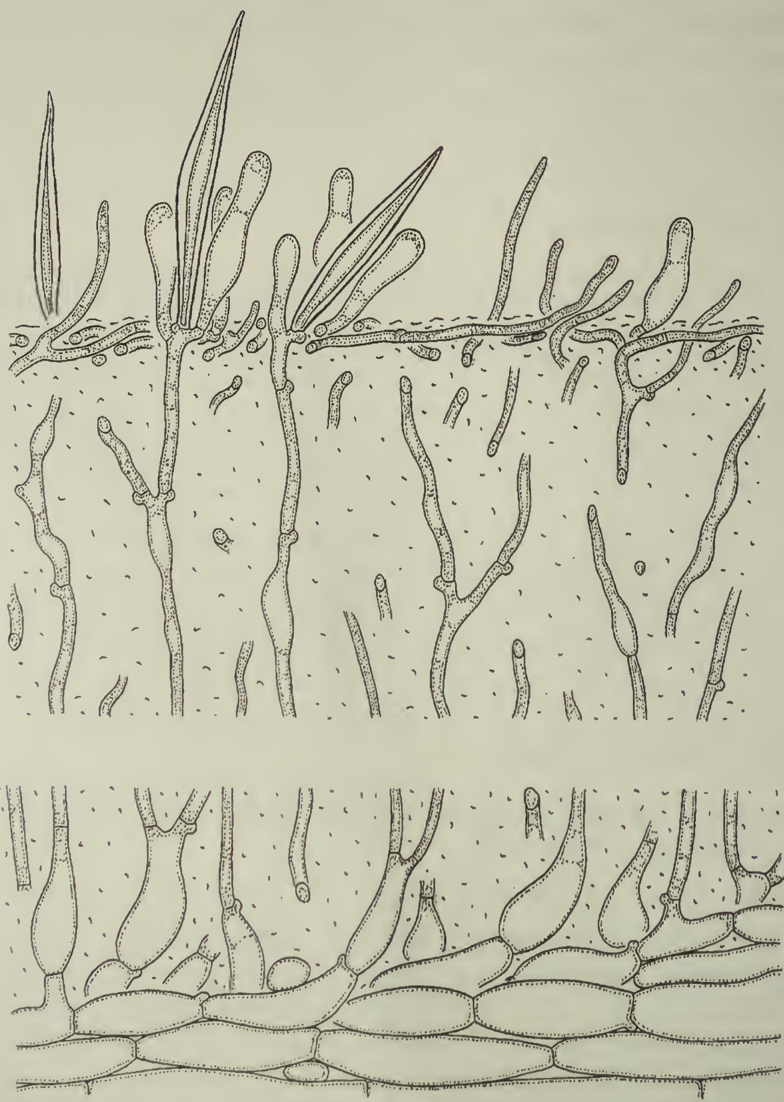


Figure 6. *Hohenbuehelia pahangensis.* Surface of pileus and (below) firm layer of flesh, x 500.

## **Hohenbuehelia perstriata** sp. nov.

**Pileu -22 mm radio, spathulatus dein subreniformis, lateralis subsessilis, ex integro striatus, pallide griseicervinus, sicco villosulus. Lamellae distantes, 4-9 primariae 2-3.5 mm latae, ordinibus 3-4, albae. Caro tenuis, strato firmo 100-400 µm crasso, strato gelatinoso 60-200 µm crasso. Odor farinaceus vel**

**nullus. Sporae 4.5-6 x 3.5-4.5 μm, laeves, late ellipsoideae vel subglobosae. Basidia 2-3-4 sporigera. Cheilocystidia 10-24 x 4-8(-10) μm, clavata vel ventricosa, nonnulla capitulo breviter stipitato praedita. Pleurocystidia (30-)50-140 x 9-17 μm, fusiformia acuta, tunicis -6 μm crassis, apices versus haud vel vix incrustata. Hyphae in carnis strato firmo 3-8 μm latae Pileocystidia -85 x 4-7 μm ut pleurocystidia sed angustiora, immersa vel superficialia erecta vel in tomenti fasciculis; superficies pilei basim versus cellulae clavatae -26 x 10 μm. Ad dejectamenta Aracearum Palmarumque. Insulae Solomonenses. Typus, Kolombangara, *RSS 1275;* herb. Corner.**

Pileus -22 mm radius, spathulate to subreniform, slightly ascending or descending (*RSS 1104*), lateral, subsessile, wholly striate, pale fawn greyish, drying finely villous-scurfy towards the base. Gills decurrent, distant, 4-9 primaries 2-3.5 mm wide, 3-4 ranks, interstices smooth, white. Flesh with a thin upper gelatinous layer. Smell none or of meal (*RSS 1104*).

On dead remains of aroids and palms (*Caryota*) in the forest. Solomon Islands.

Spores 4.5-6 x 3.5-4.5 μm, white, smooth, ellipsoid to subglobose. Basidia with 2-3-4 sterigmata (*RSS 1104*). Cheilocystidia 10-24 x 4-8(-10) μm, clavate or subventricose, some with a shortly stipitate subcapitate swelling. Pleurocystidia (30-)50-140 x 90-17 μm, fusiform, acute, wall -6 μm thick, smooth or slightly encrusted distally. Hyphae monomitic, clamped; firm layer of the flesh 100-400 μm thick, with thin-walled longitudinal hyphae, the cells -130 x 3-8 μm; gelatinous layer 60-200 μm thick hyphae ascending; gill-trama with hyphae as in the firm layer of the flesh. Surface of pileus with a thin interrupted layer of narrow, short-celled hyphae 2-5 μm wide with thin or slightly thickened walls, developing cylindric, septate, projecting hyphae -160 μm long and becoming more or less fasciculate; pileocystidia -85 x 4-7 μm, as the pleurocystidia, immersed or free and appressed or erect, becoming incorporated in the excrescent fascicles, also with a few thin-walled clavate cells -26 x 10 μm near the base of the pileus.

Collections.- Solomon Islands, Kolombangara, *RSS 1104* on dead sheaths and trunk of *Caryota*, 27 Aug. 1965; *RSS 1275* on a dead aroid stem, 5 Sept. 1965.

The two collections differ slightly but are evidently conspecific.

**Hohenbuehelia quadruplex** sp. nov. Figure 7

**Pileus -30 mm latus, pleuropodalis, spathulatus dein flabelliformis, laevis fuscicervinus, marginem denticulatum versus substiatus pallidus. Stipes 3-10 x 2-4 mm, applanatus, concolor. Lamellae decurrentes confertae hispidulosae, 15-26 primariae -1 mm latae, ordinibus 4-6, albae. Caro 1-2 mm crassa, strato gelatinoso -250 μm crasso, concolor. Odor farinaceus, haud fortis. Sporae 4.5-6 x 3.3-4 μm, laeves ellipsoideae. Cheilocystidia 12-24 x 5-14 μm, clavata, nonnulla processu -7 μm longo, saepe subcapitato, praedita. Pleurocystidia 40-90 x 11-20 μm, ventricosa acuta, tunicis flavidulis -6 μm crassis, apicibus saepe granuloso-incrustata, haud conferta. Hyphae in carnis strato firmo 3-14 μm latae. Stratum gelatinosum duplex, superius 50-60 μm crassum, inferius -250 μm, strato quasi firmo 20-30 μm crasso separatum. Superficies stipitis cystidiis crassitunicatis ut pleurocystidia in strato villoso immersis. Superficies pilei sine cystidiis. Ad lignum putridum in silva. Insulae Solomonenses, San Cristobal, fl. Warahito, 1 Aug. 1965, *RSS 905;* typus, herb. Corner.**

Pileus -3 cm wide, pleuropodal, spathulate-flabelliform, smooth, fuscous fawn, paler to the whitish substriate, incurved, minutely denticulate margin. Stem 3-10 x 2-4 mm, more or less flattened in the plane of the pileus, concolorous. Gills decurrent, crowded, narrow, 15-26 primaries -1 mm wide, 4-5 ranks, hispidulous, white. Flesh 1-2 mm thick at the base of the pileus, hygrophanous, concolorous, with a thin gelatinous layer. Smell slight, farinaceous.

On rotten wood in the forest. Solomon Islands, San Cristobal.

Figure 7. *Hohenbuehelia quadruplex.* Fruit-body in section, 2. Diagram of the junction of stem and upper side of pileus, to show the origin of the tissues in the pileus, x 50. Lower figure (from left to right), lower surface of stem near its junction with the pileus, hymenium, and surface of pileus, x 500.

Spores 4.5-6 x 3.3-4 μm, white, smooth, ellipsoid. Basidia 17-20 x 5 μm, 4-spored. Cheilocystidia 12-24 x 5-14 μm, clavate, some with a short, often subcapitate, process -7 µm long, thin-walled, as a sterile gill-edge. Pleurocystidia c. 40-90 x 11-20 µm, ventricose, acute, apex often granular encrusted, walls yellowish -6 µm thick, not crowded. Hyphae monomitic, clamped; in the firm layer of the flesh with cells -200 x 3-12 µm, in the stem with thin or slightly thickened walls and the cells often unevenly inflated; in the gill-trama with thin-walled hyphae 3-8 µm wide, not mucilaginous; gelatinous layer of the pileus double, consisting of an inner layer -250 µm thick with ascending hyphae 3-5(-7) µm wide, and a thinner upper layer 50-60 µm thick of ascending hyphae 1-2 µm wide, some of the hyphal ends projecting -60 µm, the two layers separated by a thin subgelatinous layer 20-30 µm thick of longitudinal hyphae 2-5 µm wide, all layers devoid of thick-walled cystidia. Surface of stem covered by a thin villous layer of 2-4 µm hyphae -130 µm long, 0-2 septate with clamps, often flexuous, with many erect thick-walled cystidia 40-65 x 9-14 µm embedded in the layer. Surface of the pileus with the upper gelatinous layer pierced here and there by the shortly excrescent hyphal tips -60 µm long; no thick-walled cystidia.

This species is distinguished by the double gelatinous layer of the pileus, which needs microscopic examination to ascertain, and by the thick-walled caulocystidia which do not seem to encroach on the surface of the pileus.

**Hohenbuehelia singaporensis** sp. nov.

**Receptacula ex integro fuligineigrisea dein fuligineifusca. Pileus -25 mm latus, sessilis cyphelliformis dein orbicularis vel unilateraliter flabelliformis, striatus, sicco albidivillosulus. Lamellae subconfertae, 9-12 primarie -1.5 mm latae, ordinibus 5-7. Caro 0.5-2 mm crassa, ex integra gelatinosa. Sporae 6-7 x 4-4.5 µm, laeves, late ellipsoideae. Cheilocystidia 18-26 x 8-15 µm, clavata, tenuiter tunicata, laevia. Pleurocystidia 45-85 x 12-25 µm, ventricosa acuta, tunicis -5 µm crassis brunneis, plerumque immersa, apicibus liberis incrustatis, etiam hymenialia breviora tunicisque tenuioribus. Hyphae 3-5 µm latae, hinc inde 12 µm. Superficies pilei plus minus hymeniidermis, cellulis clavatis -30 x 18 µm ut cheilocystidia, sine cystidiis crasse tunicatis. Ad lignum in silva. Singapore, Bukit Timah, *Corner s.n.* 18 April. 1940; typus, herb. Corner.**

Fruit-bodies wholly dark fuliginous grey, becoming fuliginous fuscous. Pileus -25 mm wide, sessile, at first cyphelliform, becoming subcircular and plano-resupinate or laterally flabelliform, striate, drying finely whitish villous. Gills radiating from the origin of the pileus, rather crowded, 9-12 primaries 1-1.5 mm wide, 5-7 ranks. Flesh 0.5-2 mm thick at the base, wholly gelatinous.

On a dead log in the forest. Singapore, Bukit Timah.

Spores 6-7 x 4-4.5 µm, white, smooth, ellipsoid, aguttate. Basidia 18-23 x 5-6 µm; sterigmata 4, 4 µm long. Cheilocystidia 18-26 x 8-15 µm, clavate, smooth, thin-walled, with opalescent contents, as a narrow sterile gill-edge. Pleurocystidia 45-85 x 12-25 µm, ventricose, acute, wall-5 µm thick and brownish, mostly immersed, some hymenia 38-50 x 11-18 µm with thinner walls, the emergent tip thinly encrusted. Hyphae monomitic, clamped, 3-5 µm wide, walls rather toughly gelatinous, longitudinal but shortly ascending near the surface of the pileus, some cells inflated -12 µm wide, not forming a dry layer over the gills; in the gill-trama similar. Surface of pileus more or less hymenioderm as a fairly compact palisade of clavate cells -30 x 18 μm, similar to the cheilocystidia, seated on a thin layer of compact, short-celled, longitudinal hyphae 3-5 μm wide; no thick-walled cystidia.

This fungus is very like *H. bullulifera* of South America (p. 40) in the clavate cheilocystidia and the hymenioderm on the pileus, but it had no thick-walled cystidia on the pileus. It is also like the American *H. nigra* (Schw.) Singer for which an initial cyphelliform habit is figured by Waldo (1984), but *H. nigra* has differently shaped cheilocystidia and lacks the hymenioderm (Singer and Digilio, 1952, Singer, 1969, Pegler, 1983). I describe the Singapore fungus as a different species in the hope that further collections will establish its identity.

**Hohenbuehelia subdiscipes** sp. nov.

**Pileus -14 mm latus, reniformis flabelliformis, ad basim subdiscoideum sessilis, pallide cervinibrunneus vel cervinisubochraceus, tenuiter subtomentosus. Lamellae confertae, primariae 5-7, -1 mm latae, ordinibus 5-6, pallide cervinae. Caro 1-1.5 mm crassa, fere ex integra gelatinosa. Odor farinaceus fortis. Sporae 4.5-6 x 3.3-4.3 μm, laeves late ellipsoideae. Cheilocystidia 10-18 x 5-8 μm, clavata, nonnulla subconica. Pleurocystidia 35-70 x 8-18 μm, ventricosa lanceolata acuta, tunicis -4 μm, crassis, apices versus incrustata. Hyphae in carnis strato firmo 60-100 μm crasso 3-7(-9) μm latae, tenuiter tunicatae. Superficies pilei cystidiis 25-55 x 4-12 μm ut pleurocystidiis, copiosis, haud immersis, praedita. Ad lignum delapsum in silva. Insulae Solomonenses, Ysabel, Tetamba, 28 Sept, 1965, *RSS 1466*; typus, herb. Corner.**

Pileus -14 mm wide, sessile to a short subdiscoid base, reniform flabelliform, convex then plane, pale fawn brown or fawn subochraceous, drying thinly white subtomentose. Gills crowded, narrow, 5-7 primaries -1 mm wide, 5-6 ranks, pale fawn. Flesh 1-1.5 mm thick at the base of the pileus, almost wholly gelatinous. Smell farinaceous, strong.

On a dead log in the forest. Solomon Islands, Ysabel, Tetamba.

Spores 4.5-6 x 3.3-4.3 μm, white, smooth, ellipsoid. Cheilocystidia 10-18 x 5-8 μm, mostly clavate, some subconic, not appendaged, thin-walled, smooth. Pleurocystidia 35-70 x 8-18 μm, ventricose-lanceolate acute, wall -4 μm thick, granular encrusted at least distally, the incrustation insoluble in KOH, copious. Hyphae monomitic, clamped; firm layer of flesh 60-100 μm thick, with thin-walled longitudinal hyphae 3-7(-9) μm wide; gelatinous layer much thicker; in the gill-trama as in the firm layer but more or less descending, yet at the gill-edge parallel with the edge. Surface of pileus with a thin layer 2-3 hyphae thick composed of narrow, more or less longitudinal hyphae with cells 20-60 x 2-7 μm, walls thin or slightly thickened, some thinly encrusted, with divergent ends -250 μm long near the base of the pileus; pileocystidia 25-55 x 4-12 μm as the pleurocystidia, encrusted, copious in the superficial layer, not immersed.

This could be regarded as a small or young state of *H. testudo* but I prefer to distinguish it at this stage of exploration on account of the fuller colour, the firm layer of the flesh thicker than the gelatinous layer, and the shorter wider spores.

**Hohenbuehelia suppapillosa** sp. nov. Plate 1, Figure 8-10

**Pileus -5 cm radio, -8 cm latus, pleuropodalis flabelliformis, albus dein pallide fuscibrunneus, marginem substriatum versus subochraceus, sicco basim versus albivilloslus et papillis gelatinosis -0.5 mm altis sparsim ornatus. Stipes 1-7 mm longus latusque, villosulus concolor. Lamellae confertae, 9-17 primariae -4 mm latae, ordinibus 4-6, albae. Caro 1.5-4 mm crassa, strato gelatinoso c. 1 mm crasso. Indodora. Sporae 6-7 x 4-5 μm, laeves ellipsoideae. Cheilocystidia (10-)15-30 x 6-10 μm, ventricosa, processu filiformi -20 x 1.5-2 μm saepe subcapitato. Pleurocystidia (23-)55-100 x 12-22 μm, ad lamellarum basim -130 μm, ventricosa acuta, tunicis flavidis vel brunneolis 1.5-6 μm crassis, copiosa. Hyphae in carnis strato firmo 3-16 μm latae. Superficies pilei sine cystidiis. Ad lignum emortuum in silva. Malaya, Sarawak, Typus, Malaya, Pahang, Fraser's Hill, 1300m alt., *Corner s.n.* 24 Sept. 1940.**

Pileus -5 cm in radius, -8 cm wide, slightly ascending, pleuropodal, flabelliform, hygrophanous, white then pale fuscous brownish, subochraceous towards the whitish substriate margin, smooth or slightly papillose when moist, drying thinly white villous especially near the base with scattered gelatinous papillae -0.5 mm high. Stem 1-7 mm long and wide, short, thick, pale fuscous ochraceous, drying wholly finely white villous. Gills decurrent, crowded, 9-17 primaries -4 mm wide, 4-6 ranks, white. Flesh 1.5-4 mm thick at the base of the pileus, the gelatinous layer c. 1 mm thick, concolorous drying whitish. Smell none.

On dead logs in the forest and on dead stilt-roots. Malaya, Pahang, Fraser's Hill; Sarawak, Bako National Park.

Spores 6-7 x 4-5 μm, white, smooth, ellipsoid to pip-shaped, aguttate. Basidia 18-23 x 5-5.5 μm; sterigmata 4, 2.5-3 μm long. Cheilocystidia (10-)15-30 x 6-10

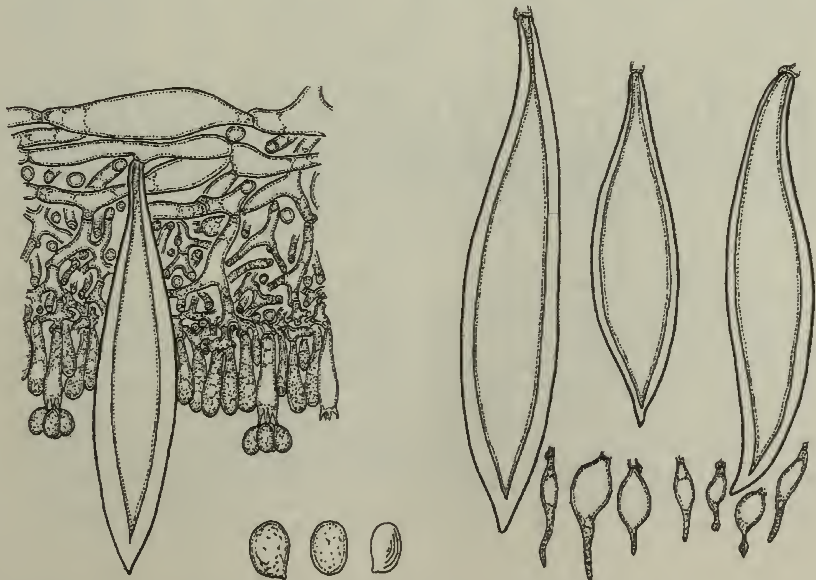


Figure 8. *Hohenbuehelia suppapillosa.* Spores, x 1000. Hymenium, pleurocystidia and cheilocystidia, x 500.

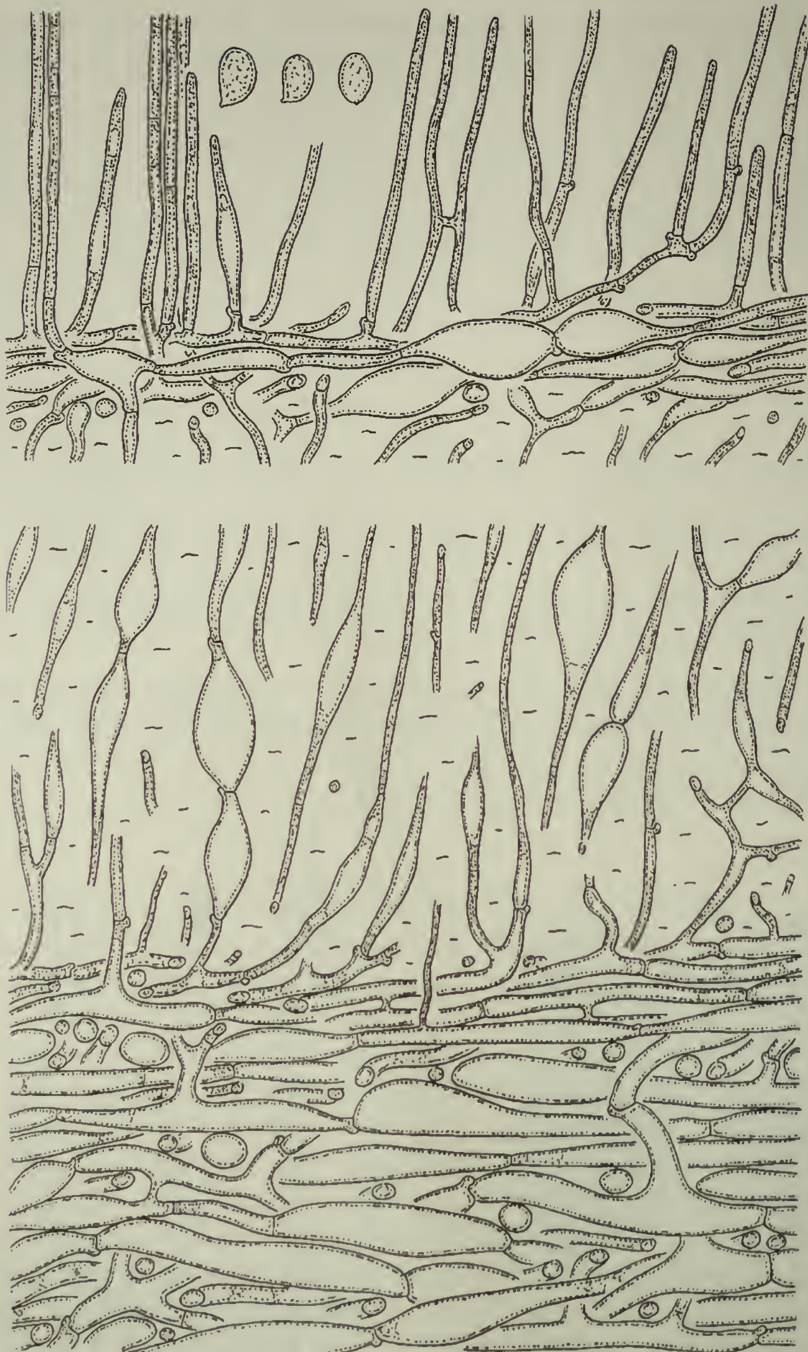


Figure 9. *Hohenbuehelia suppapillosa.* Upper part of young pileus in section, x 500. Spores, x 1000.

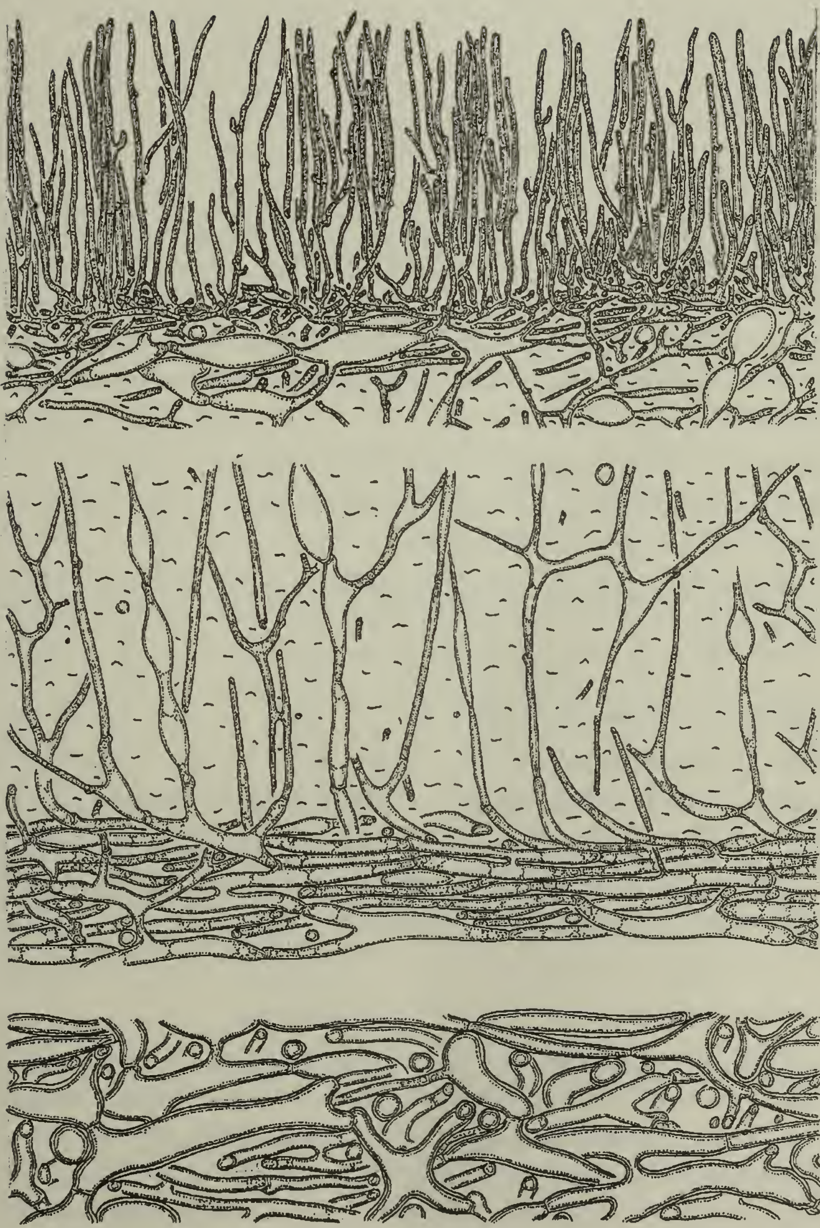


Figure 10. *Hohenbuehelia suppapillosa.* Basal part of mature pileus in section, x 250.

µm, more or less ventricose with a short or long filiform, flexous or subcapitate appendage -20 x 1.5-2 µm, thin-walled, as a narrow sterile gill-edge. Pleurocrystidia (23-)55-100 x 12-22 µm, -130 µm at the base of the gills, ventricose, acute, with very thick yellowish to brownish walls -6 µm thick, arising deeply in the trama and projecting -50 µm, sometimes slightly curved at the apex, smooth, abundant. Hyphae monomitic, clamped; in the firm layer of the flesh 3-16 µm wide, often branched at a wide angle, longitudinal and interwoven with numerous H-connections, compact near the gelatinous layer, thin-walled; in the gelatinous layer mostly 2-5 µm wide, some with a few cells 10-20 µm wide, mostly ascending; in the gill-trama as in the firm tissue of the pileus, descending and interwoven, not gelatinous, the subhymenium rather thick with hyphae 2-4 µm wide but not corticate. Surface of pileus with a narrow, fairly compact, layer of longitudinal and interwoven hyphae 3-5 µm wide but some cells 8-20 µm wide, giving rise to narrow excrescent hyphae in fascicles -250 µm high as the villous layer; no thick-walled cystidia.

Collections.- Malaya, Pahang, Fraser's Hill 1300m alt., *Corner s.n.* 24 Sept. 1940.- Sarawak, Bako National Park, on dead stilt-root, 27 Aug. 1972, *Corner P-178* (immature).

This has the tendency to inflate the hyphae in the pellicle of the pileus as in *H. mellea*.

**Hohenbuehelia testudo** (Berk.) Pegler

**Agaric Flora of Sri Lanka (1986) 173.**

***Acanthocystis testudo*** **(Berk.) Boedijn, Bull. Jard. bot. Buitenz. ser. 3, 16 (1940) 402, f. 10.**

Pileus 1-3(-6) cm wide, sessile or shortly pleuropodal, spathulate to flabelliform, nearly white becoming dirty brown, paler to the whitish margin, finely villous especially towards the base. Gills subdistant, 1-2 mm wide, 3-4 ranks, white. Flesh c. 2 mm thick, the gelatinous layer 130-390 µm thick. Smell farinaceous.

On dead wood. Ceylon, Malaya, Borneo, Krakatau.

Spores 5-6.5 x 3-3.5 µm (6-7 x 2.5-3.5 µm, Petch; 9-12.5 x 3.7-4.5 µm, Pegler). Basidia 20-24 x 5-6 µm, 4-spored (20-25 x 5-6 µm, Pegler). Cheilocystidia 15-25 x 4-7 µm, narrowly ventricose, often shortly attenuate with or without a subcapitate apex 1-2 µm wide, thin-walled (Pegler). Pleurocystidia 44-78 x 12-18 µm, ventricose, acute, with thick yellowish walls, shorter towards the gill-edge, the protruding part encrusted (Boedijn); 40-70 x 10-15 µm, fusoid ventricose, wall -7 µm thick and deep yellowish brown (Pegler); 40-70 x 3-8 µm, fusiform, more or less encrusted, (Corner). Hyphae of the firm layer of the flesh 4-8 µm wide, in the gelatinous layer 1-4 µm wide, vertically arranged; in the gill-trama as in the firm layer of the pileus. Villous hairs of the pileus as fascicles -200 x 100 µm of encrusted hyphae 3-5 µm wide, most of the hyphae ending in encrusted ventricose-lanceolate pileocystidia 70-80 x 6-12 µm; (pileipellis a disrupted repent epicutis of non-gelatinised hyphae 2-4 µm wide, sometimes forming short erect fascicles, Pegler).

This description is taken mainly from that of Boedijn, with additions from that of Pegler and observations of mine from a collection which I made at Kandy, Ceylon. The most remarkable difference is the large size of the spores given by Pegler who found them on the type-material. It is not clear that they were seen attached and there is always the possibility that they were a deposit from another fungus during collection. In recording the species from Malaya and Borneo, Pegler does not mention the spores of these collections. He gives the basidia as the same size as found by Boedijn, which seems unlikely with spores nearly twice as big as Boedijn and I found.

A collection which I made in Brunei (Ulu Belalong 15 Feb. 1959), with pilei - 5 cm wide, differed macroscopically in the crowded white gills (1.5-2 mm wide in c. 5 ranks). It had, also, the strong farinaceous smell which I noted in the specimen from Kandy. There were also slight microscopic differences, thus:-

Spores 5-6 x 3.3-3.7 µm. Basidia 20-24 x 6 µm, 4-spored. Cheilocystidia small, clavate to ventricose-capitate. Pleurocystidia 45-90 x 14-20 µm, not or slightly encrusted. Hyphae of the firm layer of the flesh -10 µm wide, short-celled, longitudinal in a narrow compact layer below the gelatinous layer, the rest of the firm layer composed of laxly interwoven and longitudinal hyphae, with walls -1 µm thick in the layer just over the gills; in the gill-trama 3-7 µm wide, with submucilaginous walls -0.5 µm thick. Surface of the pileus consisting of a thin superficial layer 8-15 µm thick, composed of longitudinal hyphae 2-3.5 µm wide with scattered processes 2.5-4 µm wide as if sterile basidia; fascicles of excrescent hyphae -200 x 70-100 µm, with narrow lanceolate, thick-walled, more or less encrusted pileocystidia -80 x 5-7 µm towards the tips of the fascicles, with rather thin-walled cystidia like the cheilocystidia sparsely set on the sides of the fascicles.

var. **glabra** var. nov.

**Differt pileo glabro, raro ad basim subvillosus; lamellis confertis, ordinibus 3-6, albis dein pallide ochraceis vel pallide cervino-ochraceis. Typus, Borneo, *RSNB 3011*; herb. Corner.**

Pileus 1-4 cm in radius, 1-6 cm wide, sessile or attenuate to a short lateral stem, spathulate to flabelliform, at first descending then horizontal and finally more or less ascending, undulate, smooth, subviscid, generally glabrous, sometimes thinly subvillous or spiculose-villous at the base, white then pallid ochraceous to pale fawn ochraceous, varying pale umber, greyish or fuscous bistre, opaque or striate towards the margin. Stem -10 x 1.5-5 mm, lateral, minutely villous. Gills decurrent, crowded, narrow, not dichotomous, 12-40 primaries (5-9 in small fruit-bodies) 1-3 mm wide, 3-6 ranks, white then pale cream ochraceous to concolorous with the pileus, edge entire. Flesh 0.5-3 mm thick at the base of the pileus, with a very thin gelatinous layer at the surface.

Smell farinaceous, slight or strong, or none (*P-165, RSS 1671*), or slightly fragrant (New Guinea 1 Oct. 1960).

On rotten wood, fallen trunks, and on the ground under rotten wood. Malaya, Borneo, New Guinea, Solomon Islands.

Spores 5-6.5 x 3.5-4.5 µm, white, smooth, ellipsoid to lacrymiform, aguttate but drying 1-2 guttulate, inamyloid. Basidia 20-25 x 5-7 µm or 18-22 x 5-7 µm; sterigmata 4; subhymenium 12-20 µm thick, composed of 2-3 µm interwoven hyphae. Cheilocystidia -25 x 4-8 µm, clavate or subventricose or subcylindric, often with a short process with or without a subglobose head 1.5-2.5 µm wide. Pleurocystidia 30-90 x 7-20 µm in some collections -120 x 25 µm, ventricose with acute apex, wall -6 µm thick, thinly encrusted or smooth, abundant. Hyphae monomitic, clamped; in the firm layer of the flesh with cells 20-150 x 3-14 µm with wall thin or 0.5-1 µm thick near the base of the pileus, longitudinal and interwoven; gelatinous layer 100-250 µm thick, with ascending hyphae 2-4(-6) µm wide; in the gill-trama 3-8 µm wide, thin-walled, descending; in the stem with cells 30-150 x 3-20 µm, often with ampulliform swellings at one end of the cell, walls 0.5-1 µm thick. Surface of stem with a sterile hymenium, becoming finely villous with 2-3 µm hyphae. Surface of pileus with a rather compact but thin layer, 20-30 µm thick, of appressed radiating hyphae 3-6(-8) µm wide, with firm or slightly gelatinous walls, not developing excrescent hyphae except in some cases at the very base of the pileus; pileocystidia 60-150 x 4-10 µm, narrowly fusiform, often with long stalk, acute, smooth or slightly encrusted, thick-walled, generally immersed in the superficial layer and some arising from the outer hyphae of the firm layer of the flesh and embedded in the gelatinous layer, not projecting from the surface.

Collections.- Sarawak, Bako National Park, *Corner P-165*, 26 Aug. 1972.- North Borneo, Mt Kinabalu, 1300-3300m alt., *RSNB 3011, 5183, 5226, 5226B, 5728* and *Corner s.n.* 30 June 1961, apparently throughout the year.- New Guinea, Oomsis, *Corner s.n.* 1 Oct. 1960.- Solomon Islands, Guadalcanal *RSS 1671*; Kolombangara *RSS 1060*; San Cristobal *RSS 738, 971*.

I treat this as a variety because I think that the whole complex about *H. testudo* needs much more investigation, especially in regard to the size of the spores, pleurocystidia and pileocystidia. Though the fruit-bodies usually smell strongly of new meal, the smell may be weak or absent, and those of the New Guinea collection were slightly fragrant. This collection also had the pilei becoming slightly villous-spiculose at the base with the pileocystidia embedded in the excrescent fascicles. Compare the Brazilian *H. testudo* (p. 45).

**Hohenbuehelia vermiculata** sp. nov. Figure 11

**Pileus -8 mm radio, -7 mm latus, breviter pleuropodalis, vel sessilis, primo conchiformis fere cyphelliformis, dein unilateraliter extensus, spathulatus griseo-alutaceus striatus, sicco basim versus**

**subvillosus. Stipes -1 x 2 mm. Lamellae subconfertae, primariae 5-7, -0.7 mm latae, ordinibus 3-4, pallide subochraceae. Caro 1 mm crassa, fere ex integra gelatinosa, strato firmo 50-200 µm crasso. Odor farinaceus. Sporae 4-6.5 x 3-4 µm, laeves subcylindricae. Cheilocystidia 9-23 x 4-7 µm, clavata vel ventricosa, nonnulla capitulo breviter stipitato praedita. Pleurocystidia 25-70 x 7-17 µm, ventricosa acuminata, dense incrustata. Hyphae in carnis strato firmo 2-6 µm latae. Pileocystidia 40-130 x 3-5(-6) µm, dense incrustata, in toto -200 x 12-20 µm vermiformia. Ad ramulos truncosque delapsos in silva. Insulae Solomonenses. Typus *RSS 1160*; herb. Corner.**

Pileus -8 mm in radius, -7 mm wide, sessile or shortly pleuropodal, at first convex-conchiform and almost cyphelliform, then unilaterally extending and spathulate, pale greyish buff, translucent striate, drying thinly villous at the base and pale bistre. Stem -1 x 2 mm, very short or none. Gills decurrent to the attachment, rather crowded, 5-7 primaries -0.7 mm wide, 3-4 ranks, pale buff ochraceous. Flesh 1 mm thick at the base of the pileus, mostly gelatinous, the firm layer 150-200 µm thick, or merely 50-100 µm (RSS 681). Smell farinaceous.

On a fallen trunk in the forest, on sticks and on dead inflorescences of *Ficus subcongesta*. Solomon Islands.

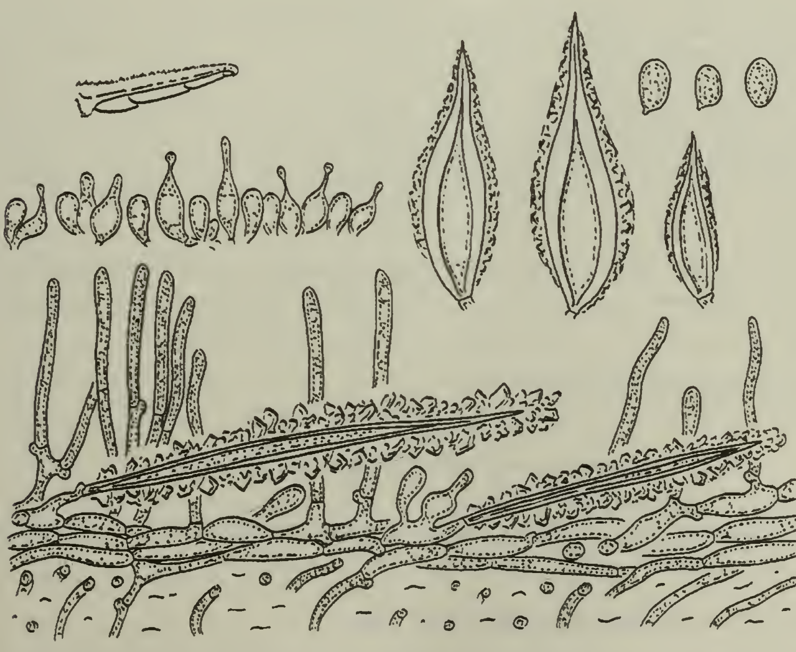


Figure 11. *Hohenbuehelia vermiculata.* Fruit-body in section, x 2. Spores, x 1000. Cheilocystidia, pleurocystidia and surface of pileus, x 500.

Spores 4-6.5 x 3-4 µm, white, smooth, subcylindric. Basidia 18-20 x 5-5.5 µm, 4-spored; no subacerose basidioles; subhymenium thin, with 2-3 µm hyphae. Cheilocystidia 9-23 x 4-7 µm, clavate to ventricose with a short, often capitate, appendage, smooth, thin-walled, as a sterile gill-edge. Pleurocystidia 25-70 x 7-17 µm, the smaller towards the gill-edge, ventricose, acuminate, heavily encrusted (at least distally), wall -6 µm thick. Hyphae monomitic, clamped; in the pileus mostly gelatinous 1.5-2.5 µm wide and ascending, in the firm layer 2-6 µm wide with slightly thickened walls, longitudinal; in the gill-trama as in the firm layer, 2-4 µm wide. Surface of pileus with a thin layer of longitudinal hyphae 3-6 µm wide bearing scattered subclavate processes -25 x 4-7 µm, and erect hyphal ends -70 x 3-6 µm, often 1-3 septate; pileocystidia 40-130 x 3-5(-6) µm, appearing as vermiform, often curved ropes of granular and crystalline material -200 x 12-20 µm overall, thick-walled.

Collections.- Solomon Islands, Guadalcanal, 4 July 1965, *RSS 681*; Kolombangara, 30 Aug. 1965, *RSS 1160*.

This is close to the alliance of *H. testudo* v. *glabra* and may be a depauperate state.

**Hohenbuehelia horakii** Courtecuisse species incertae sedis

**Doc. mycol. 14 (1984) 82.**

***Claudopus griseus*** **Mass., Kew Bull. 1899, 169.-** ***H. grisea*** **(Mass.) Horak, Nova Hedwigia Beih. 65 (1980) 315, non** ***H. grisea*** **(Pk) Singer.**

Massee gave: pileus 3-5 cm wide, conchiform with lateral stem, grey, often corrugate; gills distant, narrow, connected by veins, grey; spores 8 x 5 µm, rough; cystidia 65-70 x 14-15 µm, fusoid; on dead wood, Malay Peninsula, Perak, Ridley 11.

Horak gave: spores 4.5-6 x 2.5-3 µm, reniform, inamyloid; cystidia 30-50 x 12-18 µm, fusiform, metuloid, wall -7 µm thick, hyaline, partly encrusted with crystals.

I do not recognise this fungus.

## Notes on Extra-Malesian Species

The species here mentioned can be arranged according to my classification of the Malesian species in the following way:

**Species with thick-walled pileocystidia.**

*H. angustata*, *H. bullulifera* (with hymenioderm), *H. carbonaria*, *H. cystidioides*, *H. petaloides*, *H. testudo.*

**Species without such pileocystidia.**

a. With thick-walled hyphae in the firm layer of the flesh. *H. atrocaerulea*, *H. myxotricha*, *H.* aff. *reniformis.*

b. Hyphae thin-walled - *H. subtorulosa.*

**Hohenbuehelia angustata** (Berk.) Singer

**Lilloa 25 (1950) 109.**

Pileus -3.5 cm in radius, 4.5 cm wide, pleuropodal, spathulate-flabelliform, finely villous in the proximal half, striate near the margin, grey, pallid fuscous or pale livid bistre. Stem 3-30 x 2-5 mm, lateral, fibrous, firm, finely villous, paler concolorous. Gills deeply decurrent, very crowded, narrow, thin, 15-40 primaries 0.3-1 mm wide, 5-6 ranks, sometimes dichotomous especially near the stem, white, edge entire. Flesh fibrous, firm, white, with a very thin gelatinous layer c. 50 µm thick. Smell farinaceous, strong.

On the ground and on rotten wood in forest. North and South America.

Spores 6.5-8 x 4-5 µm, ellipsoid, or 4-4.5 x 3-3.5 µm, broadly ellipsoid to subglobose (Manaus collection), white, smooth, thin-walled. Basidia 17-23 x 6 µm, 4-spored.

Cheilocystidia 15-30 x 4-8 µm, cylindric, clavate or subventricose with a short obtuse to subacute, rarely capitate, apex, smooth, thin-walled, as a narrow sterile gill-edge. Pleurocystidia 35-85 x 14-28 µm, stoutly ventricose with short acute apex, with thick yellowish walls, not or slightly encrusted, abundant. Hyphae monomitic, clamped, 2-10 µm wide in the firm tissue of the pileus, mostly longitudinal; in the gill-trama 2-6 µm, wide, thin-walled, not gelatinous, mostly radiating and parallel with the gill-edge; gelatinous layer of pileus 20-50 µm thick. Surface of pileus with a compact layer c. 20 µm thick composed of longitudinal and interwoven appressed hyphae 2-4 µm wide, with few excrescent ends in fascicles -120 µm wide of hyphae 2-8 µm wide; pileocystidia 28-70 x 6-10 µm, fusiform with prolonged acute apex and short, often subtruncate, base, becoming overgrown by the villous layer, sometimes with thin-walled pileocystidia in the fascicles of hyphae and hyphal ends like irregular, often lobate and contorted, cheilocystidia and often with pale fuscous sap.

Collections.- Bolivia, Santa Cruz de la Sierra, on the ground, scattered or 2-3 together, 17 Jan. 1948, *Corner 41/48*. - Brazil, Amazonas, Manaus, on rotten wood, *Corner s.n.* 24 Oct. 1948.

The stipitate pileus, very crowded narrow gills and the very thin gelatinous layer on the pileus distinguish this species. Singer gave the spores as equally variable, 3.5-6.7 x 3-4.5 µm, ellipsoid to subglobose. Noteworthy is the radiate construction of the gills, as in *Panus*, which probably explains why they are so narrow. The limits between this species and *H. testudo* seem rather uncertain. Thorn and Barron (1986), however, give the gelatinous layer as 180-250 µm thick.

**Hohenbuehelia bullulifera** Singer

**Lilloa 25 (1952) 119.**

var. **brasiliensis** var. nov. Figure 12

**A typo differt pileo majori -20 mm lato, lamellis confertis, odore farinoso, sporis minoribus 4.5-5.5 x 3-3.5 µm. Typus, Brazil, *Corner 296*; herb. Corner.**

Pileus -15 mm in radius, 20 mm wide, sessile, dorsally attached, at first cyathiform then unilaterally spathulate to flabelliform, sometimes with a small resupinate foot, wholly dark fuscous fuliginous, at first paler to the whitish and persistently incurved margin, opaque or faintly striate near the margin, drying white villous at least in the proximal part. Gills radiating from the base, crowded, narrow, thin, tough, 7-11 primaries -1 mm wide, 4-6 ranks, concolorous; sometimes with minute gills on the resupinate foot. Flesh 1-1.5 mm thick at the base, wholly toughly gelatinous. Smell farinaceous, rather strong.

Figure 12. *Hohenbuehelia bulluifera* v. *brasiliensis.* Surface of pileus, x 500.

On dead wood in forest. Brazil.

Spores 4.5-5.5 x 3-3.5 µm, white, smooth, aguttate. Basidia 18-23 x 5.5-6.5 µm; sterigmata 4, 3 µm long. Cheilocystidia 15-30 x 7-16 µm, clavate, pyriform to subglobose, with thin, colourless to pale fuscous walls, smooth, with a few colourless plastid-like inclusions, as a broad sterile gill-edge. Pleurocystidia (20-)40-90 x (6-)12-18 μm, fusiform to ventricose, with fuscous brown walls 2-5 μm thick, often with a more or less distinct neck leading to the acute apex, arising deeply in the subhymenium, thinly encrusted distally; the largest with deepest origin near the bases of the gills, shorter towards the gill-edge, the shortest 20 x 6 μm mixed sparsely with the cheilocystidia; also with thin-walled cystidia like the cheilocystidia on the gill-surface especially towards the gill-edge. Hyphae monomitic, clamped; in the flesh 2-5 μm wide with rather toughly gelatinous walls, longitudinal but shortly ascending near the surface, some with inflated cells 8-16 μm wide, compact but not forming a firm dry layer over the gills; in the gill-trama similar. Surface of pileus more or less hymenioderm with cells -30 x 20 μm like the cheilocystidia, some with pale fuscous walls, seated on a compact layer of longitudinal hyphae 3-5 μm wide with fuscous walls; pileocystidia like the pleurocystidia but not so large, sometimes only near the base of the pileus; excrescent hyphae 3-6 μm wide in fascicles.

Collections.- Estado do Rio, Niteroi, *Corner s.n.* 7 Sept. 1947; Rio de Janeiro, Corovado 500m alt., 21 Nov. 1948, *Corner 296.*

This agrees essentially with Singer's description for *H. bullulifera* with spores 5.5-6.8 x 3-4 μm. Compare the very similar *H. singaporensis* (p. 29) without thick-walled pileocystidia.

**Hohenbuehelia atrocaerulea** (Fr.) Singer

I give the following notes on an English collection.

Spores 7-9 x 3.5-4 μm, subcylindric, aguttate. Basidia 25-30 x 5.5-6.3 μm, 4-spored. Cheilocystidia as sterile basidia, subclavata to ventricose and then often with a short apical and sometimes capitulate process. Pleurocystidia -110 x 10-17 μm, encrusted, smaller towards the gill-edge. Hyphae in the firm layer of the flesh 3-7 μm wide, walls 0.5-1 μm thick and pale brown near the gelatinous layer 0.5-1 mm thick with hyphae 1-3 μm wide ascending in the upper part but longitudinal in the lower part of the layer; in the gill-trama as in the firm layer of the flesh but with thickened walls only in the central part of the trama, descending. Surface of pileus without pileocystidia.

**Hohenbuehelia carbonaria** (Cke et Mass.) Pegler

**Austral. J. Bot. 13 (1965) 327.**

***Panus carbonaria*** **Cke et Mass., Grevillea 15 (1887) 94; Cooke, Handbook Austral Fungi (1892) pl. 7, fr. 46.**

Spores 7-9 x 4.5-5 μm (Pegler), 8-10 x 5-5.5 μm (Corner). Pleurocystidia 55-80 x 9-14 μm (Pegler), 60-100 x 9-16 μm (Corner), fusiform acute, thick-walled, distally encrusted. Pileocystidia -120 x 4-7 μm, fusiform, acute. Australia.

When studying *Panus* some years ago, I examined the type at Kew and noted that it had the construction of *H. geogenia* from which it differed in the larger spores. However, I failed to note the direction of the hyphae in the gelatinous layer of the pileus.

**Hohenbuehelia cystidioides** (C.G. Lloyd) comb. nov.

***Cantharellus cystidioides*** **C.G. Lloyd, Myc. Writ. 7 (1923) 1227, f. 2534, 2535.**

Pileus sessile, dimidiate, smooth, brown (about the colour of *Auricularia auricula-judae*). Gills dichotomous, thick, crowded, pruinose from the cystidia. Flesh wholly gelatinous. Spores 4-5 x 2 µm, hyaline, smooth, oblong ellipsoid, thin-walled. Basidia c. 25 x 5 µm. Cheilocystidia not seen, the gill-edge fertile. Pleurocystidia 55-120 x 15-25 µm, ventricose, the acute apex projecting 8-40 µm and rather thinly encrusted with crystals (often tetrahedral) insoluble in KOH, walls 3-8 µm thick, base attenuated and deeply inserted in the gill-trama, often curved ascending, abundant. Hyphae monomitic, clamped, 2-4 µm wide, the gelatinous walls thin or slightly thickened, branched at a wide angle but with many blind, secondarily septate, endings; in the gill-trama similar but not gelatinous. Surface of pileus with densely interwoven, more or less contiguous, hyphae with firm (not gelatinous) walls, in a layer 70-100 µm thick; pileocystidia as the pleurocystidia but shorter, scattered.

This was described from Japan, collected by J.E.A. Lewis. I examined the collection at Kew, when I was studying cantharelloid fungi, and have added the microscopical details. The species is remarkable for the dichotomous gills with fertile edge, the wholly gelatinous flesh and the unusually thick pellicle.

**Hohenbuehelia myxotricha** (Lév.) Singer

The following are my notes on an English collection

Spores 9-14 x 4-5.5 µm, cylindric, often slightly curved, aguttate or with a few minute guttulae. Basidia 25-33 x 4-6 µm; sterigmata 2, 5.5-7 µm long. Cheilocystidia -50 x 3.5-8 µm, mostly ventricose with an apical cylindric appendage -30 x 1.5-2.5 µm, some with a slightly swollen tip, others merely clavate as sterile basidia even with 2 sterigmata, with all transitions to emergent hyphae 1.5-2.5 µm wide, as a sterile gill-edge. Pleurocystidia 30-70 x 7-10 µm, subclavate, fusiform or cylindric, thick-walled, encrusted with a distal conical cap of compact crystals. Hyphae monomitic, clamped; in the stem, the firm layer of the flesh and in the gill-trama 2.5-8 µm wide, with thick walls; in the gelatinous layer 1-2 µm wide. Surface of pileus without cystidia.

**Hohenbuehelia petaloides** (Fr.) Singer — Figures 13,14

**Huijsman (1961); Murata (1979); Singer and Kuthan (1980); Doneso (1981); Watling (1985).**

This is the north temperate complex of *H. petaloides* (type-species of the genus), *H. geogenia* (Fr.) Singer, and *H. repanda* Huijsman. Its southerly allies are *H. angustata* and *H. testudo*; all have the farinaceous smell. For *H. geogenia*, I note the following points.

Hyphae in the firm layer of the flesh with cells 40-130 x 3-12 µm, thin-walled but in the stem with walls 0.5-1 µm thick; in the gelatinous layer (up to 700 µm thick) 3-6 µm wide, ascending; in the rhizomorphs monomitic, clamped, 1.5-3.5(-5) µm wide, thin-walled but the outer hyphae with slightly thickened and slightly encrusted walls; in the gill-trama 3-7 µm wide, descending. Surface of pileus with pileocystidia 50-110 x 4-7 µm, narrowly fusiform, with thick brownish walls, thinly encrusted.

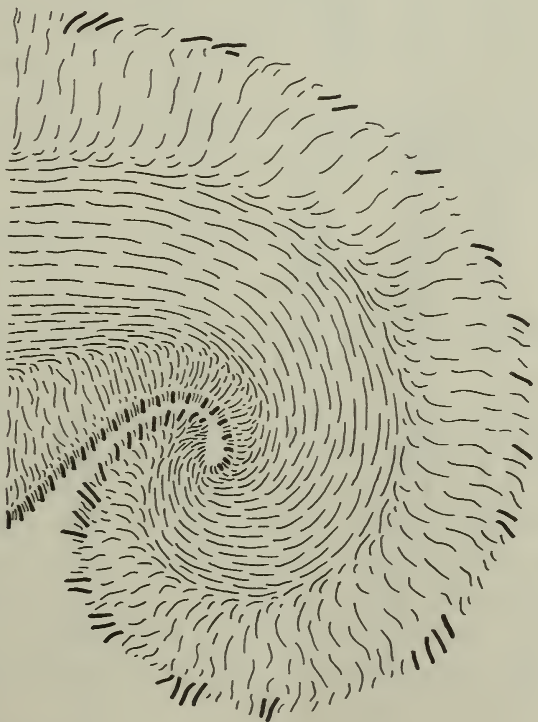


Figure 13. *Hohenbuehelia geogenia.* Margin of pileus in section, to show the upper gelatinous layer of the flesh with ascending hyphae and thick-walled pileocystidia (thick lines), and the pleurocystidia (thin lines); x 45.

**Hohenbuehelia** aff. **reniformis** (Fr.) Singer

Pileus -12 mm in radius, sessile or with a very short vague stem attached by a thin white narrow byssoid mycelium, reniform semicircular, fuscous cinereous, paler and substriate near the margin, drying pallid fuscous and shortly white

Figure 14. *Hohenbuehelia geogenia.* Surface of pileus with thick-walled pileocystidia arising in the gelatinous layer; x 1000.

villous, pruinose towards the margin, strigose near the base. Gills decurrent, crowded, narrow, tough, 8-13 primaries -1 mm wide, 4-6 ranks, white, in age yellowish. Flesh 0.3-0.5 mm thick, gelatinous except a layer c. 100 µm thick over the gills. Inodorous.

On a dead branch in forest. Brazil, Estado do Rio, Niteroi, *Corner s.n.* 31 Aug. 1947.

Spores 8-10 x 4-5 μm, white, smooth, subcylindric, aguttate, inamyloid. Basidia 22-30 x 7-8 μm; sterigmata 4, 3-4 μm long. Cheilocystidia 16-32 x 5-10 μm, ventricose with a subcapitate, mostly subhastiform, appendage 2-3 μm wide on a stalk 1.5-3 μm long, thin-walled, as a sterile gill-edge, mixed with pleurocystidia. Pleurocystidia 25-75 x 7-16 μm, lanceolate fusiform, some waisted, walls 1-3.5 μm thick and colourless, rather thinly encrusted at the acute apex, abundant and also on the gill-edge. Hyphae monomitic, clamped; in the firm layer of the flesh and in the gill-trama 3-7 μm wide with walls 0.5-1.5(-2.5) μm thick, descending in the gills; in the gelatinous layer 1-3 μm wide. Surface of pileus with subclavate processes -35 x 4-10 μm in a loose layer, with pale fuscous sap, arising from a loose pseudoparenchyma of cells 12-25 x 7-12 μm with fuscous walls and fuscous granular incrustation; villous layer composed of loose fascicles of excrescent hyphae; without thick-walled cystidia.

This fits the description of the temperate *H. reniformis*, yet it fits also diminutive *H. malesiana*. I describe it because too little is yet known of these fungi.

### Hohenbuehelia subtorulosa (Cke) comb. nov.

***Panus subtorulosus*** **Cke; Pegler, Kew Bull. Add. Ser. X (1983) 258.**

I give the following notes from my examination of the type-specimen at Kew, namely *Glaziou 9153*, Dec. 1878, Rio de Janeiro.

Fruit-bodies closely caespitose-merismatoid from a short thick common trunk, dried wholly fuliginous fuscous and horny. Pileus -25 mm in radius, often with a prolonged lateral stem, finely villous over the central part. Gills crowded, very narrow, 0.5 mm broad. Spores 4-5 x 2.5-3 μm, colourless, smooth. Pleurocystidia 35-48 x 9-16 μm, ventricose, subacute to acute, short, very thick-walled, apparently smooth, very abundant. Hyphae of the flesh wholly agglutinated, no structure discernible. Surface of pileus with the villous layer -80 μm thick, composed of 3-5 μm hyphae, clamped, more or less erect; no pileocystidia seen.

### Hohenbuehelia testudo

The following description refers to a fungus that I found in Brazil and seems almost identical with the Asian *H. testudo* (p. 34). Both *H. testudo* and *H. angustata* relate to the complex of *H. petaloides*.

Pileus -5 cm in radius, -7 cm wide, sessile, lateral, ascending, spathulate to flabelliform, pale watery ochraceous to pale fuscous brownish, whitish towards the substriate margin, drying white villous. Gills decurrent, crowded, narrow, 14-20 primaries 2 mm wide, 5-6 ranks, subreticulate at the base, white to dingy cream. Flesh 5-6 mm thick at the base, with a thin gelatinous layer above the softly floccose firmer flesh, white. Smell farinaceous.

On fallen trunks in forest. Brazil.

Spores 5-6 x 3-3.5 μm, white, smooth, broadly ellipsoid, thin-walled. Basidia 16-21 x 5-5.7 μm, (adherent in mucilage), 4-spored. Cheilocystidia -23 x 5-9 μm, subventricose with a more or less prolonged apex, as a sterile gill-edge but collapsing. Pleurocystidia 35-90 x 9-23 μm, with thick yellowish walls, smooth or slightly encrusted, ventricose acute. Hyphae monomitic, clamped; in the firm layer of the flesh with cells 20-140 x 3-24 μm, thin-walled; in the gelatinous layer 2-7 μm wide but some -18 μm wide, ascending or vertical, some of the wider hyphae with a secondary septum; in the gill-trama as in the firm layer of the flesh but with slightly thickened walls, descending. Surface of pileus with a more or less disrupted pellicle of longitudinal and interwoven hyphae 2-6 (-12) μm wide, 1-3 hyphae thick, developing excrescent clamped hyphae 4-7 μm wide in fascicles -100 x 10-50 μm; pileocystidia -90 x 7-11 μm as smooth thick-walled pleurocystidia, becoming decumbent, scattered.

Collections.- Rio de Janeiro, Corcovado, 2 Dec. 1948, *Corner 316*; Amazonas, Manaus, near Flores, 3 Oct. 1948, *Corner 125.*

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# On the Agaric Genera *Hohenbuehelia* and *Oudemansiella* Part II: *Oudemansiella* Speg.

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## Abstract

This is mainly an account of Malesian species, of which *O. crassifolia, O. lianicola* and *O. submucida* are new, but notes are added on several temperate and South American species. The structure of the pileus introduces a new criterion into the specific classification of the genus. The connection with marasmioid *Xerula* is discussed. A species from Japan, referred tentatively to *O. radicata* var. *hygrophoroides* (Sing. et Clemençon) Pegler et Young is intermediate in that it has the marasmioid subacerose basidioles in the hymenium. It is re-affirmed that the pleurocystidia conform with the basidiograph locus of *Oudemansiella* and it is suggested that the narrow basidia of *Hohenbuehelia* and *Pleurotus* and the subacerose basidioles of *Marasmius* correspond with the developing and uncharged basidia of *Oudemansiella*.

## Contents



Recent publications on this genus have enabled me to prepare this account of five Malesian species. In 1929, soon after I arrived in Singapore, I was intrigued by two common agarics. One I identified as *Collybia apalosarca*, now known to be one of the many synonyms of *O. canarii*. The other I called uncertainly *C. radicata* and it has passed unidentified, but I know now that it is *C. altissima* Mass., described from Singapore; the trouble in those days was the inadequacy of conventional description, as well as mistrust of the erratic mycologist George Massee. I have added three new species, mainly from later collections which I made in Borneo.

*Oudemansiella*, though very unlike the majority of marasmioid fungi in general appearance, now appears as the remains of the ancestry of Marasmieae and as a connection with *Pleurotus*. The genus is distinguished by the fleshy fruit-body, commonly with viscid brown to white pileus, the central stem, the large white inamyloid spores with a single large oil-drop or many small ones, the large cheilo- and pleurocystidia, the long-celled thin-walled hyphae with clamps, the palisade of clavate cells on the pileus, and the lignicolous habit, though there may be exception in one point or another. Seventeen species, some with several varieties, are recognised by Pegler and Young (1986), to which Redhead, Ginns and Shoemaker (1987) add four others, but some of these are reduced by Boekhout and Bas (1986). The ultra-structure of the spore-wall has been studied in detail by Pegler and Young.

## Classification of *Oudemansiella*

For various reasons but chiefly because it omits the structure of the surface of the pileus, I find that the revised classification of the species by Pegler and Young (1986) is unsatisfactory. My criticism arises mainly from consideration of the tropical species.

Subgen. *Oudemansiella* is separated from subgen. *Xerula* by reason of habitat, gelatinisation of the pellicle on the pileus, and manner of development. The habitat is given as lignicolous versus radicicolous but, as roots are also lignified, it is a distinction between growing on stem-wood rather than root-wood. This distinction holds in the main, as with *Amauroderma* contrasted with *Ganoderma*, but there may be anomalies such as that concerning *O. brunneimarginata* mentioned under *O. raphanipes*. Imai (1938) reported *O. radicata* on decayed wood above ground in Hokkaido. With this distinction there is coupled the presence of the pseudorhiza, said to be peculiar to subgen. *Xerula*, but there is *O. radicata* f. *arrhiza* Lange (1936) as well as the state of the species on stem-wood without the pseudorhiza, and in subgen. *Oudemansiella* there is *O. canarii* f. *radicans* that grows on wood above ground. The pseudorhiza is a facultative rhizomorph indicated, probably, by the basal plug by which all the fruit-bodies are attached to stem-wood. Concerning the gelatinisation of the pellicle, it occurs in both subgenera and is absent from some species in both, as in *O. lianicola*, which could be placed in subgen. *Oudemansiella* because it grows on stem-wood without a pseudorhiza.

Development of the fruit-body is described as bivelangiocarpic in subgen. *Oudemansiella*, according to Reijnders (1948) and as gymnocarpic in subgen. *Xerula*. The term bivelangiocarpic in this context is misleading because it implies a universal veil and a partial veil and, at most, so far as I know, there is only a partial or marginal veil in the genus. Indeed, Reijnders (1952) called *O. canarii*, which is supposed to be conspecific with the type of the genus *O. platensis*, metavelangiocarpic because what slight veil it has is formed by the union of outgrowths from the margin of the pileus and the base of the stem (Corner, 1934). Supposedly, the palisade on the pileus and the loose hyphal outgrowth on the stem are taken to be the universal veil, but I regard them as just the surface of pileus and stem in a gymnocarpic primordium; to regard them as adnate veils, as velangiocarpic implies, is like regarding the hair on one's head as a veil. This marginal veil certainly supplies the ring on the stem of *O. mucida* and that, not always present, of *O. submucida*. In *O. canarii* it is vestigial, and there may be a trace of it in *O. radicata* of subgen. *Xerula* according to Reijnders (1952), as in *O. lianicola*, but with no vestige in the expanded fruit-body. In fact, the presence or absence of this marginal veil can be proved only by microscopic study of very young primordia and it is not clear that this has been accomplished. It is unreasonable to ascribe two veils to *O. mucida* and none to *O. radicata* when both have the same kind of structure for the surface of the pileus. Thus, I regard *Oudemansiella* as gymnocarpic with or without a marginal veil.

## Surface-structure of the Pileus

This matter seems to me to supply the most important means for specific arrangement in the genus. I distinguish five states, as follows.

1. The double palisade, with an outer palisade separated from an inner palisade by a thick gelatinous layer.
   - A. The outer palisade developing moniliform rows of cells (mainly by secondary septation) to form a trichoderm, e.g. *O. platensis* (subgen. *Oudemansiella*).
   - B. The outer palisade remaining a single layer, e.g. *O. canarii* (subgen. *Oudemansiella*).
2. A single palisade, with or without a thin mucilaginous hypodermis.
   - A. The palisade developing moniliform rows of cells (mainly by secondary septation), e.g. *O. lianicola* (subgen. *Oudemansiella* in habitat, subgen. *Xerula* in lacking a gelatinous layer).
   - B. The palisade remaining a single layer of clavate cells, with or without ventricose-filiform pileocystidia. e.g. *O. mucida* and *O submucida* (subgen. *Oudemansiella*) and probably most species of subgen. *Xerula*.
3. No palisade but a fairly thick gelatinous layer, e.g. *O. crassifolia* (subgen. *Oudemansiella* in habitat).

Nevertheless, it is not clear that all these differences are absolute. Thus, in *O. altissima*, the structure of the central part of the pileus places it in Group 2A and that of the outer part in Group 2B (Corner, 1934, figures 8, 9). Then, the lack of palisades in Group 3 may not hold for the unexpanded primordial pileus which may have a slight palisade of clavate cells soon to become disrupted. Indeed, disruption of the outer palisade on expansion in pilei of Groups 1A and 1B causes the flecks on the gelatinous surface which are easily washed off by rain so as to give the appearance of Group 3 but with the inner palisade intact. Thus, in *O. platensis* and *O. canarii*, the true construction is not usually evident in mature fruit-bodies.

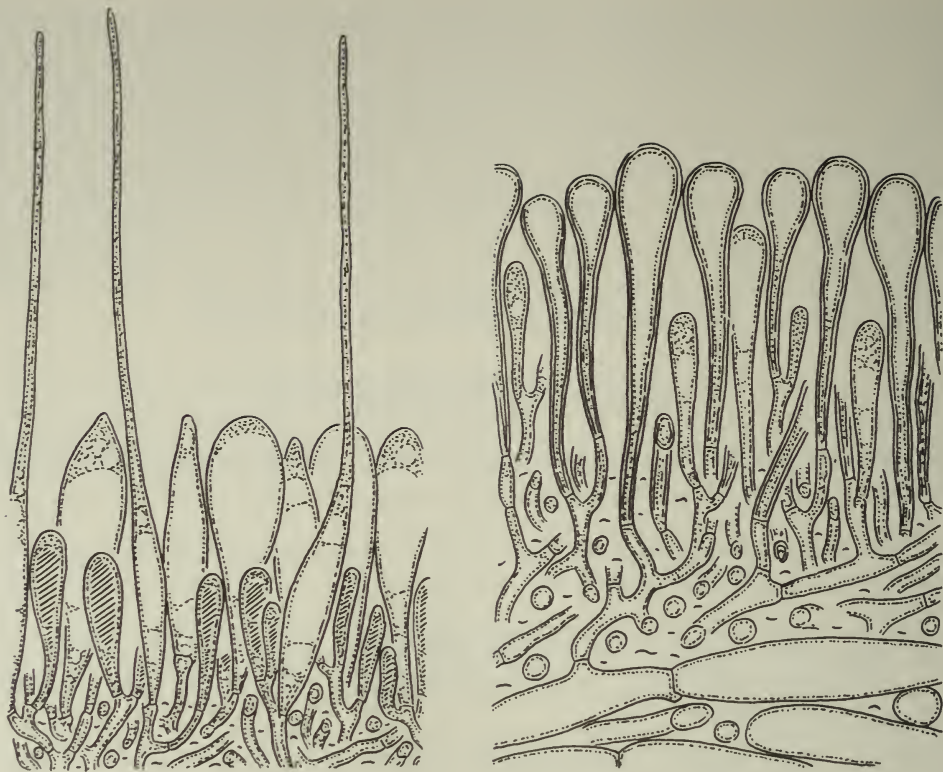


Figure 1. *Oudemansiella altissima* (left) and *O. radicata* (right). Surface of central part of pileus, x 500.

It emerges that *O. mucida* and *O. submucida* have the structure prevalent in subgen. *Xerula* though, in respect of habitat and development, they agree with subgen. *Oudemansiella*. The surface-structure cuts up the distinction between the two subgenera.

Another issue concerns the presence of clamp-connections. They occur in all the hyphae of the fruit-body but in most species that I have studied they are absent from the hyphae of the one or two palisades. They are described as present in the palisade for *X. furfuracea, X. megalospora* and *X. rubrobrunnescens* by Redhead, Ginns and Shoemaker (1987), and some of the hyphae of the palisade in *O. lianicola* are clamped. Whether the absence of clamps reflects an antecedent state with moniliform secondary septation to form a trichoderm is not clear, but I certainly consider that the trichoderm of *O. platensis* is antecedent to the single outer palisade of *O. canarii*, just as the trichoderm resolves into the hymenioderm in other basidiomycetes.

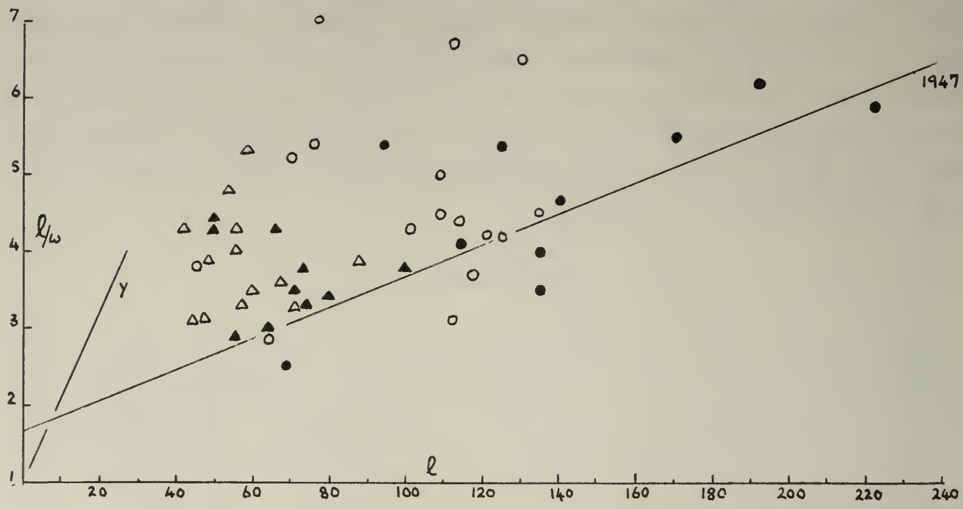
Actually, what appears as a single palisade in *O. altissima*, perhaps also in *X. caussei* and *X. kuehneri* according to Boekhout and Bas, is more complex and, in its way, triple (Corner, 1934, figure 8). There is the main layer of large clavate cells beyond which project the ventricose-filiform pileocystidia, and between the stalks of these cells there are shorter, narrower, clavate or cylindric cells with brown sap. From this construction, there emerge the other main kinds. In the simplest case, the palisade reduces to a truly single layer of cells. That of *O. canarii* adds a gelatinous layer between the small, inner and brown cells and the others, and in *O. platensis* this is complicated by secondary septation of the hyphal ends in the outer palisade.

## The Stem

In *O. mucida* and *O. submucida* the ring lies at or above the middle of the stem but the vestige of the ring or marginal veil is on the upper side of the bulbous base of the stem in *O. canarii* and *O. platensis*. The explanation is provided by *O. canarii* var. *perstipitata*. The stem of *O. canarii* corresponds with the supra-annular part of the stem of *O. mucida* (Corner, 1934, figure 11). That illustration showed how the aerial stem of species with a pseudorhiza may similarly correspond with the supra-annular part of *O. mucida*. Thus, it may be that the primordia of the fruit-bodies of subgen. *Xerula* are formed at the surface of the ground in a button-stage similar to that of *O. canarii* with or without a trace of marginal veil. The idea is supported by the fact that the pileus is not acutely conical in *Oudemansiella*, for such is usually the case with pilei initiated below ground and forced through the soil to the surface. However, Buller (1931) found the primordia of *O. radicata* were formed on the root and were pushed by the pseudorhiza to the surface of the ground. I think that the problem still needs investigation.

## Basidia and Pleurocystidia

In 1947 I showed that both the mature basidia and the pleurocystidia of *Oudemansiella* conformed to the same locus on the basidiograph that had for its definition $l/w = 1.7 + 0.02l$, giving a maximum width of 50 µm. More data have come to hand and the revised basidiograph is shown in Graph 1, along with the original locus. I see no reason to alter its slope though an upward shift in the value of the ordinates to 1.8 or 1.9 might assimilate more points. They, however, are species-points, based on mean values, whereas my original data were based on averages; thus, a basidium not fully expanded will give a higher value for $l/w$ than one that is, and it is very easy to be deceived by this detail in a specific description. Moreover, as the basidia in some species are dimorphic, more detailed enquiry is needed to discover if there is any difference in this matter between the long and short basidia. However, Buller gave the basidia of *O. radicata* as monomorphic. For the initial stage of enlargement of the basidium up to 27 µm long and before it began to be charged with dense cytoplasm, the locus was $l/w = 1 + 0.11l$, and this corresponds with that of the narrow basidia of *Hohenbuehelia* and *Pleurotus* (Corner).




Graph 1. *Oudemansiella,* basidograph (triangles) and pleurocystidiograph (circles), based on the data in this article (solid triangles and circles) and on those from the authors cited. 1947, the locus based on average data (Corner, 1947). y, the basidiograph for developing basidia.

The presence of subacerose basidioles in the hymenium of the fungus here described as *O. radicata* var. *hygrophoroides* necessitates closer study because, in this respect, it connects with *Xerula* based on *X. longipes* (Corner, in ed.). If its species-point on the basidiograph is reliable, then its basidia are tending, like those of *X. longipes*, to the narrow basidia of *Marasmius*, but its pleurocystidia are typically those of *Oudemansiella*. It seems that the subacerose basidiole, comparable in size with the developing and uncharged basidia of *Oudemansiella*, have supplied the steeper locus for the basidia and pleurocystidia of *Marasmius*, where $l/w = 1 = 0.21\,l$ to $1 = 0.071\,l$ with maxima as 5 µm and 14.1 µm respectively.

I note that the flattened or subtruncate apex of the pleurocystidium in some species may be the effect of pressure upon the adjacent gill in the crowded state of the primordial pileus, as seen in *Coprinus* and *Pluteus*.

## Monomitic or Sarcodimitic

The hyphal construction of the fruit-body in *Oudemansiella* has always seemed to me to be monomitic with long-celled inflating hyphae together with relatively few uninflated hyphae. Thus, the texture is fleshy and the stem solid. Recently, however, it has been proposed by Boekhout and Bas (1986) and by Redhead (1987) that the stem and gills are sarcodimitic, as I described for *Trogia*. I have discussed this matter in a second account of *Trogia* (Corner, 1991) and prefer my original conclusion. The waxy-cartilaginous consistency and hollow stem of

*Trogia* are not features of *Oudemansiella* and, if the long cells of this and some other genera of agarics may be the precursors of the inflated fusiform skeletal cells of *Trogia*, they are not specially differentiated.

## Affinity of *Oudemansiella*

It is generally agreed that *Oudemansiella* should be referred to Marasmiaceae (Romagnesi, 1977) or Tricholomataceae tr. Marasmieae (Singer, 1975). It is put in an allied family Xerulaceae by Jülich (1981), which covers *Oudemansiella*, *Xerula* and *Lampteromyces*. This last genus is put in Tricolomataceae tr. Clitocybeae by Singer but, as I have shown (Corner, 1981), it is impossible to distinguish clearly *Lampteromyces* from *Pleurotus*, and the custom now is to put *Pleurotus* far away in or near Polyporaceae, though it lacks entirely the peculiar hyphal construction of its key-genera *Polyporus* s. str. and *Lentinus* s. str. (Corner, 1984).

The idea of Xerulaceae has been greatly enlarged by Redhead (1987) who considers it to be essentially a sarcodimitic family that ranges into the monomitic. Thus, he places in it *Trogia*, *Oudemansiella*, *Xerula* and *Mycena*, but not *Lampteromyces* or *Marasmius*. If the sarcodimitic origin is so essential, then the polyporoid *Meripilus* must be added or given an allied family, though polyporoid allies of *Mycena* are, apparently, not to be excluded. However, as already mentioned, I am far from convinced of this aggregation, and the affinity of *Xerula* with *Marasmius* is confirmation.

*Xerula* is based on *X. longipes* or, as it is now called *X. pudens*. It has the marasmioid dry pileus, subagglutinated surface to the stem, acerose basidioles, and thick-walled caulo- and pileo-cystidia, but it has, also, the fleshier texture, large guttate spores, long-celled stem-hyphae, and the lack of clamps from the palisades of stem and pileus as in *Oudemansiella*. In size of basidia and pleurocystidia it comes between *Marasmius* and *Oudemansiella*. While this confirms the alliance of *Oudemansiella* with Marasmiaceae, it still leaves the fleshy consistency and lack of acerose basidioles as distinctive. This last point is bridged by the fungus here described as *O. radicata* v *hygrophoroides*. It joins *Oudemansiella* with *Xerula* which joins with *Marasmius*, without the intrusion of *Trogia*. *Lampteromyces* links *Pleurotus* and *Oudemansiella*. Here is a range from lignicolous on root and stem to humicolous and foliicolous fungi, and from typically agaricoid to stereoid, in the exploitation of the saprophytic habitats of the forest, parallel with the alliance of *Trogia*.

Here is confusion in the modern classification of Agaricales, which I do not attempt to amend while there are still so many gaps in knowledge and so much more to be discovered in the tropical flora.

Since this paper was written, a European fungus, first described as *Hydropus mediterraneus* Pacioni et Lalli (1985), has been transferred to *Flammulina* by

Bas and Robich who give a detailed description (Persoonia 13, 1988, 489), and most recently to *Oudemansiella* by Ortega, Vizoso and Contu (Documents mycologiques f. 82, 1991, 25). This genus was rejected by Bas and Robich on the ground that Redhead had decided that *Oudemansiella* was sarcodimitic, which I regard as a mistake. The species seems to come between *Xerula* and *Oudemansiella*. If it can be fitted into *Flammulina*, here is another instance of superfluous genera.

## Key to the Malesian species of *Oudemansiella*

1. Terricolous with rooting base from buried wood. Pileus dry. Stem fuscous brown scurfy fibrillose .......... ........ *O. altissima*

1. Lignicolous above ground.

  2. Pileus at first with a gelatinous pellicle 0.3-1 mm thick, with white to greyish flecks washing off with rain, dark umber, paler to whitish on expansion. Common ........ *O. canarii*

  2. Pileus dry or with a much thinner gelatinous pellicle, without superficial flecks.

    3. Stem with a membranous ring. Pileus smeary viscid, white to pale ochraceous. Borneo ............. ........ *O. submucida*
    (pileus dry ........ var. *persicca*)

    3. Without such a ring.

      4. Gills very thick, obtuse. Pileus -3 cm wide, with a thin viscid pellicle, white. Spores 21-28 x 19-24 µm. Borneo ........ *O. crassifolia*
      (pileus -6 cm wide, dry, pale pink as the stem); spores 19-24 µm. Malaya ....... v. *incarnata*)

      4. Gills rather thin. Pileus -3 cm wide, dry, pallid ochraceous with subferruginous and strongly reticulate centre. Spores 10.5-13 x 8.5-9.5 µm. On dead lianes. Borneo ........... *O. lianicola*

**Oudemansiella altissima** (Mass.) comb. nov. Figures 1, 2

***Collybia altissima*** **Mass., Kew Bull. 1914, 358.-** ***C. radicata*****, Corner in Trans. Brit. mycol. Soc. 19 (1934) 64, f. 8-10.**

Pileus 1-12 cm wide, convex then plane or concave, often subumbonate, dry (slightly viscid in decay), smooth or more or less extensively regulose-reticulate or rugulose rivulose, pale fuscous brownish or pale umber with darker centre; margin substriate, often slightly sulcate-crenulate. Stem 6-14 cm x 3-8 mm at the apex, 5-16 mm at ground level, with tapering root -16 cm long arising from a slender white rhizomorph 0.5 mm wide, fibrous, dry, concolorous, wholly fuscous brownish scurfy pruinose or subfibrillose but the white apex pruinose; veil none. Gills sinuate to adnexo-adnate, subdistant, rather thick and waxy, 13-33 primaries 4-12 mm wide, 3-5 ranks, not veined, white, sometimes with umber brown edge. Flesh 3-7 mm thick in the centre of the pileus, sappy, without a gelatinous layer, white. Smell sour.

On the ground, solitary or occasionally 2-3 together, from buried roots in the forest. Malesia to the Solomon Islands, uncommon, lowland to 1700 mm alt.

Figure 2. *Oudemansiella altissima.* Surface of lower part of stem, x 500.

Spores 15-19 x 12-15 µm, in some collections 11.5-15.5 x 11-14 µm, white, smooth, subglobose, the wall 0.3 µm thick, multiguttulate. Basidia 58-75 x 13-18 µm; sterigmata (2-)4, 6-10 x 3-4 µm, 9-13 x 4-6 µm on 2-spored basidia and sometimes with an abortive third sterigma; no acerose basidioles; subhymenium not corticate. Cheilocystidia as in *O. canarii*, clavate to ventricose and shortly appendaged, in some collections with brown sap. Pleurocystidia 80-190 x 18-50 µm, clavate to ventricose with a long obtuse appendage as in *O. canarii*, thin-walled. Hyphae clamped in both 2- and 4-spored fruit-bodies, but without clamps in the palisades on pileus and stem; in the stem strictly longitudinal with firm walls, the cells 100-1200 x 5-38 µm, cylindric with broad septa or with tapered ends, with few uninflated interweaving hyphae; oleiferous hyphae 3-9 µm wide, scattered. Surface of stem with loosely appressed and entangled longitudinal hyphae 3-9 µm wide, without clamps, with brown sap, ending with clavate to ventricose, often secondarily septate, cells 25-75 x 8-25 µm with brown sap, compacted into clusters towards the stem-apex, developing filiform processes 1.5-3 µm wide in the lower part of the stem (as on the pileus), these processes often bifid in 2-spored fruit-bodies. Surface of the pileus covered over the centre with a compact palisade with 3 kinds of cell (with intermediates); 1, narrowly ventricose colourless cells with the cell-body 30-60 x 4-12 µm prolonged into a filiform unbranched, aseptate, tapering process 70-350 x 1.5-3.5 µm, rarely 1-septate, eventually mucifying in old fruit-bodies; 2, large clavate or ventricose hyaline cells 40-70 x 8-20 µm, without a process; 3, small clavate or subcylindric cells 15-40 x 5-12 µm with brown sap, packed between the stalks of the other cells and forming the dense inner part of the palisade, without a gelatinous substratum. Surface of the pileus over the limb with a palisade consisting mostly of large clavate cells with brown sap, the subterminal cells often inflated with brown sap, with a thin gelatinous substratum.

This fungus, which I called *C. radicata* for convenience in 1934, is *C. altissima* Mass, according to the unmistakeable illustration of the type-collection *E.M. Burkill 112* and the specimen in the Singapore herbarium. It comes in the key of Pegler and Young (1986) to sect. *Albotomentosae* where it should come next to the otherwise very dissimilar *O. xeruloides*. A much closer species seems to be *O. japonica* (sect. *Radicatae*) of which v. *colensoi* may be identical. Once, when I was delayed in the town of Goiania in Brazil in January 1968, I found two fruit bodies in different places which seemed identical with *O. altissima*, but I had no means of making a herbarium specimen.

**Oudemansiella canarii** (Jungh.) v. Hoehn. Figures 3, 7

**Pegler and Young (1986) 589.**

***Collybia apalosarca*** **Berk. et Br.; Corner, Trans. Brit. mycol. Soc. 19 (1934) 39-88.**

Pileus 4 mm-15 cm wide, convex then plane, often gibbous, never revolute, sometimes regulose, with a smeary viscid gelatinous pellicle at first spotted with greyish flecks, striate in small specimens, dark umber becoming paler fuscous brown to dirty white when old, rarely pallid white from the first; margin slightly incurved at first, thin, acute, entire. Stem 3 mm-9 cm x 0.5-9 mm at the apex, 1-14 mm at the base, gradually tapered upwards or subcylindric, central to slightly excentric, straight or incurved, thinly pruinose or subvillous, fibrous, solid, apex often subcostate, white or, when young, pale clear yellow, sometimes with pale rufous streaks; base dilated, generally with a narrow ridge or zone round the upper margin, attached by a microscopic root; veil marginal, slight, evanescent. Gills rounded adnate, adnexed or nearly free, often separating free, sometimes with a subdecurrent tooth, more or less ventricose, rather crowded, often broad, thick, waxy to submucilaginous, not veined, 11-39 primaries 1-15 mm wide. 1-5 ranks, white, often with the edge pale clear yellow at first, becoming powdered with the spores and brownish in decay. Flesh 0.5-5 mm thick in the centre of the pileus, 0.3-3 mm thick halfway to the margin, at first firm and fleshy then rather cottony spongy, white, unchanging, with a gelatinous layer 0.3-1 mm thick next the surface of the unexpanded pileus. Smell of fresh fish, sometimes strong.

On dead trunks and branches in the forest and in the open, common. Palaeotropics.

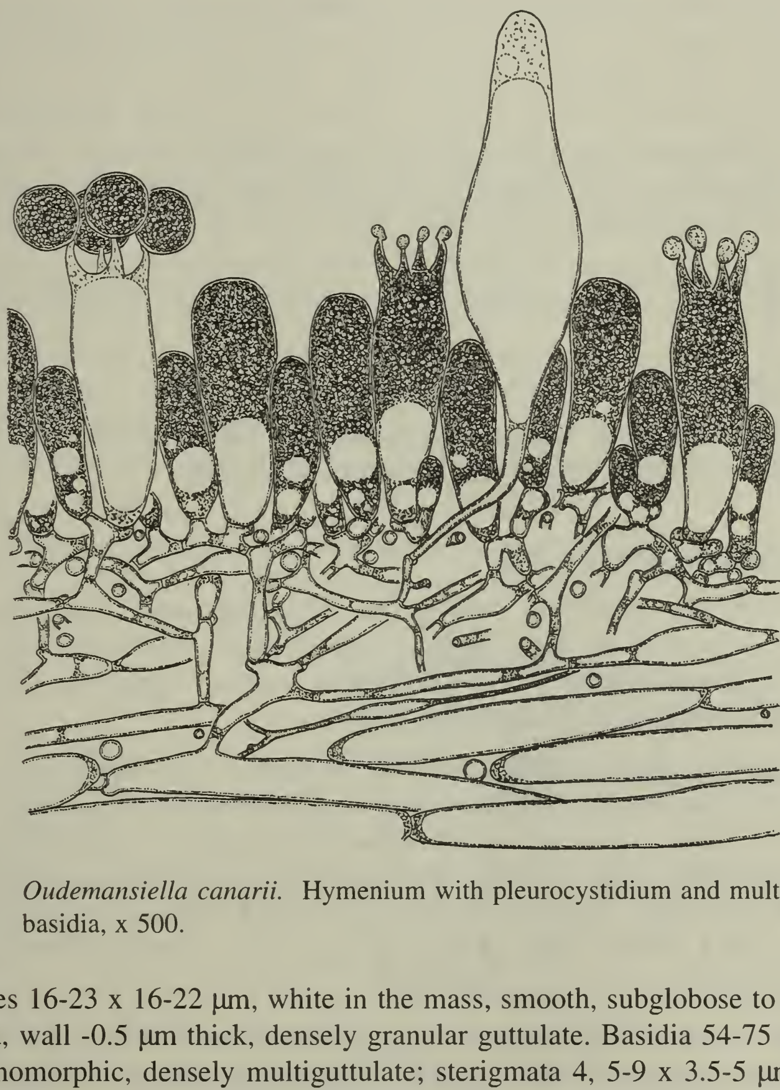


Figure 3. *Oudemansiella canarii.* Hymenium with pleurocystidium and multigittulate basidia, x 500.

Spores 16-23 x 16-22 µm, white in the mass, smooth, subglobose to broadly ellipsoid, wall -0.5 µm thick, densely granular guttulate. Basidia 54-75 x 18-25 µm, monomorphic, densely multiguttulate; sterigmata 4, 5-9 x 3.5-5 µm at the base, stout, arcuate; acerose basidioles none. Cheilocystidia 45-95 x 8-28 µm, mostly 10-15 µm, 2.5-4 µm at the base, clavate, rarely subventricose, often with a long stalk, thin-walled, vacuolate, colourless or in some specimens with yellowish oily masses as exudates. Pleurocystidia 110-280 x 23-40 µm, 10-16 µm at the apex, 3-4.5 µm at the base, very large, broadly fusiform with obtuse apex to ventricose with prolonged subcylindric apex, thin-walled, vacuolate, colourless. Caulocystidia as thin-walled terminal cells 6-17 µm wide with finely vacuolate-reticulate colourless cytoplasm, on lax superficial hyphae, in some specimens with yellowish oily masses as on the gill-edge; basal disc with a lax palisade of uninflated hyphae but the terminal cells 5-8 µm wide and often thinly encrusted with yellowish granules. Surface of the pileus pelliculose with two palisade layers separated by the gelatinous layer; outer palisade consisting of rather laxly arranged, more or less ventricose-appendaged, thin-walled cells 70-200 x 6-11 μm, mostly with pale umber sap, the hypodermic of laxly interwoven hyphae with cells 35-200 x 2-5(-12) μm, this palisade splitting into the greyish flecks on the pileus; inner palisade c. 100 μm high, composed of narrow subcylindric hyphae with cells 25-50 x 2.3-5 μm, in places -6 μm wide, with pale fuscous umber sap. Hyphae clamped except those of the palisades on pileus and stem and of the gelatinous layer of the pileus; in the pileus with cells 60-500 x 8-30 μm and some 3-5 μm uninflated; in the stem with cells 100-1200 x 8-30 μm, a few uninflated, at the base of the stem 5-12 μm wide and densely interwoven, in the basal plug 3-5 μm wide with slightly thickened walls and very densely interwoven.

forma **radicans** Corner (1934)

Stem with a rooting base as a pseudorhiza one to several cm long, from the rotten wood. Frequent with typical specimens in Malaya.

var. **perstipitate** Corner (1934)

Stem without a basal disc, the basal part elongating and bearing an indistinct zone or slight ring (as the remains of the marginal veil) about the middle. Fruit-bodies small, with pileus -5 cm wide, stem -6 cm long. Much less common than the typical state in Malaya.

This description is condensed from the extended account that I gave in 1934. It is the commonest species of the genus in Malesia, and I do not regard it as the same as *O. platensis* of South America for the reasons given under that species. Both are placed in subgen. *Oudemansiella* because of the lack of pseudorhiza but f. *radicans* belies this distinction from subgen. *Xerula*. The veil in both species is so slight that, to be sure of its presence, it is necessary to section the unexpanded primordium.

There occurs on fallen branches in Tjibodas Botanic Garden, Java, a fungus which I class temporarily with f. *radicans* but it requires fuller investigation. The fruit-bodies are rather small with a pinkish to rufous tan pileus and a rather strong sour smell. It agrees with *O. canarii* microscopically except that the outer palisade of the pileus consists of rows of 2-3 or more inflated cells with the terminal cell clavate, in the manner of *O. lianicola*.

**Oudemansiella crassifolia** sp. nov. Figure 4

**Receptacula alba. Pileus 1.2-2.5 cm latus, convexus dein planus, viscidus laevis. Stipes 12-50 x 2.5-3.5 mm, basim abruptum vel subattenuatum versus 2.5-5 mm latus, subfloccosus, apicem versus pruinosus; velo annuloque non viso. Lamellae adnatae rotundatae, subconfertae dein subdistantes, crassae obtusae, acie saepe undulata, 14-28 primariae 2-3 mm latae, ordinibus 2-3. Caro tenuis, sub pilei superficie tenuiter gelatinosa. Sporae 21-28 x 19-24 μm, subglobosae laeves multiguttulatae. Basidia 70-130 x 25-28 μm. Cheilocystidia 55-130 x 13-38 μm, ut in *O. canarii*. Pleurocystidia 105-165 x 30-50 μm, clavata vel ventricosa, copiosa. Superficies pilei strato gelatinoso 300-500 μm crasso, hyphis efibulatis 2-5 μm latis pervaso, haud vallato, hypharum apicibus decumbentibus 3-8 μm latis vel in cellulis sparsis -35 x 16 μm**

**expansis. Ad lignum emortuum ramulisque solitaria in silva montana. Borneo, Mt. Kinabalu 1700m alt. Typus *RSNB 5483B;* herb. Corner.**

var. **incarnata** var. nov.

**Differt pileo stipiteque primo pallide incarnato; sporis minoribus 19-24 µm; cheilocystidiis brevioribus 40-65 x 10-38 µm; pilei superficie strato gelatinoso tenuiori 100-150 µm crasso. Ad truncos emortuos *Mangiferae* et *Pini* in silva montana. Malaya, Pahang, Cameron Highland 1500m alt. Typus, *Corner s.n.* 1 Oct. 1966; herb. Corner.**

Fruit-bodies entirely white. Pileus 1.2-2.5 cm wide, convex then plane, smooth, with a viscid pellicle. Stem 1.2-5 cm x 2.5-3.5 mm above, 2.5-5 mm below, pruinose upwards, fibrillose and subfloccose downwards to the abrupt or subattenuate base, not discoid; veil and ring none. Gills rounded adnate, rather crowded then subdistant, with a very thick obtuse and often undulate edge, 14-28 primaries 2-3 mm wide, 2-3 ranks. Flesh thin, with a thin gelatinous layer on the upper side.

On dead wood and sticks in the forest, solitary. Borneo, Mt Kinabalu 1700m alt.

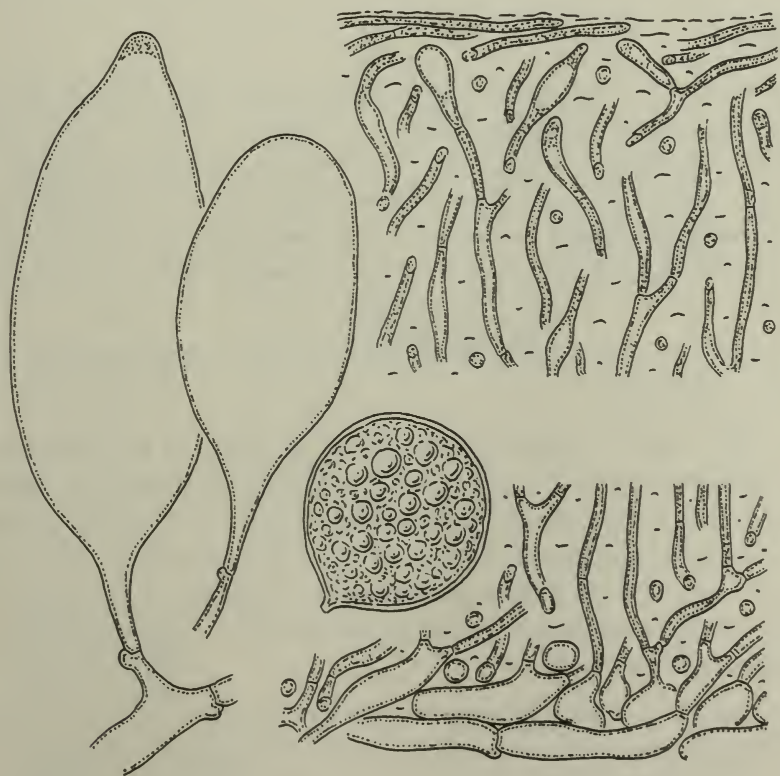


Figure 4. *Oudemansiella crassifolia.* Spore, x 1000. Pleurocystidia and surface of pileus, x 500.

Spores 21-28 x 19-24 µm, subglobose, smooth, multiguttulate. Basidia 70-130 x 25-28 µm, 4-spored; subhymenium -30 µm thick, composed of 2-3 µm hyphae, interwoven, not corticate. Cheilocystidia 55-130 x 13-38 µm, as in *O. canarii*, forming the very thick gill-edge and widest in the transitional zone to the hymenium. Pleurocystidia 105-165 x 30-50 µm, clavate or ventricose with obtuse or scarcely prolonged apex, stalk narrow, abundant, strongly projecting. Hyphae clamped except in the mucilage on the pileus; stem-cells 80-600 x 5-20 µm, cylindric or with tapered ends. Surface of stem with hyphae 3-6 µm wide, here and there entangled into fibrillose flocci, with scattered subclavate ends 5-9 µm wide. Surface of pileus with a gelatinous layer 300-500 µm thick, pervaded by 2-5 µm hyphae without clamps, branching but without forming any palisade, the hyphal ends at the surface more or less shortly decumbent on the mucilage with cylindric to subventricose ends 3-8 µm wide, also with a few scattered clavate cells -35 x 16 µm.

Collections.- Borneo, Mt Kinabalu, Bembangan and Mesilau valleys, 1700m alt.; *RSNB 5060*, 22 Jan. 1964; *RSNB 5483A*, 26 Feb. 1964; *RSNB 5483B*, 12 March 1964; *RSNB 5483C*, 16 March 1964.

var. **incarnata**

Pileus -6 cm wide, convex to plane, smooth, dry, opaque, pale pink, fading white from the centre outwards. Stem 1-1.5 cm x 2-3.5 mm, 3-4.5 mm at the abrupt base, subcylindric, thinly white villous downwards, pale pink then white. Gills adnate, separating free, thick, waxy, subdistant, 14-17 primaries -5 mm wide, 3 ranks, white. Flesh 2-3 mm thick in the centre of the pileus, floccose-tough, with a thin gelatinous layer at the surface, white. Smell rather sour and of cucumber.

On fallen trunks of *Mangifera odorata* and *Pinus sp*. Malaya, Pahang, Cameron Highlands, 1500m alt.

Spores 19-24 µm, subglobose. Basidia 60-88 x 20-24 µm; sterigmata 2-4. Cheilocystidia 40-65 x 10-38 µm, clavate to ventricose, obtuse, not appendaged, thin-walled, smooth, as a thick sterile edge of the gill, often with the subterminal cell or two inflated and ellipsoid to subglobose. Pleurocystidia 120-220 x 22-40 µm as in *O. canarii*, often slightly waisted, wall 0.5 µm thick. Structure as in var. *crassifolia* but the gelatinous layer on the pileus 100-150 µm thick with 3-6(-7) µm hyphase often disarticulating.

The fruit-bodies of this species seem characteristically small and solitary. The pileus has the gelatinous layer on the surface as in *O. canarii* but without distinct palisades unless the primordial pileus may have a single layer of clavate cells. The very thick gills with undulate edge are characteristic. I saw no sign of veil or annulus.

**Oudemansiella lianicola** sp. nov. Figures 5, 6

**Pileus -28 mm latus, convexus siccus, primo furfuraceus subvillosus, in centre valde ruguloso-reticulatus, pallide ochraceus centro subferrugineo. Stipes 30-40 x 3-4 mm, ad basim abruptum subbulbosum 5-7 mm, fistulosus, sursum albidus pruinosus, deorsum appresse fibrillosi-subfloccosus brunneus. Velum marginale vix evolutum, annulo nullo. Lamellae adnatae rotundatae subdistantes, haud vel vix venosae, 19-23 primariae 3-5 mm latae, ordinibus 3, albidae dein pallide ochraceae. Caro 3-6 mm crassa in pilei centro, firma, haud gelatinosa, flavidi-albidula. Sporae 10.5-13 x 8.5-9.5 µm, laeves, ellipsoideae multiguttulatae. Basidia 46-58 x 11-12.5 µm. Cheilocystidia 40-100 x 12-28 µm, clavate vel subfusiformia, ut acie lata sterili. Pleurocystidia 50-85 x 18-38 µm, clavate, nonnulla subtruncata, raro submucronata, copiosa. Superficies pilei e cellulis clavatis 70-120 x 15-40 µm, tunicis brunneis, et cellulis 25-70 x 8-38 µm subglobosis, tunicis brunneolis, in seriebus moniliformibus -300 µm longis instructa, sine fibulis. Ad lianos emortuos gregaria vel subcaespitosa, in silva montana. Borneo, Mt. Kinabalu 1400m alt. Typus, *RSNB 5006;* herb. Corner.**

Pileus -28 mm wide (not fully expanded), convex, dry, at first furfuraceus subvillous, strongly rugulose reticulate in the centre, minutely furfuraceous towards the substriate incurved margin, pallid bistre ochraceous or tan ochraceous, brownish towards the subferruginous centre. Stem 3-4 cm x 3-4 mm 5-7 mm at the abrupt subbulbous base, slightly attenuate upwards, hollow, fibrillose, whitish and subpruinose upwards, fawn brown and appressedly fibrillose-floccose or subfurfuraceous downwards, the base madder brown subvillous. Veil marginal,

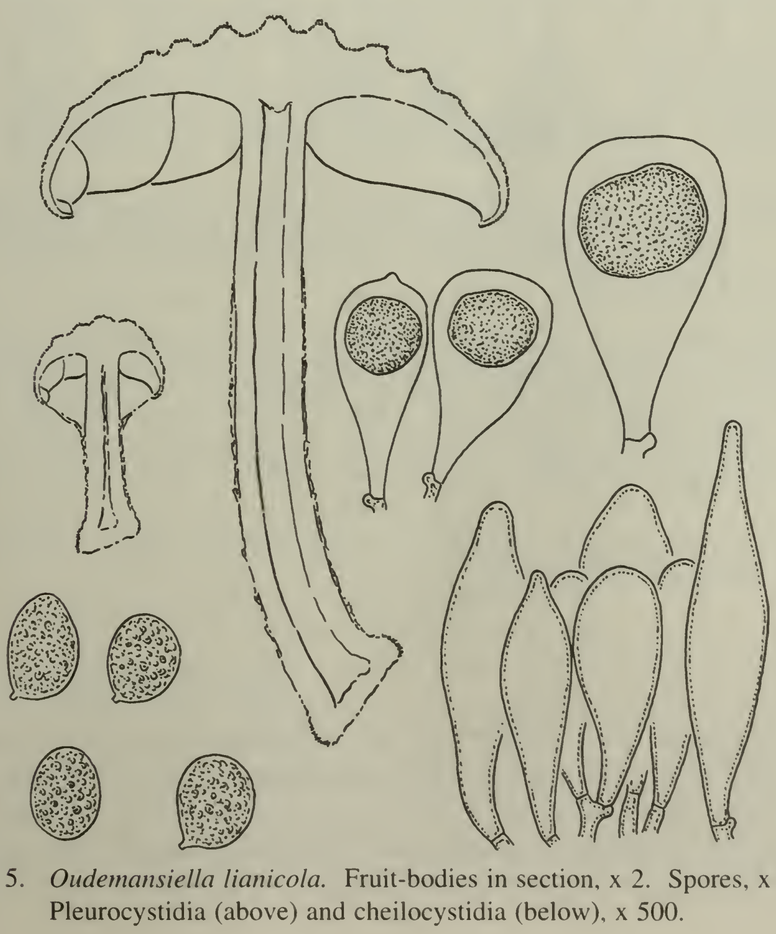


Figure 5. *Oudemansiella lianicola.* Fruit-bodies in section, x 2. Spores, x 1000. Pleurocystidia (above) and cheilocystidia (below), x 500.

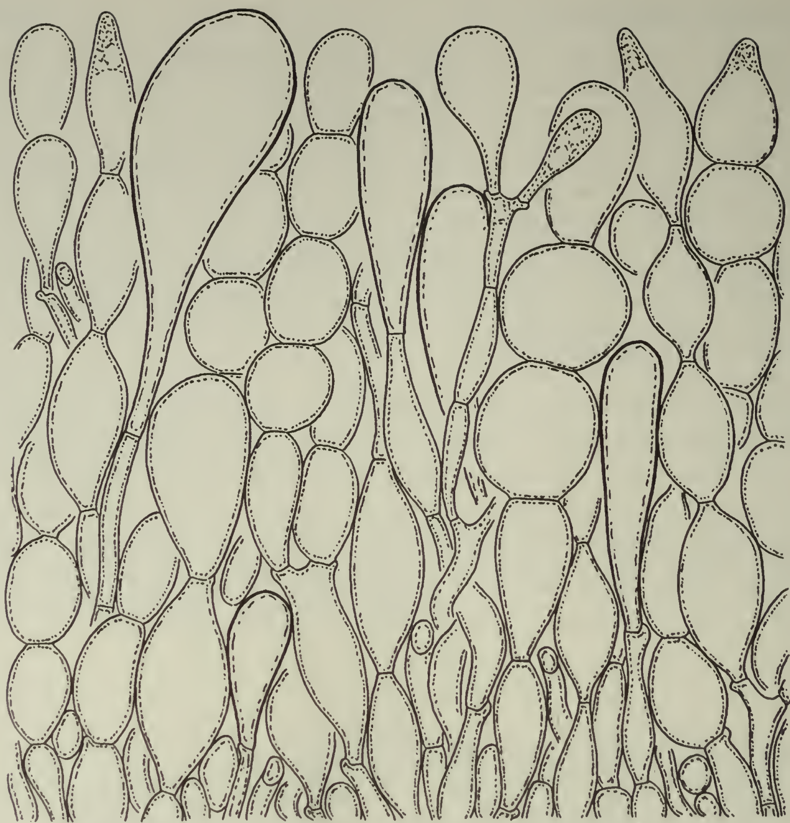


Figure 6. *Oudemansiella lianicola.* Surface of pileus, with several large clavate cells of the orighinal palisade and moniliform cell-rows of incursive hyphae, x 500.

very slight, fibrillar, leaving no trace on the stem. Gills rounded adnate, separating free, subdistant, not or scarcely veined, 19-23 primaries 3-5 mm wide, 3 ranks, cream white to pallid subochraceous. Flesh 3-6 mm thick in the centre of the pileus, rather firm, homogeneous, without a gelatinous layer, pallid yellowish white. Smell slight, subacrid.

On a dead hanging liane, gregarious to subcaespitose. Borneo, Mt Kinabalu, Mesilau 1400m alt, 18 Jan. 1964.

Spores 10.5-13 x 8.5-9.6 μm, white, smooth, ellipsoid, multiguttulate, inamyloid. Basidia 46-58 x 11-12.5 μm, 4-spored; no acerose basidioles; subhymenium narrow, composed of 2-4 μm hyphae, not corticate, becoming submucilaginous. Cheilocystidia 40-100 x 12-28 μm, clavate to subfusiform with obtuse apex, rarely shortly appendaged, thin-walled, smooth, as a broad sterile gill-edge. Pleurocystidia 50-85 x 18-38 μm, clavate, mostly subtruncate, not appendaged or occasionally submucronate, thin-walled smooth, very abundant, (the contents contracting in alcohol-formalin into a granular mass with fine membrane). Hyphae clamped; in the stem, with cells 70-500 x 5-36 µm or -50 µm wide and then often in moniliform rows at the base of the stem, septa broad and transverse to oblique. Surface of stem with loosely interwoven, longitudinal hyphae 3-12 µm wide, short-celled, with pale brown walls, the end-cells subclavate or subfusiform as on the pileus, these slight caulocystidia here and there loosely clustered into the furfuraceous particles especially towards the base of the stem with a loose tomentum of hyphae c. 200 µm thick. Surface of pileus covered by a fairly compact pile of hyphal ends 200-300 µm high in the centre or the pileus, consisting of large clavate cells 70-120 x 15-40 µm with dark brown walls and more or less moniliform rows of ellipsoid, pyriform or subglobose cells 25-70 x 8-38 µm with pale brown walls, with (and without) clamps; the young pileus covered with the large clavate cells, then on expansion developing the moniliform rows and causing the reticulation in the centre of the pileus; without a gelatinous layer.

The habitat of this fungus seems particular because, if it grew on ordinary wood fallen from trees, I would surely have found it in such places. The pileus develops the trichoderm of *Physocystidium*, though it begins with the hymenioderm as in *O. platensis*.

**Oudemansiella mucida** (Fr.) v. Hoehn. Figure 10

I have the following notes on English collections:–

Gills slightly veined at the base, 15-26 primaries 4-16 mm wide, 3-6 ranks. Flesh 3-10 mm thick in the centre of the pileus, 1-2 mm halfway to the margin, gelatinous in the gill-trama and at the surface of the pileus. Spores 14-18.5 µm, subglobose, with distinctly thickened wall. Cheilocystidia -95 x 7-12 µm, subfusiform subacute to clavate, rarely subventricose, thin-walled. Pleurocystidia none seen (collapsing), none (Ricken), -200 x 40 µm (Boursier 1926), 90-140(-180) x 15-30(-40) µm (Rea 1922). Surface of pileus with a single palisade of clavate cells 18-35 x 5-10 µm, occasionally obtusely ventricose, rather small, compact, derived from gelatinous hyphae 1.5-2.5 µm wide without clamps (other hyphae with clamps).

I note the account of physiological factors in the development of the fruit-body of this species by Semerdzieva and Musilek (1970).

**Oudemansiella platensis** Speg. Figure 7

It is now customary to regard this species, described and widely reported from south and tropical America, as identical with *O. canarii* of the Old World. I have seen these fungi commonly in Brazil and Malesia and I am not convinced that they are conspecific even though the fruit-bodies are extremely similar. Thus, I never gathered the Malesian fungus in South America or that in Malesia. They

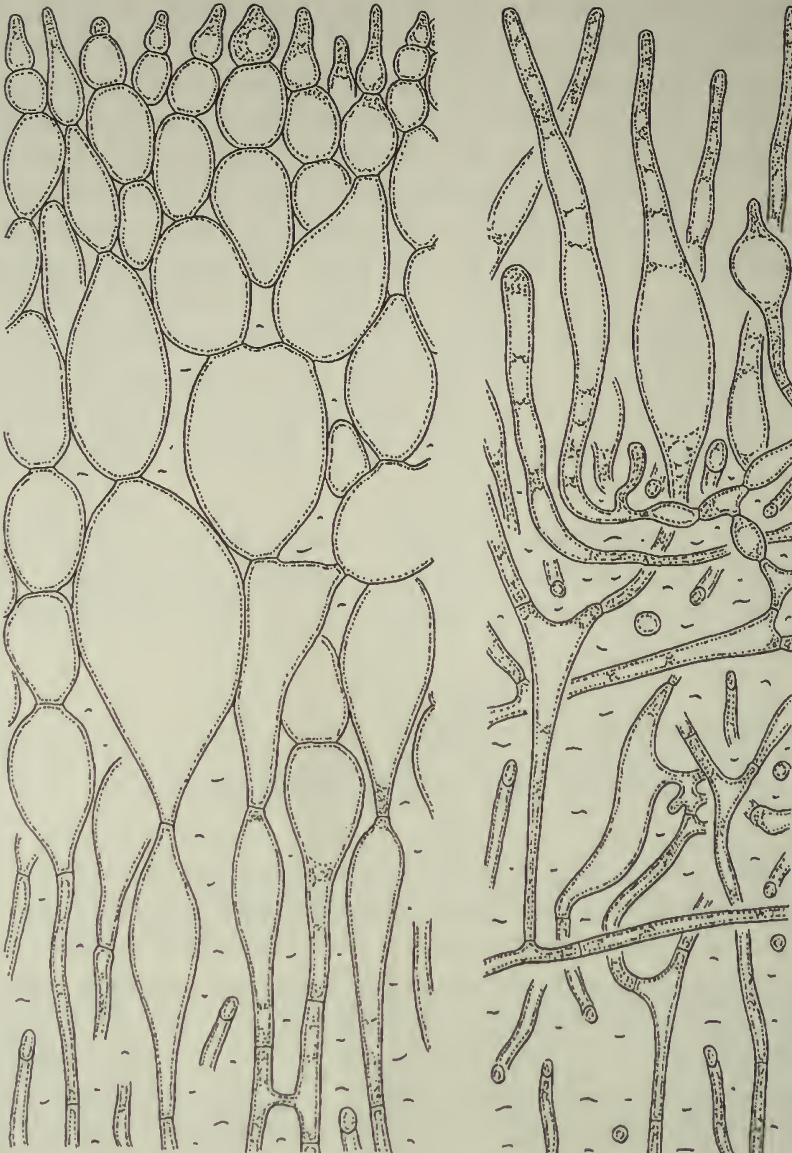


Figure 7. *Oudemansiella platensis.* (left) and *O. canarii* (right). Outer palisade on surface of pileus, x 500.

differ in the construction of the surface of the pileus which develops an almost pseudoparenchymatous tissue in what I regard as *O. platensis*. Therefore, the greyish flecks, which form from the disruption of this layer on the expansion of the pileus, are thicker and more conspicuous in the American species. I have the following details concerning *O. platensis*:-

Spores 15-25 µm wide, subglobose, wall slightly thickened. Basidia 70-80 x 18-21 µm. Cheilocystidia as in *O. canarii*. Pleurocystidia 170-280 x 30-46 µm, clavate to ventricose with a long obtuse appendage (as in *O. canarii*). Hyphae clamped except in the surface tissue of pileus and stem, but some collections of fruit-bodies apparently devoid of clamps. Surface of pileus with the double palisade of *O. canarii* but the outer palisade developing into an almost pseudoparenchymatous layer 200-300 µm thick, composed of moniliform rows of ellipsoid to subglobes cells 30-100 x 5-70 µm but smaller towards the surface and with end-cells 10-30 x 5-8 µm, mainly secondarily septate, thin-walled, colourless, this pellicle breaking into the flecks on the gelatinous layer; inner palisade with many clavate cells -40 x 7-15(-20) µm.

Collections from Niteroi, Chavantina and Manaus in Brazil; *Rick 286*, det. *O. platensis*, herb. Mus. Nac. Rio de Janeiro.

The thick superficial layer develops hypodermally from hyphal branches arising below the initial and simple outer palisade the cells of which persist among the stalks of the moniliform rows. Likewise, hyphal branches grow from just below the inner palisade into the gelatinous layer where they may also produce rows of more or less inflated cells before continuing to the outer palisade.

This complicated surface relates with that of *O. lianicola*. There may be another species in Amazonia resembling *O. platensis* but without gelatinous layer to the pileus, which I collected near Manaus 17 October 1948.

**O. radicata** (Fr.) Singer — Figure 1

For this common species I gave the following notes from collections made about Cambridge, England:-

Spores 14-16 x 10-11.5 µm. Cheilocystidia 60-130 x 10-25 µm, clavate to ventricose, obtuse, as a broad sterile gill-edge. Pleurocystidia similar, ventricose, obtuse, mostly capped by an oily brownish globule 10-28 µm wide. Surface of pileus with a single compact palisade of elegantly clavate cells 30-90 x 8-17 µm, with slender stalks, walls -1 µm thick (at least in the stalks), seated on interwoven submucilaginous hyphae 3-7 µm wide, no thick gelatinous layer, no ventricose-filiform pileocystidia. Stem hyphae with cells 250-700 x 5-45 µm (Boekhout and Bas), with broad transverse septa, clamped; some oleiferous hyphae 3-10 µm wide. Caulocystidia clavate, scattered.

**Oudemansiella ? radicata** var. **hygrophoroides** — Figure 8.
(Singer et Clemençon) Pegler et Young (1986).

The following description refers to a fungus which I collected in northern Japan and which certainly belongs to the complex of *O. radicata* in Hokkaido (Imai, 1938). However, it presents two problems. First, the presence of long pileocystidia as well as clavate cells in the palisade on the pileus, just as in the Malesian *O. altissima*, raises the question whether it belongs in sect.

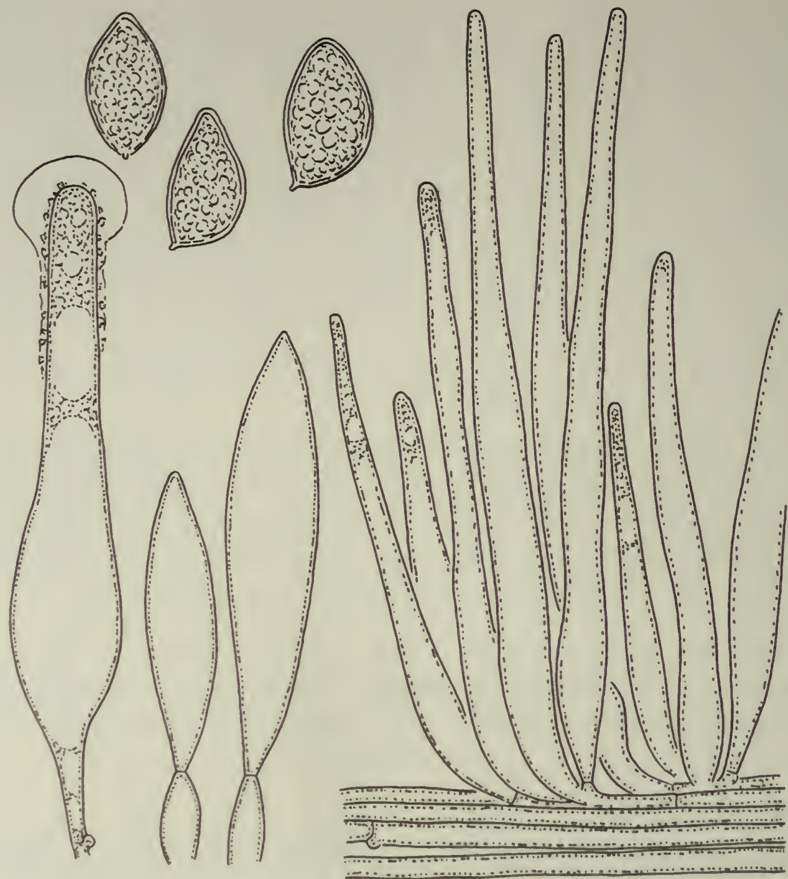


Figure 8. *Oudemansiella? radicata* var. *hygrophoroides* (from Japan). Spores, x 1000. Cheilocystidia and pleurocystidium, x 500. Caulocystidia in a cluster, x 500.

*Albotomentosae* or sect. *Radicatae*. If referred to the former, it does not fit any known species; if to the latter, it comes out as the European *O. radicata* var. *hygrophoroides*. It has the spores of *Xerula megalospora* Redhead, Ginns et Shoemaker but not its capitate cystidia. Second, there are scattered among the immature clavate basidia fusiform to subacerose basidioles which are one of the marasmioid features of *Xerula longipes*. I have never seen such basidioles in other species of *Oudemansiella*, to which genus all other features of its fruit-body conform.

Fruit-bodies as those of *O. radicata* with viscid regulose pileus 2-10 cm wide; stem finely brown scurfy from minute clusters of hairs. Rooting in the forest. Hokkaido, pr. Yamabe, 18 Sept. 1966.

Spores 16-19.5 x 9.5-11.5 μm, mango-shaped, even subapiculate, smooth, rather thin-walled, oily opalescent (alc. formalin material). Basidia 46-58 x 10-13 μm; sterigmata (3-)4, 7.5-9.5 μm long; acerose basidioles scattered among the young basidia. Cheilocystida 60-120 x 14-26 µm, ventricose, acute, not appendaged, thin-walled, but in some cases with the apex thinly oily-granular encrusted, as a sterile gill-edge. Pleurocystidia 90-160 x 18-28 µm, ventricose with prolonged subcylindric obtuse appendage 7-16 µm wide, more or less thickly oily-encrusted over the appendage, often with a brown oily resinous apical globule, thin-walled. Hyphae clamped, in the stem -14 µm wide and long-celled. Surface of stem with clusters of subcylindric or gradually tapering caulocystidia 40-220 x 6-13 µm, simple, aseptate, with smooth and firm or slightly thickened walls, the obtuse apex 3-6 µm wide, arising in clusters from the ends of 1-3 hyphae. Surface of the pileus with a palisade of clavate cells 40-70 x 8-20 µm, thin-walled or the stalks slightly thick-walled and apparently buried in mucilage, also many pileocystidia similar to the caulocystidia but narrower, 5-8 µm with the apex 3-5 µm, rarely -16 µm.

**Oudemansiella raphanipes** (Berk.) Pegler et Young (1986)

***O. brunneomarginata*** **L. Vassiljeva; Endo and Hongo, Trans. mycol. Soc. Japan 17 (1976) 345, f.1; Yokoyama, Fungi of Japan (1989) 121; Imazeki and Hongo, Coloured Illustrations of mushrooms of Japan (1987) f. 154.**

Pegler and Young give *O. brunneomarginata* as a synonym of *O. raphanipes* in sect. *Radicatae* of subgen. *Xerula*. This subgenus was defined in Pegler and Young's key as comprising fruit-bodies arising from a pseudorhiza growing from buried roots. *O. raphanipes* was distinguished in their key by the minute reflexed squamules on the stem. Yet, the Japanese fungus described and illustrated by the Japanese authors, grows on dead trunks of *Acer mono* with a pseudorhiza evidently penetrating the rotten wood, much as in *O. canarii* f. *radicans*, and it does not appear to have the recurved squamules on the stem. Whatever the true identity of the Japanese fungus may be, it transgresses the distinction in habit between the two subgenera.

**Oudemansiella steffenii** (Rick) Singer  Figure 9

**Lilloa 26(1953) 66; Pegler and Young (1986) 599.**

***O. echinospora*** **Singer, Mycologia 37 (1945) 439.**

Pileus 3-13 cm wide, convex to plane, opaque, dry, very smooth or radially rugulose towards the striate margin, fuscous fuliginous then fuscous ochraceous to fuscous bistre over the limb. Stem 6-16 cm x 3-10 mm upwards, 4-20 mm at ground level, white and fuliginous scurfy pruinose or fibrillose to more or less entirely fuliginous; rooting base rather short or up to 15 cm long. Veil and ring not formed. Gills adnexed, scarcely crowded, c. 25 primaries 4-11 mm wide, 3 ranks, white with pale fuscous edge. Flesh 3-10 mm thick in the centre of the pileus, firmly fleshy, without a gelatinous layer.

On the ground in forest, mostly solitary. South America.

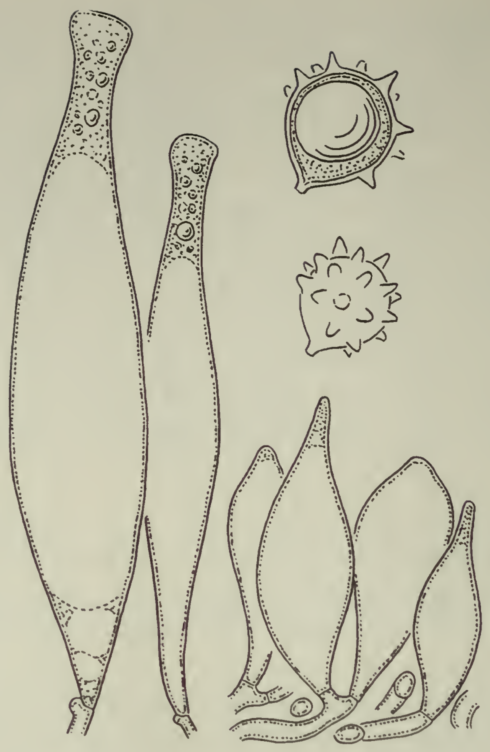


Figure 9. *Oudemansiella steffenii.* Spores, x 1000. Pleurocystidia (large) and pileocystidia, x 500.

Spores 11-15 µm wide (spore-body), white, subglobose, varying rather sparsely to closely verrucose to echinulate with conical, obtuse to acute, warts 1.5-3 x 1-1.5 µm, thin-walled, guttate, inamyloid. Basidia 65-80 x 18-24 µm, evidently dimorphic; sterigmata (2-3-)4. Cheilocystidia 40-75 x 15-30 µm, clavate, thin-walled, smooth, with fuscous sap, as a sterile gill-edge. Pleurocystidia 100-180 x 25-35 µm, ventricose-fusiform, often with subcapitate to subtruncate apex 13-17 µm wide, thin-walled, smooth. Caulocystidia as in *O. canarii* but with fuscous sap as in many superficial hyphae of the stem. Surface of pileus with a single palisade of clavate to ventricose cells 45-75 x 15-30 µm, thin-walled, with fuscous sap, arising from a firm layer of narrow, interwoven hyphae with fuscous sap, without a gelatinous layer, without long pileocystidia. All hyphae in the fruit-body with clamps.

These are my notes on the fungus as I found it, rather commonly, in Brazil.

**Oudemansiella submucida** sp. nov. Figure 10

**Pileus 1-10 cm latus, convexus dein planus, glutinoso-pelliculosus laevis, albus dein subochraceus, marginem versus substriatus. Stipes 1.5-7 cm x 1.5-10 mm, ad basim vix incrassatus, fibrosus firmus siccus, primo subfloccoso-fibrillosus, albus dein subochraceus; annulo 2-6 mm lato, prope stipitis apicem, membranaceo pendenti albo, etiam aliquando deficienti. Lamellae adnexae vel**

**adnatae, ventricosae subdistantes crassae ceraceae puberulae, haud venulosae, primariae 16-28 2-14 mm latae, ordinibus 3, albae. Caro 2-10 mm crassa in pilei centro, hygrophana, ad auperficiem tenuiter glutinoso-pelliculosa, alba. Sporae 18-25 x 17.5-23 μm, subglobosae laeves. Cheilocystidia et pleurocystidia ut in *O. canarii*. Pellicula pilei e cellulis clavatis 25-35 x 15-25(-30) μm, e strato subgelatinoso angusto orientibus, instructa. Ad truncos delapsos in silva montana. Borneo, Mt. Kinabalu c. 1700m alt. Typus, *RSNB 5201*; herb. Corner.**

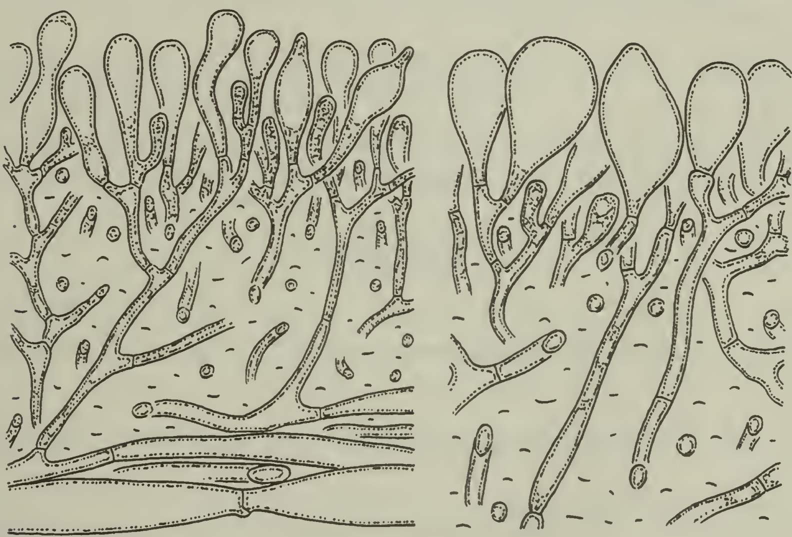


Figure 10. *Oudemansiella mucida* (left) and *O. submucida* (right). Spores of pileus, x 500.

var. **persicca** var. nov.

**Differt pileo sicco sine strato mucilaginoso, etiam pilei hymeniodermate laxe evoluto. Borneo, Mt. Kinabalu, Mesilau 1700m alt., Aprile 1964. Typus, *RSNB 5201A*; herb. Corner.**

Pileus 1-10 cm wide, convex then plane, smeary viscid, pelliculose, smooth, without flecks of veil, white to pale butter ochraceous, substriate towards the margin. Stem 1.5-7 cm x 1.5-10 mm, base slightly thickened, fibrous, firm, dry, at first slightly floccose-fibrillose, white then pale butter ochraceous from below upwards. Ring 2-6 mm wide, near the stem-apex, membranous, pendent, collapsing, white, but some specimens without the ring. Gills adnexed to adnate, subdistant, not veined, thick, waxy, puberulous, 16-28 primaries 2-14 mm wide, 3 ranks, white. Flesh 2-10 mm thick in the centre of the pileus, hygrophanous, thinly viscid-gelatinous at the surface but bounded by a pellicle, no conspicuous gelatinous layer, white.

On fallen trunks in montane forest. Borneo, Mt. Kinabalu.

Spores 18-25 x 17.5-23 μm, white, subglobose, smooth, wall slightly thickened. Cheilocystidia and pleurocystidia as in *O. canarii*. Hyphae clamped except those in the pellicle of the pileus; in the stem with cells 90-850 x 5-34 μm, the longer often tapered; in the pileus -45 µm wide and rather spindle-shaped; in the ring 3-8 µm wide, unspecialised. Pellicle on the pileus composed of a fairly compact palisade of smooth, more or less clavate, cells 25-35 x 15-25(-30) µm, seated on a narrow subgelatinous layer of hyphae 2-4 µm wide and without clamps.

Collections.- Borneo, Mt Kinabalu, Tenompok, 8 Sept. 1961, *RSNB 2890*; Mesilau 2 Feb. 1964, *RSNB 5201*.

This species comes between *O. canarii* and *O. mucida*, having the fruit-body and surface structure of the pileus as in *O. mucida* and the large spores and cystidia of *O. canarii*. It differs from *O. mucida*, also, in the dry stem and larger clavate cells on the pileus. The dryness is emphasized by var. *persicca*.

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Plate 1. *Oudemansiella altissima.* Specimens from Singapore.

# On the Agaric Genera *Hohenbuehelia and Oudemansiella*
# Index to Parts I and II

# Flora Malesianae Precursores - LVIII, Part Four*
# The Genus *Schima* (Theaceae) in Malesia

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## Abstract

This is a taxonomic treatment of 3 species of *Schima* (Theaceae) found in the Malesian region. Two, *S. brevifolia* and *S. monticola*, were at one time reduced to the status of subspecies.

## Introduction

The binomial *Schima noronhae* Reinwardt first appeared in Blumes' *Catalogus* (1823); descriptions for the genus and species were added and thus validated their status in his *Bijdragen* two years later. The generic name is derived from the Greek word *skiasma* (shadow), generally interpreted as referring to the dense crown of the plant.

Several *Schima* species were previously described under the genus *Gordonia*. Both genera are characterized by the showy, typical theaceous flowers and the usually 5-valved capsules. Blume, in defining the new genus, pointed out that *Schima* differs from *Gordonia* in their calyx and fruit characters. Subsequent authors also noted their difference in seed characters. These can be summarized as follows.

***Gordonia:–***

Sepals 5 or 6, usually large, unequal, overlapped and imbricate, free, often deciduous; capsules ellipsoid to cylindric-oblong, often angulate and sometimes sulcate; seeds ovoid or ellipsoid, flattened, with a large obliquely attached knife-shaped apical wing.

***Schima:–***

Sepals 5, rarely 6, smaller, almost equal, weakly imbricate and seemingly valvate in a fully expanded flower, united below, persistent; capsules globose or nearly so; seeds broadly reniform, surrounded by a narrow membranous wing except near the funiculus.

Species of *Schima* are distributed from E. Himalayas eastwards through Myanmar, S. China to Taiwan, Ryukyu and Bonin (Oganawara) Islands, and southwards to Thailand, Indo-China and W. Malesia. No general consensus on the number of species of the genus has been reached. For example, Melchior (1925) cited 18 species; Airy-Shaw (1973), 15 species; How (1982), 30 species; and Mabberley (1987), 1 species.

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* Part One to Three: The genera *Pyrenaria, Gordonia*, and *Camellia* (Theaceae) in Malesia, in Gardens' Bulletin, Singapore 33 (1980), 254-289; 37 (1984), 1-47; and 42 (1989), 65-69, respectively.

The last-named author obviously based his opinion on the conclusion drawn by the late Dr. S. Bloembergen (1952). In that treatment, the genus *Schima* contains only 1 species, namely, *Schima wallichii* (DC.) Korth., which, in turn, is divided into 9 subspecies. The main arguments as to why *Schima* is considered monotypic are: (1) the variation of the 'vegetative parts' (leaf-blades and petioles) varies between clear-cut and rather narrow limits, and (2) the generatives (flowers and fruits) could never be used in the delimitation of species, as they vary merely in dimensions and not in number or forms of the composing parts (Bloembergen, 1952; p. 141). He also frankly admitted that he only examined 'few examples from the area outside Indonesia', but his 'study of the scanty amount of specimens, literature and the drawings seen appeared more than sufficient covering' (p. 133).

It is a fact that size of the flower of *Schima*, like many other plants, can be affected to a certain extent by the environment (e.g., soil condition, altitude, etc.) and the age and condition of the tree, and also even small, immature fruits can be dehiscent after the processes of pressing and drying. Nevertheless, the extreme view of totally disregarding all reproductive characters appears to deviate from the traditional practise of generations of taxonomists. Furthermore it is perhaps rather imprudent to extrapolate the conclusion based on the study in a limited area to the whole range of the genus.

Incidently, should Bloembergen's broad species concept be accepted it would be probably necessary to revise almost all the existing monographs of theaceous genera, such as Kobuski's *Eurya* (1938), *Adinandra* (1947), Sealy's *Camellia* (1958), etc. and drastically reduce the number of species of each genus.

Dr. Bloembergen divided the monotypic 'species' into nine 'subspecies' and presented these 'subspecies' in a map (his Fig. A, on p. 150) which shows that most of them are geographically isolated. The fact is that these subspecies are of rather different qualifications: some of them are almost indistinguishable, while others appear to be perfectly good species in the traditional sense.

For instance, as shown in his map, subsp. *noronhae* is found in N.W. Borneo, and subsp. *crenata*, in E. Borneo. Their difference is largely based on the lamina margins: margins mostly completely entire vs. margins mostly crenate-dentate. Exceptions to this are explained in his key and again in the descriptions under each subspecies. His definition of subspp. *noronhae* and *wallichii* is even more deficient, practically all the characters mentioned in the diagnoses of both subspecies overlap. Dr. Bloembergen conceded that subsp. *wallichii* 'is very close to subsp. *noronhae*, but is evidently much less polymorphous, a typical character being the prominent nervation and the generally forked lateral nerves'. Unfortunately even the final point does not always stand.

On the other hand, in his discussion under subsp. *brevifolia*, Dr. Bloembergen (p. 176) reported that Prof. C.G.G.J. Van Steenis once erroneously mentioned the occurrence of this plant from Sumatra. He predicted that the specimens misquoted (*Steenis 8636* and *9653*) belong either to *Laplacea* or *Gordonia*. This plant in question, in fact was first named *Laplacea vulcanica* Korthals, and later, renamed *Gordonia vulcanica* (Korth.) H. Keng (Keng, 1984; p. 42). It appears to be inconceivable that these two plants so strikingly similar in many aspects should be accorded two different taxonomic status, one a species and the other a subspecies, in two closely related genera. Its small, subsessile, rounded-ovate leaves and prominent flowers are outstanding. Another of his subspecies, subsp. *monticola*, with thick coriaceous leaves and strongly thickened pedicels of flowers is deemed to be a good species in the traditional sense.

In this treatment, most of Bloembergen's subspecies as they occur in Malesia are merged into the species, with the exception of two, namely subspp. *brevifolia* and *monticola*, which are resurrected to their original specific status. Because of the limitation of knowledge and availability of materials, this treatment is confined only to the Malesian region.

## General Account of the Taxonomic Characters

The Malesian *Schima* species are mostly medium to tall evergreen trees, sometimes shrubby at higher altitudes. The branches and branchlets are generally glabrous or glabrescent, rarely pubescent.

The leaves are simple, alternate and spirally arranged on the branchlets. The leaf margins are entire, or partly or totally, weakly or strongly undulate or serrate. Petioles are long or short, or subsessile, mostly slender, sometimes thickened.

The flowers are borne in axillary, solitary or more often in an apical cluster resembling a cymose or corymbose inflorescence. Following the activation and elongation of the central dormant bud in the cluster, it becomes clear that each individual flower is actually borne in the axil of a caducous scale. Sometimes these flower clusters can be further aggregated into a terminal paniculate conglomerate.

The flowers are hermaphrodite. Pedicles long or short, slender or stout, generally 2-bracteolate at the apex; the bracteoles are caducous. Calyx and coralla are clearly differentiated. Calyx is 5-, rarely 6-lobed, the lobes deltoid-rounded, ± equal, weakly imbricate in bud, persistent. Petals are 5, rarely 6 or 4, of unequal sizes, shortly connate below; the most exterior one is the smallest, strongly concave and tightly enveloping the other petals in bud. They are white in colour, often with pink tinge on the outer surface near the base or at the tip.

The androecium consists of numerous stamens which are in 3 to 4 whorls. The stamens are briefly united below and also adnate to the base of the corolla and they shed together after anthesis.

The gynoecium consists of a globose ovary, a stout style and a club- or disc-shaped stigma. The ovary is silky tomentose, usually 5-, sometimes 6-loculate, with 3(2-5) ovules in each locule.

The fruit is a woody capsule, mostly depressed globose, rarely slightly elongated, loculicidally dehiscent into 5 valves. The valves eventually break off, leaving a persistent thick, grooved, central columella. Seeds generally 1 or 2, sometimes 3 or more in each locule, broadly reniform, flattened, narrowly winged all round except near the point of attachment. The embryo is large, fleshy and slightly curved; the endosperm is a thin layer surrounding the embryo.

## Taxonomic Treatment

**Schima** Reinwardt ex Blume

**Cat. (1823) 80, *nom. nud.*, Bijdr. (1825) 129; Benth. in B. & H. Gen. Pl. 1 (1862) 185; Melchior in E. & P. Pflanzenfam. ed. 2, 21 (1925) 138; Bloembergen in Reinwardtia 2 (1952) 134.**

Small to tall trees, rarely shrubs. Leaves simple, alternate and spirally arranged, entire or shallowly crenate or serrate. Flowers bisexual, axillary or subterminal, solitary or many congested into a racemose or cymose cluster, sometimes paniculate; pedicels long or short, with 2 bracteoles at or near the apex, caducous; calyx-lobes 5, sometimes 6, deltoid-rounded, subequal, persistent; petals 5-6, shortly connate below, unequal, the outermost one, oblong and concave; stamens numerous, briefly united and adnate to corolla at base; ovary spherical, mostly 5-loculate, with 2 to 5 (mostly 3) ovules per locule, on axile placentation; style solitary, stout, enlarged and shallowly lobed above into a stigma. Capsule globose or slightly depressed above, woody, dehiscing loculicidally into 5 (rarely 6 or 4) valves, with a thick and grooved, persistent central columella. Seeds reniform, strongly flattened, narrowly winged around except near the funicule; embryo large and fleshy, slightly curved; endosperm in a thin layer enveloping the embryo.

A genus with probably around 10-15 species occurs in East and Southeast Asia. Three species are found in western Malesia.

There is a nomenclatural complication of the generic name *Schima*. In 1823, Blume (Catalogus. p. 80) listed *Schima noronhae* Reinw. and a new species, *Schima excelsa* Bl. Only the new species was provided with a very brief description. Later he realized that *S. excelsa* belongs to the genus *Gordonia*, and to which it was duely transferred (Bijdr. 3, p. 130). Meantime, he also prepared generic and specific descriptions for Reinwardt's naked names of *Schima* and *Schima noronhae*, thus validating both.

The crucial point is the validity of the earlier *Schima* in 1823 as it mentioned two species of which only one was described. Lacking a generic description, the description of one species (namely *S. excelsa*) could therefore be maintained as a combined generic and specific description. Thus if the *Schima* Reinw. ex Bl.

1823 was validly published, then the 1825 name was a later homonym and could only be maintained by conservation. The late Professor C.G.G.J. van Steenis (in Taxon 2 (1953)115) therefore proposed to conserve *Schima* Reinw. ex B1. 1825. A majority of the members of the Committee for Spermatophyte Conservation of generic names of IAPT at a 1959 meeting, however, decided that the 1823 publication was invalid and the 1825 name could stand without conservation (Taxon 9 (1960) 15).

## Key to the species

A. Petioles of leaves subsessile, generally 2-3mm long; leaf-blades mostly rounded ovate to obovate. .......... **S. brevifolia**

A. Petioles of leaves usually more than 1 cm long; leaf-blades generally lanceolate to oblong.

- B. Leaf-blades generally thick coriaceous; pedicels, especially the upper part strongly thickened (usually over 3 mm across). .......... **S. monticola**
- B. Leaf-blades generally chartaceous to coriaceous; pedicels mostly slender (generally less than 2 mm across). .......... **S. wallichii**

### **Schima brevifolia** (Hook. f.) Stapf

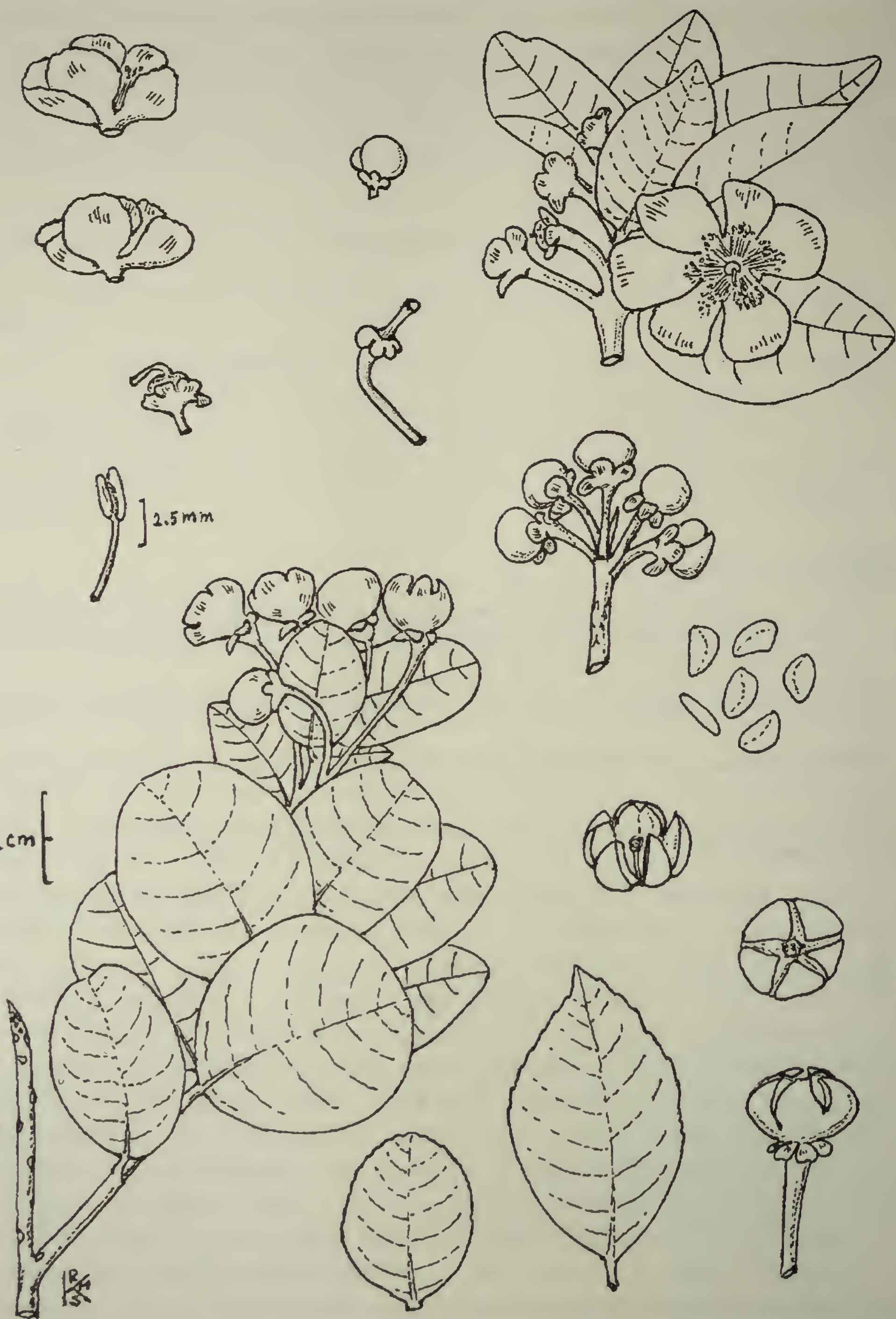
**Hook, Icon, Pl. 23(4)(1893) *pl. 2264;* in Trans. Linn. Soc. Bot. 2(4) (1894) 135; Gibbs in J. Linn. Soc. Bot. 42 (1914) 60; Airy-Shaw in Kew Bull. 1914 (1914) 498: Melch. in E. & P. Pflansenfam. ed. 2, 21 (1925) 139.**

***Gordonia brevifolia* Hook. f. in Trans. Linn. Soc. 23 (1860) 162; Burk. in J. Str. Br. As. Soc. Beng. 76 (1917) 158.**

***Schima noronhae* Reinw. ex B1. subsp. *brevifolia* (hook. f.) Steenis in Bull. Jard. Bot. Btzg. III. 13 (1936) 50.**

***Schima wallichii* (DC.) Korth. subsp. *brevifolia* (Hook. f.) Bloemb. in Reinwardtia 2 (1952) 177, f. C 8 & 10. J. 5-9.**

A spreading shrub, 1.5-2m high, rarely a small tree, to 5m tall. Leaves generally crowded on the tips of branches; leaf-blades coriaceous, broadly ovate or ovate-elliptic, sometimes suborbicular, 2.5-5(-8) cm long, 2-4 (-6.5) cm wide, apex obtuse or rounded, sometimes briefly subcaudate, base rounded or subcordate; margin subentire or finely crenulate; lateral veins 6-9 pairs, merged and looped into submarginal reticulation; young leaves soft white silky pubescent beneath, mature ones glabrous or glabrescent on both surfaces; petiole short and stout, usually 2-3 mm long. Flowers 4-5 cm across, solitary in upper leaf-axils, often congested at the top of branchlets, in cyme-like or raceme-like clusters; pedicels 1.2-1.6 (-3) cm long, slightly thickened toward the apex, 2-bracteolate, glabrous or pubescent; calyx mostly 5-lobed, the lobes deltoid or subcordate, 3-5 mm long; petals 5, rarely 6, creamy white, often with a tinge of pink near the base, obovate or rounded, subequal, 2-2.5 cm long with a cuneate base, soft pubescent or pilose on the outer surface especially near the base ovary globose, hirsute. Capsule depressed globose, 1.6-2.5 cm across, glabrous or velvet.




**Schima brevifolia** (Hook. f.) Stapf

Distribution. Borneo (Sabah and Sarawak).

Sabah. Ranau, Mt. Kinabalu (numerous collections, only representative specimens cited), *J. & M.S. Clemens 32444, 32637; G. Mikil SAN 31772, 41769; J. Sinclair et al. 80383.*

Sarawak, Kalabit Highlands, Mt. Murud, *P. Chai 02045*; *H.P. Nooteboom & P. Chai 02272.*

Ecology. In montane oak forest, mossy forest, or on sandstone at the summit or on slopes; from 1800 to 3500m.

**Schima monticola** Kurz

**J. As. Soc. Beng. 43(2)(1874) 93, 181; For. Fl. Burm. 1 (1877) 107; Szyszyl. in E. & P. Pflanzenfam. 3(6) (1895) 186.**

***Schima noronhae*** **Reinw. ex Bl. var.** ***rigida*** **Ridl. Fl. Mal. Pen. 1 (1922) 202.**

***Schima forrestii*** **Airy-Shaw in Kew Bull. 1936 (1936) 496.**

***Schima wallichii*** **(DC.) Korth. subsp.** ***monticola*** **(Kurz) Bloemb. in Reinwardtia 2 (1952) 176,** ***f. C9 & 11, J4 a-c.***

Small, medium-sized to tall tree, 5-10 up to 35m high, much branched; bark dark brown, scaly, or coarsely irregularly dippled; the branches and branchlets glabrous or silky pubescent. Leaf-blades thick-coriaceous, elliptic or oblong lanceolate, 6-10 (-15) cm long, 4-7 (-8) cm wide, apex acute, acuminate or subrounded, base obtuse, margin crenulate to crenate-serrate, lateral veins 9-12 pairs, less distinct, glabrous above, glabrescent or silky pubescent beneath; petiole 1-2 cm long. Flowers 4.5-7 cm across, axillary, solitary, often congested above in raceme- or cyme-like clusters; pedicels 1.5-3 (-5) cm long, prominently swollen over their entire length especially the upper part, shallowly two-keeled on the dried specimens; bracteoles deltoid, 3-6 mm wide; calyx reddish, mostly 5-lobed, the lobes subrounded, 3-6 mm long, silky pubescent externally; corolla 4.5-6 cm across, white with pink tinge on the outer surface. Fruit depressed globose, 1.5-2.5 cm across, silky tomentose.

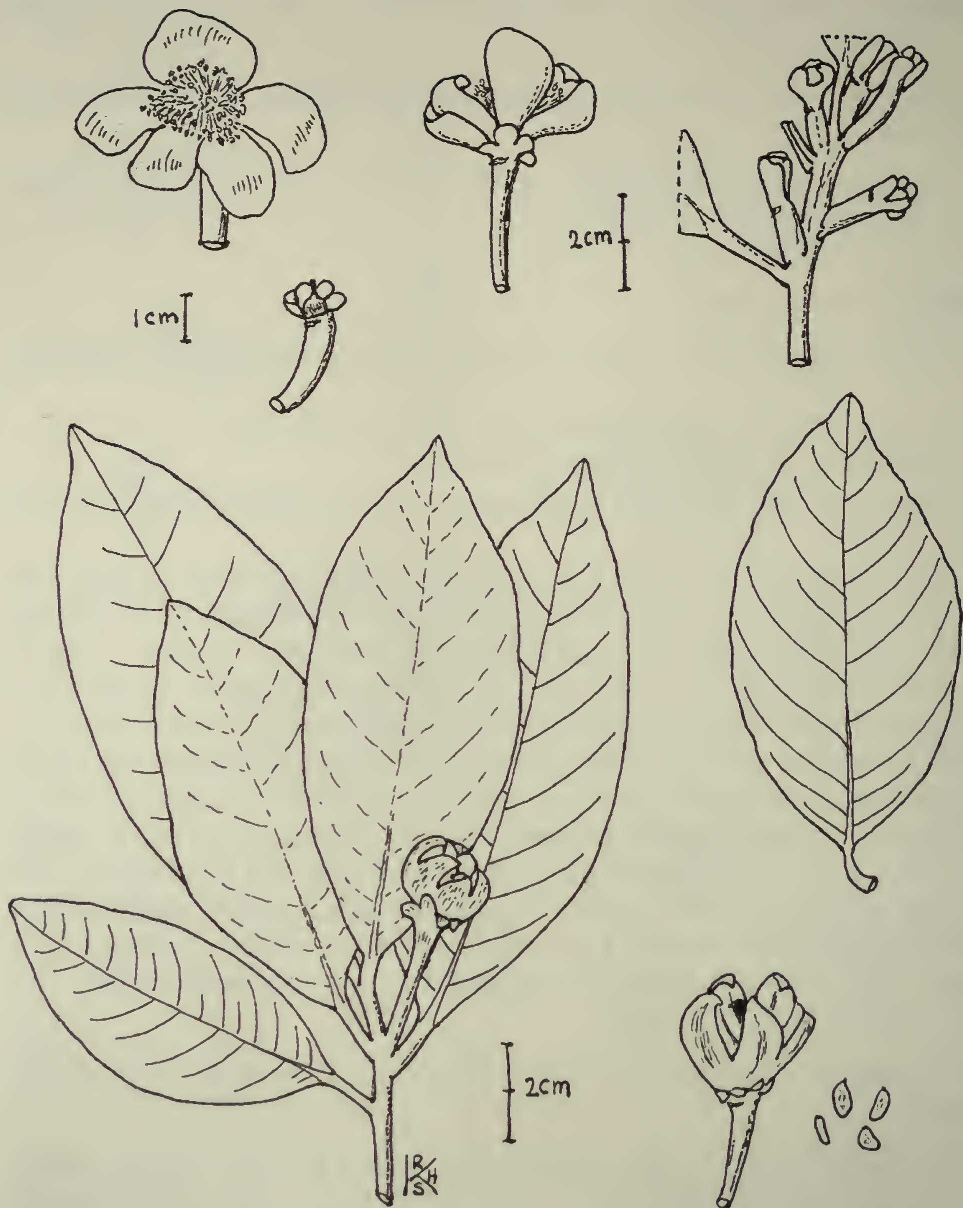
Distribution. Myanmar, S.W. China and Malesia (The Malay Peninsula and Borneo).

Malay Peninsula: G. Tapis, Pahang, *Y.C. Chan FRI 19858, P.F. Cockburn FRI 11004*; Cameron Highlands, *J.F. Maxwell 78193*; G. Ulu Kah, Pahang and Selangor Border, *T.C. Whitmore FRI 12210*; G. Padang, Trengganu, *Whitmore FRI 12660, 12664, 12724.*

Borneo (Sarawak, Brunei, Sabah and Kalimantan)

Sarawak. Ulu Sg. Dapur, Mt. Murud, *Ilias Paie S 26446*; Kalabit Highlands, *H.P. Nooteboom & P. Chai 01721, P. Chai S35927.*

Brunei. Ulu Tanburong, Medaint Watershed Ridge, *P.S. Ashton 2553.*




**Schima monticola** Kurz

Kalimantan. G Paris, South of Long Bawan, Krayan, *Koto Okamoto & Ueda Walujo B. 7488.*

Sabah. (Representative specimens) Mt. Kinabalu, *W.L. Chow & E.J.H. Corner RSNB 4082, J. & M.S. Clemens 31987, 32435, 33197; G.H.S. Wood SAN 16717.*

Ecology. It is usually found in dipterocarp or oak forests at 1400 to 1800m, sometimes can reach as high as 2200m on top of the ridges. It also occurs in *Agathis* forest or heath forest at 500-700m in certain coasts of Borneo.

**Schima wallichii** (DC.) Korth.

**Kruidk (1842) 143; Choisy in Zoll. Syst. Verz. 2 (1854) 144; Miq. Fl. Ind. Bat. 1 (1859) 492; Foxw. in Philip. J. Sc. 4 (Bot.) (1909) 503; Bloemb. in Reinwardtia 2 (1952) 136,*p.p.*; Back. & Bakh. f. Fl. Java 1 (1963) 321.**

***Gordonia Wallichii* DC. Prodr. 1 (1824) 528.**

***Schima noronhae* Reinw. ex Bl. Cat. (1823) 80, *nom. nud.*, Bijdr. (1825) 130; Miq. Fl. Ind. Bat. 1 (1859) 492; Ridl. Fl. Mal. Pen. 1 (1922) 201.**

***Schima crenata* Korth. Kruidk (1842) 143,*pl. 29.***

***Schima antherisosa* Korth. Kruidk (1842) 145; Miq. Fl. Ind. Bat. 1 (1859) 492.**

***Schima hypoglauca* Miq. Sum. (1862) 190, 484.**

***Schima bancana* Miq. Ann. Mus. Bot. Lugd.-Bat. 4 (1868) 113.**

***Schima rigida* Miq. l.c. 4 (1868) 113.**

***Schima sulcinervia* Miq. l.c. (1868) 113.**

***Schima lobbii* (Hook. f.) Pierre, Fl. For. Cochinch. 2 (1887) pl. 121.**

***Schima pulgarensis* Elm. Leafl. Philip. Bot. 5 (1915) 1843.**

Small to large tree, 5-30 (-45)m tall; young branchlets appressed pubescent, old ones glabrous or glabrescent; bark pale reddish to dark brown, fissured. Leaf-blades usually chartaceous to thin coriaceous, lanceolate to oblong-elliptic, 7-15 (-24) cm long, 1.5-5 (-7.5) cm wide, apex acute or acuminate, base acute, margin entire, shallowly crenate to serrate, glabrous or glabrescent on both surfaces, glaucous or sometimes pubescent below, especially along the midrib; petiole 1-2.5 (-3) cm long. Flowers 4.5-7 cm across; pedicel slender, often slightly thickened near the tip, 1.5-4 (-6) cm long; calyx-lobes subrounded, 2.5-3 mm across; petals ovate or obovate, unequal, white, sometimes with a tinge of pink near the base externally, 2-3.5 cm long, labrous or glabrescent on the inner surface, pubescent or partly so on the outer surface; ovary densely pubescent. Capsule spherical or depressed globose, silvery pubescent, 1.5-2 cm across, generally bearing a style-base.

Distribution. From Nepal, Sikkim, Assam, Myanmar, S. China to Malesia (The Malay Peninsula, Sumatra, Java, Borneo, Celebes and the Philippines.) (only representative specimens are cited)

The Malay Peninsula. Fraser's Hill, Pahang, *van Balgooy 2071*; Penang Hill, Penang, *S. Chelliah FRI 98134*; Maxwell's Hill, Taiping, *B. Everrett FRI 13570*; G. Ledang, Johore, *H.S. Loh FRI 19200*; Taman Negara, Pahang, *E. Soepadmo 910.*

Sumatra. Banka, *Bünanmeijer 1409, 1903*; G. Malintang, *Bünnanmeijer 3624*; Palembang, *F.H. Endert 314*; G. Leuser, Atjeh, *de Willde & de Willde-Duyfjes 15614.*

Java. G. Salak, Preanger, *Bakh. v./d. Brink 1728*; G. Papandajan, *S.H. Caerb 635*; Tijbodas, *Danser 5932*; G. Malabar, *H.O. Fobres 959d, 1072a.*

Borneo. Sarawak. Bt. Tibong, Kapit, *J.A.R. Anderson et al. S28679*, Bt. Goram, P. Chai *S36103*; Bt. Pantau, Melinau, *Ilias Paie S25723*; Telok Bandung, Santubong, *Ilias & Jugah S38685*. Brunei. Bt. Teraya, P.S. Ashton *S7894*. Sabah. Bt Tangunan, Telupid, *Abd. Rahim et al. SAN 93288*, Mt. Tambayukan, Renau, *Aban Gibot SAN 55427*; Sosopedon, Renau, *G. Mikil SAN 34515*. Kalimantan. Grayau, Selim Bau, W. Borneo, *J.J. Afriastini 1122*, Central E. Borneo, *F.H. Endert 3635*; Loa Byanan, W. of Samarinda, *Dostermans 6400*; G. Niut, Ponitanak, *G. Shea 28145.*

The Philippines. Mt. Pugar, Palawan, *ADE. Elmer 13191* (isotype of *Schima pulgarensis* Elm.); Baguio, Mt. Province, *M.L. Steiner 2110.*

Celebes. N.E. of Makassar, *W. Meijer 10747.*

Ecology. In oak-laurel forest or mossy forest, or on slopes of dry hill side, from coastal heath forest near the sea level to 1500 m or sometimes reaching 2500 m in montane forest in Malesia.


## Acknowledgements

I am grateful to the Executive Director, National Parks Board, Singapore for the herbarium and library facilities provided, and to the Director and staff of the Rijksherbarium, Leiden for the loan of the entire collection of *Schima* specimens.

I would also like to extend my thanks to Dr. Ding Hou for his effort to search some literature which are not available in Singapore, to Mrs. Ng Siew Yin and Dr. Chin See Chung, Inche Md. Shah and other staff of the Herbarium of the Singapore Botanic Gardens for their willing assistance in many ways, and to my wife, Mrs. Ro-siu Ling Keng for preparing the illustrations reproduced in this paper and for her constant encouragement.

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# BENJAMIN CLEMENS STONE
# 1933-1994

Photograph taken at Philippine National Herbarium, Oct. 1992 by Ali Ibrahim.

Dr Stone arrived in Peninsular Malaysia in 1965 to take up a teaching position in Botany, at the University of Malaya, Kuala Lumpur. It was from there that he began his long association with the Singapore Herbarium and the Botanic Gardens. In the pursuit of his many botanical interests, including what he termed "the big game of the plant world," members of the Pandanaceae, he made repeated visits to the Herbarium and the Gardens. Periodically over the years he would send seeds to the Gardens from his field trips around the region. More frequently than seeds came manuscripts. Twenty of his papers, including those posthumously published in this issue, have been accepted by this Bulletin. These reflect his wide interests in botany and covered topics from the families, Pandanaceae, Rutaceae, Araliaceae, Joinvilleaceae, Nymphaeaceae and Myrsinaceae.

The staff of the National Parks Board who knew Dr Stone, some since his first visit in 1967, were shocked and grieved when news of his fatal heart attack arrived. His enthusiasm and intellect have been inspirational to many who knew him; to some of us he was a teacher and friend as well. We will all miss the sharing of his ideas and this Bulletin will miss his contributions.

NATIONAL PARKS BOARD
SINGAPORE

# In Memoriam B. C. Stone (1933-1994)

A. Latiff

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As was almost simultaneously announced by Drs. Domingo Madulid in Manila and Sy Sohmer in Fort Worth, Texas, Dr. Benjamin Clemens Stone died about three months before his 61st birthday, on 19 March 1994. His sudden death took everybody who knew him by suprise. His first publication about Malesian botany and plants was in 1960. He has thus devoted some 29 years of his life to the study of the Malesian flora. His first interest, however, was in the Hawaiian Flora with a first publication in 1957. He has also worked on other flora, notably that of the Pacific Basin.

Ben was born as the only child to an English father and American mother, in Shanghai, China on 26 May 1933. Before the war, his mother took Ben to live in the San Diego area in California, sensing the coming of troubles in the Far East. The Stone family was united after the war, after his father was interned in a camp in Japan. Ben married Michiko and they had a son, David and a daughter, Sylvia.

Ben received his primary and secondary education in the San Diego area, and his B.A. in Botany from Pomona College, in Claremont, California in 1954. He was so sentimentally attached to that college that he supported David studying there with great pride. He wrote a thesis on the pandans and earned his Ph.D from the University of Hawaii in 1960. His major professor in Hawaii was Dr. Harold St. John, a fixture in Hawaiian botany from 1926 to 1991, when he passed away at the age of 99. Ben's career path then took him to Washington, where he was a research assistant in the Department of Botany at the U.S. National Museum of Natural History at the Smithsonian Institution, from 1960-61. From there he went to Guam where he was made Professor of Biology at the College (now University) of Guam from 1961 to 1965. It was during this period that he wrote the Flora of Guam single-handedly and established *Micronesica*, the journal of the University of Guam.

While in Guam he showed his initial interest in Flora Malesiana (1960) when he confessed that he wished to master the flora of the adjacent Malesian region after mastering the flora of Polynesia and Micronesia. He grabbed the opportunity to work on the Malesian flora by taking a lecturer position in the Department of Botany, University of Malaya at Kuala Lumpur in 1965.

From 1965 to 1983 he taught botany and in particular plant taxonomy, supervised numerous under- and post-graduate students, researched on plants and vegetation, looked after the herbarium (KLU) and contributed intellectual and scientific integrity, in the Department of Botany at the University of Malaya. His inspired scholarship and untiring dedication contributed towards putting Malaysian taxonomy in particular, and botany in general, at its height to-day. Scores of students were attracted to botany as a result of his mentoring and he developed an understanding about the culture, custom and tradition of the region, especially of Polynesia, Micronesia, Malaysia and later the Philippines.

I entered the University of Malaya in 1969 and only in my final year, came to know him closely. I remembered him as a lecturer, plant taxonomist, botanist extraordinaire, story teller, jazz flautist, devoted model airplane builder and plant collector. As a botanist he saw the necessity for herbaria to facilitate taxonomic works (1965), strategies for conservation of ecosystems and plants (1968), national parks as reservoirs of biodiversity (1969, 1968), understanding plant genetic resources (1974, 1979), taxonomic man-power to conduct research (1974), scholarly publications as an extension of mental exercise (1975), botanical gardens to complement the herbarium (1978), natural history museums for general education (1981), and excellent plant collecting techniques to ensure collections useful to future botanists (1983, 1987). As a plant taxonomist he was not as conservative as the late Dr. M. Jacobs and Dr. P.W. Leenhouts of Rijksherbarium, Leiden, for instance, in his recognition of *Glycosmis calcicola* (1972), and some myrsinaceous taxa in Malesia (1982). He was a Malesian taxonomist extraordinaire who mastered four difficult plant families, viz. initially the Pandanaceae, then the Rutaceae, the Araliaceae and lately the Myrsinaceae. He also worked on the Theophrastaceae, Alangiaceae, Orchidaceae, and many others including some ferns.

Apart from taxonomy, his research and publications covered evolutionary biology, ecology, plant geography, cytology, phytochemistry and vegetation study. Although he gave far greater importance to gross morphological characters as the basis for classification, he had a great interest in the contributions given by comparative anatomical, palynological and cytological studies. I noticed he had not used the work ‘cladistic’ at all in his publications which prompts me to believe that he had no interest in that subject.

As a man I found him very honest and liberal in his thoughts. He always smiled and never once had I observed him to lose his cool though there were many occasions when others would have shouted or split hairs. He had wanted to call me “Lat” a shorter form of my second name which I disliked because that was the name of a cartoonist! He was very helpful in the field teaching me many Latin names and diagnostic features of various plant families that we encountered. I remembered very well in 1982 that he was overjoyed when he could at last buy himself a fancy electric typewriter. The man loved to type his correspondence though he had excellent hand-writing.

In 1983 after 18 years in humid Kuala Lumpur, he pondered seriously about the college education of his children, David and Sylvia. He talked about his aged mother and a flat he had bought in California. In 1984 he decided to move back to the U.S. by taking an optional retirement as a Reader in Botany from the University of Malaya and took the position of Chairman, Department of Botany of the Philadelphia Academy of Natural Science, a position he held until 1990 when he joined the Flora of the Philippines Project as the Principal Investigator for the Philippine Plant Inventory at the urging of Dr. Sy Sohmer at Hawaii. When the latter moved to BRIT at Fort Worth, Texas, he gladly joined the staff as Senior Research Botanist.

In Philadelphia he felt wasted, the department was too spacious but under-staffed and under-equipped. The place had no IBM PC system to store type collections or word processing. He was very ambitious indeed to start working on Malesian plants, but the department had no interest in Malesia. Thus he tried to build the Asiatic collection in order to initiate research development. He had wanted to arrange exchange programmes for plant specimens and also develop a joint proposal between his department and Malesian or Asian institutions and herbaria, especially the Tree Flora of Sabah and Sarawak Project. The programme should have an adequate opportunity for post-graduate training and post-doctoral exchange. He had wanted his friends in the universities (Prof. Ruth Kiew, Prof. E. Soepadmo and myself) to look after the former aspects.

From 1990 to the day when he passed away he lived at intervals in the U.S. and Manila. On that fateful Saturday, 19th March 1994 he routinely went to the herbarium to take some plant presses off the driers. He collapsed and the security guard on duty failed to revive him. So ended a life that began in Shanghai, China and ended in Manila, where he had began his second intimate affair with the Malesian plants through the Philippine Flora Project.

Ben was the author or editor of more than 300 articles and books. He was a specialist in four difficult tropical families, the Pandanaceae, Rutaceae, Araliaceae and Myrsinaceae. He wrote or co-authored numerous monumental papers in these families and his reputation as a *Pandanus* worker was unsurpassed. Unfortunately, he died before he could finish his monograph of *Freycinetia* and contribute the family Myrsinaceae for the Tree Flora of Sabah and Sarawak as well.

Ben has had some influence on the development of Malaysian botany, of a magnitude large enough for his name to be forever linked to it. He has also been quite diverse in all fields in which he has been active. A great botanist has passed away after 61 long, well-spent and useful years, of which almost 34 years was devoted to botany alone. He was a friend to many all over the world, and he was always prepared to help people with his vast knowledge.

He will be missed very much.

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**A list of taxa named in honour of Dr. B. C. Stone**

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# Citrus Fruits of Assam: A New Key to Species, and Remarks on *Citrus assamensis* Bhattacharya and Dutta, 1956

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## Abstract

The revision of *Citrus* in Assam by Bhattacharya and Dutta, 1956, is a work on citriculture and citrus taxonomy the importance of which is not limited to the Asean region; it contains a new species, *C. assamensis*, and a key to all the Assam citrus, as well as full descriptions of all taxa including the floral features. The utility of this work is enhanced by illustrations but constructional errors in the key have prevented its correct and effective use. A new key expressing the authors' intentions, as well as remarks on *Citrus* taxa and relationships and notes on the typification of *C. assamensis* are presented in this paper.

## Introduction

S.C. Bhattacharya and S. Dutta published their important study of Assam *Citrus* "Classification of the *Citrus* Fruits of Assam" (1956) in Monograph 20 of the Indian Council of Agricultural Research. It is a major work in several important respects, as it includes not only full descriptions, including floral features, of all taxa, but it provides numerous vernacular names, a key to the species, and the diagnosis of a newly proposed species, *C. assamensis*. This contribution is thus valuable both to agriculture and to botany. It is also noteworthy for its adoption of several *Citrus* species which were suppressed (regarded as synonyms or hybrids) by Swingle in his classic revision of the Orange subfamily Aurantioideae (1943, 1967). While the authors generally follow Swingle's classification, they accept six species not recognized by Swingle among the 17 species recorded for Assam. These six species are *C. jambhiri, C. karna, C. limetta, C. nobilis, C. megaloxycarpa*, and their new *C. assamensis*.

Unusual for agricultural literature devoted to *Citrus*, Bhattacharya and Dutta include full technical data on the flowers of all taxa treated, omitting information only when their data was incomplete. Thus they provide fuller descriptions than is often the case, and the rather liberal use of illustrations also assists the botanist or agriculturist seeking information or identification. As experienced agriculturists their opinions are valuable, and their field knowledge, much gleaned in tribal villages with citriculture little influenced by modern commerce, presented in a generally judicious balance with botanical and "varietal" (cultivar) data, enhances the work.

Taxonomically Bhattacharya and Dutta are much closer in their taxonomic outlook to the conservative Swingle system than to the much more elaborate and finely divided system of Tanaka (1954). Reece (1967) in his editing of Swingle's work hardly modified it, though Hodgson (1965) accepted several more species than did Swingle. In this respect, Bhattacharya and Dutta agree rather closely with Hodgson. The controversial taxa of *Citrus* are virtually all cultivated, and differences in classification therefore particularly involve citriculturists.

## Key to Species

One of the worthy features of the Bhattacharya & Dutta study is, rightly, the inclusion of a key to the species. For practical purposes, such a key is always desirable, whether for agricultural or purely botanical purposes.

However the reader attempting to use this key soon encounters almost insuperable difficulties due partly to some peculiarities of its construction. In effect it is not so much a key as a collection of short, partial diagnoses. It is not possible at this date to understand why the key was prepared in this manner. Though in part dichotomous, the key later on becomes polychotomous. In effect the key is difficult to use at best and often enough is unworkable.

Because of this, it seemed beneficial to prepare a new key, based on the same data that Bhattacharya and Dutta used, which would be strictly dichotomous and effective. Without necessarily accepting all the taxa of *Citrus* that they recognize, any botanist or citriculturist will benefit from having a functional key permitting identification of the taxa as construed by these authors. Furthermore, a usable key may stimulate collecting and further investigations of *Citrus* both in Assam and perhaps elsewhere.

Correction of the Key.- An analysis of the key shows some functional couplets. The initial couplet divides the genus into the two groups recognized by Swingle as "Eucitrus" and "Papeda" (Bhattacharya & Dutta, 1956, p. 11, postscript). These two groups are subgenera in Swingle's classification. Within subg. Papeda the couplet N/NN separates *Citrus ichangensis* from *C. latipes*; subsequently however there is a solitary lead O, with a subordinate P, rather than couplets (P describes but does not fully discriminate *C. macroptera*). Within subg. Citrus ("Eucitrus"), *C. medica* is discriminated, but lead B is one of a trichotomy B/BB/BBB. Under BB, *C. limon* is discriminated, but leads D, E, G, and H are solitary, though there is a couplet F/FF. Lead E seems to indicate that the peel of both *C. limetta* and *C. megaloxycarpa* is loose, which is not true. In the last group under BBB the first "couplet is another trichotomy K/KK/KKK, each ending with a species; yet KKK is followed by 3 more leads, L, LL, and M (L and LL do not form a true couplet, as the half-couplet which should have been marked MM is annexed as the latter part of LL). Moreover *C. grandis* (from lead M) can be compared to *C. aurantifolia* (from LL), but lead L is inaccessible from the preceding KKK. Faults such as these prevent a user from successfully operating this key in a manner which is both baffling and misleading.

**TABLE I**

| Species sequence in KEY | Species sequence in TEXT |
|---|---|
| *C. medica* | *C. medica* |
| *C. limon* | *C. limon* |
| *C. jambhiri* | *C. jambhiri* |
| *C. karna* | *C. karna* |
| *C. reticulata* | *C. aurantifolia* |
| *C. indica* | *C. limetta* |
| *C. limetta* | *C. reticulata* |
| *C. megaloxycarpa* | *C. nobilis* |
| *C. aurantium* | *C. indica* |
| *C. sinensis* | *C. sinensis* |
| *C. assamensis* | *C. aurantium* |
| *C. nobilis* | *C. grandis* |
| *C. aurantifolia* | *C. megaloxycarpa* |
| *C. grandis* | *C. ichangensis* |
| *C. latipes* | *C. macroptera* |
| *C. macroptera* | *C. assamensis* |

Sequence of species in the classification.- The sequence of species in the key is not the same as that in the following systematic treatment. This is not necessarily very important, but it is of interest to compare the two sequences (Table 1).

The TEXT sequence is basically like the sequence in Swingle (1943, 1967), though it differs in two ways - first by the insertion of species not accepted by Swingle (these are in positions which at least implicitly indicate their taxonomic relationship); and second by the transposition of some species (e.g. in Swingle's arrangement, *C. aurantium* is no. 4, *C. sinensis* is no. 5, and *C. reticulata* is no. 6; in the Bhattacharya and Dutta sequence, *C. reticulata* with the immediately following *C. nobilis* - not in Swingle - precedes *C. aurantium* and *C. sinensis*, which are in reverse order. The pomelo, *C. maxima*, is in position no. 7 in both treatments, but in Bhattacharya & Dutta it is followed by *C. megaloxycarpa* (not in Swingle). Finally, the members of subg. Papeda come last. The last species in Bhattacharya & Dutta's sequence is *C. assamensis*, which is clearly asserted NOT to be a member of subg. Papeda; it ought to be inserted just after *C. megaloxycarpa*, its nearest (putative) relative. In fact in the key, *C. assamensis* is found between *C. sinensis* and *C. nobilis*, yet the authors take pains to show it is not closely related to *C. hystrix*, which is certainly a member of subg. Papeda. By inference one may conclude that they thought that *C. assamensis* was related closely to either *C. sinensis* or *C. nobilis*, or both. In a short chapter on hybrid forms, the authors describe a cultivar called "hash-khuli' which, they suggest, may be a hybrid of *C. assamensis* and *C. maxima* (*C. grandis*). In my opinion, *C. assamensis* may be related to *C. megaloxycarpa* and to *C. maxima*, evidence being the similarity of leaf and petiole and in the former also the purplish corolla. In fact, Singh & Nath (1969) relegated *C. assamensis* to synonymy under *C. maxima*, or more precisely to one of the synonyms, *C. megaloxycarpa* var. *pennivesiculata*.

## REVISED KEY TO *CITRUS* OF ASSAM

1. Pulp-vesicles lacking acrid oil droplets. Petiole unwinged, or marginate, or with a small to moderate wing never much more than 1/4 as long as the blade and less than 1/3 as wide. Stamens more or less connate or polyadelphous.

Subg. CITRUS

2. Petiole unwinged, not articulated. Petals tinged purplish. Flowers dimorphic, staminate and perfect. Fruit large, usually elongated, yellow, the rind thick, hard, usually somewhat sweet or palatable. CITRON. .......... *Citrus medica* L.

2' Petiole unwinged, moderately winged, or noticeably winged, and articulated.

3. Petals noticeably purplish-tinged. Fruit greenish to yellow, ellipsoid to ovoid or elongated, often nippled at the end.

4. Rind rather bumpy or warty, moderately to weakly adherent. Carpels rather easily separable. Petals 12-21 mm long. Stamens 21-28 per flower. Fruit up to 9.5 cm diameter. ROUGH LEMON .......... *Citrus jambhiri* Lush.

4' Rind relatively smooth, rather strongly adherent. Carpels strongly adherent. Petals 18-29 mm long. Stamens 19-49 per flower.

5. Tree flowering all year round. Fruit rind rather thin, 3-10 mm thick, firm, not sweet, pulp and juice sour. Fruit subglobose to oblong, nippled, up to 9 cm diameter. Stamens 26-49 per flower. Petals 18-29 mm long. LEMON. .......... *Citrus limon* (L.) Burm. f.

5' Tree flowering but once a year, or only one major crop per year. Rind moderately thin, 5-7 mm thick, or thick to very thick, up to 35 mm. Stamens 19-42 per flower.

6. Rind 10-35 mm thick. Fruit rather to quite large, often 12-14 cm diameter, sometimes smaller (7-12 cm diam.), not scented with ginger-like or eucalyptus-like odor.

7. Fruit usually 7-12 cm diameter, rind soft and spongy, sweet, smooth or slightly pitted. Petiole wing 8-16 mm long, 2-3 mm wide. Stamens 24-29 per flower. KARNA .......... *Citrus karna* Raf.

7' Fruit usually 10-14 cm diameter, rind firm, leathery, or brittle, not sweet. Petiole wing usually 10-30 mm wide (rarely only 5-10 mm wide), about 1/7 to 1/4 as long as blade. Stamens 19-38 per flower. AMILBED. .......... *Citrus megaloxycarpa* Lushington

6' Rind 6-7 mm thick, leathery. Fruit 7-10 cm diameter, subglobose to almost turbinate. Rind oil with gingery or eucalyptus scent. Rind light yellow or pale greenish, almost smooth. Petiole wings somewhat broad, obovate, about 1/4 as long as wide as the blade. Stamens 26-42 per flower. ADA-JAMIR .......... *Citrus assamensis* Bhattach. & Dutta

3' Petals pure white. Fruit green, yellow, orange, or reddish, not lemon-like except in some forms of *C. aurantifolia*.

8. Fruit with a loose, easily detached or separable rind. Cotyledons green. Leaves often rather narrowly elliptic or oblong-elliptic or somewhat rhombic.

9. Seeds large orbicular flattened, 14-15 mm long, smooth. Fruit small, 2.5-4 cm diameter, oblate, the rind red, with scanty, slimy, very sour juice.
Filaments pubescent. Leaf apex somewhat caudate. Petiole scarcely winged.
INDIAN WILD ORANGE ............................................................ *Citrus indica* Tanaka

9' Seeds small, medium, or large (to 16 mm long), somewhat cuneate, slightly rough, or somewhat clavate with fin-like projection of testa. Fruit orange to red, often oblate, sour to quite sweet, juice not slimy, rather copious and palatable. Filaments glabrous. Leaf apex not caudate. Petiole wing small and narrow (or nil) or broad and obovate-oblanceolate.

10. Petiole wing conspicuous, broadly spathulate, up to nearly half as long as the blade, but only one-fourth as wide. Stamens mostly 22-32 per flower. Rind 5-9 mm thick. KING ORANGE ......................................................................... *Citrus nobilis* Lour.

10' Petiole wing small, very narrow, or nil. Stamens 14-24 per flower. Rind about 5 mm thick. MANDARIN ............................................................ *Citrus reticulata* Blanco

8' Fruit with tightly adherent rind. Seeds with white cotyledons. Leaves various in shape, but not rhombic.

11. Petiole short and virtually wingless. Rind light yellow, glossy. Fruit subglobose, lemon-like. Pulp vesicles whitish. Juice sweet. Chalazal cap ochre-yellow. SWEET LIME ...... ........................................................................................ *Citrus limetta* (Risso) Lush.

11' Petiole winged, wings narrow to broad.

12. Petiole wing small, narrow, up to 12-15 mm long and 5-10 mm wide.

13. Fruit 4-5 cm diameter, subglobose to oblong. Rind very thin. Pulp vesicles greenish to whitish. Juice sour. Chalazal cap brown. LIME ............................... ............................................................ *Citrus aurantifolia* (Christm.) Swingle

13' Fruit 5-9 cm diameter, subglobose. Rind 4-7 mm thick, yellow to orange. Pulp vesicles yellowish to orange. Juice usually sweet. Chalazal cap "Indian red." Petiole wing 10-20 mm long, 1-3 mm wide. SWEET ORANGE ....................... ........................................................................................ *Citrus sinensis* L.

12' Petiole wing larger, broader, up to 7 cm long and 5 cm wide.

14. Inflorescence glabrous, few-flowered. Stamens 22-24 per flower. Fruit 6.5-8.5 cm diameter, deep orange to scarlet. Rind 7-10 mm thick. Pulp vesicles yellow to orange. Juice very sour and somewhat bitter. Seeds 12-16 mm long. Chalazal cap "Indian red." SOUR, BITTER, or SEVILLE ORANGE ....................................................................... *Citrus aurantium* L.

14' Inflorescence racemose-glomerate, pubescent, with up to about 10 flowers. Stamens mostly 30-40 (rarely as few as 22) per flower. Fruit often 10-15 cm diameter, green to yellow, sometimes tinged pinkish, the rind often 10-20 mm thick or more. Juice rather bland, or mildly tart or sweet. Seeds 15-23 mm long. Chalazal cap brown or reddish-brown. POMELO ....................... ............................................................................ *Citrus maxima* (L.) Merr.

1' Pulp vesicles containing acrid oil droplets. Petiole long, broadly winged, the wing almost as wide or as wide as the blade, and from half as long to longer than the blade. Stamens usually free, rarely coherent.
Subgenus PAPEDA

15. Leaf apex acuminate-caudate. Stamens coherent. Pulp vesicles globose to obovoid, white. Juice sour and scanty. Seeds numerous, 12-20 mm long, 10-28 mm wide. Chalazal cap broad, brown. .............. ..................................................................................................... *Citrus ichangensis* Swingle

15' Leaf apex not caudate. Stamens free. Seeds somewhat smaller. Chalazal cap light red.

16. Leaf apex acute to subcaudate. Fruit about 5-10 cm diameter. Style 4-8 mm long. ..................... ........................................................................................................... *Citrus latipes* Swingle

16' Leaf apex rounded to obtuse. Fruit usually over 10 cm diameter. Style 1-4 mm long. MELANESIAN PAPEDA. ........................................................................ *Citrus macroptera* Montrouzier

## Vernacular Names

Bhattacharya and Dutta provide a wealth of vernacular names applied to various forms and cultivars of the Citrus species in Assam. For completeness these are repeated here; those capitalized are the "preferred' names.

*Citrus medica*. (CITRON). Birajora; mithajora; soh-manong; bakol-khowatenga; soh-madeh; jaara-jamir; tumehan-thor; haijange; naya-changney; bhimra; mokari; mohalung; sutrung; madh-kunkur; madh-kakri; maulung; natterun.

*Citrus jambhiri* (ROUGH LEMON). Soh-myndong; soh-jalia; kata-jamir; sinduri-nemutenga; mithu-tulia; nemu-tenga.

*Citrus limon* (LEMON). Naya-changney; pati-lebu; katajamuri; elachi-lebu; soh-long; soh-synteng; pani-jamir.

*Citrus karna* (KARNA). Karna; soh-sarkar.

*Citrus megaloxycarpa* (AMILBED). Amilbed; bor-tenga; hukma-tenga; holong-tenga; jama-tenga.

*Citrus assamensis* (ADA-JAMIR). Ada-jamir.

*Citrus indica* (INDIAN WILD ORANGE). (No vernacular names recorded).

*Citrus nobilis* (KING ORANGE). Jeneru-tenga.

*Citrus reticulata* (MANDARIN). Sweet forms: soh-niamtra; soh-umkdai; naga-santra. Sour forms: soh-siem; kapura-tenga.

*Citrus limetta* (SWEET LIME). Mitha-kagzhi; mou-muri; soh-bakhlein.

*Citrus aurantifolia* (LIME). Kagzhi.

*Citrus sinensis* (SWEET ORANGE). Soh-niangriang.

*Citrus aurantium* (SOUR ORANGE). Karun-jamir; gondh-kuntra.

*Citrus maxima* (POMELO). Rebab-tenga; soh-myngor; mat.

*Citrus ichangensis*. (No vernacular names recorded).

*Citrus latipes*. Soh-kympho-shrieh.

*Citrus macroptera* (MELANESIAN PAPEDA). Sat-kara; tith-kara.

## Note On Typification of Citrus assamensis

In the protologue, Bhattacharya and Dutta do not specifically mention a "type" but they remark (1956, p. 787) "The original specimen had . . . been sent to Kew Herbarium . . . " and it may be assumed that by this they indicated the type. I have examined the relevant material at Kew and choose the fuller sheet as the lectotype. The label of this specimen reads as follows: "Herbarium, Citrus Fruit Research Station, Burnihat, Assam. - Fam. Rutaceae. *Citrus assamensis* Dutta & Bhattacharya, sp. nov. Vernac. name, ada-jamir. - Plant medium-sized, very thorny, stout; leaves coriaceous, glossy; petiole spathulate, margin revolute; flower purple; fruit spherical smooth; aroma eucalyptus smell; pulp free from oil droplets." The locality data is: ASSAM, Karimganj, alt. about 300 ft., 6 November 1938, S. Dutta & S.C. Bhattacharya no. 2365. K! (lectotype).

Because of the significance of this species, and to provide an example of the thoroughness of the descriptions employed by Bhattacharya and Dutta, the original description is suggested as a model of its kind. From the original publication, the authors note is here quoted. "The specimen of ada-jamir as it is known locally has been collected from an interior village in Karimganj subdivision of the district of Cachar, Assam . . . identical specimens have also been found to occur particularly in Sylhet, North Cachar hills, and Khasi hills. It is sporadically grown in home gardens." (Note that Sylhet now is within Bangladesh).

Bhattacharya & Dutta showed that *C. assamensis* could not be assigned to *C. hystrix* (a table of differences is presented) but nevertheless referred to subgenus Papeda which includes *C. hystrix*. However, the absence of acrid oil droplets in the pulp-vesicles must exclude *C. assamensis* from subg. Papeda.

More probably *C. assamensis* is closely related to the Pomelo, *C. maxima* (*C. grandis, C. decumana*), and to the Amilbed or Sour Pomelo, *C. megaloxycarpa* - with which the Ada-jamir shares its purplish petals and sour juice. The placement of *C. assamensis* in the original key (of Bhattacharya & Dutta) between *C. sinensis* and *C. nobilis* apparently does not indicate relationship.

The "ginger or eucalyptus odor" specified for *C. assamensis* is noted as very characteristic; "the fruits are valued locally for their peculiar aromatic flavour and intense sour juice. The aroma of the rind approaches to eucalyptus smell but people characterize it to be similar to that of the ginger, *Zingiber officinale*, and hence the name "ada-jamir" (ada = ginger; jamir = citrus). It is also called Soh-sying (soh = soft; sying = ginger) in the Khasi hills of Assam."

## Postscript

This paper clarifies the key structure in the work by Bhattacharya & Dutta; clarifies the typification and posited relationship of their new species *Citrus* *assamensis*; and commends their descriptive work to botanists and agriculturists as a suitable model. The status of *C. assamensis* remains controversial; renewed study of it is recommended. Good specimens of *C. indica*, *C. assamensis*, *C. ichangensis*, *C. latipes*, and *C. jambhiri* are worth obtaining in the Assam area.

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# Additional Notes on the Genus *Glycosmis* Correa (Rutaceae)

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**Abstract**

Updating of the Conspectus of the genus *Glycosmis* of Stone, 1985 is required as certain additions and corrections have to be made, and comments on recent publications that have dealt with this genus are required in the context of a monographic perspective. Three new proposed species are discussed, as well as various nomenclatural and taxonomic questions.

## Introduction

Since the appearance of the author's "Conspectus of the Genus *Glycosmis*" (Stone, 1985) two new taxonomic contributions have been made to the genus (Tao, 1984; Huang, 1987) dealing chiefly with Chinese species. Also some anomalies have been detected in the Conspectus that require some taxonomic or nomenclatural adjustments. This paper is therefore intended as an extension of the Conspectus, to bring recent information and conclusions into the monographic perspective that is required.

## Comments on three proposed new species of *Glycosmis*

### 1. **Glycosmis motuoensis** D.D. Tao

**Acta Botanica Yunnanica 6(3): 285-287, 1984; ex Huang, Flora Xizangica 3: 30, 1986.**

This tentatively accepted species seems to be closely allied to *G. cyanocarpa* var. *cymosa* Kurz, differing in (i) petals glabrous but very slightly ciliolate, and (ii) lateral veins somewhat more numerous and slender. These differences are minor at best, but may prove to be correlated with others when better material is available. If so, the taxon may stand. However, the status of *G. cyanocarpa* itself requires review. Currently, several varieties are distinguished within *G. cyanocarpa* (Bl.) Sprengel, including var. *cymosa* Kurz. This variety has been regarded as a distinct species by Narayanaswamy (1941), who made a new combination (*G. cymosa* (Kurz) Narayan.). Unfortunately, as previously discussed in the Conspectus, Narayanaswamy conceptualized this species as jointly comprising the taxon *G. longifolia* Tanaka, which had been published earlier; this name should therefore have been adopted by Narayanaswamy for his species. Despite this, the combination *G. cymosa* is validly published when *G. longifolia* is conceptually excluded. In other words, Narayanaswamy made a viable binomial with his combination of Kurz's varietal epithet, but incorrectly applied it to the taxon he recognized. At any rate, it is to Kurz's variety that Tao's *G. motuoensis* seems most similar, and not to *G. longifolia* (thus not to *G. cymosa* sensu Narayanaswamy!).

The type collection of *G. motuoensis* (Qinghai-Xizang Expedition no. 74-4540), was kindly made available on loan from Dr Tao and the South China Institute of Botany, Kunming, P.R.C. The type collection is from Medog, Tibet, at an altitude of about 800 m. It is thus quite possible that the plants formed part of a scattered population or series of populations that extend into Sikkim Himalaya. Plants of this series in other herbaria (especially in India) may have been previously identified as *G. cyanocarpa* var. *cymosa*.

The material seen is in an early state of flowering before anthesis; the floral parts are therefore smaller than their potential dimensions, which are estimated as being about twice those evident in the specimen. The stamens, although described as subequal, are definitely alternately longer and shorter, as is normally the case in most species of *Glycosmis*. The anthers do have connective glands, although they are smaller than the apical gland. Little else can be added to Tao's diagnosis, though it may be noted that the leaflet undersurfaces are pale grayish-green with a faint pinkish-brown tinge. More significantly, the dissection of the flowers shows that the ovary may be either 4- or 5-merous. Ovary locule number is an important character in the genus and should always be determined. In my synoptic key, *G. motuoensis* would key out to Group D, next to species 7 (*G. cyanocarpa*).

The protologue states that *G. motuoensis* is related to *G. erythrocarpa* Hay. (of Taiwan), probably on the basis of the shared trifoliolate character; but that relationship is not very close. For a fuller understanding of the proposed new species it appears necessary to obtain good material with ripe flowers and fruits, and to search for it also in adjacent areas (e.g. Bhutan and Nepal).

2. **Glycosmis lucida** Wall.

**ex Huang, Guihaia 7(2): 119-120, 1987.**

C.C. Huang has here validated Wallich's nomen nudum and applied it to a taxon conceptually identical to *G. cyanocarpa* var. *cymosa* Kurz. The synonymy has already been stated by Kurz (1876) and Narayanaswamy (1941), who used the binomial *G. cymosa* (Kurz) Narayan. However as mentioned above, because Narayanaswamy included *G. longifolia* Tanaka (1928) in his concept of *G. cymosa*, he should have adopted Tanaka's existing name for it. *G. longifolia* Tanaka is in fact conceptually identical to *G. cyanocarpa* var. *simplicifolia* Kurz.

Huang apparently typifies *G. lucida* Wall. ex Huang by a Grifith specimen (*no. 523* in *K*). This collection is mentioned by Kurz in his description of *G. cyanocarpa* var. *cymosa* Kurz.

Huang excludes *G. longifolia* from his concept of *G. lucida*; therefore the name *G. cymosa* (Kurz) Narayan. is the correct name to be adopted for this taxon. The name *G. cymosa* Zipp. ex Span. (1841) is mentioned by Huang, but that name, being a nomen nudium, has no validity and cannot pre-empt the usage of the epithet 'cymosa.' If this taxon deserves species rank, it must be called *Glycosmis cymosa* (Kurz) Narayan. (1941), and *G. longifolia* Tanaka (*G. cyanocarpa* var. *simplicifolia* Kurz) must be excluded.

If however the taxon is regarded as having varietal rank under a different species name, then Kurz's varietal epithet must be retained. If the variety is considered to be conspecific with (even if not convarietal with) *G. cyanocarpa* var. *simplicifolia* then the binomial '*G. cymosa* cannot be used, and the earlier valid name *G. longifolia* Tanaka must be used. This has the same lectotype as *G. cyanocarpa* var. *simplicifolia.*

Huang also mentions other synonyms, which with one exception are also previously cited in the Conspectus (1985), viz. *G. oxyphylla* Wall., nom. nud.; *G. tetraphylla* Wall., nom. nud.; *G. pentaphylla* var. *yunnanensis* Huang, Icon. Corm. Sin. Suppl. 2: 159, 1983, nom. nud.

3. **Glycosmis oligantha** Huang

**Guihaia 7(2): 122-123, 1987.**

This validly published name (Latin diagnosis is provided) denotes a plant from Guangxi; the designated type specimen is *S.C. Chen 3153.* It is described as being similar to *G. gracilis* (Huang writes '*G. gracilis* Tanaka' which is an illegitimate name; the correct name is *G. gracilis* Stone, 1985). It seems however even closer to *G. craibii* Tanaka. It apparently belongs to Group D (in the key in the Conspectus), and according to this classification, *G. craibii* is better regarded as a variety of *G. puberula* Lindl. which is found in Group E, as it generally has unifoliolate, though sometimes 2-3-foliolate, leaves. *Glycosmis oligantha* is described as having mainly 4-7 leaflets; leaflet number being variable, there is probably no serious impediment to the implied relationships. More problematical, however, is the question of ovary-locule number, which is omitted in Huang's diagnosis. If for example the ovary is 3-locular, a relationship to *G. gracilis* would be more definitely supported; but if not, then a relationship with *G. puberula* var. *craibii* (Tan.) Stone could be supported. The diagnosis of *G. oligantha* also lacks a specification of the number and position of the anther glands, features which are often useful in the taxonomy of *Glycosmis.*

Huang cites seven specimens, all from Guangxi, mostly from forest habitats between 250 and 560 m altitude. For the present, judgment on the status of this species is reserved.

## Other taxa discussed by Huang (1987)

In the same paper in which he describes *G. oligantha*, Huang discusses several other taxa for which he attempts some elucidation (he remarks that he . . . "attempted to elucidate those of the doubted and confused species so far . . . recorded from China.") To facilitate reference to these, I take these up here in the same order and add commentary as deemed appropriate.

**Glycosmis cochinchinesis** (Lour.) Pierre ex Engl.

Huang (1987) and Stone (1985) clearly agree on the delimitation, typification, and synonymy of this species.

**Glycosmis montana** Pierre

**Fl. For. Cochinch. Pl. 285b. 1893.**

This species is included under *G. lanceolata* (Bl.) Sprengel in the Conspectus. On further consideration this now seems incorrect, and I believe that Huang's interpretation of this taxon is correct or at least preferable. The short synonymy he gives is in agreement, so far as it goes, with my concept, except for *G. tonkinensis* Tanaka. The latter name, as cited (Tanaka ex Guillaumin, in Humbert, Fl. Gen. Indoch. Suppl. 1: 629. 1946) is an invalidly published name, without nomenclatural standing; it lacked a Latin diagnosis. It properly belongs as a synonym of *G. tetracronia* Stone (1985), and is definitely not the same as *G. montana* Pierre. The latter has a predominantly 3-locular ovary, the former a predominantly 5-(or 4-) locular ovary, an important difference in this genus. If *G. lanceolata* and *G. montana* are to be kept apart, a more exacting discrimination should be undertaken to establish reliable differentiating features. The latter seems to be the same taxon as *G. greenei* var. *simplex* Stone. The application of the name *G. lanceolata* as used in the Conspectus is incorrect; research on this matter is still in progress.

**Glycosmis pseudoracemosa** (Guill.) Swingle

**Not. Syst. 2: 162, 1911.**

Both Huang (1987) and Stone (1985) fully agree on the status and synonymy of this species.

**Glycosmis longifolia** Tanaka

**Bull. Soc. Bot. France 75: 709. 1928.**

This taxon has figured in the earlier discussions (see above). By recognizing this species, Huang implicitly accepts a division of the broad species concept of

*G. cyanocarpa* (Bl.) Sprengel; i.e. he agrees with Tanaka that *G. cyanocarpa* var. *simplicifolia* Kurz deserves separate status as a species. Moreover, he accepts species rank for *G. cyanocarpa* var. *cymosa*, although the name *G. lucida* which he applied to it is unnecessary; the correct name is *G. cymosa* (Kurz) Narayan.

Taxonomically, a subdivision of *G. cyanocarpa* sens. lat. is not at all objectionable, although in the Conspectus it was retained in the broad sense (but with ten recognized varieties!). If *G. cyanocarpa* is reinterpreted as a narrower concept, it becomes a strictly Malesian taxon; the Indian, Sri Lankan, Thai, Burmese, Chinese, and Tibetan populations would be excluded. This approach would reinstate both *G. longifolia* and *G. cymosa* as distinct species. However, such reinstatement does not fully satisfy the problem.

Huang cites the authority of *G. longifolia* as "(Oliver) Tanaka" but this is incorrect. Tanaka (1928) clearly distinguishes when he is publishing a new species and making a new combination. For example, see his paragraph on *G. esquirolii* which he clearly designates: '*G. esquirolii* (Levl.) Tanaka, n. comb.' In contrast, for *G. longifolia*, the form is: '*G. longifolia* Tanaka, n. sp.' This is a perfectly clear indication of Tanaka's nomenclatural meaning. Also, he distinctly includes a Latin diagnosis- something not ordinarily provided for a new combination.

It may also be noted that Oliver published the name '*longifolia*' at the rank of subvariety. This rarely used rank explains why Kurz's taxon, var. *simplicifolia*, bears a legitimate name. Oliver does not cite a holotype, but he does cite four specimens (i.e. syntypes) to typify the subvariety. Jenkins' Assam specimen has already been designated as lectotype (Stone, 1985) for both subvar. *longifolia* and *G. longifolia*. Tanaka states only "Type: Herb. Kew" without specifying a particular specimen.

**Glycosmis pentaphylla** (Retz.) DC.

Huang (1987) and Stone (1985) essentially agree on the interpretation of this historically confused and much abused name. However, Huang attributes the contribution to Correa (Ann. Mus. Paris 6: 384, 1805), but Correa never actually made this combination; it was first made, in fact, by De Candolle (Prodr. 1: 538. 1824), although De Candolle misapplied the name. Both Huang and Stone include in *G. pentaphylla* the serrulate-margined plants originally named *Limonia arborea* Roxb. (i.e. *G. arborea* (Roxb.) DC.).

**Glycosmis esquirolii** (Levl.) Tanaka

The synonymy for this species as given by Huang (1987) is correct, essentially the same as that given in the Conspectus (1985), but I have also included *G. winitii* Craib, of Thailand, as the same species.

**Glycosmis parviflora** (Sims) Little

**Phytologia 2: 463. 1948.**

Huang attributes this name to Kurz (he cites Journ. Bot. n.s. 5: 40. 1876). However, Kurz did not mention Sims as author, nor did he specifically cite *Limonia parviflora* as a basionym, though he gave a reference to Bot. Mag. t. 2416; in any case, Kurz did not accept the name, as he only mentions it as a synonym (under *G. citrifolia*, just the opposite of our modern conclusion as to the relative nomenclatural status of the two binomials). I do not believe that Kurz effectively made this combination, and prefer to attribute it to Little, who most explicitly did make it.

**Glycosmis craibii** Tanaka

**Bull. Mus. Hist. Nat. Paris ser, 2, 2: 159, 1930.**

Huang (1987) accepts this in the original conception of Tanaka; in the Conspectus, I have placed it as a variety of *G. puberula* Lindl., a relatively minor difference of interpretation. We agree on the delimitation of the taxon.

**Glycosmis craibii** var. **glabra** (Craib) Tanaka

**l.c. 1930.**

Huang (1987) accepts this variety in Tanaka's original sense. In the Conspectus, I consider it rather as a synonym of *G. ovoidea* Pierre, a species not discussed by Huang.

## Corrections to the Conspectus

### The correct name for *G. lanceolata* sensu Stone

In the Conspectus (p. 10) the name *G. lanceolata* is used for a rather broad concept covering 11 synonyms. It is now increasingly apparent that, while the taxon intended is comparatively homogeneous, the binominal *G. lanceolata* should not have been applied to it. Current research suggests that the correct name for this taxon is *G. trifoliata* (Bl.) Sprengel.

Correspondingly, the taxon denoted by *G. lanceolata* in the original sense is probably best suggested by Narayanaswamy (1941) in his interpretation. The relationship is probably near *G. pentaphylla*. A full resolution of this problem is still required.

### The correct name for *G. sapindoides* is *G. macrophylla*

By some inexplicable oversight, the name *G. sapindoides* Lindl. in Wall. ex

Oliv. was retained despite the clear citation of an earlier binomical in the synonymy. The long usage of *G. sapindoides* would in another situation argue for its conservation, but it must be relegated to synonymy. The correct name and synonymy for this species are presented here, to serve as a replacement for species no. 34, in Proc. Acad. Nat. Sci. Philad. 137: 18. 1985. In addition, two new combinations are required, as shown below.

[34.] **Glycosmis macrophylla** (Blume) Miquel

**Fl. Ned. Ind. 1, 2: 522, 1859. Type: Java, Tjanjor; Blume, L!**

**Syn. *G. sapindoides* Lindl. in Wall. ex Oliver, J. Linn. Soc. Bot. 5, Suppl. 2:38, 1861. Type: Penang, *Wallich cat. 6376*, K!**

**Syn. *G. cyanocarpa* var. *sapindoides* (Lindl.) Kurz, J. Bot. 14: 34. 1876.**

**Syn. *G. elata* Ridley, J. Fed. Mal. St. Mus. 10: 130. 1920. Type: Malaya, Kelantan, Chaning woods; Ridley, SING!**

**Syn. *Sclerostylis macrophylla* Blume, Bijdr. Fl. Ned. Ind. 3: 135. 1825. Type: Java, Tjanjor; Blume, L!**

[34b.] **Glycosmis macrophylla** var. ***microphylla*** (Stone) Stone, comb. nov.

**Syn. *G. sapindoides* var. microphylla *Stone, Proc.* Acad. Nat. Sci. Philad. 137: 18. 1985. Type: Flores Island, *Kostermans 22059*, AAU!**

[34c.] **Glycosmis macrophylla** var. **australiensis** (Stone) Stone, comb. nov.

**Syn. *G. sapindoides* var. *australiensis* Stone, Proc. Acad. Nat. Sci. Philad. 137: 18. 1985. Type: Western Australia, Augustin Island, *Wilson 19775*, PERTH!**

## References


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# Supplement to the Rutaceae in Peninsular Malaysia

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with account of *Melicope*
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## Abstract

Since the publication of the Rutaceae in the "Tree Flora of Malaya" (vol.1,1972), there have been a number of changes both bibliographic and taxonomic which ought to be accommodated in this account. The genus *Terminthodia* has been subsumed within *Tetractomia*; a new genus *Maclurodendron* has been established to include some species formerly placed in *Acronychia*; and *Tetradium* has been revived to hold certain species of *Euodia*. The remaining species of *Euodia* are now believed to be most correctly placed in *Melicope*. They are herein revised by T.G. Hartley. His account shows that *Melicope* is represented in Peninsular Malaysia by 10 species. Among these, *M. corneri* T. Hartley is proposed as a new species, *M. pahangensis* T.Hartley as a new name, and *M. pachyphylla* (King) T. Hartley and *M. macrocarpa* (King) T. Hartley as new combinations. In the Aurantioideae, there are now improved treatments of *Glycosmis* and *Citrus,* and the plant referred to as "Citrus sp. A" in the 1972 treatment was subsequently described as a new species, *C.halimii.* Some controversial matters such as the discrimination of certain genera and species are discussed herein. Finally the key to genera, which was imperfect, has been reworked and corrected. This account thus summarizes these details and presents, where useful, a new treatment to substitute for the old; it should be used in conjunction with the 1972 treatment. To facilitate use, the keys, generic, and specific accounts are set out here in the same form as in that volume.

## ANNOTATED KEY TO GENERA OF MALAYAN RUTACEAE
(Based chiefly on vegetative characters)

1. Woody climbers, never trees or erect shrubs; stems with recurved or hooklike spines .............................. 2
1. Trees or erect shrubs, not climbers .............................. 4

2. Leaves simple, shortly stalked; flowers solitary or clustered in axils, with 4 or 5 petals; fruits globose to obovoid, sometimes lobed, smooth to rough, lacking pulp-vesicles; seeds few ........... (some) *Paramignya*
2. Leaves compound, pinnate or trifoliolate (sometimes unifoliolate in juveniles) .............................. 3

3. Leaves with 3-9 leaflets; twigs and leaf-stalks prickly; fruits dry, splitting open; medium sized climbers. Hantu duri. .............................. *Zanthoxlyum nitidum*
3. Leaves with 3 leaflets; leaf stalk not winged; twigs and leaf-stalks not prickly, but axils with usually recurved spines. Flowers in axillary recemes or panicles; fruits globose to ellipsoid, mucilaginous, without pulp-vesicles; seeds 1-3 .............................. *Luvunga* Buch.-Ham. RIDLEY (1922) 354. SWINGLE (1943)244. Indomalaya, c. 12 spp., 2 spp. in Malaya. Fruits look and smell like small limes.
4. Erect shrub of mangrove or Nipa fringe; fruit 3-4-celled and angled, resembling an angled lemon; seeds very large, to 35mm long; ovules usually 4 per cell, but one maturing. Leaves simple; spines single or paired, straight .............................. *Merope*
4. Not as above .............................. 5

5. Buds densely covered with minute rusty-reddish-brown hairs; leaves usually alternate, but rarely opposite, simple or compound pinnate with up to about 9 leaflets. Ovary 2-5-celled, the cells 1-ovulate. Fruit slightly fleshy, resinous .............................. *Glycosmis*

5. Buds glabrous, or if hairy, the hairs whitish, tawny, or grey. Leaves simple or pinnate, opposite or alternate. Ovary cells usually with 2 or more ovules (except *Paramignya*). Fruit dry or fleshy .............................. 6

6. Twigs and often also trunk prickly, with scattered prickles .................................................. *Zanthoxylum*
6. Twigs unarmed, not prickly, sometimes with solitary or paired spines in the axils .................................. 7

7. Leaves mostly with 3 to many leaflets ............................................................................................... 8
7. Leaves simple or at most with 3 leaflets .......................................................................................... 15

8. Leaves with 9-13 leaflets, those at base smallest, in a graded series with those at leaf tip the largest; leaf stalk flattened, narrowly winged; fruit large, ellipsoid, firm, the pulp fleshy and resinous; seeds numerous, large ........................................................................................................................ *Merrillia*
8. Leaves with subequal leaflets, leaf-stalk winged or not; fruit various ....................................................... 9

9. Leaves with 5-31 leaflets, rarely a few with only 3; leaves sometimes pubescent .................................. 10
9. Leaves usually with 3-7, often 5, leaflets ........................................................................................ 13

10. Inflorescence terminal, large, open, to 30cm long; flowers racemosely disposed, well spaced; crushed tissues foul-smelling ........................................................................................ *Clausena excavata*
10. Inflorescence up to 15cm long; flowers cymosely disposed, crowded; crushed parts fragrant or not ..... 11

11 Leave opposite; trees; fruit a dehiscent capsule of follicles ....................................................... *Tetradium*
11. Leaves alternate; trees or shrubs; fruit a berry ................................................................................ 12

12 Leaves faintly scented if crushed; unripe fruits oblong; wild plants ...................................... *Micromelum*
12. Leaves spicy-scented if crushed; fruits globose; cultivated plants .................................. *Murraya koenigii*

13 Leaflets 5, large, c. 12-18cm long; flowers very small (2.5mm long), in panicles c. 30 cm long; ovary 4-celled, glabrous, with bulging glands .................................................................. *Clausena macrophylla*
13. Leaflets 3-7, smaller, usually somewhat rhomboid to obovate; ovary 2-6-celled .................................... 14

14. Leaf stalk broadly winged; fruit large, woody, globular, 5-7.5 cm wide; deciduous, cultivated tree .......... ....................................................................................................................... *Limonia acidissima*
14. Leaf stalk not winged; fruit small, berrylike, to 12mm wide; seeds 1 or 2, hairy; wild or cultivated, evergreen, small tree or shrub ....................................................................................... *Murraya*

15 Leaves with usually 3, sometimes only 1 or 2, leaflets. ...................................................................... 16
15. Leaves simple or unifoliolate ......................................................................................................... 18

16. Twigs unarmed; leaves opposite; fruit indehiscent ........................................................................ *Melicope*
16. Twigs armed with axillary spines; leases alternate; fruit indehiscent ...................................................... 17

17. Flowers 4- or 5-merous; fruit many-seeded, with hard woody shell; deciduous cultivated tree ................. ....................................................................................................................... *Aegle marmelos*
17. Flowers 3-merous; fruit 1-3-seeded, fleshy; evergreen cultivated shrub .......................... *Triphasia trifolia*

18. Twigs unarmed; leaves opposite ...................................................................................................... 19
18. Twigs armed with axillary spines; leaves alternate .............................................................................. 22

19. Fruit dry, dehiscent .......................................................................................................................... 20
19. Fruit fleshy, indehiscent ................................................................................................................... 21

20. Terminal bud glabrous; flowers with 4 stamens alternating with 4 staminodes; seeds winged *Tetractomia*
20. Terminal bud nearly glabrous to velutinous; flowers with 4 or 8 stamens (or staminodes); seeds not winged. ....................................................................................................................... *Melicope*

21. Flowers bisexual; petals valvate; staminal filaments hairy .................. *Acronychia pedunculata* (L.) Miq., Fl. Ind. Bat. Suppl. (1861) 532, including A. laurifolia Bl. fide Hartley, J. Arnold Arbor. 55 (1974) 549.
21. Flowers unisexual; petals imbricate; staminal filaments glabrous .................................... *Maclurodendron*

22. Axillary spines short, curved, paired; fruit small, round, 2-seeded; shrubby plant.. *Paramignya cuspidata*
22. Axillary spines longer, single or paired, straight; fruit usually 4cm wide or more, seeds usually more than 2; shrub or tree .................................................................................................................. 23

23. Fruit 3-5-celled, each cell with 1 or 2 seeds; stamens twice as many as petals; small, wild trees *Atalantia*
23. Fruit 3-18-celled, each cell with 2-12 seeds; stamens 4 (or more) times as many as petals .................... 24

24. Fruit 3-7-celled, each cell with 1 or 2 seeds; stamens connate basally; fruit rind thin, soft, palatable; cultivated shrub .......... *Fortunella*
24. Fruit usually 8-18-celled, each cell with 4-12 seeds: stamens free or basally connate,the filaments irregularly, often loosely, connate; fruit rind firm but flexible, somewhat fleshy, not or marginally palatable; wild or cultivated shrub or tree .......... *Citrus*

Supplementary notes:
Herbs of the genus *Ruta* (*R.graveolens L.*), the Rue plant, are occasionally grown as pot plants; they are readily recognizable by their herbaceous habit, glaucous foliage of compound leaves, pungent aroma, yellow flowers, capsular fruits, and angular seeds.
There is a recent revision of *Clausena* in : Molino, J.-F. (1994). Revision du genre *Clausena* Burm. f. (Rutaceae). Bull. Mus. Hist. Nat. (Paris), ser. 4, Sect. B, Adansonia 16(1), 105-153

## **Citrus** L.

***Citrus halimii* Stone, in Stone, Lowry, Scora & Jong, Biotropica 5 (1973) 102.**
**(after Sultan Abdul Halim Mu'azzam Shah ibni Almarhum Sultan Badlishah of Kedah.**
***Citrus* sp. A: Stone, in Tree Flora of Malaya 1 (1972) 375.**

A tree up to 23m tall, trunk cylindric, straight, with ascending branches; bark smooth gray, thin; wood white. *Leaves* elliptic or narrowly elliptic, thin coriaceous, margins entire to obscurely and minutely subcrenulate, undersurface slightly paler than upper, somewhat olivaceous when dry, the blades 8-15cm long, 3.5-7.5 cm wide, copiously glandular but the adult leaves not highly fragrant; petioles articulated at both ends, usually 1-2cm long, the margins distinctly but narrowly winged. Main lateral nerves 7-11 pairs. *Flowers* solitary, in axils, pedicels to 3.5mm long; calyx of 5 deltate sepals with minutely ciliate margins; petals white, 3-5 (or more) mm long. Stamens 18-20, free or the filaments loosely connate in small groups of 2 or 3, glabrous, the anthers yellow. Ovary 6-10-celled, on a flat disc; style columnar, with 5-6-angled flat stigma; ovary cells with 1-3, rarely 5, ovules, *Fruit* about 5 x 5 cm but variable in size, subglobose to pyriform, at apex slightly concave, the rind glossy deep yellow, bumpy, copiously glandular, firmly adherent, about 6mm thick, with thin white endocarp; pulp vesicles numerous, subglobose to pyriform with slender stalk, pale greenish to yellowish-white translucent, containing acid juice. *Seeds* numerous, monoembryonic, to 18+ per fruit, large, flat, about 20 x 9mm, 3-3.5mm thick, narrowed at base, veiny rugulose, the chalazal cap pale magenta-pink; cotyledons white, the hypocotyl pale greenish-white.

S. Peninsular Thailand and Peninsular Malaysia, and Borneo (Sabah). In Malaya mostly in the Main Range at moderate altitudes typically between 2000 and 4500 feet (640-1450m). on ridges in submontane forest.

N.v. "limau kedut kera" or "Limau Kedangsa."

## **Glycosmis** Correa

(Gr. glucus = sweet; osmion=smell)

**Ann. Mus. Paris 6 (1805) 384. Ridley, Flora 1 (1922) 348-51. Burkill, Dictionary (1935) 1086. Corner, Wayside Trees (1940) 571. Swingle, Citrus Ind. (1943) 153. Phoenicimon Ridl. (under Sapindaceae), Flora 5 Suppl. (1925) 301. Stone, in Whitmore, Tree Fl. Malaya 1 (1972) 380.**

A genus of about 45 species from India and Sri Lanka through Burma, Thailand, southern China, Indochina, Taiwan, throughout Malesia E to NW & NE Australia, and introduced/naturalized in Florida, W.Indies,and elsewhere.

Continuing studies of this genus (Stone, Proc. Acad. Nat. Sci. Philadelphia 137, 1985) have greatly changed the taxonomy and nomenclature of this group and thus of the earlier account in the Tree Flora of Malaya, so the present account must completely replace the earlier one.

### Key to Peninsular Malaysia species of *Glycosmis*

1. Leaves all simple .......... 2
1. Leaves with 3 or more leaflets, or rarely with 2 or 1 leaflet, these mingled with multifoliolate leaflets on the same plant .......... 3

2. Leaves leathery, oblong-obovate, to 6cm wide, with obscure veins, alternate; inflorescences much reduced, axillary .......... *G. crassifolia* Ridl. J. Roy. Asiat. Soc. Str. Br. 75 (1917) 14. Endemic, rare; known from Malacca and Pahang (Taman Negara).
2. Leaves thin coriaceous, elliptic to ovate, wider than 6cm, with obvious veins, sometimes opposite .......... *G.chlorosperma* (Bl.) Spr. var *lindleyana* (Swingle) Stone, Proc. Acad. Nat. Sci. Phila. 137 (1985) 3. (G.lindley-ana Swingle, Citrus Ind. 1 (1943) 155; G. macrophylla Lindl.: Ridl. Flora 1 (1922) 349. Penang, Perak.

3. Leaves of 3 leaflets, or sometimes only 2 or 1 or rarely 4 .......... 4
3. Leaves with 5 or more leaflet,s rarely 4 or 3 .......... 7

4. Ovary reddish pubescent;leaflets usually 1-3, elliptic, with about 6 pairs of secondary veins. Sometimes on limestone hills .......... *G. puberula* Lindl. ex Oliver J. Linn Soc. Bot. 5 Suppl. 2 (1861) 39. Penang and Perak; S. Thailand, and a variety in Vietnam
4. Ovary glabrous or with a very few, ephemeral, scattered hairs .......... 5

5. Fruits to 2cm diam.; leaflets large, to 25 x 6cm, ovate, acuminate with 5-8 pairs of secondary veins; inflorescence pseudoterminal .......... *G. collina* Stone Proc. Acad. Nat. Sci. Phila. 137 (1985) 4. G. macrocarpa sensu Ridl. Flora 1 (1922) 349, non Wight 1840. Perak (G.Bubu), Pahang (Fraser's Hill). Montane. Endemic.
5. Fruits smaller; leaflets smaller and/or of different form, with 4-15 pairs of secondary veins; inflorescences axillary .......... 6

6 Leaflets up to c.7.5 cm long, elliptic, with rather few (4-6) secondary veins; fruits c. 4-5mm diam. Ovary glabrate, at first usually with a very few ephemeral scattered hairs. Coastal areas, especially limestone, and limestone hills .......... *G. mauritiana* (Lam.) Tan., Bull. Soc Bot. France 75 (1928) 708. G. rupestris Ridl. J. Roy. Asiat. Soc. Str. Br 59 (1911) 81; Flora 1 (1922) 350. Perlis, Kedah, Perak, Penang, Kelantan. Widespread and variable; also in

India, Sri Lanka, Andaman Islands, Nicobar Islands. Mauritius, Laos, Hainan, and SE Borneo.

6. Leaflets often 12-15+ cm long, elliptic-lanceolate, with up to 15-16 pairs of secondary veins; fruit 10-12 mm diam. Ovary quite glabrous. Coastal areas, and secondary vegetation, sometimes in cultivation ............ ........................................................................................ *G. pentaphylla* (Retz.) DC. Prod. (1824) 538. G. citrifolia sensu Ridley, Flora 1 (1922) 349, non Lindley, 1826. In Malaya chiefly in the north. Also in India, Sri Lanka, Burma, Thailand, SW China, and Indochina.

7. Leaflets 5-7, leathery, each with about 18 pairs of secondary veins, glabrous above, reddish-scurfy beneath, large (to 23cm long and 10cm wide, the petiole 6mm long. Panicles elongated, to 20 cm long, densely reddish-pubescent, almost spikelike, with densely crowded small flowers; ovary 3-celled ........................ ........................................................................................ *G. decipiens* Stone, Tree Fl. Mal. 1 (1972) 381. Phoenicimon rubiginosa Ridl. Flora 5 Suppl. (1925) 301; not G. rubiginosa Ridl. Kew Bull. (1925) 78. Negri Sembilan, Pahang, Johore, Trengganu; Pulau Tioman and Anambas Islands. Rare but distinctive.
7. Leaflets large or considerably smaller and with few pairs of secondary veins; inflorescences much shorter, not spikelike ........................................................................................ 8

8. Ovary reddish-puberulent, 3-celled; leaflets 5 to 7, up to 34 cm long, but with only 6-9 pairs of secondary veins; petals puberulent outside ................................................ *G. macrophylla* (Bl.) Miq. Fl. Ned. Ind. 1 (1859) 522. Sclerostylis macrophylla Bl. Bijdr. (1825) 135. G. sapindoides Lindl. ex Oliver J. Linn. Soc. Bot. 5 Suppl. 2 (1861) 38. G. elata Ridl. J. Fed. Mal. St. Mus. 10 (1920) 130. Kedah, Kelantan, Penang. Andaman and Nicobar Islands, Thailand, Sumatra, Java, Sunda Isl., Kei Isl., Papua and W. Australia.
8. Ovary glabrous, 5- or 4-celled ........................................................................................ 9

9. Leaflets 7-12, linear-lanceolate; rheophytic shrub ..................... *G. perakensis* Narayanaswamy, Rec. Bot. Surv. India 14 (1941) 59. Perak, Pahang. Endemic.
9. Leaflets mostly 5-7, rarely 9 or only 3 or 4, not linear-lanceolate; not rheophytic ................................. 10

10. Leaflets small, usually 3-5, rarely 1 or 7, mostly 2.5-5 cm long, rounded and slightly notched at apex; flowers 4-merous ........................................................................ *G. trichanthera* Guillaumin Bull. Bot. Soc. France 91 (1945) 216. Limestone hills in various states; W of Main Range as var. *trichanthera* (syn. G.calcicola Stone, Gard. Bull. Sing. 26 (1972) 55); in Kelantan, var. *kelantanica* (Stone) Stone. Proc. Acad. Nat. Sci. Phila. 137 (1985) 22, with much larger leaflets. Restricted to karst limestone. The typical variety occurs in Vietnam; another is found in Burma, and one more in Sumatra. The notched leaflet tips together with small 4-merous flowers are reliable characters. This is a sharply distinct species.
10. Leaflets somewhat larger, not rounded and notched at the tip. Flowers 5-merous ................................ 11

11. Leaflets usually elliptic to ovate, with wide-spaced rather few veins prominent beneath; inflorescences terminal ........................................................................................ 12
11. Leaflets mostly elliptic-lanceolate, with rather numerous fine secondary veins; inflorescences axillary ... ........................................................................................ *G. pentaphylla* (Retz.) DC. (see above)

12. Inflorescences glabrous or nearly so ........................................ *G. chlorosperma* (Bl.) Sprengel, Syst. Veg. ed. 16, 4 (1827) 162. Cookia chloro-sperma Bl. Bijdr. 3 (1925) 135. G.malayana Ridl. J. Roy. Asiat. Soc. Str.Br. 75 (1917) 12. G. monticola Ridl. 1.c. Widespread through the Malay Peninsula, lowlands and hills, in forest; common in W. Malesia. (1) var. *chlorosperma*: Widespread in the Peninsula. (2) var. *angustifolia* Narayana-swamy, Rec. Bot. Surv. India 14 (1941) 43. Perak, very local; S.Borneo. With narrow leaflets. (3) var. *paraphyllophora* Stone, Proc. Acad. Nat. Sci. Phila. 137 (1985) 3. Penang, Kedah, S. Thailand. Inflorescence bases with conspicuous paraphylls. (4) var. *lindleyana* (Swingle) Stone 1.c. Penang. With large 'simple' opposite leaves.

12. Inflorescences densely reddish-pubescent ................................ *G.tomentella* Ridl. J. Roy. Asiat. Soc. Str. Br. 75 (1917) 14; Flora 1 (1922) 350. Selangor (G.Nuang), rare in montane forest. Also in Sumatra.

## **Limonia** L.

*Limonia acidissima* L. is the correct name for *Feronia limonia* (L.) Swingle, as used in Tree Flora Mal. 1 (1972) 370 (*F. elephantum* Corr. is another synonym). The genus *Feronia* is a synonym of *Limonia* which is monotypic. This species is exotic in the Malayan flora, and occurs only in cultivation. The woody-shelled fruits, the leaves with strongly winged rachis and usually 5 leaflets, and the deciduous habit distinguish it readily. For a fuller explanation of the nomenclature, see Stone & Nicholson, Taxon 27 (1978) 551.

## **Maclurodendron** Hartley

**Gard. Bull. Sing. 35 (1982) 1-19.**

**(After F.A MaClure, American botanist specialized in bamboos)**

Small to medium trees, all apparently dioecious. Indumentum brownish to rusty, of simple or fascicled hairs. *Leaves* opposite, unifoliolate, blades pinnately veined, pellucid glandular-punctate. Inflorescences axillary in upper axils, cymose, paniculate, or racemose. *Flowers* unisexual, 4-merous, the sepals valvate, petals narrowly imbricate, deciduous; stamens 8, free, unequal, those opposite petals shorter than the others, the longer ones about as long as the petals; filaments glabrous; anthers dorsifixed, sterile in pistillate flowers. Gynoecium 4-carpellate, rudimentary in staminate flowers, with an irregularly, shallowly 8-lobed disc; carpels 2-ovulate, the ovules collateral to subcollateral; style straight, with 4-lobed capitate stigma. *Fruit* a syncarpous drupe of 4 cells, with glandular leathery exocarp, pergamentaceous endocarp, and 1 or 2 ovoid to reniform glossy black *seeds* per cell; endosperm copious; embryo straight; cotyledons flattened.

A genus of 6 species from Burma, E to Indochina and S China, in W Malesia from the Malayan Peninsula to the Philipines; two species in Peninsular Malaysia.

## Key to Malaysian species of *Maclurodendron*

1. Flower buds 2.5-3 mm wide, sepals and petals densely pubescent outside; style scars distinct on fruit as 4 crowded dots. Leaflet blades 23.5-18.5cm long .................... *M. magnificum* Hartley, Gard. Bull. Sing. 35 (1982) 15. Pahang (Genting Highlands, Ulu Kali, 1500 m). Endemic. Montane forest.

1. Flower buds 1-2mm wide, sepals and petals pubescent to glabrous outside; style scar unitary (scars confluent) at drupe apex. leaflet blades 5.5 - 24cm long ........ *M.porteri* (Hook.f.) Hartley, Gard. Bull. Sing. 35 (1982) 8. Acronychia porteri Hook. f. Fl. Brit. India 1 (1875) 498. All states and Singapore; Burma; W.Malesia.

## **Melicope** J. R. & G. Forster

by T. G. Hartley

**Char. Gen. Pl. (1775) 28, ed. 2 (1776) 55. Engler in Engler & Prantl, Nat. Pflanzenfam. ed. 2.19a (1931) 231. Hartley, Sandakania 4 (1994) 47.**

**(Gr. *meli*, honey, and *kope*, a cutting, referring to the emarginate lobes of the nectar-secreting, intrastaminal disc)**

Shrubs (rarely scandent) or trees. *Leaves* opposite or whorled, digitately trifoliolate or unifoliolate. *Inflorescences* cymose or thyrsiform or sometimes reduced to solitary flowers, axillary or ramuligerous (i.e., on branchlets below leaves) or rarely terminal, ramigerous, or cauligerous. *Flowers* small, bisexual or functionally unisexual; sepals 4; petals 4, distinct, valvate or narrowly imbricate; stamens (rudimentary in ♀ flowers) 8 or 4 or rarely 8-4, distinct; disc intrastaminal, pulvinate to annular or cupular; gynoecium (rudimentary or sometimes obsolete in ♂ flowers) 4-carpellate, the carpels connate basally or up to their full length, with a common apical or subapical style or the stylar elements rarely becoming divergent, the stigma punctiform to capitate, peltate, or 4-branched, the ovules 2 or 1 per carpel. *Fruit* of 1-4 basally connate follicles (the abortive carpels, if any, persistent) or grading to syncarpous (carpels united into a 4-locular, loculicidally dehiscent capsule); endocarp pergamentaceous to cartilaginous, adnate to or separate from epicarp in mature fruit but not expelled at dehiscence. *Seeds* solitary or in pairs, remaining attached in dehisced fruit; testa with thick inner layer of dense, black sclerenchyma and spongy outer layer bounded externally by a shiny, black pellicle; endosperm copious; embryo straight or slightly curved, the cotyledons ± flattened, elliptic, planate, the hypocotyl superior.

Malagasy and Indo-Himalayan regions eastward to the Hawaiian and Marquesan Islands and south to New Zealand. About 230 species, 10 of which occur in the Malayan Peninsula (i.e., in Peninsular Malaysia and/or Singapore).

*Melicope* is characterized mainly by its combination of opposite or whorled, digitately trifoliolate or unifoliolate leaves, dehiscent fruit, and shiny, black, pelliculose seeds which remain attached in the dehisced fruit. *Euodia* J.R.& G. Forster, with which *Melicope* was long confused, consists of seven species and ranges from New Guinea and northeastern Australia east to Samoa, Tonga, and Niue. Like *Melicope*, it has opposite, digitately trifoliolate or unifoliolate leaves and dehiscent fruit, but its seeds are neither shiny nor pelliculose and they are forcibly expelled, along with the endocarp, when the fruit dehisces. This classification of the two genera was first proposed in a revision of the southeast Asian genus *Tetradium* Lour. (Hartley, Gard. Bull. Sing. 34 (1981) 91-131), which itself was long confused with *Euodia*, and was followed in a recent account of the Bornean species of *Melicope* (Hartley, Sandakania 4 (1994) 47-74).

The manner of attachment of the seed in the dehisced fruit or *Melicope* is variable and provides a useful taxonomic character. In some species, the attachment is either by a partially detached axile strip of pericarp tissue or by a partially detached raphe, or by both. This kind of attachment, which is seen in species 1, as enumerated below, is designated as Type A. In other species, neither the pericarp nor the raphe detaches and the two are connected by a funiculus which ranges up to about 3 mm in length. This manner of attachment, which is seen in species 2-10 below, is designated as Type B.

Seeds of *Melicope* are often irregularly angled when two develop in a single fruiting carpel. These shapes, which are caused by crowding, are not given in the descriptions.

In the above-mentioned account of the Bornean species of *Melicope*, full descriptions were given for five species that also occur in the Malayan Peninsula, namely, *M. accedens* (Blume) T. Hartley, *M. denhamii* (Seem.) T. Hartley, *M. glabra* (Blume) T. Hartley, *M. hookeri* T. Hartley, and *M. lunu-ankenda* (Gaertn.) T. Hartley. Those descriptions are not repeated here. The synonymies given herein are intended to be relevant only to the Malayan Peninsula. *Melicope accedens, M. denhamii, M. glabra,* and *M. lunu-ankenda* have additional synonyms outside this region. With one exception (see *Evodia* sensu Gaertner, mentioned in the synonymy of *M. lunu-ankenda*), the original spelling *Euodia* is used throughout the synonymies, correcting the orthographic variant *Evodia*, which was used by most of the authors.

## Key to species of *Melicope* in the Malayan Peninsula

1. Leaves, or most of them, unifoliolate .................... 2
1. Leaves, or most of them, trifoliolate .................... 3

2. Flowers with 8 stamens; endocarp separate in mature fruit; young branchlets 4-5 mm wide in third internode, becoming manifestly corky .................... 1. *M. suberosa*
2. Flowers with 4 stamens; endocarp adnate in mature fruit; young brachlets 2.5-3.5 mm wide in third internode, not becoming manifestly corky .................... 10. *M. pahangensis*

3. Leaflet blades (as seen in the Malayan Peninsula) lobed, sinuate, or repand; plants cultivated or possibly escaped .................... 2. *M. denhamii*
3. Leaflet blades entire .................... 4

4. Trichomes mostly fasciculate or stellate .................... 7. *M. hookeri*
4. Trichomes, or most of them, simple .................... 5

5. Petals (2.4-) 3.3-4 mm long, the abaxial surface appressed-pubescent; fruiting carpels 8-10 mm long, the endocarp glabrous; indumentum of leaflet blades mostly restricted to midrib and margin ............ ............ 9. *M. pachyphylla*
5. Petals (as seen in the Malayan Peninsula) 1-3 mm long, the abaxial surface glabrous or with sparse indumentum; fruiting carpels (as seen in the Malayan Peninsula) 2.5-5 mm long, or, if larger, then the endocarp pubescent; indumentum of leaflet blades, if present, not as above ............ 6

6. Fruiting carpels (7.5-) 10-11 mm long; endocarp and locules of ovary with indumentum 8. *M. macrocarpa*
6. Fruiting carpels 2.5-5 mm long; endocarp and locules of ovary glabrous ............ 7

7. Petals 1-1.5 mm long, glabrous, persistent in fruit; fruiting carpels 2.5-3 mm long ............ 5. *M. corneri*
7. Petals (1.5-) 2-2.5 (-3) mm long, with indumentum, especially adaxially, or glabrous, deciduous in fruit; fruiting carpels 3-5 mm long ............ 8

8. Terminal leaflet blades obovate or broadly so, (7.5-) 9-16.5 cm long, the main veins plane or impressed above, 9-15 on each side of midrib, divergent at angle of 50-60°, the apex usually abruptly and obtusely short-acuminate; main branches of inflorescences ascending; fruiting carpels 3-4 mm long ............ 3. *M. glabra*
8. Terminal leaflet blades (as seen in the Malayan Peninsula) elliptic to obovate, 6-30 cm long, the main veins prominulous to impressed above, 11-22 on each side of midrib, divergent at angle of 60-70°, the apex usually acuminate; main branches of inflorescences spreading or ascending; fruiting carpels 3.5-5 mm long ............ 9

9. Leaflet blades glabrous or nearly so, up to 22 cm long, the main veins prominulous above; main branches of inflorescences usually ascending; fruiting carpels about 5 mm long ............ 4. *M. lunu-ankenda*
9. Leaflet blades nearly glabrous to pubescent below, up to 30 cm long, the main veins usually impressed above; main branches of inflorescences usually spreading; fruiting carpels 3.5-4.5 mm long ............ 6. *M. accedens*

## 1. **Melicope suberosa** B. Stone

**Gard. Bull. Sing. 36 (1983) 94,** ***fig. 1,2; tab. 1.*** **Type: Peninsular Malaysia: Pahang: Genting Highlands, Gunong Ulu Kali,** ***Stone & Lowry 15338*** **(CANB, Isotype).**

Tree to 10 m high, trunk to 15 cm diam., like the branches with rugose pale corky bark; trichomes simple or fasciculate. Young branchlets like the petioles glabrous or nearly so, becoming manifestly corky, 4-5 mm wide in third internode; terminal bud densely puberulent. *Leaves* opposite, unifoliolate, 7.5-21.5 cm long; petiole 1-4 cm long, 1-2 mm wide at middle; petiolule obsolete; leaflet blade chartaceous, glabrous, elliptic or elliptic-obovate, 6.5-17.5 x 3-9.5 cm, the base obtuse to acute, the margin entire or in occasional leaves few-crenulate toward apex, the apex obtuse to subacuminate, the midrib plane above, the main veins prominulous above, 10-15 per side, divergent at angle of 65-70°, the veinlet reticulation ± obscure. *Inflorescences* axillary, few-flowered, 1.5-2 x 1.3-1.5 cm, the peduncle nearly glabrous or sparsely puberulent, 0.8-1.3 cm long, the pedicels puberulent, 1.5-2 mm long (about 3 mm long in fruit). *Flowers* unisexual (only ♀ seen), plants probably dioecious; sepals puberulent or sparsely so abaxially, glabrous adaxially, connate at base, ovate-triangular, about 1.5 mm long, persistent in fruit; petals greenish white, narrowly imbricate, sparsely puberulent abaxially, glabrous adaxially, ovate-elliptic, about 4 mm long, deciduous in fruit; stamens 8, infertile, the antesepalous ones about 2 mm long, the filament glabrous, narrowly obtuse at apex, the anther 0.6-0.8 mm long; disc glabrous; gynoecium 2.2-2.7 mm long, the ovary puberulent or sparsely so, the carpels 2-ovulate, the style puberulent in proximal 1/2, including stigma 1.5-2 mm long, the stigma capitate, weakly 4-lobed, about 0.6 mm wide. *Fruiting carpels* connate at base, divaricate, subglobose to broadly ellipsoid, about 8 mm long, the exocarp dry, glabrate, the endocarp glabrous, separate; seed attachment Type A; *seeds* ellipsoid, about 7 mm long.

Known only from the type locality in central Peninsular Malaysia; forest at 1550 m.

*Melicope suberosa* is most nearly related to *M. jugosa* T. Hartley and *M. sororia* T. Hartley, which are endemic to Borneo. It differs from those species mainly in having manifestly corky branchlets, persistent sepals, puberulent petals and ovary, and smaller fruiting carpels. Among its congeners in the Malayan Peninsula, it is the only species with 8-staminate flowers, separate endocarp, and Type A seed attachment.

The specific epithet (from the Latin *suberosus*, corky) refers to the thick bark of the branches and trunk.

2. **Melicope denhamii** (Seem.) T. Hartley

**Sandakania 4 (1994) 57. *Picrasma denhamii* Seem., Fl. Vit. (1865) 33. Type: New Hebrides : Aneitum [Aneityum], *McGillivray 46* (BM, Holotype).**

***Aralia quercifolia* Anon., Gard. Chron. (1881) 785, *fig. 140*, nom, prov.; hort. ex Truff., Rev. Hort. (1891) 224. *Euodia quercifolia* (hort. ex Truff.) Ridl., Gard. Chron., ser. 3, 76 (1924) 303. Type not designated. The illustration of *Aralia quercifolia* is reasonably adequate for the identification of this plant.**

***Euodia ridleyi* Hochr., Icon. Bogor 2 (1905) *tab. 151. Euodia schullei* var. *ridleyi* (Hochr.) Lauterb., Bot. Jahrb. Syst. 55 (1918) 230. *Euodia suaveolens* var. *ridleyi* (Hochr.) Bakh. f., Blumea 6 (1950) 365. Probable type: Java: Bot. Gard. Bogor (ex Bot. Gard. Singapore), *Backer,* Dec. 1904 (U, Isotype).**

Borneo east to the southern Philippines and Caroline Islands and southeast throughout eastern Malesia to the Solomon Islands, New Hebrides, and Fiji. In the Malayan Peninsula, only putative cultigens of the species are known. These are represented by collections made from Bot. Gard. Univ. Malaya (Kuala Lumpur) and Bot. Gard. Singapore.

From their congeners in the Malayan Peninsula, the cultigens of *Melicope denhamii* (which apparently orginated in Papuasia) are immediately recognizable by their lobed, sinuate, or repand leaflet blades. The specific epithet commemorates H. M. Denham, a British sea captain.

3. **Melicope glabra** (Blume) T. Hartley

**Sandakania 4 (1994) 60. *Fagara glabra* Blume, Catalogus (1823) 40. *Euodia glabra* (Blume) Blume, Bijdr. (1825) 245. *Ampacus glabra* (Blume) Kuntze, Revis. Gen. Pl. 1 (1891) 98. Type: Java: *Blume* (US, Lectotype, designated by Hartley, opp. cit.).**

***Euodia kingii* Engl. in Engl. & Prantl. Nat. Pflanzenfam. III. 4 (1896) 121. Type: Malakka [Malaya sensu Engler]: "*E. glabra* King in herb." The B material of this was presumably lost. It was probably the same plant that King (J.Asiat. Soc. Bengal, pt. 2, Nat. Hist. 62 (1893) 208) correctly identified as *Euodia glabra* (Blume) Blume.**

Malayan Peninsula to Sumatra and western Java. In the Malayan Peninsula, known from Penang, Perak, Trengganu, Selangor, Pahang, Johore, and Singapore; primary and secondary forest from near sea level to 450 m.

*Melicope glabra* is most nearly related to *M. lunu-ankenda*, differing mainly in the following combination of features: terminal leaflet blades obovate or broadly so, (7.5-) 9-16.5 x 4-12 cm, the apex abruptly and usually obtusely acuminate or sometimes rounded, obtuse, or emarginate, the midrib impressed above, the main veins plane or impressed above, 9-15 per side, divergent at angle of 50-60°; fruiting carpels 3-4 mm long.

4. **Melicope lunu-ankenda** (Gaertn.) T. Hartley

**Sandakania 4 (1994) 61. *Fagara lunu-ankenda* Gaertn., Fruct. Sem. Pl. 1 (1788) 334, *tab. 68, fig. 9. Fagara zeylanica* J.F. Gmelin, Syst. Nat. 2 (1791) 258 (not seen); Syst. Veg. 1 (1796) 258, nom. illeg. *Zanthoxylum zeylanicum* (J. F. Gmelin) DC., Prodr. 1 (1824) 728, nom. illeg. *Euodia lunu-ankenda* (Gaertn.) Merr., Philipp. J. Sci. (Bot.) 7 (1912, publ. 1913) 378, as *lunur-ankenda*. Type: Ceylon, *König* (L, Holotype).**

**[*Fagara triphylla* sensu Roxb., Fl. Ind. 1 (1820) 436, excl. syn., non Lam. 1798.] *Zanthoxylum roxburghianum* Cham., Linnaea 5 (1830) 58. *Euodia roxburghiana* (Cham.) Benth., Fl. Hongk. (1861) 59. *Ampacus roxburghiana* (Cham.) Kuntze, Revis. Gen. Pl. 1 (1891) 98. *Euodia malayana* Ridl., Fl. Malay Penins. 1 (1922) 342, nom, illeg. Type: cult. Bot. Gard. Calcutta; introduced by Roxburgh from Penang (not seen).**

Roxburgh's description, apparently drawn up from living material at Calcutta, is reasonably adequate for the identification of this plant. It is doubtful if a type was preserved. Roxburgh incorrectly gave Linnaeus as the author of *Fagara triphylla.* In the reference he cited (Sp. Pl. ed. Willd. 1 (1798) 666). Willdenow correctly referred the species to Lamarck.

Himalaya southward to Ceylon, Java, Celebes, and southwestern Philippines. In the Malayan Peninsula, known from Province Wellesley, Perak, Selangor, Pahang, Negri Sembilan, Malacca, Johore, and Singapore; coastal and inland primary and secondary well-drained forest and peat swamp; to 60 m.

*Melicope lunu-ankenda* is most nearly related to *M. glabra* (q.v.). The specific epithet is a Ceylonese name for the plant.

5. **Melicope corneri** T. Hartley, sp. nov.

**Type: Peninsular Malaysia: Selangor: Ulu Gombak, *Carrick 1468* (L, Holotype).**

**Arbor 4.5-7.5 m alta, trichomatibus pro parte maxima simplicibus; foliis trifoliolatis, 34-51 cm longis; foliolorum laminis chartaceis, saltem subtus in costa et venis primariis et supra in costa ± sparse pubescentibus, in foliolo terminali ellipticis usque obovatis, 20-31 x 7-12 cm; inflorescentiis axillaribus, multifloris, 4-10 x 3-8 cm, ramis principalibus patentibus; floribus unisexualibus (plantae dioeciae); sepalis ca. 0.5 mm longis, in fructu persistentibus; petalis glabris, 1-1.5 mm longis, in fructu persistentibus; staminibus 4, in floribus ♂ ca. 2.5mm longis (in floribus ♀ 1-1.5 mm longis), filamento glabro, apice subulato usque filiformi, anthera ca. 0.6 mm longa (in floribus ♀ ca. 0.3 mm longa); gynoecio in floribus ♀ ca. 1 mm longo (in floribus ♂ ca. 0.3 mm longo), stigmate capitato, inconspicue 4-lobato; carpellis fructificantibus basi connatis, 2.5-3 mm longis, endocarpio glabro, saltem apicem versus adnato; seminibus per Type B affixis, ca. 2 mm longis.**

Tree 4.5-7.5 m high, trichomes mostly simple. Young branchlets like the petioles pubescent, 5.4-7 mm wide in third internode; terminal bud velutinous. *Leaves* opposite, trifoliolate, 34-51 cm long; petiole 12-19 cm long, 2-4 mm wide at middle; petiolule in lateral leaflets obsolete or up to 3 mm long, in terminal leaflet 2-5 mm long; leaflet blades chartaceous, ± sparsely pubescent, at least on midrib and main veins below and on midrib above, in lateral leaflets elliptic or elliptic-obovate, in terminal leaflet elliptic to obovate, 20-31 x 7-12 cm, the base in lateral leaflets obtuse to acute, in terminal leaflet acute to subattenuate, the margin entire, the apex acuminate, the midrib and main veins slightly impressed above, the main veins in terminal leaflet 15-20 per side, divergent at angle of 60-70°, the veinlet reticulation prominulous to obscure. *Inflorescences* axillary, many-flowered, 4-10 x 3-8 cm, the axis and branches pubescent, the peduncle 1-5 cm long, the main branches spreading, the pedicels puberulent or sparsely pubescent, 0.7-2 mm long (1.5-2 mm long in fruit). *Flowers* unisexual, plants dioecious; sepals sparsely puberulent abaxially, glabrous adaxially, connate at base or up to 1/4 their length, ovate or ovate-triangular, about 0.5 mm long, persistent in fruit; petals cream or greenish, narrowly imbricate, glabrous, ovate-elliptic, 1-1.5 mm long, persistent in fruit; stamens 4, in ♂ flowers about 2.5 mm long (1-1.5 mm long in ♀ flowers),the filament glabrous, subulate to filiform at apex, the anther about 0.6 mm long (about 0.3 mm long in ♀ flowers); disc pubescent or sparsely so; gynoecium in ♀ flowers about 1 mm long (about 0.3 mm long in ♂ flowers),. the ovary pubescent or sparsely so, the carpels 2-ovulate, the style pilosulose, at least in proximal 1/2, including stigma about 0.7 mm long, the stigma capitate, weakly 4-lobed, 0.25-0.3 mm wide. *Fruiting carpels* connate at base, divaricate, subglobose or broadly ovoid to obovoid, 2.5-3 mm long, the exocarp subfleshy, glabrate, the endocarp glabrous, adnate, at least toward apex; seed attachment Type B, the funiculus about 0.6 mm long, 0.3-0.5 mm wide at middle; *seeds* ellipsoid, about 2 mm long.

Endemic to Peninsular Malaysia; primary forest and borders; 18-750 m.

Paratypes: Peninsular Malaysia: Selangor: Gunong Bunga Buah, *Whitmore FRI 337* (A, L); Ulu Gombak, *Stone 6892* (CANB); genting Simpah, *Poore 236* (CANB). Pahang: Genting Highlands, *Chung 1* (KLU). Negri Sembilan: Jelebu, *Everett KEP 104947* (A, L), Johore: Gunong Belumut, *Whitmore FRI 8771* (L); Kota Tinggi, Sungai Pelepah, *Corner SF 31433* (A, BO). Peninsular Malaysia without precise locality, *Herb. Maingay Kew Distrib. No. 277* pro parte (L).

*Melicope corneri* is most nearly related to *M. accedens*, differing mainly in its smaller anthers and seeds and its combination of usually smaller, glabrous, persistent petals and usually smaller fruiting carpels. The specific epithet commemorates Edred J. H. Corner.

6. **Melicope accedens** (Blume) T. Hartley

**Sandakania 4 (1994) 67. *Euodia accedens* Blume, Bijdr. (1825) 246. *Zanthoxylon accedens* (Blume)**

**Miq., Fl. Ned. Ind. 1(2) (1859) 671. *Ampacus accedens* (Blume) Kuntze, Revis. Gen. Pl. 1 (1891) 98. Type: Java, *Blume* (L, Lectotype, designated by Hartley, opp. cit.).**

***Euodia pilulifera* King, J. Asiat. Soc. Bengal, pt. 2, Nat. Hist. 62 (1893) 210. Syntypes: Peninsular Malaysia: Perak: Larut, *King's collector* (*Kunstler*) *6275* (CAL, Holosyntype; L, US, Isosyntypes); without precise locality, *Scortechini 360* (not seen), *Wray 2995* (not seen).**

Andaman Islands east to Vietnam and south to Java. In the Malayan Peninsula, known from Kedah, Perak, Trengganu, Selangor, Pahang, Malacca, and Johore; primary and secondary forest from near sea level to 1980 m.

*Melicope accedens* is most nearly related to *M. corneri* (q.v.). The specific epithet (from the Latin *accedo*, approaching or resembling) was most likely intended by Blume to refer to the relationship of the species to *Euodia macrophylla* Blume. The latter is now considered to be conspecific with *M. accedens* (Hartley, Sandakania 4 (1994) 67).

As Hartley noted in Sandakania 4 (1994) 69, two variants of *Melicope accedens* occur in Peninsular Malaysia. Plants described in that account as Variant A correspond with specimens centering around the type of *M. accedens*, whereas those described as Variant B corresponds with specimens centering around the type of *M. pilulifera.*

7. **Melicope hookeri** T. Hartley

**Sandakania 4 (1994) 70. *Euodia robusta* Hook. f., Fl. Brit. Ind. 1 (1875) 488. *Ampacus robusta* (Hook.f.) Kuntze, Revis, Gen. Pl. 1 (1891) 98. Syntypes: Malayan Peninsula: Penang, *Phillips* (not seen); Singapore, *Herb. Maingay Kew Distrib. No. 278* pro parte (GH, Lectotype, designated by Hartley, opp. cit.). A Leiden sheet with this Maingay number is *Melicope glabra.***

Peninsular Malaysia (Negri Sembilan: Berembun Forest Reserve), Singapore (Bukit Timah Forest Reserve), Sumatra, and Borneo; primary and secondary forest and borders; at lower altitudes throughout the range and ascending to 1600 m in Borneo.

*Melicope hookeri* is very closely related to *M. incana* T. Hartley, which occurs in east-central Sumatra, Borneo, and northern Celebes. The latter species differs mainly in its densely whitish-tomentose leaflet blades. From its trifoliolate congeners in the Malayan Peninsula, *M. hookeri* is readily distinguishable (with adequate magnification) by its mostly fasciculate or stellate trichomes.

8. **Melicope macrocarpa** (King) T. Hartley, comb. nov.

***Euodia macrocarpa* King, J. Asiat. Soc. Bengal, pt.2, Nat. Hist. 62 (1893) 209. Syntypes: Peninsular Malaysia: Perak: Larut, *King's collector 7489* (L, Lectotype, here designated; US, Isolectotype); without precise locality, *Wray 2618* (not seen), *3266* (not seen).**

Tree 5-21 m high, trichomes mostly simple. Young branchlets like the petioles and inflorescences velutinous or minutely so or rarely sparsely puberulent, 5-8 mm wide in third internode; terminal bud velutinous or rarely appressed-pubescent. *Leaves* opposite, trifoliolate (occasional leaves unifoliolate), 18-43 cm long; petiole 4.5-16.5 (-20) cm long, 2-4 mm wide at middle; petiolule in lateral leaflets 1-9 mm long, in terminal leaflet 2-12 mm long; leaflet blades subcoriaceous or coriaceous, sparsely puberulent to pubescent below, especially on midrib and main veins, puberulent on midrib or glabrous above, elliptic or narrowly so to obovate or in lateral leaflets sometimes narrowly ovate-elliptic, in terminal leaflet 11-32 x 5-15 cm, the base acute to subattenuate, the margin entire, the apex acuminate or abruptly so or sometimes rounded, the midrib plane or slightly impressed above, the main veins prominulous to slightly impressed above, in terminal leaflet 14-22 per side, divergent at angle of 60-75°, the veinlet reticulation prominulous or plane below or obscure. *Inflorescences* axillary, many-flowered, 7-14 x 3.5-13cm, the peduncle 1-6 cm long, the main branches ascending, the pedicels 1.5-2 mm long (2.5-3 mm long in fruit). *Flowers* unisexual, plants dioecious; sepals nearly glabrous to puberulent abaxially, glabrous adaxially, connate at base or up to 1/4 their length, ovate, 0.6-1 mm long, persistent in fruit; petals white, narrowly imbricate, glabrous or rarely sparsely strigillose abaxially, glabrous or rarely in proximal 1/3-1/2 sericeous adaxially, ovate-elliptic, 2.7-3 mm long, deciduous in fruit; stamens 4, in ♂ flowers 4-4.5 mm long (1.5-2 mm long in ♀ flowers), the filament glabrous abaxially, sparsely pilosulose in proximal 1/4 adaxially, subulate to filiform at apex, the anther about 1.5 mm long (0.8-1 mm long in ♀ flowers); disc pubescent or villosulous; gynoecium in ♀ flowers about 2.5 mm long (about 1 mm long in ♂ flowers), the ovary pubescent, the carpels 2-ovulate, the style pubescent to pilosulose, including stigma about 1.5 mm long, the stigma capitate, weakly 4-lobed, about 0.6 mm wide. *Fruiting* carpels connate at base, divaricate, ellipsoid to obovoid, (7.5-) 10-11 mm long, the exocarp subfleshy, puberulent to velutinous, the endocarp pubescent, adnate, at least toward apex; seed attachment Type B, the funiculus 1.5-2.5 mm long, 0.5-0.6 mm wide at middle; *seeds* ovoid to ellipsoid or rarely subglobose, (4-) 5.5-7 mm long.

Peninsular Malaysia (Penang, Perak, Selangor, and Pahang) and northern Sumatra; primary and secondary forest; mostly at lower altitudes but ascending to 1500 m in Pahang.

From its congeners in the Malayan Peninsula, *Melicope macrocarpa* differs mainly in having indumentum on its endocarp and in the locules of its ovary.

9. **Melicope pachyphylla** (King) T. Hartley, comb. nov.

***Euodia pachyphylla*** **King, J. Asiat. Soc. Bengal, pt. 2, Nat. Hist. 62 (1893) 210; Ann. Roy. Bot. Gard. (Calcutta) 9 (1901) 12, *tab. 15.* Syntypes: Peninsular Malaysia: Perak: Gunong Batu Puteh, *Wray 229* (L, Lectotype, here designated); Gunong Babu, *King's collector* (*Kunstler*) *7432* (L, Isosyntype), *Scortechini 732* (not seen), *Wray 3835* (not seen). Pahang: Gunong Berumbun, *Wray 1571* (UC, Isosyntype).**

Shrub or tree 1.2-4.5 m high, trichomes mostly simple. Young branchlets like the terminal bud, petioles, and inflorescences pubescent to velutinous, 3-5.5 mm wide in third internode. *Leaves* opposite, trifoliolate, 6-25 cm long; petiole 2-11 cm long, 1.5-3 mm wide at middle; petiolules 1.5-15 mm long; leaflet blades subcoriaceous or coriaceous, puberulent or pubescent on midrib below and, toward base, on midrib above and margin, otherwise glabrous or nearly so, elliptic to obovate, in terminal leaflet 4-12.5 x 2-5.5 cm, the base acute to attenuate or in lateral leaflets obtuse, the margin entire, the apex rounded or emarginate to short-acuminate, the midrib impressed above, the main veins prominulous above, in terminal leaflet 9-13 (-17) per side, divergent at angle of 70-75°, the veinlet reticulation obscure. *Inflorescences* axillary, several- or many-flowered, 3-9 x 2-3.5 cm, the peduncle (0.35-) 1.5-6 cm long, the main branches ascending, the pedicels 1-3 mm long (3-4 mm long in fruit). *Flowers* unisexual, plants dioecious; sepals pubescent to velutinous abaxially, glabrous adaxially, connate at base, ovate or ovate-triangular, (1-) 1.5-2 mm long, persistent in fruit; petals white or cream, narrowly imbricate, rather fleshy, appressed-pubescent abaxially, sericeous-pubescent adaxially, ovate-elliptic, (2.5-) 3.3-4 mm long, deciduous in fruit; stamens 4, about 3 mm long, the filament glabrous abaxially, sparsely pilosulose in proximal 1/6-1/3 adaxially, narrowly obtuse or sometimes acute at apex, the anther in ♂ flowers 1.5-1.7 mm long (0.7-0.8 mm long in ♀ flowers); disc glabrous; gynoecium in ♀ flowers 1.2-2.5 mm long (about 0.6 mm long in ♂ flowers), the ovary and style pubescent, the carpels 2-ovulate, the style including stigma 0.6-1.5 mm long, the stigma clavate or rarely capitate and weakly 4-lobed, 0.3-0.4 mm wide. *Fruiting carpels* connate at base, divaricate, ellipsoid, 8-10 mm long, the exocarp dry, puberulent or glabrate, the endocarp glabrous, adnate, at least toward apex; seed attachment Type B, the funiculus about 1 mm long, about 1 mm wide at middle; *seeds* subglobose or ellipsoid, 4.5-5 mm long.

Endemic to Peninsular Malaysia, where known from Perak and Pahang; forest and open ridges, 1350-2000 m.

From its trifoliolate congeners in the Malayan Peninsula, *Melicope pachyphylla* is distinguishable mainly by its petals, which are rather fleshy, appressed-pubescent abaxially, sericeous-pubescent adaxially, and comparatively large; by its stigma, which is usually clavate; by its fruiting carpels, which are comparatively large and have glabrous endocarp; and by its leaflet blades, in which the indumentum is mostly restricted to the midrib and margin.

10. **Melicope pahangensis** T. Hartley, nom. nov.

***Euodia simplicifolia*** **Ridl., J. Linn. Soc., Bot. 38 (1908) 306. Type: Peninsular Malaysia: Pahang: Gunong Tahan, *Wray & Robinson 5492* (BM, Holotype; SING, Isotype). The specific epithet *simplicifolia* is pre-empted in *Melicope*.**

Shrub about 2 m high, trichomes simple. Young branchlets like the petioles nearly glabrous to puberulent and ± glaucous, 2.5-3.5 mm wide in third internode; terminal bud sparsely puberulent to appressed-pubescent. *Leaves* opposite, unifoliolate (rarely occasional leaves bifoliolate), 6-11.5 cm long; petiole 1-2 cm long, 1-1.5 mm wide at middle; petiolule obsolete; leaflet blade subcoriaceous or coriaceous, glabrous, ovate to elliptic, 5-10 x 2.5-4.5 cm, the base rounded to acute, the margin entire, the apex acute to acuminate, the midrib prominulous or plane above, the main veins prominulous above, 8-11 per side, divergent at angle of 60-70°, the veinlet reticulation prominulous or ± obscure. *Inflorescences* axillary, puberulent, several-flowered, 2-2.5 x 0.8-1 cm, the peduncle 1-1.8 cm long, the main branches ascending, the pedicels 1.5-2.5 mm long (1.5-3.5 mm long in fruit). *Flowers* unisexual (only ♀ seen), plants probably dioecious; sepals sparsely puberulent abaxially, glabrous adaxially, connate at base, ovate-triangular, 0.7-0.8 mm long, persistent in fruit; petals (colour unknown) narrowly imbricate, glabrous abaxially, sparsely and minutely puberulent in proximal 1/3 adaxially, ovate-elliptic, about 2 mm long, deciduous in fruit; stamens 4, infertile, 0.6-0.8 mm long, the filament glabrous, acute at apex, the anther 0.3-0.5 mm long; disc pubescent; gynoecium 2-2.5 mm long, the ovary pubescent, the carpels 2-ovulate, the style pubescent in proximal 1/3, including stigma 1.5-2 mm long, the stigma capitate, weakly 4-lobed, 0.5-0.6 mm wide. *Fruiting carpels* connate at base, ascending, ellipsoid, 6.5-8.5 mm long, the exocarp dry, puberulent or glabrate, the endocarp glabrous, adnate, at least toward apex; seed attachment Type B, the funiculus about 0.4 mm long, about 0.6 mm wide at middle; *seeds* subglobose to ellipsoid, 4.5-5 mm long.

Endemic to Peninsular Malaysia, where known only from Pahang (Gunong Tahan and Gunong Brinchang); forest from 1500-2100 m.

From its congeners in the Malayan Peninsula, *Melicope pahangensis* differs mainly in its combination of unifoliolate leaves, 4-staminate flowers, adnate endocarp, and Type B seed attachment.

## Excluded species

In his treatment of *Euodia* in Tree Fl. Malaya 1 (1972) 376-379, Stone included two species that are now believed not to occur in the Malayan Peninsula, namely, *E. latifolia* DC. and *E. euneura* (Miq.) Miq. The former, which has been transferred to *Melicope* (Hartley, Sandakania 4 (1994) 72), ranges from Java northward to Borneo and the Philippines and eastward to Samoa. It is superficially similar to *M. accedens* and *M. corneri*, with which Stone apparently confused it. The latter, which is to be transferred to *Melicope*, is believed to be endemic to southern Sumatra. Stone apparently confused it with pubescent-leaved plants of *M. macrocarpa*, which is one of its close relative, although his description of the fruit fits neither species.

## Index to numbered collections of Melicope from the Malayan Peninsula

The numbers in parentheses refer to the corresponding species in the text.

Anderson *25* (4). Burkill *798* (9); *SF 1441, SF 6607* (4). Burkill & Haniff *13248* (6). Carrick *1468* (5). Chew *894* (6). Chung *1* (5); *2, 3* (6). J. & M. S. Clemens *5028* (4); *22429* (2). Cockburn *FRI 8211* (9). Corner *SF 21200* (4); *SF 31433* (5); *SF 31927* (3). Cuming *2270* (4). Curtis *2428* (3). Derry *110, 182* (4); *1016* (6). Everett *FRI 14005* (4); *FRI 14315, FRI 14355* (3); *KEP 104947* (5). Franck *1058* (4). Furtado *SF 34842* (2). Herb. Griffith *1175* (4); *1176* (6). Haniff *SF 6947, SF 10318* (6). Henderson *11289* (8); *11477* (6); *SF 17892, SF 23315* (9). Hooker *837* (8). Hou *694* (4). Ismail *KEP 104882* (7). Ismail & Sauji *KLU C-42* (2). Jones & Baya *2050, 2053, 2054* (8). Jones et al. *2021d* (6). Kadim & Mamud *97* (8). Kadim & Nur *326* (4). King's collector (mostly leg. Kunstler) *698* (8); *775, 1034* (4); *4390* (3); *5269, 5491, 5649* (4); *6130, 6190* (3); *6241* (8); *6275* (6); *7432* (9); *7489* (8); *7556, 7573* (4); *10367, 10630* (3). Kochummen *FRI 2064* (4); *KEP 76685* (3); *KEP 79122* (6); *KEP 93139* (4). Kunstler (see King's collector). Herb. Kuntze *6088* (4). Liew *SF 37255* (3). Littke *589* (10). Loh *FRI 13374, FRI 13422, FRI 13545* (6). Mahmud *Univ. Malaya 13358* (4). Herb. Maingay *Kew Distrib. No. 276* (4); *Kew Distrib. No. 277* (GH=6, L=5); *Kew Distrib. No. 278* (GH=7, L=3). Maxwell *78-245* (4). Moysey & Kiah *SF 33799* (3). Ng *FRI 5699* (4); *FRI 5955* (9). Nur *SF 2155* (4) *SF 32951* (6); *SF 33691* (4). Ogata *KEP 105160* (4). Poore *236* (5). Ridley *1633* (6); *5104* (4); *6327, 6329* (3); *6767* (4); *15949* (10). Scortechini *84* (6). Shah & Nur *776* (4); *899* (8). Sinclair *SF 40632* (3). Singh *1012* (4). Soepadmo *967* (10). Soepadmo & Mahmud *1033* (4). Sow *KEP 71485* (4). Spare *SF 36250* (4). Stone *5551, 6436* (6); *6892* (5); *7207, 7235* (9); *14526* (8). Stone & Lowry *15338* (1). Suppiah *FRI 11388, FRI 11827, FRI 11934* (3). Symington *KEP 32207* (9); *FMS 36298* (6). Teo & Pachiappan *92, 316* (4). Univ. Malaya *8007* (9). Whitmore *FRI 337* (5); *FRI 3214* (6); *FRI 3416* (8); *FRI 8771* (5); *FRI 12591* (6); *FRI 12615, FRI 15163* (3). *Wray 229, 1571* (9); *1885* (6); *2295, 2510, 2716* (4); *3161* (3); *3978* (6). Wray & Robinson *5492* (10).

## Acknowledgements

Thanks are extended to the directors and curators of A, AAU , BISH, BM, BO, BRI, CAL, CANB, GH, K, KLU, L, MEL, NSW, NY, P, SING, U, UC, UKMB, US, and W for making specimens in their care available for this study.

## **Tetractomia** Hook.f.

This genus has been revised by Hartley (J. Arnold Arb. 60 (1979) 127) with *Terminthodia* Ridley being reduced to synonymy under it. The species *Terminthodia viridiflora* Ridley, previously accepted in the Tree Flora account (p. 385) has also been reduced to a synonym of *Tetractomia tetrandrum* (Roxb.) Craib. Hartley recognizes three forms in the Malayan Peninsula, the "generalized form," the "Malayan mountain race," and the "peat swamp race." He regards *Terminthodia* as a representative of the Malayan mountain race, in which he also includes *Tetractomia holtumii* (already synonymized in the Tree Flora account.) Hartley states that " a complete range of intermediates between the generalized form and the Malayan mountain race exists in Malayan forests between 900 and 1400 m altitude, and it is evident that the latter is merely a high mountain extreme of the former. The peat swamp race is reasonably distinct from the generalized form in the Malay Peninsula in having inflorescences shorter than the subtending leaves and a tendency toward smaller petals and follicles." *Tetractomia majus* is upheld as a distinct species. The account of *Tetractomia* therefore remains as originally published except for the inclusion of *Terminthodia*, and the reduction of *Terminthodia viridiflora* to the synonymy of *Tetractomia tetrandrum.*

It may be emphasized that the gender of the name *Tetractomia* is neuter, not feminine. The name *T. majus* is correct but deceptive, as the epithet is the comparative form of the adjective for large, i.e. equivalent to 'larger'.

## **Tetradium** Lour.

**Loureiro, Fl. Cochinch. (1790) 91; not of Dulac, 1867. HARTLEY Gard. Bull, Sing. 34 (1981) 91.**

**Gr. *tetradion,* quaternion, referring to the 4-merous flowers and fruit of *Tetradium trichotomum* Lour.**

Trees or shrubs, usually dioecious, deciduous or evergreen. Indument of simple hairs. *Leaves* opposite, pinnate, mostly with a terminal leaflet, the lateral leaflets usually stalked, their blades usually oil-dotted. *Inflorescences* corymbose to occasionally paniculate, terminal or both terminal and in the upper axils. *Flowers* unisexual (but rarely bisexual), 4-5-merous, with valvate, persistent sepals; petals narrowly imbricate in bud, deciduous; stamens opposite the sepals, longer than the petals in staminate flowers; filaments usually villous up to the middle, anthers ovoid, dorsifixed; stamens rudimentary or obsolete in pistillate flowers. Intrastaminal disc present. Gynoecium in pistillate flowers about as long as the petals, carpels free or connate at base, forming a lobed to subglobose or obovoid ovary; carpels 2- (or 1-) ovulate; style apical with peltate 4-5-lobed stigma, Carpels in staminate flowers rudimentary, fingerlike. *Fruit* follicular, the follicles 1-2-seeded, dehiscent adaxially, apically and partly down the abaxial surface; endocarp cartilaginous, persistent. *Seeds* dark brown to glossy black, smooth, retained within the follicle; endosperm fleshy; embryo straight; cotyledons plano-convex; hypocotyl terminal.

A genus of 9 species of India, Indochina, China, Korea, Japan and the Ryukyu Islands, W.Malesia including the Philippines and Sumatra, but not in Borneo. Most of the species had originally or subsequently been placed in *Euodia* and there is a general resemblance. Two species in Peninsular Malaysia; both very rare and only in the northern region.

## Key to the Peninsular Malaysian species of *Tetradium*

1. Follicles 2-seeded though ofter seemingly 1-seeded; flowers 4-merous; leaflets greenish, hairy ............... ........................................................................................................ *Tetradium sambucinum*

1. Follicles 1-seeded; flowers 5-merous; leaflets glabrous or slightly pubescent, usually glaucous beneath... ........................................................................................................ *Tetradium glabrifolium*

**Tetradium sambucinum** (Bl.) Hartley
(Like Sambucus, Caprifoliaceae)

**Gard. Bull.Sing. 34 (1981) 100. *Philagonia sambucina* Bl. Cat. Pl. Buitenz. (1823) 21; Bijdr. (1825) 250. *Euodia sambucina* (Bl.) Hook.f.ex Koord. & Val. Med. Lands Plantent. 17 (1896) 216.**

Medium to large tree to 34 m tall, branchlets puberulent but glabrate. *Leaves* to 36 cm long; of 3-6 pairs of leaflets; stalks of lateral leaflets to 10 mm long; blades elliptic-oblong to ovate, lanceolate, or oblanceolate, 6-18 cm long, 2-5 cm wide, at base usually somewhat oblique (except in terminal leaflet), with 13-16 pairs of main secondary veins, the margins crenulate distally, the apex acuminate; conspicuously gland-dotted, drying pale green or brownish, usually with appressed pubescence on midrib and main veins. *Inflorescences* to 25 cm long, the axes slightly pubescent, pedicels less than 1.5 mm long. *Flowers* 4-merous, petals yellow-green drying brownish, to 3 mm long, somewhat villous inside. *Fruit* of 4 follicles, each 3-4 mm long and high, free to base or nearly so; endocarp sparsely pubescent; *seeds* 2 per follicle, coherent (like a single one), 1.5-2 mm long.

W. Malaysia, Sumatra, Java, and Sumbawa. In Peninsular Malaysia, known only in Trengganu, G. Andi Mangin (Whitmore *FRI 12139*).

**Tetradium glabrifolium** (Champ. ex Benth.) Hartley
(glabrous leaved)

**Gard. Bull. Sing. 34 (1981) 109. *Boymia glabrifolia* Champ. ex Benth. in Hook. J. Bot. Kew Gard. Misc. 3 (1851) 330. *Megabotrya meliaefolia* Hance ex Walp. Ann. Bot. Syst. 2 (1852) 259. *Evodia meliaefolia* (Hance ex Walp.) Benth. Fl. Hongkong (1861) 58. *Phellodendron burkillii* Steenis, Gard. Bull. Sing. 17 (1960) 357.**

Small or medium tree to 20 m tall, branchlets finely pubescent but fully glabrate. *Leaves* to 38 cm long, with 2-9 (rarely but 1) pairs of leaflets, the blades elliptic to oblong-elliptic, 4-15 cm long, 1.7-6 cm wide, the lateral ones acute to subtruncate at base, usually oblique, the apex acuminate, the margins entire to crenulate, with 8-18 pairs of secondary veins, gland-dots inconspicuous, undersurface whitish or pale green and usually distinctly glaucous; lateral leaflet stalks 3-15 mm long. Inflorescences to 19 cm long, the axes finely pubescent to glabrous, pedicels to 4 mm long. *Flowers* mostly 5-merous; petals greenish to yellowish or white, to 4 mm long. *Fruit* usually 5-carpellate, all or only 1-4 carpels maturing as follicles, these puberulent on the sides, 1-seeded. *Seed* black, subglobose or ovoid, 2.5-4 mm long, usually paired with a smaller aborted seed.

NE India and Sikkim Himalaya to S China and Indochina, N to Japan, Taiwan, S to Peninsular Malaysia, Sumatra, and NE to the Philippines.

In Peninsular Malaysia, known from Kedah (Enggang Forest Reserve,. KEP 78904, type of "Phellodendron burkillii") and Gunung Jerai (Kedah Peak, FRI 021715); recorded as a tree to 16 m (50 ft.) tall with smooth slightly lenticellate bark. Rare.

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## Singapore

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*Sterculia acuminatissima* Merr., Philip. J. Sci. 21 (1922) 524.

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# Recent Botanical Collections from the Nature Reserves of Singapore

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## Abstract

A botanical survey of the Nature Reserves in Singapore conducted in 1992-93 resulted in the gathering of more than 2,600 vascular plant specimens. More than 600 species were represented, including two species not previously recorded from Singapore. The results of the survey are discussed in the paper.

## Introduction

A botanical survey of the Singapore Nature Reserves was conducted in order to obtain a better understanding of their current flora. Emphasis was placed on the Central Catchment Area rather than Bukit Timah Nature Reserve as the former has been much less well investigated than the latter.

## Methods

The survey used the technique of collecting fertile plant material to make voucher herbarium specimens which could be accurately identified and then used as a permanent record of the contemporary flora of the Nature Reserves. Teams of collectors visited all parts of the Central Catchment Area in the three month period of April-June 1992. More collections were made in the same months of the following year. Further sporadic collecting trips were made by the authors. When in the field, the teams endeavoured to collect specimens from all species of plants they found flowering, fruiting or sporulating. The teams used extension cutters which aid in the collection of material from heights of up to 5m. Clearly this meant that it was rarely possible to obtain fertile material from tall trees.

The specimens gathered were usually pressed in the late afternoon of the day of collection, or on the morning of the next day. Unpressed specimens were stored at 4 °C if they were kept overnight. The specimens were dried at 60 °C in a drying oven and then poisoned with 2.5 % (w/v) mercuric chloride in 95 % ethanol, redried and then mounted on acid-free paper. A few specimens were preserved in 70 % ethanol. The specimens were numbered in one Nature Reserves Survey (NRS) sequence (with the exception of a minority of collections recorded under personal series) and identified largely by matching to named specimens in the herbarium of the Singapore Botanic Gardens. Sets of specimens have been deposited in the herbarium of the Department of Botany, National University of Singapore (SINU) and the herbarium of the Singapore Botanic Gardens (SING).

A numbered grid square system was devised (Fig. 1) to localise the collections. Information on the NRS specimens has been entered into a computerized database.

## Results

The NRS series reached 2613 over the collecting period, with a large number of duplicates gathered. Over 600 species (see Appendix 1) have been identified from the collections. Most of these species are small trees and shrubs, climbers, herbs and some aquatics reflecting our inability to make good collections from tall trees. Plants typical of secondary forest, which covers much of the Central Catchment Area, were found e.g. *Macaranga* spp., *Trema* spp., *Adinandra dumosa* and *Rhodamnia cinerea*, and a fair number of introduced and escaped plants e.g. *Hydrocera triflora*, *Ochna kirkii*, *Canna indica*, *Dioscorea sansibarensis*, *Wikstroemia ridleyi*, *Heliconia psittacorum* and *Cardiospermum halicacabum*. However, many native species more clearly associated with primary forest were also collected. These included trees and shrubs such as *Dracaena* spp., *Campnosperma squamatum*, *Canarium patentinervium*, *Lindera lucida*, *Litsea* spp., *Sterculia* spp., *Horsfieldia polyspherula*, *Gymnacranthera forbesii*, *Matthaea sancta*, and a number of species in the Rubiaceae and Euphorbiaceae. Climbers e.g. *Uvaria cordata*, *Pyramidanthe prismatica*, *Salacia grandiflora*, *Gnetum* spp., *Dissochaeta* spp., *Stephania capitata*, a number of members of the Vitaceae and many rattan species; and herbs such as *Amischotolype gracilis*, *Aglaonema* spp., *Mapania* spp., *Globba leucantha*, *Hanguana malayana*, *Peliosanthes teta*, *Stachyphrynium griffithii*, *Labisia pumila* and *Ophiorrhiza singaporensis* are all good indicators of primary forest status wherever they are found.

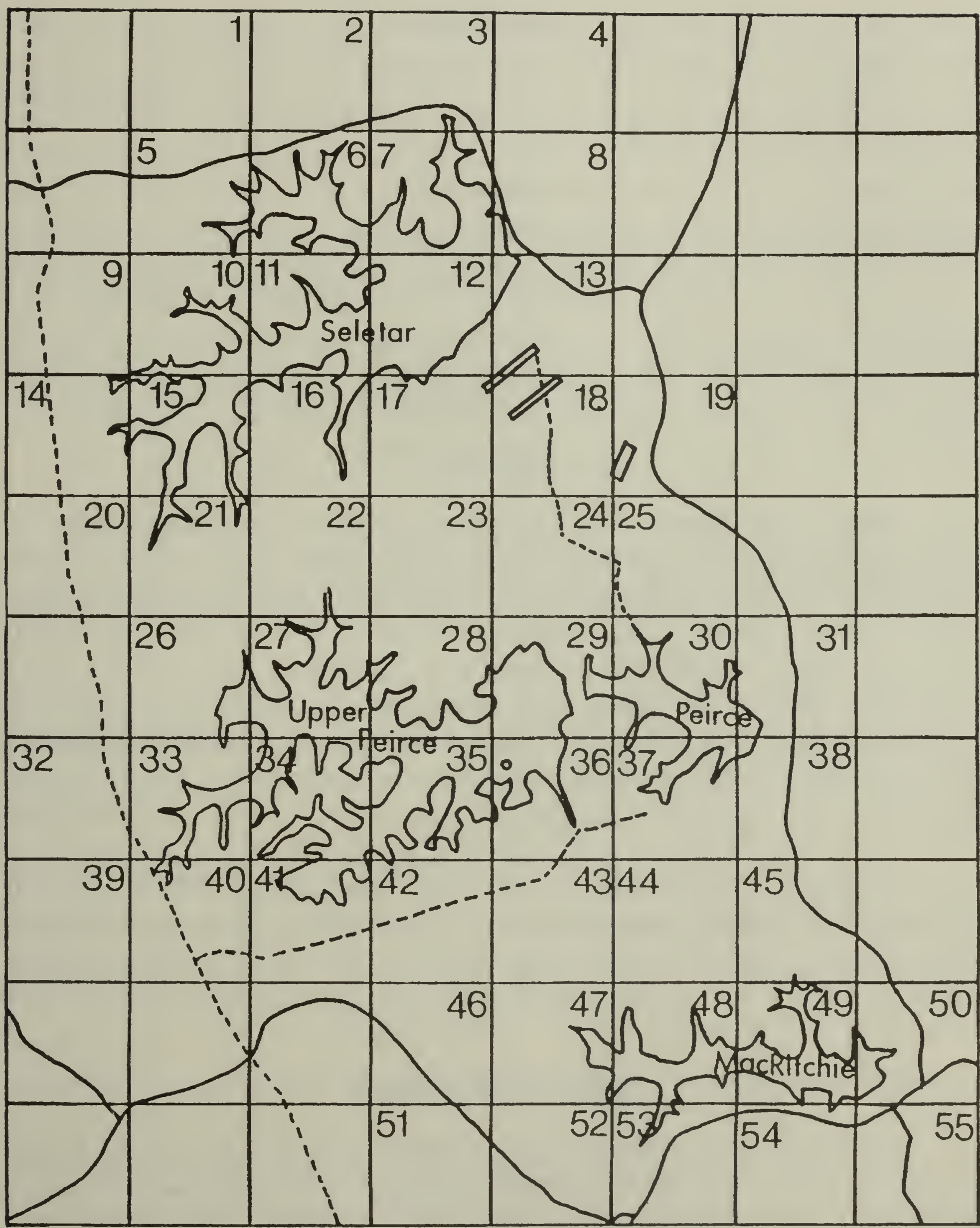


**Fig. 1.** Map showing the grid system used to localise specimens collected during the botanical survey of the Nature Reserves. Based on 1:50 000 topographical map produced by the Singapore Mapping Unit of the Ministry of Defence (1983).

## Discussion

Without doubt the area that provided the most interesting specimens was the primary swamp forest around the SAF Firing Range at Nee Soon. It was the only site where several of the orchid species, such as *Bulbophyllum macranthum*, *Plocoglottis javanica*, and *Nephelaphyllum pulchrum* were collected. Other interesting species probably restricted to this, the last patch of swamp forest in Singapore, include *Kopsia singapurensis* and *Luvunga crassifolia*. The forest around the range still maintains a primary nature and contains some very large trees, though an alarming number are dead possibly reflecting a change in the drainage regime. Only Bukit Timah Nature Reserve can boast a vegetation as botanically exciting. It certainly merits the highest conservation status.

Elsewhere in the Central Catchment Area there are other patches of forest that approach the primary lowland forest type, most notably around MacRitchie Reservoir. Though most of the rest of the Catchment Area is covered with secondary forest, or even so degraded as to be reduced to lallang or resam stands, interesting plants can still be found. These areas are also of value in that they may represent future areas of colonisation for species currently restricted to tiny, fragmented primary areas. An expansion of range that is much to be encouraged as it will help ensure the future survival of those species in Singapore.

A number of the species collected were of particular interest. *Bulbophyllum gusdorfii* and *Iodes cirrhosa* are new records for Singapore (Turner, Tan & Chua, 1994). *Daphniphyllum laurinum* was found to occur when it had been reported as probably extinct in Singapore (Keng, 1990).

## Acknowledgements

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## Appendix

List of collections made during the survey with their grid locality (CCA number). Specimens collected in Bukit Timah Nature Reserve are indicated as such by the appearance of the code BTNR.

### LYCOPODOPHYTA

#### Lycopodiaceae

*Huperzia phlegmaria* (L.) Rothm. - NRS0544 CCA 47; NRS1457 CCA 47

#### Selaginellaceae

*Selaginella argentea* (Wall.) Spr. - NRS1972 CCA 18

*Selaginella atroviridis* (Wall.) Spr. - NRS1782 CCA 48; NRS2299 CCA 7; NRS2477 CCA 7; NRS2540 CCA 44; NRS2607 CCA 6

*Selaginella intermedia* (Blume) Spring - NRS1285 CCA 43

*Selaginella willdenowii* (Desv.) Bak. - NRS0606 CCA 17

### FILICINOPHYTA

#### Adiantaceae

*Syngramma alismifolia* (C. Presl) J. Sm. - NRS0632 CCA 17; NRS1610 CCA 18; NRS1951 CCA 18; NRS1968 CCA 18

*Taenitis blechnoides* (Willd.) Sw. - NRS0348 CCA 30 and many others

*Taenitis interrupta* Hook. & Grev. - NRS0247 CCA 17

**Aspleniaceae**

*Asplenium batuense* Alderw. - NRS1185 CCA 18; NRS1518 CCA 13; NRS1621 CCA 18; NRS1924 CCA 25; NRS1944 CCA 18

*Asplenium longissimum* Blume - NRS0394 CCA 30; NRS0630 CCA 17

*Asplenium nidus* L. - NRS0349 CCA 30

*Asplenium tenerum Forst.* - NRS1611 CCA 18

**Blechnaceae**

*Blechnum finlaysonianum* Hook. & Grev. - NRS0343 CCA 30

*Blechnum orientale* L. - NRS0267 CCA 17; NRS2111 CCA 12

*Stenóchlaena palustris* (Burm.) Bedd. - NRS0343 CCA 30; NRS1218 CCA 7; NRS1589 CCA 18; NRS1649 CCA 46; NRS1838 CCA 16; NRS2086 CCA 17; NRS2295 CCA 7

**Cyatheaceae**

*Cyathea glabra* (Blume) Copel. - NRS1526 CCA 13; NRS1893 CCA 16; NRS1913 CCA 25; NRS1950 CCA 18

*Cyathea latebrosa* (Wall. ex Hook.) Copel. - NRS1508 CCA 13; NRS1600 CCA 18

**Dennstaedtiaceae**

*Histiopteris incisa* (Thunb.) J.Sm. - NRS0634 CCA 17

*Lindsaea doryophora* Kramer - NRS1519 CCA 13

*Lindsaea ensifolia* Sw. ssp. *coriacea* (Alderw.) Kramer - NRS2281 CCA 28

*Lindsaea parasitica* (Roxb. ex Griff.) Hieron. - NRS1075 CCA 17; NRS0158 CCA 18; NRS0631 CCA 17

*Microlepia speluncae* (L.) Moore var. *hancei* (Prantl) C.Chr. - NRS1664 CCA 46

*Pteridium caudatum* (L.) Maxon ssp. *yarrabense* (Domin) Parris - NRS0156 CCA 18; NRS0633 CCA 17

**Dryopteridaceae**

*Pleocnemia olivacea* (Copel.) Holttum - NRS1792 CCA 48

*Tectaria singaporeana* (Wall. ex Hook. & Grev.) Copel. - NRS0274 CCA 17; NRS1483 CCA 49; NRS1814 CCA 48; NRS2156 CCA 17; NRS2520 CCA 15

**Gleicheniaceae**

*Gleichenia truncata* (Willd.) Spr. - NRS1868 CCA 16; NRS1981 CCA 24

**Hymenophyllaceae**

*Trichomanes christii* Copel. - NRS0867 CCA 18

*Trichomanes javanicum* Blume - NRS1295 CCA 43

*Trichomanes obscurum* Blume - NRS1094 CCA 33; NRS0258 CCA 17

**Lomariopsidaceae**

*Teratophyllum aculeatum* (Blume) Mett. ex Kuhn - NRS0051 CCA 13

*Teratophyllum ludens* (Fée) Holttum - NRS0132 CCA 18

*Teratophyllum rotundifoliatum* (Bonap.) Holttum - NRS0675 CCA 17

**Oleandraceae**

*Nephrolepis acutifolia* (Desv.) Chr. - NRS1403 CCA 7; NRS1491 CCA 49; NRS1830 CCA 15; NRS1922 CCA 25; NRS2602 CCA 6

*Nephrolepis biserrata* (Sw.) Schott - NRS2263 CCA 28

**Parkeriaceae**

*Ceratopteris thalictroides* (L.) Brongn. - NRS0720 CCA 10

**Polypodiaceae**

*Drynaria quercifolia* (L.) Sm. - NRS1327 BTNR

*Lecanopteris sinuosa* (Wall. ex Hook.) Copel. - NRS0157 CCA 18; NRS0221; NRS1193 CCA 7; NRS0529 CCA 36; NRS0455 CCA 46

*Platycerium coronarium* (Koenig) Desv. - NRS1603 CCA 18; NRS1652 CCA 46; NRS2439 CCA 7

*Pyrrosia longifolia* (Burm.) Morton - NRS0131 CCA 18

*Pyrrosia piloselloides* (L.) M.G. Price - NRS2441 CCA 7

**Pteridaceae**

*Pteris ensiformis* Burm. - NRS2383 CCA 45

**Salviniaceae**

*Salvinia molesta* D.S. Mitchell - NRS0834 CCA 11

**Schizaeaceae**

*Lygodium longifolium* (Willd.) Sw. - NRS1439 CCA 44; NRS1647 CCA 15; NRS1699 CCA 45; NRS1745 CCA 47; NRS1770 CCA 47; NRS1906 CCA 25; NRS2021 CCA 24; NRS2116 CCA 12; NRS2227 CCA 36; NRS2368 CCA 45; NRS2216 CCA 43

*Lygodium microphyllum* (Cav.) R.Br. - NRS0243 CCA 17; NRS2248 CCA 28

*Schizaea dichotoma* (L.) Sm. - NRS0479 CCA 17; NRS1850 CCA 16; NRS2088 CCA 17; NRS2561 CCA 43

*Schizaea digitata* (L.) Sw. - NRS0384 CCA 17; NRS0171 CCA 18; NRS2055 CCA 24; NRS2359 CCA 45

**Thelypteridaceae**

*Christella dentata* (Forssk.) Brownsey & Jermy - NRS0263 CCA 17

*Christella parasitica* (L.) Lév. - NRS0629 CCA 17; NRS0145 CCA 18

*Cyclosorus interruptus* (Willd.) H. Itô - NRS0242 CCA 17

*Mesophlebion motleyanum* (Hook.) Holttum - NRS1750 CCA 12

*Pronephrium triphyllum* (Sw.) Holttum - NRS0286 CCA 17

**Vittariaceae**

*Vittaria ensiformis* Sw. - NRS1832 CCA 15; NRS2406 CCA 45

## GNETOPHYTA

**Gnetaceae**

*Gnetum gnemonoides* Brongn. - NRS0781 CCA 18

*Gnetum macrostachyum* Hook.*f.* - NRS1262 CCA 29; NRS0325 CCA 30; NRS0244 CCA 17; NRS0196 CCA 18

*Gnetum microcarpum* Blume - NRS0915 CCA 6

## CONIFEROPHYTA

**Podocarpaceae**

*Podocarpus polystachus* R.Br. ex Endl. - NRS0428 CCA 47; NRS0344 CCA 30

## ANGIOSPERMOPHYTA

**Acanthaceae**

*Asystasia nemorum* Nees - NRS0400 CCA 30; NRS0820 CCA 11

*Hygrophila ringens* (L.) R.Br. ex Steud. - NRS2438 CCA ?

*Ruellia repens* L. - NRS1049 CCA 41; NRS0029 CCA 13

*Ruellia tuberosa* L. - NRS0965 CCA 26

*Staurogyne setigera* Kuntze - NRS0166 CCA 18

*Thunbergia alata* Boj. ex Sims - NRS0741 CCA 10; NRS0916 CCA 6

*Thunbergia grandiflora* Roxb. - NRS0454 CCA 46

**Amaranthaceae**

*Alternanthera sessilis* (L.) R.Br. ex DC. - NRS0496 CCA 17

*Amaranthus tricolor* L. - NRS0913 CCA 6

**Anacardiaceae**

*Buchanania arborescens* (Blume) Blume - NRS1932 CCA 25

*Buchanania sessifolia* Blume - NRS0241 CCA 17; NRS1372 CCA 10

*Campnosperma squamatum* Ridl. - NRS1010 CCA 18; NRS1413 CCA 7; NRS2427 CCA 13

**Ancistrocladaceae**

*Ancistrocladus tectorius* (Lour.) Merr. - NRS1523 CCA 13

**Anisophylleaceae**

*Anisophyllea disticha* (Jack) Baill. - NRS0591 CCA 53; NRS0488 CCA 17; NRS0217 CCA 25; NRS0307 BTNR

**Annonaceae**

*Artabotrys costatus* King - NRS1358 CCA 18

*Artabotrys suaveolens* (Blume) Blume - NRS0694 CCA 45; NRS0827 CCA 11; NRS0249 CCA 17; NRS0341 CCA 30; NRS1412 CCA 7

*Cyathocalyx ramuliflorus* (Maingay ex Hook.*f.* & Thomson) Scheff. - NRS0585 CCA 53; DJM177 BTNR

*Cyathostemma viridiflorum* Griff. - NRS0651 CCA 17; NRS0483 CCA 17; NRS0703 CCA 45; NRS0885 CCA 54

*Desmos dasymaschala* (Blume) Saff. - NRS1235 CCA 54; NRS1293 CCA 43

*Ellipeia cuneifolia* Hook.*f.* & Thomson - NRS1983 CCA 24

*Fissistigma fulgens* (Hook.*f.* & Thomson) Merr. - NRS0666 CCA 17

*Friesodielsia latifolia* (Hook.*f.* & Thomson) Steenis - NRS0216 CCA 25

*Goniothalamus macrophyllus* (Blume) Hook.*f.* & Thomson - NRS1171 CCA 18; NRS0313 BTNR

*Goniothalamus ridleyi* King - NRS0160 CCA 18

*Mitrella kentii* (Blume) Miq. - NRS0119 CCA 18; NRS0546 CCA 47; NRS1042 CCA 41

*Phaeanthus ophthalmicus* (Roxb. ex G.Don) J. Sinclair - NRS1208 CCA 7; NRS1276 CCA 5; NRS1402 CCA 7; DJM179 BTNR

*Polyalthia angustissima* Ridl. - NRS2133 CCA 17

*Polyathia cauliflora* Hook.*f.* & Thomson - NRS1234 CCA 54; NRS1233 CCA 54; NRS1787 CCA 48

*Polyalthia lateriflora* (Blume) King - NRS1419 CCA 43

*Polyathia macropoda* King - NRS1069 CCA 17; NRS1311 CCA 35; NRS1219 CCA 54; NRS2137 17

*Popowia fusca* King - NRS1307 CCA 43

*Popowia pisocarpa* (Blume) Endl. - NRS0695 CCA 45; NRS1389 CCA 49; NRS1415 CCA 43

*Pyramidanthe prismatica* (Hook.*f.* & Thomson) Merr. - NRS0277 CCA 17; NRS0470 CCA 46; CCA 17

*Uvaria cordata* (Dunal) Alston - NRS0120 CCA 18; NRS0355 CCA 30; NRS0543 CCA 47

*Uvaria hirsuta* Jack - NRS1334 CCA 49

*Xylopia ferruginea* (Hook.*f.* & Thomson) Hook.f. & Thomson - NRS1222 CCA 54

*Xylopia malayana* Hook.*f.* & Thomson - NRS1335 CCA 49; NRS2054 CCA 24; DJM100 CCA 18

**Apocynaceae**

*Allamanda cathartica* L. - NRS0796 CCA 11

*Alstonia angustifolia* Wall. ex A.DC. - NRS0905 CCA 6; NRS1207 CCA 7; NRS1142 CCA 36

*Kibatalia maingayi* (Hook.*f.*) Woodson - NRS0224 CCA ?

*Kopsia singapurensis* Ridl. - NRS0126 CCA 18

*Leuconotis griffithii* Hook.*f.* - NRS0900 CCA 6

*Leuconotis maingayi* Dyer ex Hook.*f.* - NRS0169 CCA 18

*Tabernaemontana corymbosa* Roxb. - NRS0975 CCA 26; NRS1085 CCA 20

*Tabernaemontana pauciflora* Blume - NRS0903 CCA 6; NRS1270 CCA 5; NRS1110 CCA 33; NRS1316 CCA 35

*Willughbeia coriacea* Wall. - NRS0048 CCA 13; NRS0077 CCA 24; NRS2335 CCA 47

*Willughbeia tenuiflora* Dyer ex Hook. *f.* - NRS0245 CCA 17

**Araceae**

*Aglaonema nebulosum* N.E.Br. - NRS0673 CCA 17; NRS1225 CCA 54; NRS0161 CCA 18; NRS1475 CCA 47

*Aglaonema nitidium* (Jack) Kunth - NRS0766 CCA 18; NRS0009 CCA 13; NRS0994 CCA 13; NRS0142 CCA 18; NRS0604 CCA17; NRS0367 CCA 30

*Aglaonema simplex* Blume - NRS0868 CCA 18; NRS1103 CCA 33; NRS1060 CCA 41; NRS1038 CCA 18; NRS1019 CCA 18; DJM315 BTNR

*Alocasia denudata* Engl. -NRS0712 CCA 45; NRS0297 BTNR; NRS0453 CCA 46; NRS1465 CCA 47

*Alocasia macrorrhizos* (L.) G.Don - NRS0970 CCA 32; NRS0989 CCA 32

*Anadendrum montanum* (Blume) Schott - NRS0081 CCA 24; NRS1470 CCA 47; NRS2418 CCA 13; DJM158 BTNR

*Cryptocoryne griffithii* Schott - NRS1525 CCA 13; NRS1978 CCA 18

*Cyrtosperma merkusii* (Hassk.) Schott - NRS1091 CCA 33; NRS1090 CCA 33; NRS0889 CCA 18; NRS1500 CCA 13

*Homalomena griffithii* (Schott) Hook.*f.* - NRS2519 CCA 58

*Homalomena sagittifolia* Jungh. ex Schott - NRS0538 CCA 47; NRS1263 CCA 41; NRS2419 CCA 18

*Pothos latifolius* Hook.*f.* - NRS1415 CCA 43; NRS1450 CCA 47; NRS1819 CCA 48; NRS2013 CCA 24; NRS2148 CCA 17; NRS2503 CCA 15

*Rhaphidophora korthalsii* Schott - NRS1591 CCA 18; NRS1969 CCA 28

*Rhaphidophora lobbii* Schott - NRS1485 CCA 49

*Rhaphidophora sylvestris* (Blume) Engl. var. *montana* (Blume) Nicols. - NRS0992 CCA 13

*Schismatoglottis wallichii* (Roxb.) Hook.*f.* - NRS1604 CCA 18; NRS1721 CCA 43

*Scindapsus hederaceus* (Zoll. & Moritzi) Miq. - NRS1509 CCA 13

*Scindapsus pictus* Hassk. - NRS1756 CCA 47; NRS1815 CCA 48; NRS2169 CCA 17; NRS2323 CCA 6; NRS2514 CCA 15

*Syngonium podophyllum* Schott - NRS1371 CCA 10; NRS2430 CCA 12

**Aristolochiaceae**

*Thottea grandiflora* Rottb. - NRS1377 CCA 49; NRS1458 CCA 47; NRS1458 CCA 47

**Asclepiadaceae**

*Dischidia major* (Vahl) Merr. - NRS0810 CCA 11

*Dischidia nummularia* R.Br. - NRS0576 CCA 46; NRS0547 CCA 47

*Hoya lacunosa Blume* - NRS0640 CCA 17; NRS1356 CCA 24

*Hoya sp*. - NRS0948 CCA 28

*Hoya parasitica* (Roxb.) Wall. ex Wight - NRS0519 CCA 36; NRS0584 CCA 53; NRS0414 CCA 47; NRS0446 CCA 47; NRS0561 CCA 46; NRS1147 CCA 36; NRS2468 CCA 7

*Hoya ridleyi* King & Gamble - NRS2063 CCA 24

**Balsaminaceae**

*Hydrocera triflora* (L.) Wight & Arnott - NRS0480 CCA 17; NRS0742 CCA 10; NRS1216 CCA 7

**Bignoniaceae**

*Jacaranda filicifolia* D.Don. - NRS0327 CCA 30

*Spathodea campanulata* Beauv. - NRS0760 CCA 18

**Bombacaceae**

*Neesia synandra* Mast. - NRS0320 BTNR; NRS0356 CCA 30; NRS0996 CCA 13

**Boraginaceae**

*Cordia cylindristachya* Roem. & Schultz - NRS0934 CCA 6; NRS1129 CCA 33

*Heliotropium indicum* L. - NRS1159 CCA 16; NRS0032 CCA 13

**Bromeliaceae**

*Ananas comosus* (L.) Merr. - NRS0628 CCA 17

**Burmanniaceae**

*Burmannia coelestis* D.Don - NRS1323 48

**Burseraceae**

*Canarium patentinervium* Miq. - NRS0581 CCA 53

**Butomaceae**

*Limnocharis flava* (L.) Buchenau - NRS0019 CCA 13; NRS1089 CCA 20

**Cabombaceae**

*Cabomba aquatica* Aubl. - NRS0017 CCA 13

**Cannaceae**

*Canna indica* L. - NRS0963 CCA 32

**Capparaceae**

*Cleome rutidosperma* DC. - NRS0174 CCA 18; NRS0912 CCA 6

**Celastraceae**

*Bhesa paniculata* Arn. - NRS0170 CCA 18; NRS0521 CCA; NRS0579 CCA 53; NRS0057 CCA 25; NRS1202 CCA 7; NRS1030 CCA 18

*Kokoona reflexa* (Laws.) Ding Hou - DJM346 BTNR

*Salacia grandiflora* Kurz - NRS0128 CCA 18

**Commelinaceae**

*Amischotolype gracilis* (Ridl.) I.M. Turner - NRS0272 CCA 17; NRS0179 CCA 18; NRS0377 CCA 17; NRS0875 CCA 18; NRS1306 CCA 43; NRS2521 CCA 15

*Commelina diffusa* Burm.*f.* - NRS0238 CCA 17

**Compositae**

*Ageratum conyzoides* L. - NRS0084 CCA 24

*Blumea lacera* (Burm.*f.*) DC. - NRS0151 CCA 18

*Crassocephalum crepidiodes* (Benth.) S.Moore - NRS1215 CCA 7

*Eclipta prostrata* (L.) L. - NRS0926 CCA 6

*Elephantopus scaber* L. - NRS0773 CCA 18; NRS0873 CCA 18

*Emilia sonchifolia* (L.) DC. ex Wight - NRS0928 CCA 6

*Erechtites hieracifolia* (L.) Rafin. ex DC. - NRS0939 CCA 28

*Mikania micrantha* Kunth - NRS0226 CCA 25; NRS0396 CCA 30; NRS0736 CCA 10

*Sparganophorus sparganophora* (L.) C. Jeffrey - NRS1206 CCA 7

*Synedrella nodiflora* (L.) Gaertn. - NRS0918 CCA 6

**Connaraceae**

*Agelaea borneensis* (Hook.*f.*) Merr. - NRS0641 CCA 17; NRS0638 CCA 17; NRS2422 CCA 12

*Agelaea macrophylla* (Zoll.) Leenh. - NRS1538 CCA 28

*Cnestis palala* (Lour.) Merr. - NRS2129 CCA 13

*Rourea fulgens* Planch. - NRS0860 CCA 18

*Rourea mimosoides* (Vahl) Planch. - NRS1553 CCA 28

**Convallariaceae**

*Peliosanthes teta* Andr. ssp. *humilis* (Andr.) Jessp. - NRS1169 CCA 18; NRS1031 CCA 18

**Convolvulaceae**

*Aniseia martinicensis* (Jacq.) Choisy - NRS0951 CCA 28; NRS0977 CCA 26

*Argyreia ridleyi* Prain ex Ooststr. - NRS0001 CCA 13

*Cuscuta australis* R.Br. - NRS1364 CCA 5

*Erycibe malaccensis* C.B. Clarke - NRS1354 CCA 24; NRS1577 CCA 15

*Erycibe tomentosa* Blume var. *tomentosa* - NRS0423 CCA 47; NRS0536 CCA 47; NRS0405 CCA 30; NRS0398 CCA 30; NRS0181 CCA 18; NRS0365 CCA 30; NRS0205 CCA ?; NRS0800 CCA 11; NRS0968 CCA 26; NRS0552 CCA 46

*Ipomoea congesta* R.Br. - NRS2425 CCA 13

*Ipomoea pes-caprae* (L.) Sweet ssp. *brasiliensis* (L.) Ooststr. - NRS0625 CCA 17

*Merremia hederacea* (Burm.*f.*) Hallier *f.* - NRS0003 CCA 13

*Merremia tridentata* (L.) Hallier *f.* - NRS0891 CCA 6; NRS0971 CCA 26; NRS0219 CCA 25

**Costaceae**

*Costus lucanusianus* J. Braun & K. Schum. - NRS0826 CCA 11

*Costus speciosus* (J. König) Sm. - NRS0967 CCA 32

**Cucurbitaceae**

*Momordica charantia* L. - NRS0895 CCA 6

*Trichosanthes celebica* Cogn. - NRS0392 CCA 17

*Trichosanthes wawraei* Cogn. - NRS0078 CCA 24; NRS0842 CCA 11

**Cyperaceae**

*Cyperus digitatus* Roxb. - NRS0717 CCA 10

*Cyperus halpan* L. - NRS0594 CCA 53

*Fimbristylis globulosa* (Retz.) Kunth - NRS0919 CCA 6

*Gahnia tristis* Nees - NRS1138 CCA 33; NRS1820 CCA 16; DJM320 BTNR

*Hypolytrum nemorum* (Vahl) Spreng. - NRS0961 C29/37; NRS1176 CCA 18; NRS1158 CCA 16; NRS1236 CCA 54; NRS0040 CCA 13; NRS0607 CCA 17; NRS0082 CCA 24; NRS0093 CCA 24; NRS1477 CCA 47

*Mapania cuspidata* (Miq.) Uittien - NRS1290 CCA 43; NRS0304 BTNR; NRS1620 CCA 18; NRS1743 CCA 47

*Mapania palustris* (Hassk. ex Steud.) Fern.-Vill. - NRS1278 CCA 43; NRS0369 CCA 17

*Mapania squamata* (Kurz) C.B. Clarke - NRS1505 CCA 13

*Rhynchospora corymbosa* (L.) E. Britton - NRS0095 CCA 24

*Scleria biflora* Roxb. - NRS2483 CCA 7

*Scleria ciliaris* Nees - NRS0620 CCA 17

*Scleria levis* Retz. - NRS0831 CCA 11; NRS1927 CCA 25; NRS2301 CCA 7; NRS2372 CCA 45

*Thoracostachyum bancanum* (Miq.) Kurz - NRS0362 CCA 30; NRS2396 CCA 45

**Daphniphyllaceae**

*Daphniphyllum laurinum* (Benth.) Baill. - NRS0416 CCA 47

**Dilleniaceae**

*Dillenia suffruticosa* (Griff.) Martelli - NRS0197 CCA ?

*Tetracera indica* (Christm. & Panz.) Merr. - NRS0184 CCA 18; NRS0287 CCA 17; NRS0485 CCA 17; NRS0946 CCA 28; NRS0711 CCA 45; NRS0415 CCA 47; DJM178 BTNR

**Dioscoreaceae**

*Dioscorea laurifolia* Wall. ex Hook.*f.* - NRS0443 CCA 47; NRS0042 CCA 13

*Dioscorea prainiana* R.Knuth NRS2270 CCA 28

*Dioscorea pyrifolia* Kunth - NRS0481 CCA 17

*Dioscorea sansibarensis* Pax - NRS1224 CCA 54

*Dioscorea stenomeriflora* Prain & Burkill - NRS1632 CCA 33

**Dipterocarpaceae**

*Dipterocarpus* sp. - NRS0691 CCA 17

**Dracaenaceae**

*Dracaena aurantiaca* Wall. - NRS0292 CCA 17; NRS0113 CCA 24; NRS0139 CCA 18

*Dracaena fragrans* (L.) Ker-Gawl. - NRS0909 CCA 6; NRS0813 CCA 11

*Dracaena granulata* Hook.*f*. - NRS1104 CCA 33

*Dracaena porteri* Baker - NRS0334 CCA 30; NRS0059 CCA 25; NRS1260 CCA 29; NRS1221 CCA 54; NRS0956 C29/37; NRS0067 CCA 25

*Dracaena umbratica* Ridl. - NRS1167 CCA 18; NRS1146 CCA 33; NRS1066 CCA 17

**Ebenaceae**

*Diospyros lanceifolia* Roxb. - NRS2014 CCA 24

**Elaeocarpaceae**

*Elaeocarpus ferrugineus* (Jack) Steud. - NRS0088 CCA 24

*Elaeocarpus mastersii* King - NRS0055 CCA 25; NRS0328 CCA 30; NRS0435 CCA 47; NRS0475 CCA 46; NRS0713 CCA 10; NRS0693 CCA 45

*Elaeocarpus petiolatus* (Jack) Wall. - NRS0525 CCA 36; NRS0582 CCA 53; NRS0643 CCA 17

*Elaeocarpus polystachyus* Wall. - NRS0978 CCA 26; NRS0906 CCA 6; NRS1107 CCA 33

*Elaeocarpus stipularis Blume* - NRS0060 CCA 25

**Eriocaulaceae**

*Eriocaulon longifolium* Nees - NRS0436 CCA 47

**Euphorbiaceae**

*Actephila excelsa* (Dalz.) Müll.Arg. var. *javanica* (Miq.) Pax & K. Hoffm. - NRS0299 BTNR

*Agrostistachys longifolia* (Wight) Benth. ex Hook.*f.* - NRS0378 CCA 17; NRS0189 CCA 18; NRS0605 CCA 17

*Alchornea villosa* Müll.Arg. - NRS0239 CCA 17

*Antidesma cuspidatum* Müll.Arg. - NRS0856 CCA 18; NRS0270 CCA 17; NRS0639 CCA 17; NRS0648 CCA 17; NRS0880 CCA 18; NRS0473 CCA 46

*Antidesma neurocarpum* Miq. - NRS0116 CCA 18; NRS0882 CCA 18

*Aporusa benthamiana* Hook.*f.* - NRS1231 CCA 54

*Aporusa confusa* Gage - NRS1359 CCA 18

*Aporusa frutescens* Blume - NRS0193 CCA 18

*Aporusa microstachya* (Tul.) Müll.Arg. - NRS2018 CCA 24

*Aporusa prainiana* King ex Gage - NRS0094 CCA 24; NRS0570 CCA 46

*Aporusa symplocoides* (Hook.*f.*) Gage - NRS0899 CCA 6; NRS402 CCA30; NRS0838 CCA 11; NRS1096 CCA 33; NRS0876 CCA18; NRS0333 CCA 30; NRS0340 CCA 30; NRS0459 CCA 46; NRS0425 CCA 47; NRS0904 CCA 6; NRS0567 CCA 46

*Baccaurea kunstleri* King ex Gage - DJM232 BTNR

*Baccaurea parviflora* (Müll.Arg.) Müll.Arg. - NRS0315 BTNR

*Baccaurea racemosa* (Reinw.) Müll.Arg. - DJM209 BTNR

*Breynia coronata* Hook.*f.* - NRS1115 CCA 28

*Breynia reclinata* (Roxb.) Hook.*f.* - NRS0461 CCA 46

*Claoxylon indicum* (Reinw. ex Blume) Endl. ex Hassk. - NRS0718 CCA 10

*Croton laevifolius* Blume - NRS0872 CCA 18; NRS0859 CCA 18

*Endospermum diadenum* (Miq.) Airy Shaw - NRS1351 CCA 24

*Glochidion littorale* Blume - NRS0941 CCA 28; NRS0441 CCA 47

*Glochidion superbum* Baill. - NRS0007 CCA 13; NRS0358 CCA 30; NRS0943 CCA 28

*Hevea brasilensis* (Willd. ex A. Juss.) Müll.Arg. - NRS1255 CCA 29; NRS0958 CCA 29/37

*Koilodepas longifolium* Hook.*f.* - NRS1305 CCA 43

*Macaranga conifera* (Zoll.) Müll.Arg. - NRS1250 CCA 29

*Macaranga gigantea* (Rchb. *f.* & Zoll.) Müll.Arg. - NRS0957 C29/37; NRS0954 CCA 28

*Macaranga heynei* I.M. Johnston - NRS0492 CCA 17

*Macaranga punticulata* Gage - NRS0716 CCA 10; NRS0984 CCA 32

*Macaranga triloba* (Reinw.) Müll.Arg. - NRS0037 CCA 13; NRS0599 CCA 17; NRS0194 CCA 18; NRS0213 CCA 25

*Mallotus paniculatus* (Lam.) Müll.Arg. - NRS0211 CCA 25; NRS0715 CCA 10; NRS0984 CCA 32; NRS0716 CCA 10; DJM129 BTNR

*Manihot glaziovii* Müll.Arg. - NRS0707 CCA 45; NRS0223 CCA 25; NRS0565 CCA 46; NRS0728 CCA 10

*Neoscortechinia kingii* (Hook.*f.*) Pax & K. Hoffm. - NRS0771 CCA 18; NRS2611 CCA 6

*Sauropus androgynus* (L.) Merr. - NRS0232 CCA 25

*Trigonostemon longifolius* Baill. - NRS1279 CCA 43

**Fagaceae**

*Castanopsis lucida* (Nees) Soepadmo - DJM141 BTNR

*Lithocarpus cantleyanus* (King ex Hook.*f.*) Rehder - NRS1163 CCA 16; NRS0808 CCA 11

*Lithocarpus conocarpus* (Oudem.) Rehder - NRS0539 CCA 47; NRS0564 CCA 46; NRS0498 CCA 17

*Lithocarpus encleisacarpus* (Korth.) A. Camus - NRS0668 CCA 17

*Lithocarpus lucidus* (Roxb.) Rehder - NRS0080 CCA 24

**Flacourtiaceae**

*Flacourtia rukam* Zoll. & Moritzi - NRS0448 CCA 46; NRS0419 CCA 47; NRS0851 CCA 18; NRS1015 CCA 18; NRS0855 CCA 18; NRS0559 CCA 18; NRS0557 CCA 46

**Flagellariaceae**

*Flagellaria indica* L. - NRS0015 CCA 13; NRS2121 CCA12; NRS2458 CCA 7; DJM165 BTNR

**Gesneriaceae**

*Aeschynanthus albidus* (Blume) Steud. (= A. purpurascens Hassk.) - NRS1012 CCA 18; NRS1037 CCA 18

**Gramineae**

*Bambusa tulda* Roxb. - NRS0346 CCA 30

*Centotheca latifolia* (Osbeck) Trin. - NRS0615 CCA 17

*Coix lacryma-jobi* L. - NRS0921 CCA 6

*Dendrocalamus asper* (Schult.f.) Baker ex Heyne - NRS0523 CCA 36

*Imperata cylindrica* (L.) P. Beauv. - NRS2277 CCA 28

*Isachne globosa* (Thunb.) Kuntze - NRS0438 CCA 47

*Isachne pulchella* Roth ex Roem. & Schultz - NRS0168 CCA 18

*Leptaspis urceolata* (Roxb.) R.Br. - NRS0039 CCA 13

*Thysanolaena latifolia* (Roxb. ex Hornem.) Honda - NRS0020 CCA 13; NRS0587 CCA 53

**Guttiferae**

*Calophyllum lanigerum* Miq. var. *austrocoriaceum* (T.C. Whitmore) P.F. Stevens - NRS0278 CCA 17; NRS2336 CCA 48

*Calophyllum tetrapterum* Miq. - NRS0578 CCA 53; NRS0440 CCA 47

*Calophyllum teysmannii* Miq. - NRS1118 CCA 28

*Cratoxylum cochinchinense* (Lour.) Blume - NRS0172 CCA 18

*Garcinia forbesii* King - NRS0359 CCA 30; NRS0937 CCA 28; NRS0887 CCA 18; NRS0858 CCA 18; NRS0352 CCA 30; NRS1404 CCA 7; NRS2420 CCA 17

*Garcinia griffithii* T. Anderson - NRS0108 CCA 24; NRS1938 CCA 24; DJM101 CCA 18

*Garcinia mangostana* L. - NRS1410 CCA 7

*Garcinia parvifolia* (Miq.) Miq. - NRS2002 24; NRS2059 24

*Garcinia urophylla* Scort. ex King - NRS1326 BTNR

*Ploiarium alternifolium* (Vahl) Melch. - NRS0098 CCA 24; NRS1143 CCA 36

**Hanguanaceae**

*Hanguana malayana* (Jack) Merr. - NRS0298 BTNR; NRS0035 CCA 13; NRS1077 CCA 17; NRS0598 CCA 53; NRS1862 CCA 16; NRS2145 CCA 17

**Hydrocharitaceae**

*Hydrilla verticillata* (Roxb.) Royle - NRS0395 CCA 30; NRS0016 CCA 13

**Hypoxidaceae**

*Curculigo latifolia* Dryand. - NRS0371 CCA 17; NRS0025 CCA 13; NRS1144 CCA 33; NRS1095 CCA 33; NRS1132 CCA 33

**Icacinaceae**

*Gomphandra quadrifida* (Blume) Sleumer var. *ovalifolia* (Ridl.) Sleumer - NRS1309 CCA 35; NRS1226 CCA 54; NRS0777 CCA 18; NRS0751 CCA 18

*Iodes cirrhosa* Turcz. - NRS0026 CCA 13

*Iodes ovalis* Blume - NRS0004 CCA 13

*Phytocrene bracteata* Wall. - NRS0714 CCA 10; NRS0980 CCA 32; NRS2039 CCA 24

**Iridaceae**

*Trimezia martinicensis* (Jacq.) Herbert - NRS0134 CCA 18; NRS0993 CCA 13; NRS0595 CCA 53

**Ixonanthaceae**

*Ixonanthes icosandra* Jack - NRS0099 CCA 24; NRS0901 CCA 6

*Ixonanthes reticulata* Jack - NRS0783 CCA 18

**Labiatae**

*Hyptis brevipes* Poit. - NRS0551 CCA 46

*Hyptis capitata* Jacq. - NRS0974 CCA 26

**Lauraceae**

*Cassytha filiformis* L. - NRS1080 CCA 20; NRS0723 CCA 10

*Cinnamomum iners* Reinw. ex Blume - NRS0236 CCA 25; NRS1259 CCA 29

*Cinnamomum javanicum* Blume - DJM230 BTNR

*Cryptocarya ferrea* Blume - NRS1005 CCA 13; DJM175 CCA 18

*Lindera lucida* (Blume) Boerl. - NRS0337 CCA 30

*Litsea costata* (Blume) Boerl. - DJM310 BTNR

*Litsea elliptica* Blume - NRS0936 CCA 28

*Litsea ferruginea* Blume - NRS0572 CCA 46

*Litsea ridleyi* Gamble - NRS1183 CCA 18

**Leeaceae**

*Leea indica* (Burm.*f.*) Merr. - NRS0214 CCA 25; NRS0969 CCA 26; NRS1044 CCA 41; NRS1119 CCA 28; NRS0046 CCA 13; NRS0439 CCA 47

**Leguminosae**

*Archidendron clypearia* (Jack) I.C. Nielsen - NRS0261 CCA 17; NRS0212 CCA 25; NRS0421 CCA 13; NRS0254 CCA 17; NRS0574 CCA 46; NRS1058 CCA 414

*Bauhinia semibifida* Roxb. - NRS0255 CCA 17; NRS0990 CCA 13; NRS0290 CCA 17; NRS1050 CCA 41; NRS0772 CCA 18; NRS0511 CCA 36; DJM154 CCA 18

*Cassia siamea* Lam. - NRS1078 CCA 20

*Centrosema pubescens* Benth. - NRS0164 CCA 18; NRS0925 CCA 6; NRS0733 CCA 10

*Chamaecrista mimosoides* (L.) Greene - NRS0735 CCA 10

*Clitoria laurifolia* Poir. - NRS0133 CCA 18; NRS0182 CCA 18; NRS1079 CCA 20

*Crotalaria retusa* L. - NRS1082 CCA 20

*Derris amoena* Benth. var. *maingayana* (Baker) Prain - NRS0655 CCA 17; NRS0118 CCA 18; NRS0545 CCA 47

*Desmodium heterocarpon* (L.) DC. - NRS0518 CCA 36

*Entada spiralis* Ridl. - NRS1130 CCA 33; NRS0510 CCA 17

*Indigofera hirsuta* L. - NRS1084 CCA 20

*Milletia atropurpurea* (Wall.) Benth. - NRS1261 CCA 29

*Mimosa pigra* L. - NRS0542 CCA 47

*Parkia speciosa* Hassk. - NRS1232 CCA 54

*Saraca thaipingensis* Cantley - NRS0779 CCA 18

*Senna alata* (L.) Roxb. - NRS0730 CCA 10; NRS0522 CCA 36

*Spatholobus ferrugineus* Benth. - NRS2414 CCA 13

**Lentibulariaceae**

*Utricularia bifida* L. - NRS1342 CCA 48

*Utricularia caerulea* L. - NRS1324 CCA 48; NRS1343 CCA 48

*Utricularia gibba* L. - NRS1344 CCA 48

**Linaceae**

*Indorouchera griffithiana* (Planch.) Hallier f. - NRS0814 CCA 11; NRS1257 CCA 29; NRS0462 CCA 46; NRS0100 CCA 24; NRS0155 CCA 18

**Loganiaceae**

*Fagraea fragrans* Roxb. - NRS0269 CCA 17; NRS0745 CCA 10; NRS0908 CCA 6

*Fagraea racemosa* Jack ex Wall. - NRS1068 CCA 17; NRS1065 CCA 17; NRS1027 CCA 18

**Loranthaceae**

*Dendrophthoe pentandra* (L.) Miq. - NRS0388 CCA 17; NRS0987 CCA 26; NRS0614 CCA 17

*Macrosolen cochinchinensis* (Lour.) Tiegh. - NRS0387 CCA 17

*Scurrula ferruginea* (Jack) Danser - NRS0293 CCA 17; NRS0426 CCA 47; NRS0323 CCA 30; NRS0609 CCA 17

**Malvaceae**

*Sida cordifolia* L. - NRS0509 CCA 36

*Sida rhombifolia* L. - NRS0931 CCA 6

*Urena lobata* L. - NRS0932 CCA 6; NRS0898 CCA 6

**Marantaceae**

*Phrynium parvum* (Ridl.) Holttum - NRS1228 CCA 54

*Stachyphrynium griffithii* (Baker) K. Schum. - NRS1283 CCA 43

**Melastomataceae**

*Clidemia hirta* (L.) D. Don. - NRS0043 CCA 13

*Dissochaeta celebica* Blume - NRS1056 CCA 41; NRS1043 CCA 41; NRS0065 CCA 25

*Dissochaeta pallida* (Jack) Blume - NRS0659 CCA 17

*Melastoma malabathricum* L. - NRS0427 CCA 47; NRS2122 CCA 12

*Pachycentria maingayi* (C.B. Clarke) J.F. Maxwell - NRS1723 43

*Pternandra coerulescens* Jack - NRS0754 CCA 18; NRS0264 CCA 17; NRS0861 CCA 18; NRS0645 CCA 17

*Pternandra echinata* Jack - NRS0192 CCA 18; NRS0474 CCA 46; NRS0420 CCA 47

*Pternandra tuberculata* (Korth.) Nayar - DJM251 BTNR

*Sonerila heterostemon* Naud. - NRS0778 CCA 18; NRS2412 CCA 18

**Meliaceae**

*Dysoxylum cauliflorum* Hiern. - NRS0381 CCA 17; NRS1348 CCA 49

**Menispermaceae**

*Fibraurea tinctoria* Lour. - NRS0593 CCA 53; NRS0143 CCA 18; NRS0644 CCA 17; NRS0004 CCA 30; NRS0087 CCA 24; NRS0408 CCA 47; NRS0401 CCA 30; NRS1035 CCA 18; NRS0332 CCA 30; NRS1047 CCA 41; NRS0864 CCA 18; NRS0817 CCA 11; NRS0761 CCA 18; NRS1341 CCA 49

*Limacia scandens* Lour. - NRS0229 CCA 25; NRS0147 CCA 18; NRS0713 CCA 10; NRS0627 CCA 17; NRS1822 CCA 15

*Stephania capitata* (Blume) Spreng. - NRS0159 CCA 18; NRS0794 CCA 11

*Tinomiscium petiolare* Miers. ex Hook.*f.* & Thomson - NRS0091 CCA 24; NRS1062 CCA 17; NRS0671 CCA 17

*Tinospora macrocarpa* Diels - NRS0849 CCA 18

**Menyanthaceae**

*Nymphoides indica* (L.) Kuntze - NRS0897 CCA 6; NRS0732 CCA 10; NRS0832 CCA 11; NRS1272 CCA 5

**Monimiaceae**

*Matthaea sancta* Blume - NRS1003 CCA 13; NRS0012 CCA 13; NRS1024 CCA 18; NRS1023 CCA 18; NRS1034 CCA 18; NRS1503 CCA 13

**Moraceae**

*Artocarpus gomezianus* Wall. ex Tréc. - NRS0513 CCA 36; NRS2437 CCA?

*Ficus apiocarpa* Miq. - NRS0811 CCA 11; NRS1559 CCA 28; NRS2128 CCA 13; NRS2160 17

*Ficus aurantiacea* Griff. - NRS0318 BTNR

*Ficus aurata* Miq. var. *aurata* - NRS0324 CCA 30; NRS0933 CCA 6; NRS0825 CCA 11; NRS0612 CCA 17; NRS0284 BTNR

*Ficus aurata* Miq. var. *longipilosa* Corner - NRS0209 CCA ?; NRS0797 CCA 11; NRS0803 CCA 11; NRS1140 CCA 36

*Ficus binnendykii* Miq. var. *coriacea* Corner - NRS0250 CCA 17; NRS0279 CCA 17

*Ficus bracteata* Wall. ex Miq. - NRS1532 CCA 13

*Ficus chartacea* Wall. ex King - NRS0295 CCA 17; NRS0623 CCA 17; NRS1469 CCA 47; DJM130 BTNR

*Ficus consociata* Blume var. *murtoni* King - NRS0514 CCA 17

*Ficus deltoidea* Jack - DJM12 BTNR

*Ficus fistulosa* Reinw. ex Blume var. *fistulosa* - NRS0010 CCA 13; NRS0195 CCA 18; NRS0234 CCA 25; NRS0137 CCA 18; NRS0757 CCA 18; NRS1123 CCA 28; NRS1128 CCA 28

*Ficus globosa* Blume - NRS0183 CCA 18; NRS0130 CCA 18; NRS0430 CCA 47; NRS0424 CCA 47; NRS0434 CCA 47; NRS0959 CCA 29/37; NRS0888 CCA 18; NRS1253 CCA 29; NRS0680 CCA 17

*Ficus grossularioides* Burm.*f.* - NRS0750 CCA 10; NRS0802 CCA 11; NRS0747 CCA 10

*Ficus heteropleura* Blume - NRS0202 CCA ?; NRS0203 CCA ?; NRS1254 CCA 29; NRS0960 C29/37; NRS1180 CCA 18

*Ficus laevis* Blume - DJM362 BTNR

*Ficus pisocarpa* Blume - DJM318 CCA 18

*Ficus sagittata* Vahl - NRS0618 CCA 17

*Ficus scortechinii* King - NRS1174 CCA 18

*Ficus sinuata* Thunb. - NRS0186 CCA 18; NRS1000 CCA 13

*Ficus sundaica* Blume - NRS0014 CCA 13

*Ficus trichocarpa* Blume - DJM171 CCA 18

*Ficus villosa* Blume - NRS1618 CCA 18; NRS1896 CCA 16; NRS1954 CCA 18; NRS2120 CCA 12

*Streblus elongatus* (Miq.) Corner - NRS0512 CCA 36; NRS0308 BTNR; NRS1370 CCA 10

**Musaceae**

*Heliconia bihai* L. - NRS0835 CCA 11

*Heliconia psittacorum* L.*f*. - NRS0045 CCA 13; NRS0701 CCA 45

**Myristicaceae**

*Gymnacranthera farquhariana* (Hook.*f*. & Thomson) Warb. - NRS1052 CCA 41

*Gymnacranthera forbesii* (King) Warb. - NRS1190 CCA 18; NRS0464 CCA 46

*Horsfieldia polyspherula* (Hook.*f*. emend King) J. Sinclair var. *sumatrana* (Miq.) W.J. de Wilde - NRS0520 CCA 36

*Horsfieldia punctatifolia* J. Sinclair - DJM132 BTNR

*Knema latericia* Elm. - NRS0869 CCA 18; NRS0769 CCA 18; NRS0866 CCA 18; NRS1026 CCA 18; NRS0086 CCA 24; NRS0637 CCA 17

*Knema laurina* (Blume) Warb. - NRS0074 CCA 24

*Knema malayana* Warb. - NRS0030 CCA 13

*Myristica elliptica* Wall. ex Hook.*f*. & Thomson - NRS0391 CCA 17; NRS0049 CCA 13; NRS1243 CCA 54

*Myristica maingayi* Hook.*f*. - DJM309 BTNR

**Myrsinaceae**

*Ardisia colorata* Roxb. - NRS0018 CCA 13; NRS0685 CCA 45; NRS1161 CCA 16; NRS1124 CCA 28; NRS0596 CCA 53; NRS0312 BTNR; NRS0610 CCA 17; NRS0819 CCA 11; NRS0795 CCA 11; NRS0792 CCA 11; NRS0886 CCA18

*Ardisia miqueliana* Scheff. - NRS0767 CCA 18

*Ardisia singaporensis* Ridl. - NRS2079 CCA 17

*Ardisia villosa* Roxb. - NRS0883 CCA 18

*Embelia canescens* Jack - NRS0947 CCA 28

*Embelia lampani* Scheff. - NRS0468 CCA 46; NRS0613 CCA 17

*Embelia ribes* Burm. - NRS0463 CCA 46; NRS0589 CCA 53; NRS0452 CCA46; NRS0208 CCA 25

*Labisia pumila* (Blume) Fern.-Vill. - NRS0686 CCA 45; NRS1186 CCA 18; NRS1039 CCA 18; NRS0140 CCA 18; NRS0376 CCA 17; NRS1014 CCA 18; NRS0180 CCA 18; NRS0753 CCA 18; NRS1384 CCA 49; NRS1466 CCA 47; NRS1800 CCA 48

*Maesa ramentacea* Wall. ex Roxb. - NRS0724 CCA 10; NRS1249 CCA 29; NRS0467 CCA 46

**Myrtaceae**

*Aphanomyrtus rostrata* Miq. - NRS0878 CCA 18

*Decaspermum fruticosum* J.R. Forst. & G. Forst - NRS0727 CCA 10; NRS0602 CCA 17; NRS0791 CCA 11; DJM174 CCA 18

*Eugenia cerina* M.R. Hend. - NRS0235 CCA 25

*Eugenia cumingiana* Vidal - NRS1332 CCA 49

*Eugenia filiformis* Duthie var. *filiformis* - NRS1267 CCA 5; NRS0537 CCA 47

*Eugenia filiformis* Duthie var. *clavimyrtus* (Koord. & Valeton) M.R. Hend. - NRS1994 CCA 24

*Eugenia grandis* Wight - NRS0231 CCA 25; NRS0350 CCA 30; NRS0924 CCA 6

*Eugenia longiflora* (Presl) Fern.-Vill. - NRS0013 CCA 13; NRS0062 CCA 25; NRS0237 CCA 17; NRS0894 CCA 6; NRS0938 CCA 28

*Eugenia oblongifolia* Duthie - NRS0497 CCA 17

*Eugenia pachyphylla* Kurz - NRS0138 CCA 18

*Eugenia polyantha* Wight - NRS0562 CCA 18; NRS1274 CCA 5; NRS1361 CCA 18

*Eugenia pustulata* Duthie - NRS1347 CCA 49

*Eugenia ridleyi* King - NRS0555 CCA 5

*Eugenia spicata* Lam. - NRS0743 CCA 10; DJM322 CCA 48

*Psidium guajava* L. - NRS0890 CCA 6

*Rhodamnia cinerea* Jack - NRS0257 CCA 17; NRS0491 CCA 17; NRS0910 CCA 6; NRS0929 CCA 6; NRS0114 CCA 28; NRS0892 CCA 6; NRS1059 CCA 41; NRS0418 CCA 47

*Rhodomytrus tomentosa* (Ait.) Hassk. - NRS0981 CCA 26

**Najadaceae**

*Najas indica* (Willd.) Cham. - NRS0403 CCA 30; NRS0838 CCA 18

*Najas malesiana* Delile - NRS0090 CCA 24

**Nepenthaceae**

*Nepenthes ampullaria* Jack - NRS0345 CCA 30

*Nepenthes gracilis* Korth. - NRS0422 CCA 47; NRS0603 CCA 17; NRS1102 CCA 33

*Nepenthes rafflesiana* Jack - NRS0268 CCA 17; NRS0601 CCA 17; NRS1093 CCA 33

**Nymphaeaceae**

*Nymphaea pubescens* Willd. - NRS0008 CCA 13

**Ochnaceae**

*Gomphia serrata* (Gaertn.) Kanis - NRS0301 BTNR

*Ochna kirkii* Oliv. - NRS0793 CCA 11

**Olacaceae**

*Erythropalum scandens* Blume - NRS0390 CCA 17; NRS0657 CCA 17; NRS0845 CCA 18; NRS1017 CCA 18; NRS0566 CCA 46; NRS0844 CCA 18; NRS1876 CCA 18; NRS2423 CCA 12

*Strombosia ceylanica* Gardn. - NRS1392 CCA 49; NRS1714 CCA 43; NRS1946 CCA 18

*Strombosia javanica* Blume - DJM333 BTNR

**Onagraceae**

*Ludwigia adscendens* (L.) Hara - NRS0729 CCA 10

*Ludwigia hyssopifolia* (G. Don) Exell - NRS0033 CCA 13; NRS0489 CCA 17

*Ludwigia octovalvis* (Jacq.) Raven - NRS0410 CCA 47

**Opiliaceae**

*Champereia manillana* (Blume) Merr. - NRS0265 CCA 17; NRS0465 CCA 46; NRS0600 CCA 17; NRS0588 CCA 53; NRS1125 CCA 28; NRS0442 CCA 47; NRS0698 CCA 45; NRS0335 CCA 30; NRS0699 CCA 45

*Lepionurus sylvestris* Blume - NRS2337 CCA 47

**Orchidaceae**

*Arundina graminifolia* (Don) Hochr. - NRS0115 CCA 18; NRS0966 CCA 26; NRS0737 CCA 10

*Bromheadia finlaysoniana* (Lindl.) Rchb.*f.* - NSR0985 CCA 26; NRS0399 CCA 30

*Bulbophyllum gusdorfii* J.J.Sm. - NRS1683 CCA 45

*Bulbophyllum macranthum* Lindl. - NRS1320 CCA 18

*Bublophyllum vaginatum* (Lindl.) Rchb.*f.* - NRS1682 CCA 45

*Calanthe pulchra* (Blume) Lindl. - NRS2089 CCA 16

*Claderia viridiflora* Hook.*f.* - NRS0002 CCA 13; NRS1113 CCA 28

*Cymbidium finlaysonianum* Lindl. - NRS2175 CCA17

*Dendrobium crumenatum* Sw. - NRS0110 CCA 24; NRS0200 CCA ?; NRS1081 CCA 20

*Eulophia graminea* Lindl. - NRS0124 CCA 18

*Lecanorchis malaccensis* Ridl. - NRS1533 CCA 13

*Nephelaphyllum pulchrum* Blume - NRS0775 CCA 18; NRS0847 CCA 18; NRS1936 CCA 18

*Plocoglottis gigantea* (Hook.*f.*) J.J.Sm. - NRS0122 CCA 18; NRS0125 CCA 18; NRS1002 CCA 13

*Plocoglottis javanica* Blume - NRS0999 CCA 13; NRS1516 CCA 13

*Pteroceras pallidum* (Ridl.) Holttum - NRS1935 CCA 18

*Spathoglottis plicata* Blume - NRS0021 CCA 13; NRS0738 CCA 10; NRS0548 CCA 47; NRS1923 CCA 25

*Taeniophyllum obtusum* Blume - NRS1318 CCA 18

*Thrixspermum trichoglottis* (Hook.*f.*) Kuntze - NRS1319 CCA 18

*Vanilla griffithii* Rchb.*f.* - NRS0955 CCA 28; NRS1112 CCA 28; NRS1353 CCA 24; NRS2140 CCA 17

**Oxalidaceae**

*Averrhoa carambola* L. - NRS0922 CCA 6

*Oxalis barrelieri* L. - NRS0437 CCA 47; NRS0776 CCA 18; NRS0914 CCA 6

**Palmae**

*Areca alicae* F.v.M. - NRS0962 C29/37

*Areca catechu* L. - NRS1088 CCA 20

*Calamus diepenhorstii* Miq. - NRS1245 CCA 54; NRS1239 CCA 54

*Calamus insignis* Griff. - NRS1302 CCA 43

*Calamus lobbianus* Becc. - NRS1300 CCA 43; NRS0294 BTNR

*Calamus oxleyanus* Teijsm. & Binn. - NRS1299 CCA 43; NRS0316 BTNR

*Caryota mitis* Lour. - NRS0457 CCA 46; NRS0407 CCA 47

*Daemonorops angustifolia* (Griff.) Martelli - NRS0677 CCA 17; NRS0833 CCA 11; NRS0683 CCA 17; NRS0031 CCA 13; NRS2431 CCA 13; NRS0505 CCA 17

*Daemonorops didymophylla* Becc. - NRS0360 CCA 30; NRS0818 CCA 11; NRS1298 CCA 43; NRS0682 CCA 17; NRS0824 CCA 11; NRS1240 CCA 54; NRS0676 CCA 17; NRS0311 BTNR; NRS0366 CCA 30

*Daemonorops geniculata* (Griff.) Martelli - NRS0541 CCA 47; NRS0450 CCA 46

*Daemonorops grandis* (Griff.) Martelli - NRS0283 CCA 17; NRS0503 CCA 17; NRS0506 CCA 17

*Daemonorops hystrix* (Griff.) Martelli - NRS0502 CCA 17; NRS0056 CCA 25; NRS0806 CCA 11; NRS0815 CCA 11

*Daemonorops leptopus* (Griff.) Martelli - NRS1109 CCA 33

*Daemonorops longipes* (Griff.) Martelli - NRS0386 CCA 17; NRS0505 CCA 17; NRS0361 CCA 30; NRS0385 CCA 17; NRS0681 CCA 17; NRS0280 CCA 17; NRS2424 CCA 13

*Daemonorops periacantha* Miq. - NRS0684 CCA 17

*Iguanura wallichiana* (Wall. ex Martelli) Hook.*f*. - NRS0177 CCA 18; NRS1313 CCA 35

*Korthalsia echinometra* Becc. - NRS1175 CCA 18

*Licuala ferruginea* Becc. - NRS0550 CCA 47; NRS1177 CCA 18; NRS0597 CCA 53

*Nenga pumila* (Martelli) Wendl. - NRS0364 CCA 30; NRS0821 CCA 11; NRS0744 CCA 10; NRS1248 CCA 54

*Oncosperma horridum* (Griff.) Scheff. - NRS0342 CCA 30

*Pinanga malaiana* (Martelli) Scheff. - NRS0109 CCA 24; NRS0135 CCA 18; NRS0382 CCA 17; NRS0879 CCA 18

*Plectocomia elongata* Martelli ex Blume - NRS0107 CCA 24; NRS1111 CCA 33; NRS0549 CCA 47; NRS1266 CCA 41; NRS0678 CCA 17

*Rhopaloblaste singaporensis* (Becc.) Hook.*f*. - NRS1308 CCA 35; NRS1444 CCA 43; NRS1455 CCA 47

**Pandaceae**

*Galearia fulva* (Tul.) Miq. - NRS0654 CCA 17; NRS1230 CCA 54; NRS0881 CCA 18

**Pandanaceae**

*Freycinetia angustifolia* Blume - NRS2057 24; NRS2131 CCA 17

*Freycinetia imbricata* Blume - NRS1420 CCA 43

*Frecinetia javanica* Blume - NRS1527 CCA13; NRS1597 CCA 18; NRS1959 CCA 18

*Pandanus atrocarpus* Griff. - NRS1993 CCA 24; NRS2097 CCA 17; NRS2198 CCA 25

*Pandanus houlletii* Carriere - NRS1418 CCA 43

*Pandanus monotheca* Martelli - NRS0710 CCA 45; NRS1303 CCA 43; NRS1241 CCA 54

*Pandanus motleyanus* Solms - NRS2183 CCA 25

*Pandanus parvus* Ridl. - NRS1776 CCA 48

*Pandanus scortechinii* Martelli - NRS2072 CCA 16

**Passifloraceae**

*Adenia macrophylla* (Blume) Koord. var. *singaporeana* (Wall. ex G. Don) W.J. de Wilde - NRS0058 CCA 25; NRS0447 CCA 46; NRS1028 CCA 18; NRS1357 CCA 25

*Passiflora foetida* L. - NRS0726 CCA 10

*Passiflora laurifolia* L. - NRS1237 CCA 54

*Passiflora suberosa* L. - NRS0260 CCA 17; NRS0527 CCA 36

**Phormiaceae**

*Dianella ensifolia* (L.) DC. - NRS1136 CCA 33; NRS0281 CCA 18

**Piperaceae**

*Piper caninum* Blume - NRS1472 CCA 47; NRS1432 CCA 43; NRS2042 CCA 24

*Piper muricatum* Blume - NRS1187 CCA 18

*Piper pedicellosum* Wall. ex C. DC. - NRS1265 CCA 41

**Polygalaceae**

*Polygala paniculata* L. - NRS0952 CCA 28

*Xanthophyllum affine* Korth. - NRS0816 CCA 11; NRS1213 CCA 7; NRS0995 CCA 13; NRS1762 CCA 47; NRS1783 CCA 48; NRS2016 CCA 24

*Xanthophyllum ellipticum* Korth. - NRS0575 CCA 46; NRS2338 CCA 47

*Salomonia cantoniensis* Lour. - NRS0105 CCA 24

**Polygonaceae**

*Polygonum barbatum* L. - NRS0022 CCA 13; NRS1198 CCA 7

*Polygonum chinense* L. - NRS0976 CCA 26; NRS0964 CCA 26

*Polygonum orientale* L. - NRS1105 CCA 33

**Pontederiaceae**

*Monochoria hastata* (L.) Solms - NRS1083 CCA 20

*Monochoria vaginalis* (Burm.*f.*) Presl - NRS0036 CCA 13; NRS0658 CCA 17

**Rhizophoraceae**

*Gynotroches axillaris* Blume - NRS0432 CCA 47; NRS1053 CCA 41; NRS0207 BTNR; NRS0608 CCA 17

*Pellacalyx axillaris* Korth. - NRS0218 CCA 25; NRS0146 CCA 18; NRS0411 CCA 47; NRS1258 CCA 29; NRS1362 CCA 18

**Rosaceae**

*Prunus polystachya* (Hook *f.*) Kalkman - NRS0201 BTNR; NRS0191 CCA 18; NRS0150 CCA 18; NRS0347 CCA 30; NRS0106 CCA 24

*Rubus moluccanus* L. - NRS1117 CCA 28; NRS1170 CCA 18; NRS1273 CCA 5; NRS1310 CCA 35; NRS0530 CCA 47

**Rubiaceae**

*Aidia wallichiana* Tirveng. - NRS1339 CCA 49

*Borreria laevicaulis* (Miq.) Ridl. - NRS10 CCA41

*Canthium confertum* Korth. - NRS0251 CCA 17

*Canthium glabrum* Blume - NRS2342 CCA 48

*Canthium horridum* Blume - NRS0044 CCA 13

*Cephaelis singaporensis* Ridl. - NRS2223 CCA 43

*Chasalia chartacea* Craib - NRS0788 CCA 11; NRS0768 CCA 18; NRS1048 CCA 41; NRS1099 CCA 33; NRS1229 CCA 54; NRS1314 CCA 35; NRS1025 CCA 18

*Chasalia curviflora* (Wall.) Thwaites - NRS0271 CCA 17; NRS0649 CCA 17

*Diodia ocymifolia* (Willd. ex Roem. & Schultz) Bremek. - NRS0429 CCA 47

*Diplospora malaccensis* Hook.*f.* - NRS0763 CCA 18; NRS1264 CCA 41

*Gaertnera grisea* Hook.*f.* ex C.B. Clarke - NRS0302 BTNR

*Gaertnera obesa* Hook.*f.* ex C.B. Clarke - NRS0586 CCA 53; NRS0590 CCA 53; NRS0073 CCA25; NRS0061 CCA 25; NRS1707 45; NRS1989 CCA 24

*Gaertnera viminea* Hook.*f.* ex C.B. Clarke - NRS0303 BTNR; NRS1312 CCA 35

*Gynochthodes sublanceolata* Miq. - NRS0445 CCA 47; NRS1471 CCA 47

*Hedyotis auricularia* L. - NRS0141 CCA 18

*Hedyotis capitellata* Wall. ex G. Don - NRS0076 CCA 24; DJM166 CCA 18

*Hedyotis congesta* R.Br. ex G. Don - NRS0577 CCA 53; NRS0809 CCA 11; NRS1145 CCA 36; NRS1108 CCA 33; NRS0540 CCA 47; NRS0101 CCA 24; DJM139 CCA 18

*Hedyotis herbacea* L. - NRS0050 CCA 13; NRS0911 CCA 6; NRS1214 CCA 7

*Hydnophytum formicarium* Jack - NRS0444 CCA 47; NRS0650 CCA 17; NRS1723 CCA 43

*Ixora congesta* Roxb. - NRS0330 CCA 17; NRS0517 CCA 36; NRS0372 CCA 17; NRS0451 CCA 46; NRS0516 CCA 36; NRS0841 CCA 11; NRS0725 CCA 10; NRS0721 CCA 10; NRS0979 CCA 26; NRS0972 CCA 26; NRS1133 CCA 33; NRS1135 CCA 33; NRS1134 CCA 33; NRS1098 CCA 33; NRS1101 CCA 33; NRS1092 CCA 33; NRS0246 CCA 17; NRS0053 CCA 13; NRS1481 CCA 47; DJM239 BTNR

*Ixora javanica* (Blume) DC. - NRS0230 CCA 17; NRS0380 CCA 17; NRS1065 CCA 17

*Ixora lobbii* King & Gamble - NRS2410 CCA 13; NRS2091 CCA 17; NRS2064 CCA 16; NRS1667 CCA 5

*Ixora pendula* Jack - NRS0240 CCA 17; NRS0379 CCA 17; NRS1238 CCA 54; NRS1281 CCA 43; NRS1294 CCA 43; NRS310 BTNR; NRS0104 CCA 24

*Jackiopsis ornata* (Wall.) Ridsdale - NRS0749 CCA 10

*Lasianthus appressus* Hook.*f.* or *L. attenuatus* Jack - NRS1291 CCA 43; NRS0998 CCA 13; NRS1178 CCA 18; DJM203 BTNR

*Lasianthus attenuatus* Jack - NRS0023 CCA 13

*Lasianthus constrictus* Wight - NRS0034 CCA 13; NRS0482 CCA 17; NRS1008 CCA 18; NRS1006 CCA 13; NRS1011 CCA 18; NRS1182 CCA 18; NRS1172 CCA 18

*Lasianthus cyanocarpus* Jack - NRS1464 CCA 47; NRS1897 CCA 16

*Lasianthus densifolius* Miq. - NRS0829 CCA 11; NRS0756 CCA 18; NRS1157 CCA 16; NRS1073 CCA 17; NRS1196 CCA 7; NRS1200 CCA 7; DJM312 BTNR

*Lasianthus griffithii* Wight - NRS1949 CCA 18

*Lasianthus perakensis* King & Gamble - NRS0103 CCA 24; NRS1155 CCA 16

*Lasianthus ridleyi* King & Gamble - NRS0306 BTNR

*Lasianthus scabridus* King & Gamble - NRS2048 CCA 24

*Lasianthus tomentosus* Blume - DJM6 BTNR

*Lucinaea membranacea* King - NRS0862 CCA 18; NRS1022 CCA 18; NRS0188 CCA 18

*Morinda citrifolia* L. - NRS0167 CCA 18; NRS0669 CCA 17; NRS0986 CCA 32

*Morinda umbellata* L. - NRS0940 CCA 28; NRS1121 CCA 28; NRS2411 CCA 18

*Mussaenda erythrophylla* Schum. & Thonn. - NRS1401 CCA 7

*Mussaenda glabra* Vahl - NRS0266 CCA 17; NRS0041 CCA 13; NRS0047 CCA 13; NRS0755 CCA 18; NRS1086 CCA 20; NRS1188 CCA 18; NRS0326 CCA 30

*Mussaendopsis beccariana* Baill. - NRS0991 CCA 13

*Ophiorrhiza singaporensis* Ridl. - NRS0165 CCA 18; NRS1975 CCA 18; DJM160 BTNR

*Paederia scandens* (Lour.) Merr. - NRS0982 CCA 26; NRS0983 CCA 32

*Pavetta wallichiana* Steud. - NRS0647 CCA 17; NRS0642 CCA 17; NRS0123; NRS0828 CCA 11; NRS0759 CCA 18; NRS0854 CCA 18; NRS1141 CCA 33; NRS1072 CCA 17; NRS0692 CCA 45; NRS1013 CCA 18

*Porterandia anisophylla* (Jack ex Roxb.) Ridl. - NRS0852 CCA 18; NRS0507 CCA 36; NRS0764 CCA 18; NRS0839 CCA 11; NRS0850 CCA 18; NRS0616 CCA 17; NRS0532 CCA 47

*Psychotria* sp. - NRS1067 CCA 17

*Psychotria helferiana* Kurz - NRS0789 CCA 11; NRS1405 CCA 7; NRS1565 CCA 15; NRS1803 CCA 48; NRS1861 CCA 16

*Psychotria maingayi* Hook.*f.* - NRS1863 CCA 16

*Psychotria obovata* Wall. - NRS1148 CCA 33

*Psychotria ovoidea* Wall. - NRS0469 CCA 46; NRS0329 CCA 30; NRS0460 CCA 46; NRS1440 CCA 43; NRS1543 CCA 28; NRS1623 CCA 33; NRS1659 CCA 46; NRS2215 CCA 43; NRS2284 CCA 28; NRS2529 CCA 44

*Psychotria penangensis* Hook.*f.* - NRS0770 CCA 18; NRS0874 CCA 18; NRS1400 CCA 7; NRS1497 CCA 49; NRS1629 CCA 33; NRS2596 CCA 6

*Psychotria rostrata* Blume - NRS2153 CCA 17; NRS2331 CCA 6

*Psychotria sarmentosa* Blume - NRS0173 CCA 18; NRS1071 CCA 17; NRS0626 CCA 17; NRS1663 CCA 46; NRS1825 CCA 15; NRS2045 CCA 24; NRS2125 CCA 12; NRS2192 CCA 25; NRS2266 CCA 28; NRS2303 CCA 7; NRS2352 CCA 45; NRS2566 CCA 43

*Psydrax* sp. 10 - DJM250 BTNR

*Rothmannia macrophylla* (R.Br. ex Hook.*f.*) Bremek. - NRS1268 CCA 5; NRS2003 CCA 24; NRS2046 CCA 24

*Tarenna odorata* (Roxb.) B.L. Rob. - NRS0083 CCA 24; NRS0871 CCA 18; NRS2138 CCA 17

*Tarenna stellulata* (Hook.*f.*) Ridl. - NRS2065 CCA 16

*Timonius wallichianus* (Korth.) Valeton - NRS0857 CCA 18; NRS0092 CCA 24; NRS0210 CCA 25; NRS0762 CCA 18; NRS0920 CCA 6; NRS0840 CCA 11; NRS1269 CCA 5; NRS1628 CCA 33; NRS1644 CCA 15; NRS2060 CCA 24; NRS2208 CCA 43; NRS2391 CCA 45

*Uncaria cordata* (Lour.) Merr. - NRS0556 CCA 46; NRS0233 CCA 25; DJM172 CCA 18

*Uncaria gambir* (Hunter) Roxb. - NRS1164 CCA 16; NRS1355 CCA 24

*Uncaria lanosa* Wall. var. *glabrata* (Blume) Ridsdale - NRS0508 CCA 36

*Uncaria longiflora* (Poir.) Merr. - NRS1898 CCA 16, NRS2224 CCA 43

*Urophyllum blumeanum* (Wight) Hook.*f.* - NRS0752 CCA 18; NRS0799 CCA 11; NRS0617 CCA 17; NRS1531 CCA 13; DJM204 BTNR

*Urophyllum glabrum* Wall. - NRS0162 CCA 18; NRS0148 CCA 18; NRS0163 CCA 18; NRS0253 CCA 17; NRS0296 BTNR; NRS0592 CCA 53; NRS0413 CCA 47; NRS0531 CCA 47; NRS0528 CCA 36; NRS0330 CCA 30; NRS0621 CCA 17; NRS1380 CCA 49; NRS1813 CCA 48; NRS1885 CCA 16

*Urophyllum griffithianum* (Wight) Hook.*f.* - NRS0688 CCA 45; NRS1247 CCA 54; DJM384 BTNR

*Urophyllum hirsutum* (Wight) Hook.*f.* - NRS0687 CCA 45; NRS0300 BTNR; NRS1315 CCA 35; NRS1284 CCA 43; DJM383 BTNR

*Urophyllum* sp. 2 of Wong (Tree Flora Vol. 4) - NRS0096 CCA 24; NRS0176 CCA 18; NRS0790 CCA 11; NRS1192 CCA 7; NRS1162 CCA 16; NRS1191 CCA 7; NRS1057 CCA 41; NRS0812 CCA 11; NRS1595 CCA 18; NRS2141 CCA 17; DJM125 BTNR

*Urophyllum streptopodium* Wall. ex Hook.*f.* - NRS2609 CCA 6; DJM152 BTNR

**Rutaceae**

*Citrus medica* L. - NRS0071 CCA 25

*Clausena excavata* Burm.*f.* - NRS0524 CCA 36; NRS0973 CCA 26

*Glycosmis chlorosperma* (Blume) Spreng. - NRS0262 CCA 17; NRS0798 CCA 11

*Luvunga crassifolia* Tanaka - NRS0635 CCA 17

*Murraya koenigii* Spreng. - NRS0988 CCA 26

**Santalaceae**

*Dendrotrophe varians* (Blume) Miq. - NRS0085 CCA 24; NRS1210 CCA 7

**Sapindaceae**

*Cardiospermum* halicacabum L. - NRS0902 CCA 6

*Guioa pubescens* (Zoll. & Moritzi) Radlk. - NRS0935 CCA 28; NRS1122 CCA 28

*Nephelium cuspidatum* Blume var. *eriopetalum* (Miq.) Leenh. - NRS2432 CCA ?

*Nephelium lappaceum* L. - NRS0006 CCA 13; NRS0927 CCA 6; NRS0075 CCA 24; NRS1403 CCA 18

**Sapotaceae**

*Palaquium obovatum* (Griff.) Engl. var. *obovatum* - NRS0351 CCA 30

*Planchonella maingayi* (C.B. Clarke) van Royen - NRS0321 BTNR

*Planchonella obovata* (R.Br.) Pierre - NRS0412 CCA 47

**Scrophulariaceae**

*Adenosma javanicum* (Blume) Koord. - NRS0225 CCA 25

*Limnophila sessiliflora* (Vahl) Blume - NRS0836 CCA 11; NRS1195 CCA 7; NRS1194 CCA 7; NRS1211 CCA 7

*Limnophila villosa* Blume - NRS0063 CCA 25; NRS0068 CCA 25

*Lindernia crustacea* (L.) F.Muell. - NRS0024 CCA 13

*Lindernia elata* (Benth.) Wettst. - NRS1212 CCA 7; NRS0484 CCA 17

*Striga asiatica* (L.) Kuntze - NRS0494 CCA 17

**Smilacaceae**

*Smilax bracteata* Presl var. *barbata* (Wall. ex DC.) Koyama - NRS0129 CCA 18; NRS0944 CCA 28; NRS0417 CCA 47; NRS1545 CCA 28; NRS2269 CCA 28

*Smilax calophylla* Wall. - NRS0314 BTNR; NRS0997 CCA 13

*Smilax leucophylla* Blume - NRS1576 CCA 15

**Solanaceae**

*Solanum torvum* Sw. - NRS0907 CCA 6; NRS0739 CCA 10

**Sterculiaceae**

*Commersonia bartramia* (L.) Merr. - NRS0652 CCA 17; NRS1018 CCA 18; NRS1156 CCA 16; NRS0558 CCA 46

*Melochia corchorifolia* L. - NRS0945 CCA 28; NRS0487 CCA 17

*Sterculia* sp. - NRS0804 CCA 11; NRS1021 CCA 18

*Sterculia coccinea* Jack - NRS0370 CCA 17; NRS0696 CCA 45; NRS0700 CCA 45; NRS1275 CCA 5; NRS0580 CCA 53; NRS0054 CCA 13; NRS0339 CCA 30; NRS1205 CCA 7; NRS1199 CCA 7; NRS0515 CCA 36; NRS0121 CCA 18; NRS0569 CCA 46; NRS1152 CCA 16

*Sterculia rubiginosa* Vent. - NRS0719 CCA 10

**Symplocaceae**

*Symplocos adenophylla* Wall. ex D. Don - NRS0748 CCA 10

**Taccaceae**

*Tacca integrifolia* Ker-Gawl. - NRS0456 CCA 46; NRS0336 CCA 30; NRS1599 CCA 45; NRS1929 CCA 25

**Theaceae**

*Adinandra dumosa* Jack - NRS0198 CCA 18; NRS0353 CCA 30; NRS0734 CCA 10; NRS0930 CCA 6; NRS0949 CCA 28

*Eurya acuminata* DC. - NRS0052 CCA 13; NRS0486 CCA 17; NRS0222 CCA 25; NRS0563 CCA 46; NRS0865 CCA 18

*Gordonia singaporiana* Wall. ex Ridl. - NRS0319 BTNR

*Pyrenaria acuminata* Planch. ex Choisy - NRS1016 CCA 18; NRS0619 CCA 17; NRS0705 CCA 45

**Thymelaeaceae**

*Wikstroemia ridleyi* Gamble - NRS0248 CCA 17; NRS2340 CCA 47

**Tiliaceae**

*Grewia acuminata* Juss. - NRS0185 CCA 18; NRS0646 CCA 17; NRS0117 CCA 18; NRS0801 CCA 11; NRS0870 CCA 18; NRS0848 CCA 18

*Microcos blattaefolia* (Corner) Rao - NRS0653 CCA 17; NRS0822 CCA 11

**Ulmaceae**

*Gironniera nervosa* Planch. - NRS0066 CCA 25; NRS0622 CCA 17

*Trema cannabina* Lour. - NRS0338 CCA 30: NRS0153 CCA 18: NRS0397 CCA 30: NRS0746 CCA 10: NRS0611 CCA 17

*Trema tomentosa* (Roxb.) Hara - NRS0740 CCA 10: NRS0896 CCA 6; NRS0152 CCA 18

**Umbelliferae**

*Centella asiatica* (L.) Urb. - NRS0288 CCA 17

**Urticaceae**

*Poikilospermum suaveolens* (Blume) Merr. - NRS0305; NRS0472 CCA 46: NRS1020 CCA 18: NRS0526 CCA 36: NRS0837 CCA 11

**Verbenaceae**

*Callicarpa longifolia* Lam. - NRS0893 CCA 6

*Clerodendrum deflexum* Wall. - NRS0533 CCA 47; NRS1009 CCA 18; NRS0830 CCA 11; NRS1289 CCA 43; NRS1160 CCA 16; NRS1131 CCA 33; NRS1097 CCA 33; NRS1150 CCA 33

*Clerodendrum laevifolium* Blume - NRS0154; NRS0363 CCA 30: NRS0823 CCA 11; NRS0690 CCA 45; NRS0758 CCA 18; NRS0072 CCA 25; NRS0154 CCA ?; NRS0466 CCA 46

*Clerodendrum paniculatum* L. - NRS0846 CCA 18: NRS1001 CCA 13

*Clerodendrum villosum* Blume - NRS0097 CCA 24: NRS0005 CCA 13: NRS0038 CCA 13: NRS0950 CCA 28

*Lantana camara* L. - NRS0765 CCA 18

*Stachytarpheta indica* (L.) Vahl - NRS0175 CCA 18

*Vitex pinnata* L. - NRS0070 CCA 25: NRS0731 CCA 10: NRS0136 CCA 18

*Vitex vestita* Wall. ex Schau. - NRS0220 CCA 25: NRS1139 CCA 33; NRS1137 CCA 33

**Viscaceae**

*Viscum ovalifolium* Wall. ex DC. - NRS0389 CCA 17

**Vitaceae**

*Ampelocissus elegans* (Kurz) Gagnep. - NRS0317 BTNR; NRS0431 CCA 47: NRS0215 CCA 25;

NRS0722 CCA 10; NRS1149 CCA 36; NRS0807 CCA 11; NRS0011 CCA 13; NRS0554 CCA 46

*Ampelocissus gracilis* (Wall.) Planch. - NRS1296 CCA 43; NRS1117 CCA 28; NRS1170 CCA 18; NRS1273 CCA 5; NRS1310 CCA 35; NRS0530 CCA 47

*Cayratia novemfolia* (Wall.) Burkill - NRS0393 CCA 17

*Cissus hastata* (Miq.) Planch. - NRS0187 CCA 18; NRS0853 CCA 18

*Cissus repens* Lam. - NRS0884 CCA 18

*Pterisanthes polita* (Miq.) Laws. - NRS0127 CCA 18; NRS1288 CCA 43; NRS1179 CCA 18; NRS1040 CCA 18; NRS1184 CCA 18; NRS1120 CCA 28; NRS1292 CCA 43; NRS0112 CCA 24

**Zingiberaceae**

*Alpinia galanga* (L.) Sw. - NRS0697 CCA 45

*Alpinia purpurata* (Vieill.) K. Schum. - NRS0709 CCA 45

*Amomum xanthophlebium* Baker - NRS0636 CCA 17

*Globba leucantha* Miq. - NRS0368 CCA 17

*Hornstedtia leonurus* (Koenig) Retz. - NRS1100 CCA 33

*Hornstedtia scyphifera* (Koenig) Steud. - NRS0409 CCA 47; NRS1304 CCA 43; NRS1151 CCA 36; NRS1061 CCA 41; NRS0259 CCA 17; NRS1734 47

*Zingiber griffithii* Baker - NRS0787 CCA 18; NRS1173 CCA 18; NRS1127 CCA 28; NRS1004 CCA 13

*Zingiber puberulum* Ridl. - NRS0309

# The Tree Communities of the Central Catchment Nature Reserve, Singapore

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## Abstract

A sample survey was conducted to study the tree communities of the Central Catchment Nature Reserve. The forests were stratified into types using vertical aerial photographs. Some 62 sampling units, each about 0.2 ha in size, were laid down in 3 forest types, consisting mainly of secondary forests, of different degrees of maturity, and relatively undisturbed patches of primary forests. The sampling percent was 0.8

The trees were measured for girths down to 30 cm and identified down to species. In all 7,462 trees were sampled and these were found to belong to 499 species, 46 of which could not be identified. The sample netted in some 20 species of dipterocarps with 154 individuals. A surprising discovery is the presence of 3 *Shorea curtisii* in a patch of primary Lowland Dipterocarp Forest, *sensu* Symington (1941) north of MacRitchie Reservoir. The species is not known to be associated with this forest type in Peninsular Malaysia and Singapore. Another distributional record is the discovery of 2 trees of *Shorea ochrophloia* in another patch of primary forest, though not within the sample. This belongs to the Heavy Hardwood (Balau) Group of the genus *Shorea* and so far none of its members has been recorded in Singapore.

Based on the trends of the species-area curves, the sample appears to have netted in most of the secondary forest species but the primary stands are likely to yield many more species if an inventory of a higher intensity of sampling is carried out.

Stand tables are given to show the distribution of the species in each forest type. Fifty-two species were found to be common to all the three forest types, there being no dipterocarps amongst them, as expected.

The stands from the relatively undisturbed patches of primary forests were compared with those at Bukit Timah. In terms of species complexity some stands of forests of the two places compare well with one another, but in terms of stand densities, and absolute number of species per unit area, the stands of the Catchment Reserve appear to be better than those of the Bukit Timah forests.

The secondary forests of the Reserve are supposed to have been developed on degraded soil. The present edaphic conditions are good.

## Introduction

The Central Catchment Nature Reserve (hereafter referred to as the Catchment Reserve or simply the Reserve), estimated in this study to be about 1,660 ha in extent, occupies a central position on Singapore Island (see Fig.1). The vegetation is mostly of a secondary nature but patches of primary forest are scattered


**Fig. 1.** Distribution of sampling units (clusters) in the Central Catchment Nature Reserve. Insert shows the position of the Nature Reserves within Singapore.

within the mosaic of secondary forests, undergoing different stages of succession.

Many qualitative observations concerning the plant communities within the Reserve have been made in the past. Gilliland (1958) was probably the first ecologist to have made some quantitative study over a small area of the forests. Recently Corlett (1991) while studying the succession in the secondary forests sampled selected areas of the more matured forests. So far as is known no quantitative sampling has ever been done to study the tree populations of the patches of primary forests, which are known to be dipterocarp bearing.

The National Parks Board (NParks), now administering all nature reserves in Singapore, has in the past few years commissioned various scientists and specialists to make studies on both the physical features & biological components of the Reserve. We were asked to study in particular the tree communities. The study covers an area of about 1,530 ha, with an overall sampling intensity of 0.8 %, but with much higher proportions of the sampling units located in older forest types and none in the open areas with early stages of ecological succession (see Table 1). Three of our sampling units are located in the Nee Soon Swamp Forest, estimated to be about 96 ha in extent. Sampling began in early 1992 and a detailed technical report was submitted to NParks in early 1993 (Wong, 1993).

The sampling points are permanently marked at site for future follow-up studies. Fig.1 shows the approximate positions of the sampling points.

## Method of Study

### 1. Stratification of the Study Area into Forest Types

The forests were stratified using black and white vertical aerial photographs of scale 1:20,000 and taken in 1990. Four strata, based on the structures of the forests, could be recognised and were delineated. The phototypes, designated as Forest Types 1 - 4 (FT 1, FT 2, FT 3 & FT 4) were then traced out and a vegetation map produced. The general characteristics of these forest types, based on both photo appearance & ground checks, are briefly described below and the estimated area of each type is given in Table 1.

**FT 1.** Vegetation of early succession with few scattered trees or groups of trees, the ground being covered with thick Resam ferns

(*Dicranopteris spp.*), or tall shrubs, tall grasses and/or sedges. Tangles of woody climbers are common. The climber *Smilax bracteata* var. *barbata* could be rampant locally, smothering tree crowns.

**FT 2.** Vegetation with many small trees, 8 to 15 m tall. There is general closure of the canopy, but gaps with Resam and climber tangles are still quite common, although in the areas with a canopy cover, the climbers and ferns may be on their way out. The tree crowns are small; distinct tree crowns may not be discernible in the aerial photos. *Smilax* may still be rampant in places, with tangles of their stems carpeting the forest floor. The tree population has a high proportion of *Adinandra dumosa* and *Rhodamnia cinerea. Myrica esculenta* may also be locally abundant. Advanced growth of sizable trees may be scattered amongst the smaller trees.

**FT 3.** Vegetation with larger trees and higher density. Canopy is generally continuous. In the aerial photos, distinct tree crowns are discernible, as the larger trees have larger crowns. The canopy may range from 10 to 20m high. Advanced growth or relics of larger trees may be present. *Rhodamnia cinerea* still assumes a high proportion, although that for *Adinandra dumosa* may be reduced (see Appendix 2). The ground may still have some Resam ferns, but if present they exist in a sparse condition. Climbers may still be present. However, no tangles may be on the ground, except in open gaps.

Composition of the trees assumes a more complex nature with many more species to the unit area. High forest trees like species of *Calophyllum* & many species of *Eugenia* may be in the admixtures. *Garcinia* species are also common.

**FT 4.** Vegetation with a continuous canopy and much taller trees. The profile is typically multi-storey. Some areas may have structures and girth class distribution resembling those of primary forests. Relics left behind by previous fellings would have attained large to enormous sizes. Isolated crowns of emergents are clearly visible in the aerial photos. To this type also belong some patches of near-primary jungles, with the family Dipterocarpaceae showing some degree of structural and family dominance.

Included in this type is also the Nee Soon Swamp Forest.

## 2. Estimation of Areas of the Reserve and Forest Types

A dot-grid was used to make the estimate and the results are presented in Table 1.

**Table 1.** Area of Catchment Reserve, with Breakdown into Forest Types (FT) and Sampling Percentage Therein

| FT | 1 | 2 | 3 | 4 | Total |
|---|---|---|---|---|---|
| Area (Ha) | 124.3 | 144.4 | 979.4 | 283.5 | 1531.6* |
| No. of sampling units | 0 | 5 | 35 | 22 | 62 |
| Equivalent Hectares | 0 | 1.0 | 7.0 | 4.4 | 12.4 |
| Percentage Sampling | 0 | 0.7 | 0.7 | 1.5 | 0.8 |

*Note: Including an area of 130 ha not studied in this survey, the total area of the Reserve appears to be in the region of 1,660 ha. No sampling was done in FT 1, hence the 0's.

## 3. Sampling Method

The sampling units were located subjectively in the different FT's. As the present study is both an ecological and botanical study, our bias was to locate more of the sampling units in the more matured forests and the near-primary forests (FT's 3 & 4). This is the reason why we did not sample FT 1, and located only 5 clusters in FT 2, which was found in essence to be an earlier stage of FT 3. We also tended to put the sampling units where the trees were.

The sampling unit each consists of a cluster of 4 circles. Each circle is given a radius of 12.6 m; its area is therefore 449 square metres. The 4 circles together therefore have an area of 1,996 square metres or very near to 0.2 ha. For some clusters, the 4 circles were laid systematically in the directions of the cardinal points about, and equidistant from, a centre. This is done when the forest was uniform. When such a systematic layout would hit gaps, the 4 circles were sited subjectively where the trees were. Half the number of the clusters were sited in this way.

In view of the subjective siting of the clusters and also of some of the circles of the cluster, it has therefore to be noted that the results as presented here may be on the optimistic side for each forest type and all interpretations of the results or extra-polation of the data would have to be viewed in this light.

4. **Enumeration And Plant Identification**

Within each circle of a cluster, all trees with girths equal to or larger than 30 cm were measured for girths at 1.3 m from the ground (referred to as girth breast height or gbh). A tree with buttresses higher than 1.3 m from the ground was measured above the buttresses or if these were too high, then the girth of the tree had to be estimated. For a tree with multiple stems, or with coppice shoots, if the bifurcation or splitting occurred at below 1.3 m, then each stem was measured and booked as though it was a separate tree, if its girth met the minimum requirement. Such cases are very common for species like *Rhodamnia cinerea*, *Adinandra dumosa* and *Gynotroches axillaris. Timonius wallichianus* and even *Eugenia grandis* also occasionally exhibit such a phenomenon, which is likely to have been induced by fire during early stages of succession. Vestiges of fire damage of very recent occurrences could be seen in areas of FT 1.

After measuring the girth, the tree was notched or lightly blazed with a knife, so as to avoid double accounting. The tree was then identified as far as possible down to species. As most of the trees are sterile at any one period of the year, identification in most cases are based on leaf and bark characteristics, including exudates from within the bark. If the tree could not be identified fully in the field then collection of leaf specimens had to be made for further identification in the herbarium.

The book was closed for every circle.

For the collection of leaf specimens, in most cases it was fairly easy to pick the right leaves on the forest floor. However, in some cases when the tree crown was smothered with heavy climbers, this could prove a difficult task. Indeed in some cases we just failed to know which could be the right leaves. For these, one would just have to give up and record such a tree as "unknown". In the list of trees presented in Appendix 2, the class at the end of the list labelled "ZU" shows such trees. There were in all 19 such individuals, each assumed to be a species. In other cases, although we had good specimens from the field, all matching work in the herbarium nevertheless failed. There were 37 such individuals and we have placed them under 27 species. The numerals prefixed with a "Z" at the end of the plant list in Appendix 2 show these unidentifiable plants.

There are thus in all some 46 species of trees, with 56 individuals, which could not be identified. This is a small percentage (0.73) considering that there are 7,462 trees in the sample of 62 clusters.

## Results and Discussions

### 1. **Floristic Composition**

#### (a) General

The sample of 62 clusters netted in a total of 7,462 individual trees. A breakdown showing the number of clusters in each forest type and the number of species and individuals sampled therein is summarised in Table 2. FT 4, with 22 clusters, included three clusters located in the Nee Soon Swamp Forest. As stated earlier, 46 species with 56 individuals could not be identified. Of the 7,406 individuals which were identified, they have been found to belong to 453 species and these in turn fall under 63 families.

The list has included a couple of new records for dipterocarps. A few more of the non-dipterocarp species may also turn out to be new records for Singapore and checking is continuing at the Herbarium to confirm this.

The species are listed in Appendix 2 with indications of the number of individuals occurring in each forest type. Table 2 gives a summary of some of the stand attributes.

FT 2 and FT 3 consist of stands with an abundance of secondary forest species. The ubiquitous species is *Rhodamnia cinerea*. It occurs in all the forest types and in 50 of the total sample of 62 clusters. Even in the 15 relatively undisturbed primary forest stands of FT 4, some 60 individuals are found in 6 of them. It is, however, not present in the 3 clusters located within the Nee Soon Swamp Forest.

One reason why a secondary forest species like *Rhodamnia cinerea* appears to be so overwhelmingly present is our treatment of coppiced stems as "individuals" in our enumeration under certain conditions stated earlier. If we had considered only rooted frequency, then its overall numbers would be substantially less. We have, however, not compiled the data in that manner.

**Table 2.** Species And Individuals In Different Forest Types (FT)
(Species include the 46 unidentifiable species with 56 individuals)

| FT | 2 | 3 | 4 | Overall |
|---|---|---|---|---|
| No. of Clusters | 5 | 35 | 22 | 62 |
| No. of Individuals | 823 | 4386 | 2253 | 7462 |
| Total No. of Species | 65 | 287 | 417 | 499* |
| No.of identified species | 64 | 271 | 386 | 453* |
| Families of the identified species | 31 | 50 | 58 | 63* |

*Note : The totals for species & families do not agree with the sum of the individual values because of overlap in species distribution in the different forest types.

The other dominant secondary species are *Adinandra dumosa, Timonius wallichianus* and *Macaranga conifera.* All these secondary species, appear to diminish in proportion in the population as the secondary forest gets older. Reference to Appendix 2 will show that *Adinandra* forms 11.5% of the population in FT 2 and it drops to 7.1% in FT 3. In FT 4 the percentage is only 1.3. *Rhodamnia* drops from 31.3%, through 27.9% to 7.3%. The drop for *Macaranga conifera* is dramatic from 17.1%, through 1.0% to 0.22%. *Timonius wallichianus* drops from 4.3% to 2.7% and persists with the latter proportion in FT 4. A species like *Gynotroches axillaris,* which is of frequent occurrence in old secondary forests and primary forests, on the other hand shows about 1.0% in FT 2, 2.4% in FT 3 and 2.0% in FT 4.

One species which is not actually a secondary forest species but nevertheless registers strongly in FT 3 is *Garcinia parvifolia.* Its presence in FT 2 is only 4 individuals out of a population of 823, or less than half a percent, but its proportion goes up to nearly 5%, or 10 times more, in FT

3, showing that originally fruits of this species from perhaps the primary forests had come in to seed up the young secondary forests and as the resultant stands and individuals mature they in turn produce seeds to enable the species to proliferate further. Seedlings of *Garcinia parvifolia* are found in large numbers on the forest floor. The fruits of *Garcinia* are eaten by bats and rodents and these must have been responsible for spreading the species. Reference to Appendix 2 will show similar pattern of succession from FT 2 to FT 3 for some of the *Calophyllum* species, *Gynotroches axillaris*, *Elaeocarpus mastersii,* and *Litsea elliptica.* Whether the same agents are responsible for their spread & proliferation is uncertain.

We present in Table 3 a list of the species common to all the three forest types. There are 52 of them. The list also shows their relative abundance in each of the forest types. Noticeably, but not surprisingly, there are no dipterocarps in the list. However, quite a number of these are high forest species and they are making their presence felt in FT 2 and FT 3, which are essentially secondary forests. Looking at the totals of the list, we note that the total number of individuals of these 52 species amounts to 4,814, or 64.5% of the total individuals in the sample population. The total of 52 is only about 11.6% of the species total of 499.

### (b) **The Dipterocarps**

The dipterocarps are perhaps the most important tree family in the primary lowland forests in Malaysia and Singapore. Twenty-five clusters, 18 in FT 4 and 7 in FT 3, have species of dipterocarps. Taking the whole girth range of => 30cm, there are 154 individuals in the 25 clusters. These belong to 20 species of this family, and the most widespread, though not the most abundant, species is *Vatica ridleyana*, with 15 individuals occurring in 11 of the 25 clusters. The distribution of the other species is shown in the list in Table 4. *Vatica ridleyana* has individuals which are relatively small trees compared with other dipterocarps. If we take the greater girths of the sample, say => 61 cm, we have a population of 114 individuals, then the list is topped by *Shorea pauciflora* with 13 individuals distributed over 10 clusters. Specimens of *S. pauciflora* are huge, the largest encountered has a girth of 386 cm. In contrast the largest tree of *V. ridleyana* has a girth of only 140 cm.

Concerning the dipterocarps, one very interesting and indeed surprising find is the presence of Seraya (*Shorea curtisii*) in Cluster 13 of the Catchment Reserve. The forest type in which this cluster occurs is essentially Lowland Dipterocarp Forest (LDF), *sensu* Symington (1941) and in Peninsular Malaysia this species is not known to grow in LDF.

**Table 3.** Species Common to All Forest Types

| | Species | No. of Individuals | | | TOTAL |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | |
| 1 | *Adinandra dumosa* | 95 | 312 | 29 | 436 |
| 2 | *Alstonia angustifolia* | 19 | 39 | 6 | 64 |
| 3 | *Alstonia angustiloba* | 1 | 3 | 2 | 6 |
| 4 | *Antidesma cuspidatum* | 1 | 2 | 10 | 13 |
| 5 | *Aquilaria malaccensis* | 2 | 18 | 12 | 32 |
| 6 | *Archidendron clypearia* | 34 | 16 | 3 | 53 |
| 7 | *Arthrophyllum diversifolium* | 1 | 3 | 2 | 6 |
| 8 | *Artocarpus rigidus* | 1 | 6 | 5 | 12 |
| 9 | *Artocarpus scortechinii* | 2 | 32 | 19 | 53 |
| 10 | *Beilschmiedia madang* | 2 | 9 | 15 | 26 |
| 11 | *Buchanania sessilifolia* | 1 | 1 | 2 | 4 |
| 12 | *Calophyllum pulcherrimum* | 1 | 151 | 7 | 159 |
| 13 | *Calophyllum tetrapterum* | 1 | 23 | 35 | 59 |
| 14 | *Campnosperma auriculatum* | 22 | 93 | 19 | 134 |
| 15 | *Campnosperma squamatum* | 1 | 38 | 7 | 46 |
| 16 | *Castanopsis wallichii* | 1 | 2 | 1 | 4 |
| 17 | *Cratoxylum arborescens* | 1 | 8 | 2 | 11 |
| 18 | *Decaspermum fruticosum* | 7 | 1 | 1 | 9 |
| 19 | *Dysoxylum cauliflorum* | 1 | 9 | 22 | 32 |
| 20 | *Elaeocarpus ferrugineus* | 2 | 37 | 4 | 43 |
| 21 | *Elaeocarpus mastersii* | 18 | 46 | 4 | 68 |
| 22 | *Elaeocarpus petiolatus* | 1 | 17 | 2 | 20 |
| 23 | *Endospermum diadenum* | 4 | 7 | 5 | 16 |
| 24 | *Eugenia glauca* | 1 | 33 | 3 | 37 |
| 25 | *Eugenia grandis* | 2 | 65 | 3 | 70 |
| 26 | *Eugenia longiflora* | 37 | 29 | 4 | 70 |

| | Species | No. of Individuals | | | TOTAL |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | |
| 27 | *Eugenia microcalyx* | 22 | 16 | 22 | 60 |
| 28 | *Euodia glabra* | 13 | 1 | 4 | 18 |
| 29 | *Fagraea fragrans* | 1 | 9 | 7 | 17 |
| 30 | *Ficus lamponga* | 1 | 1 | 1 | 3 |
| 31 | *Garcinia parvifolia* | 4 | 213 | 40 | 257 |
| 32 | *Gironniera nervosa* | 11 | 60 | 47 | 118 |
| 33 | *Gynotroches axillaris* | 8 | 107 | 46 | 161 |
| 34 | *Horsfieldia polyspherula* | 1 | 12 | 18 | 31 |
| 35 | *Ixonanthes reticulata* | 9 | 38 | 11 | 58 |
| 36 | *Knema intermedia* | 5 | 6 | 5 | 16 |
| 37 | *Lithocarpus ewyckii* | 1 | 7 | 11 | 19 |
| 38 | *Litsea elliptica* | 1 | 67 | 33 | 101 |
| 39 | *Litsea firma* | 3 | 59 | 10 | 72 |
| 40 | *Litsea grandis* | 5 | 18 | 3 | 26 |
| 41 | *Macaranga conifera* | 141 | 45 | 5 | 191 |
| 42 | *Macaranga triloba* | 8 | 11 | 4 | 23 |
| 43 | *Porterandia anisophylla* | 4 | 29 | 14 | 47 |
| 44 | *Prunus polystachya* | 1 | 29 | 42 | 72 |
| 45 | *Pternandra echinata* | 2 | 47 | 15 | 64 |
| 46 | *Rhodamnia cinerea* | 258 | 1217 | 165 | 1640 |
| 47 | *Scorodocarpus borneensis* | 2 | 1 | 6 | 9 |
| 48 | *Streblus elongatus* | 6 | 14 | 15 | 35 |
| 49 | *Styrax benzoin* | 1 | 1 | 1 | 3 |
| 50 | *Timonius wallichianus* | 27 | 188 | 61 | 276 |
| 51 | *Vitex pinnata* | 1 | 6 | 1 | 8 |
| 52 | *Xanthophyllum ellipticum* | 1 | 2 | 3 | 6 |
| | Total | 796 | 3204 | 814 | 4814 |

**Table 4.** Dipterocarps in 25 Clusters, 18 in FT 4 and 7 in FT 3.

(All species => 30 cm girth)

(15 clusters in FT 4 are relatively undisturbed Primary Forests)

(INDI = No.of individuals, CSP = No. of clusters in which the species occur.)

| | SPECIES | INDI | CSP |
|---|---|---|---|
| 1 | *Vatica ridleyana* | 15 | 11 |
| 2 | *Shorea pauciflora* | 13 | 10 |
| 3 | *Shorea macroptera* | 18 | 9 |
| 4 | *Dipterocarpus sublamellatus* | 16 | 7 |
| 5 | *Shorea parvifolia* | 7 | 6 |
| 6 | *Anisoptera megistocarpa* | 7 | 5 |
| 7 | *Hopea griffithii* | 11 | 4 |
| 8 | *Hopea mengarawan* | 10 | 4 |
| 9 | *Shorea gibbosa* | 6 | 4 |
| 10 | *Shorea leprosula* | 7 | 4 |
| 11 | *Vatica maingayi* | 5 | 4 |
| 12 | *Dipterocarpus grandiflorus* | 15 | 3 |
| 13 | *Shorea bracteolata* | 3 | 3 |
| 14 | *Shorea ovalis* | 5 | 3 |
| 15 | *Dipterocarpus cornutus* | 5 | 2 |
| 16 | *Shorea gratissima* | 4 | 2 |
| 17 | *Shorea platycarpa* | 2 | 2 |
| 18 | *Dipterocarpus apterus* | 1 | 1 |
| 19 | *Shorea curtisii* | 3 | 1 |
| 20 | *Vatica ?ridleyana* | 1 | 1 |
| | Total | 154 | |

(Same Stands but with species => 61 cm girth)

| | SPECIES | INDI | CSP |
|---|---|---|---|
| 1 | *Shorea pauciflora* | 13 | 10 |
| 2 | *Shorea macroptera* | 12 | 6 |
| 3 | *Shorea parvifolia* | 7 | 6 |
| 4 | *Vatica ridleyana* | 9 | 6 |
| 5 | *Anisoptera megistocarpa* | 4 | 4 |
| 6 | *Dipterocarpus sublamellatus* | 9 | 4 |
| 7 | *Shorea gibbosa* | 5 | 4 |
| 8 | *Shorea leprosula* | 7 | 4 |
| 9 | *Hopea griffithii* | 8 | 3 |
| 10 | *Dipterocarpus grandiflorus* | 14 | 2 |
| 11 | *Hopea mengarawan* | 4 | 2 |
| 12 | *Shorea bracteolata* | 2 | 2 |
| 13 | *Shorea gratissima* | 4 | 2 |
| 14 | *Shorea ovalis* | 4 | 2 |
| 15 | *Vatica maingayi* | 3 | 2 |
| 16 | *Dipterocarpus apterus* | 1 | 1 |
| 17 | *Dipterocarpus cornutus* | 4 | 1 |
| 18 | *Shorea curtisii* | 3 | 1 |
| 19 | *Shorea platycarpa* | 1 | 1 |
| Total | | 114 | |

There, the species is found in the hill forests in the Main Range and other localities, generally beginning to occur at an elevation of about 300 m asl and rising up to 800 m asl, although in some Coastal Hill Forests, *sensu* Symington (1941) it begins to occur at much lower elevations.

In Singapore hitherto Seraya was known only from Bukit Timah. The forest at Bukit Timah is a Coastal Hill Forest according to Symington's classification.

Four Seraya trees were found, one of which was dead. The elevation of the site as shown in a topographic map is about 30 - 40 m asl. All four trees have attained a fair size. The three living ones have girths of 210, 216, and 267 cm. The trees are growing on a slight slope and regeneration appears to be quite numerous on the ground, with the taller ones having reached a height of about 3 to 4 m.

We also stumbled upon two *Shorea ochrophloia*, one near Cluster 21 and another near Cluster 55. This belongs to the Balau (Heavy Hardwood) Group of the genus *Shorea*. This is a new record for Singapore. Subsequent to this discovery, two more trees were found in a sample plot in Bukit Timah Nature Reserve. The plot has been used in a study undertaken by the Smithsonian Tropical Research Institute in collaboration with the National Institute of Education in Singapore. Hitherto, the heavy hardwood Shoreas have not been found in Singapore, although they are of common or sporadic occurrences in the Malaysian jungles, both in the lowland and in the hill forests. It is a matter for conjecture as to why we do not see more of the balaus in the Catchment Reserve. One reason could be that their timbers are naturally durable and were therefore continuously sought for constructional purposes during the early days of timber utilisation, when the technology for preservation had not been developed, taking not only big trees for conversion into sawn timbers but also pole sized timbers for rustic uses, perhaps also for use as firewood in the cooking of gambier, because dense timbers, such as they are, normally have higher calorific values. If the balaus were in the Catchment forests before, it is perhaps the continuous exploitation of small poles in addition to big sized timbers that had spelt their doom. They are very slow growing and conceivably poles were taken out even before they had reached reproductive age.

Another interesting find is *Dipterocarpus apterus.* Although not exactly a new record, only one specimen had been collected near MacRitchie Reservoir in 1957. We found the only specimen in our sample in Cluster 58, at the extreme west of Seletar Reservoir.

As pointed out earlier FT 3, essentially forests of a secondary nature, also has 7 stands with dipterocarps. This may give the impression that they are making a comeback in the secondary forests. This, however is not the case; it is more the outcome of our having used structure to delineate the forests into photo-types. In this process, highly disturbed forests with remnants of dipterocarps have been classified as FT 3.

2. **Degrees of Complexity of the Tree Flora**

We use the conventional *Mischungsquotient* (Richard, 1964), which is simply the ratio of the number of individuals per species of a population, to show the complexity. Under normal stand densities, the smaller the ratio, meaning few individuals to the species, the more complex is the specific composition of a forest. The ratio has been worked out for each cluster by forest type and the results are presented in Appendix 1. Looking at the mean values of the ratios for the forest types, as expected, one notes a gradation from a high to a low value as the forests mature from FT 2, through FT 3 to FT 4. The mean value for FT 2 is 7.3, that for FT 3, 3.9, and that for FT 4, 2.1. This shows higher complexity as the forests mature. In simple terms, for the stands of FT 2, for every species we encounter, there may be over 7 individuals in the forests, and the respective figures for FT 3 & FT 4 are about 4 and 2 individuals.

3. **The Species-Area Curve**

In our sample we have netted in 499 species of the trees with the minimum girth of 30 cm. To what extent have we exhausted the species list or are we likely to find more species of the same girth range? To give us some indications of this, we have plotted two species-area curves, one for FT 4 alone and the other for FT 2 & FT 3 combined. The reason for combining FT 2 & FT 3 is that these stands are located in secondary or highly disturbed, but not clear felled, regenerated forests, while FT 4 are in patches of primary forests, although 5 of these stands also have species lists suggesting they are matured secondary forests.

There are several ways of plotting a species-area curve (Greig-Smith, 1964). The method we have used here is perhaps the least efficient according to him. The area of a particular point in the graph is simply the cumulative total of areas of clusters added up to that point. Likewise the corresponding cumulative total for the species of the clusters is used. For the toting up we followed the numerical order in which the clusters were sampled in each forest type. FT 2 & FT 3 has a combined population of 5,209, and FT 4 2,253, individuals. The respective number of species are 293 and 417.

**Table 5**. Girth Class and Basal Area Distribution
of trees in the Catchment Reserve
(All trees with girths => 30 cm included. B.A.=basal area in $m^2$/ha.)

| Girth (cm) | 30-<60 | 60-<90 | 90-<120 | 120-<150 | 150-<180 | 180-<210 | 210-<240 | >=240 | Total |
|---|---|---|---|---|---|---|---|---|---|
| **FT 2/3** | | | | | | | | | |
| (1) No. of sampled trees | 3242 | 1277 | 411 | 145 | 66 | 36 | 14 | 18 | 5209 |
| (2) No.of trees/ha | 405 | 160 | 51 | 18 | 8 | 5 | 2 | 2 | |
| (3) B.A. of (1) | 48.0 | 52.9 | 34.3 | 20.5 | 13.7 | 10.6 | 5.6 | 11.3 | 196.9 |
| (4) B.A./ha | 6.0 | 6.6 | 4.3 | 2.6 | 1.7 | 1.3 | 0.7 | 1.4 | |
| **FT 4** | | | | | | | | | |
| (1) No. of sampled trees | 1178 | 493 | 215 | 127 | 91 | 57 | 36 | 56 | 2253 |
| (2) No.of trees/ha | 268 | 112 | 49 | 29 | 21 | 13 | 8 | 13 | |
| (3) B.A. of (1) | 17.5 | 21.0 | 18.1 | 17.7 | 19.1 | 17.0 | 13.9 | 35.6 | 159.9 |
| (4) B.A./ha | 4.0 | 4.8 | 4.1 | 4.0 | 4.3 | 3.9 | 3.2 | 8.1 | |

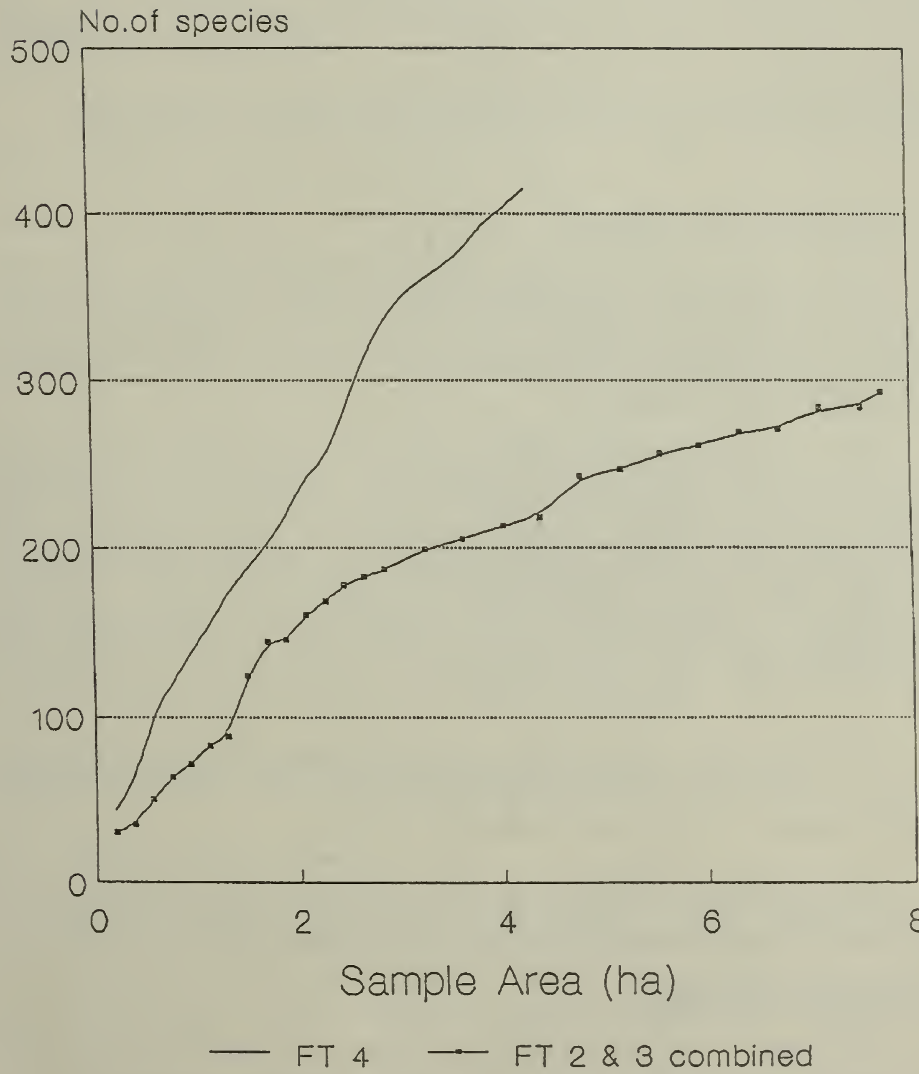


**Fig. 2.** Species / area curves
FT 2/3: S'dary foreests, 40 plots, 293 spp
FT 4: Mainly primary,, 22 plots, 417 spp

The two species-area curves are presented in Fig. 2. They show very characteristic trends. The curve for FT 2/3 shows not only a more gradual gradient, indicating more gradual species recruitment as the area increases, but also a definite gradual flattening out, indicating that our sample has perhaps netted in most of the species. Contrasting, the curve for FT 4 rises much more steeply and at the end still shows no flattening out, indicating that our sample of 22 clusters has in no way yet got most of the species. As a corollary, if we sample FT 4 more thoroughly, we are likely to net in many more species.

## 4. Stand Density Attributes

Table 5 shows the stem densities and basal areas by girth classes. We are showing separately these attributes for FT 2 and FT 3 combined (40 clusters) and FT 4 by itself (22 clusters) for comparison. In both cases, the whole range of girth classes of =>30 cm is used.

It can be seen that the structure, in terms of girth class distribution, is typical of uneven-aged forests, with a high proportion of small stems, and as girth size increases, the number of trees drops rapidly. For the secondary forests one would expect the girth distribution to show a truncation after a certain point. The fact that FT 2/FT 3 have individuals dragging into the higher girth classes could be due to FT 3 having a few stands with relics or advanced growth.

In the FT 2/FT 3 forests, the strong presence of young poles in the 30 - 60 cm class shows that recruitment for the forest as a whole is good and this augers well for the Catchment Reserve.

As expected, FT 4 does show that the population has many individuals with very large girths, far outnumbering those of the younger stands in FT 2 & FT 3.

## 5. Vegetation dynamics

Although we did not sample FT 1, there is no doubt that within the Catchment Reserve this open type of vegetation would in time develop into the FT 2 type of forests, thence to FT 3, in the natural succession. The speed with which this process will take place would no doubt depend on edaphic, aerial and biotic factors. From FT 1 to FT 2, incidence of bush fire could play an important role. While it may destroy a stand of small trees, it may on the other hand burn up an existing climber or Resam thicket to enable the area to be seeded up by tree species. From FT 2 to FT 3, the presence of nearby seed sources would certainly speed up succession. The existing stands of FT 4 and the more matured stands of FT 3 will form such sources. Dispersal of such high-forest genera like *Garcinia,* *Calophyllum*, *Eugenia* and *Gynotoches* from these sources is definitely helped by birds, rodents and bats.

In general, at the moment, compositions of the FT 2 and FT 3 stands bear close similarities to Stage 3 & Stage 4 respectively of the succession described by Corlett (1991).

The influence of proximity of a seed source in succession is very much borne out by the observations of Sim et al (1992). They laid down 7 sample plots in secondary forests now dominated by *Adinandra dumosa*, perhaps much like FT 2 in our present study. All but one were isolated areas, the exception being in the Bukit Timah Nature Reserve. They have stated that succession in these plots has been arrested due inter alia to low pH, poor soil nutrients and the lack of a seed source to add new species to such communities. However, scrutiny of their plant lists reveals the presence of a substantial proportion of high forest tree species in their Bukit Timah plot. These species occur exclusively in that particular plot. The species are *Calophyllum pulcherrimum, Calophyllum* sp.1, *Calophyllum* sp.2, *Eugenia* sp.1, *Eugenia* sp.2, *Eurycoma longifolia, Gynotroches axillaris, Ochanostachys amentacea, Palaquium gutta, Psychotria* sp., and *Santiria apiculata.* It is clear evidence that succession has progressed beyond the *Adinandra/Rhodamnia* (equivalent to our FT 2) stage and the factor that is responsible is undoubtedly a nearby source of seeds of such high-forest species from within the Bukit Timah Nature Reserve.

## 6. **Forests Of Bukit Timah and Catchment Reserve Compared**

### (a) **Floristic compositions**

As the Coastal Hill Forest, *sensu* Symington (1941), on Bukit Timah is the only other dipterocarp forest of a primary nature found in Singapore we would like to compare it with the stands of the primary forest of the Catchment Reserve which essentially is typical Lowland Dipterocarp Forest.

For this comparison we have taken the sampling units sited in the relatively undisturbed primary forest stands of the Catchment Reserve, but excluding the Nee Soon Swamp Forest, and those on Bukit Timah reported by Wong (1987). There are respectively 15 and 16 clusters. As the Bukit Timah sampling was for trees =>24 inches (61 cm) corresponding data of the Catchment Reserve were used.

**Table 6**. Comparison of Dipterocarps In Bukit Timah (BT) and the Central Catchment Reserve (CR)

(All trees with girth =>61 cm. The sample at BT has 16 clusters, at CR 15 clusters.)

| | SPECIES | No.of individuals BT | CR |
|---|---|---|---|
| 1 | *Anisoptera costata* | 1 | 0 |
| 2. | *Anisoptera megistocarpa* | 0 | 4 |
| 3. | *Dipterocarpus apterus* | 0 | 1 |
| 4. | *Dipterocarpus caudatus* ssp *penangianus* | 29 | 0 |
| 5. | *Dipterocarpus cornutus* | 0 | 4 |
| 6. | *Dipterocarpus grandiflorus* | 0 | 14 |
| 7. | *Dipterocarpus sublamellatus* | 3 | 7 |
| 8. | *Hopea griffithii* | 0 | 8 |
| 9. | *Hopea mengarawan* | 3 | 4 |
| 10. | *Shorea bracteolata* | 1 | 1 |
| 11. | *Shorea curtisii* | 41 | 3 |
| 12. | *Shorea gibbosa* | 0 | 4 |
| 13. | *Shorea gratissima* | 3 | 4 |
| 14. | *Shorea leprosula* | 7 | 6 |
| 15. | *Shorea macroptera* | 4 | 8 |
| 16. | *Shorea ovalis* | 0 | 1 |
| 17. | *Shorea parvifolia* | 0 | 4 |
| 18. | *Shorea pauciflora* | 9 | 9 |
| 19. | *Vatica maingayi* | 0 | 3 |
| 20 | *Vatica ridleyana* | 0 | 3 |
| 21. | *Vatica sp.A* | 1 | 0 |
| | Total | 102 | 88 |

Table 6 shows that the Catchment Reserve has 18 species of dipterocarps and Bukit Timah 11 species. this despite the fact that the trees of Bukit Timah were sampled with 16 clusters while those of the Catchment Reserve with 15. However, this is to be expected as those clusters sited in the Catchment Reserve are spread over a much wider area, whereas those in Bukit Timah are located within a solid block of forests of 75 ha. In terms of individuals, the Bukit Timah stands appear to have more dipterocarps, there being 102 individuals compared to 88 in the Catchment Reserve sample. This superiority in numbers is due to the presence of large numbers of *Shorea curtisii* and *Dipterocarpus caudatus* ssp *penangianus* in the Bukit Timah stands.

(b) **Relative floristic complexity & stand densities of the two Areas**

We now compare the *Mischungsquotients* of the two areas. The comparison is presented in Table 7. It can be seen that the average stand of the Bukit Timah forest has a smaller quotient of 1.5, compared to 1.9 of the average stand in the Catchment Reserve. As stated earlier under normal stand densities, the smaller the quotient, the more complex is the stand. However, it has to be said that a low stocking, concomitant with the number of species being constant, could also give rise to small quotients. Looking at Table 7 and 8, the species per cluster of the two areas did not vary much (BT = 22.9 & CR = 24.5 species/cluster) but the stand densities of the Bukit Timah forests appear to be consistently much below those of the Catchment forests, showing that the reason for the lower quotients in Bukit Timah is exactly what has been just stated. So despite their smaller mean, the complexity of the forests in absolute terms appears to be not as good as that of the Catchment forests. To put it in another way, the Catchment forests have overall denser stocking and a higher number of species per unit area. The Catchment Reserve being more species rich is also borne out by the fact that for the 16 stands in the Bukit Timah forests there are 178 species of trees with girths => 61 cm. but the number in the Catchment Reserve is 215 species.

Our first reaction to the higher stocking density in the Catchment Reserve, when compared to stands at Bukit Timah, is that the stands in the Catchment Reserve may have smaller trees, because it is quite common to have young stands with a high density but with the numbers made up of small trees. To check on this point we present a comparison of the girth class distribution of the forests of the two places in Table 8. Looking at this comparison one is amazed by the fact that for the girth distributions of the two areas, class for class the number of trees per ha for the Catchment Reserve outnumbers that obtained for the Bukit Timah forests. And looking at the basal area per tree figures, class for class the size of the average tree of CR is remarkably similar to that of BT, showing that the higher stocking of the forests in the Catchment Reserve is achieved not through having a population of small trees.

**Table 7**. *Mischungsquotients* or Number of Individuals per Species

(Comparing the 15 less disturbed clusters of FT 4 with 16 clusters of primary forests of Bukit Timah. All trees are with gbh => 61 cm. The relevant stands of the Catchment Reserve contain 215 spp., the Bukit Timah stands only 178 spp.)

| | Bukit Timah | | | Catchment Reserve | | |
|---|---|---|---|---|---|---|
| | No.of Indiv. | No.of Species | *Mischungs-quotient* | No.of Indiv | No.of Species | *Mischungs-quotient* |
| | 28 | 19 | 1.5 | 51 | 24 | 2.1 |
| | 42 | 28 | 1.5 | 31 | 23 | 1.4 |
| | 38 | 22 | 1.7 | 43 | 23 | 1.9 |
| | 42 | 27 | 1.6 | 27 | 17 | 1.6 |
| | 37 | 25 | 1.5 | 51 | 28 | 1.8 |
| | 39 | 27 | 1.4 | 55 | 26 | 2.1 |
| | 30 | 25 | 1.2 | 20 | 10 | 2.0 |
| | 32 | 20 | 1.6 | 50 | 23 | 2.2 |
| | 24 | 23 | 1.0 | 50 | 36 | 1.4 |
| | 24 | 20 | 1.2 | 52 | 26 | 2.0 |
| | 32 | 19 | 1.7 | 51 | 26 | 2.0 |
| | 39 | 24 | 1.6 | 59 | 22 | 2.7 |
| | 50 | 25 | 2.0 | 50 | 33 | 1.5 |
| | 27 | 21 | 1.3 | 35 | 13 | 2.7 |
| | 33 | 23 | 1.4 | 60 | 37 | 1.6 |
| | 23 | 19 | 1.2 | - | - | - |
| Total | 540 | 367 | | 685 | 367* | |
| Mean | 33.7 | 22.9 | 1.5 | 45.7 | 24.5 | 1.9 |

*Note: the two totals are exactly the same; this is entirely fortuitous.

**Table 8**. Distribution of Girths & Basal Areas (B.A.) in Stands of Bukit Timah and FT 4 of the Catchment Reserve (CR)

(All trees with girths =>61 cm. The same stands as used in Table 6 are used here for comparison)

| Girth Classes (cm) | 60-<90 | 90-<120 | 120-<150 | 150-<180 | 180-<210 | 210-<240 | >=240 | Total |
|---|---|---|---|---|---|---|---|---|
| CR No.of trees/ha | 93 | 47 | 28 | 22 | 15 | 8 | 16 | 32.7 |
| B.A. ($m^2$) | 4.0 | 3.9 | 3.9 | 4.6 | 4.4 | 3.2 | 10.5 | 4.9 |
| B.A./tree | 0.04 | 0.08 | 0.14 | 0.21 | 0.29 | 0.40 | 0.66 | |
| BT No.of trees/ha | 70 | 43 | 18 | 13 | 10 | 7 | 8 | 24.1 |
| B.A. ($m^2$) | 3.1 | 3.6 | 2.6 | 2.9 | 3.0 | 2.8 | 5.5 | 3.3 |
| B.A./tree | 0.04 | 0.08 | 0.14 | 0.22 | 0.30 | 0.40 | 0.69 | |

At the upper extremes of the girth classes (=> 240 cm) there are actually 48 trees in the sample of the Catchment Reserve; 16 of these trees have girths exceeding 300 cm. The corresponding numbers for the Bukit Timah sample are 26 trees and 5 trees. However, the largest tree in the Bukit Timah sample (a *Shorea curtisii*) has a girth of 194 inches (or about 490 cm), whereas that in the Catchment Reserve (a *Dyera costulata*) is only 424 cm. The largest dipterocarp in the FT 4 in the sample is a *Shorea pauciflora* with a girth of 386 cm. (Note: the largest tree we came across in the Catchment Reserve, not in the sample, but not far from Cluster 13 northwest of MacRithchie Reservoir, is a *Dyera costulata* with a girth at breast height of 615 cm.)

From the above comparison of the less disturbed dipterocarp bearing stands of the two areas, one can conclude that such patches of forests in the Catchment Reserve are in some ways superior to the stands at Bukit Timah.

## Conclusions

The relatively undisturbed stands of the primary forests of the Central Catchment Nature Reserve are indeed valuable natural assets because of their very diverse specific compositions and they therefore still contain a very large gene pool. The stands of secondary forests with very varied specific compositions also constitute a valuable scientific asset. They have redeveloped by themselves after the original forests were cleared and the land parcels used for long periods of cultivation until they were declared as protected catchment areas when cultivation was stopped. For the areas now with a tree cover, the regrowth period may vary from 50 to well over 130 years. The stands offer a good insight on plant succession under such conditions and could be used for scientific comparisons with vegetation developed in other parts of the Tropics.

The present study shows beyond doubt that some of the forest stands have floristic compositions and structural characteristics similar to those of primary forests in the Malaysian region. We do not know the exact history of these stands. Some of these could have been undisturbed; others could have been reserved for the supply of fuel wood for the gambier plantations and were therefore exploited to different degrees during the last Century. However, if they were so disturbed before, the vestiges of disturbance are now completely absent. Some of these areas surrounding the MacRitchie Reservoir must have been protected since the construction of this reservoir in 1867 (Anon., PUB publication, 1985). Over this long period of time, even if the stands had been disturbed, natural regeneration aided by the relics, including the dipterocarps, would have made such stands recover completely, ensuring also their biological diversity.

These primary stands are classified under Forest Type 4 (FT 4). Although according to the aerial phototyping and estimate of areas, this type amounts to some 280 ha, some of these have been found to be matured stands of secondary forests with big advanced growth or relics, including species of dipterocarps. The exact extent of the really primary patches is likely to be somewhat less than this.

Analysing the stand attributes of these primary stands, one is of the view that some stands are superior to those on Bukit Timah, traditionally regarded as the only place in Singapore with primary forests.

The species/area curve of the stands of FT 4 and that for the Bukit Timah forests show similar form with a sharp gradient without any flattening out, indicating that in both places more species are expected to be found, if a more intensive inventory is done.

The stands of secondary forests show the dynamics of succession in the Catchment Reserve and are developing well. The older of the truly secondary stands which have developed on land abandoned after prolonged cultivation (Corlett, 1991) though with superior stocking and with many high forest species now, yet do not have any species of dipterocarps. As dipterocarps have very inefficient seed dispersal, seeding under natural conditions may not happen and such stands might eventually mature into non-dipterocarp forests.

Corlett (1991) reckons that the secondary forests within the Catchment Reserve have developed from land severely degraded or exhausted by cultivation (gambier, pepper & pineapple being important crops). Degradation and exhaustion, however, were not defined. Agronomically we would regard severe sheet erosion, so much so that substantial layers of the solum are gone, and with severe gully formations, as severe degradation. We have during the 10 months of field work not found any evidence of severe gully formation and now that the forest cover is so good with a good litter on the forest floor and a good organic layer beneath, even if sheet erosion had occurred before, it would be difficult to discern now. We did, however, see some excavated spots, trenches here and there, and vestiges of roads and rides.

Looking at some of the trenches present (dug presumably during the War), the soil is deep and the profile is just as good as any one could see in a Rengam Series, an Ultisol of granitic origin, which is what the soil in the Reserve is, excepting of course the swamps and riparian fringes.

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**Appendix 1**. *Mischungsquotients* or No. of Individuals/Sp. for All Clusters of the Catchment Reserve (All trees => 30 cm gbh)

| FT | Cluster | No. of Indiv | No. of Species | *Michungsquotient* |
|---|---|---|---|---|
| 2 | 38 | 150 | 18 | 8.3 |
| 2 | 45 | 192 | 13 | 14.8 |
| 2 | 46 | 158 | 18 | 8.8 |
| 2 | 59 | 150 | 40 | 3.8 |
| 2 | 60 | 173 | 24 | 7.2 |
| | Total | 823 | 113 | |
| | Mean | 164.6 | 22.6 | 7.3 |
| 3 | 1 | 84 | 30 | 2.8 |
| 3 | 2 | 92 | 23 | 4 |
| 3 | 3 | 162 | 34 | 4.8 |
| 3 | 8 | 78 | 31 | 2.5 |
| 3 | 9 | 106 | 23 | 4.6 |
| 3 | 10 | 112 | 24 | 4.7 |
| 3 | 14 | 157 | 21 | 7.5 |
| 3 | 17 | 100 | 58 | 1.7 |
| 3 | 18 | 124 | 56 | 2.2 |
| 3 | 20 | 97 | 21 | 4.6 |
| 3 | 23 | 136 | 41 | 3.3 |
| 3 | 24 | 132 | 26 | 5.1 |
| 3 | 25 | 140 | 33 | 4.2 |
| 3 | 29 | 133 | 34 | 3.9 |
| 3 | 30 | 124 | 21 | 5.9 |
| 3 | 31 | 117 | 16 | 7.3 |
| 3 | 32 | 105 | 44 | 2.4 |
| 3 | 33 | 137 | 30 | 4.6 |
| 3 | 34 | 120 | 25 | 4.8 |
| 3 | 35 | 124 | 43 | 2.9 |
| 3 | 37 | 141 | 23 | 6.1 |
| 3 | 39 | 101 | 29 | 3.5 |
| 3 | 40 | 119 | 54 | 2.2 |
| 3 | 41 | 164 | 37 | 4.4 |
| 3 | 42 | 164 | 38 | 4.3 |
| 3 | 43 | 198 | 31 | 6.4 |
| 3 | 44 | 126 | 41 | 3.1 |
| 3 | 48 | 121 | 19 | 6.4 |

| FT | Cluster | No. of Indiv | No. of Species | *Michungsquotient* |
|---|---|---|---|---|
| 3 | 50 | 112 | 32 | 3.5 |
| 3 | 51 | 96 | 28 | 3.4 |
| 3 | 53 | 125 | 22 | 5.7 |
| 3 | 54 | 168 | 27 | 6.2 |
| 3 | 57 | 116 | 38 | 3.1 |
| 3 | 61 | 123 | 21 | 5.9 |
| 3 | 62 | 132 | 48 | 2.8 |
| | | Total | 4386 | 1122 |
| | | Mean | 125.3 | 32.1 3.9 |
| 4 | 4 | 90 | 44 | 2.0 |
| 4 | 5 | 92 | 25 | 3.7 |
| 4 | 6 | 63 | 50 | 1.3 |
| 4 | 7 | 71 | 39 | 1.8 |
| 4 | 11 | 70 | 43 | 2.0 |
| 4 | 13 | 105 | 56 | 1.9 |
| 4 | 15 | 95 | 42 | 2.3 |
| 4 | 16 | 81 | 44 | 1.8 |
| 4 | 19 | 85 | 42 | 2.0 |
| 4 | 21 | 94 | 29 | 4.6 |
| 4 | 26 | 108 | 53 | 2.0 |
| 4 | 27 | 107 | 71 | 1.5 |
| 4 | 28 | 121 | 61 | 2.0 |
| 4 | 36 | 128 | 61 | 2.1 |
| 4 | 47 | 132 | 36 | 3.7 |
| 4 | 49 | 110 | 50 | 2.2 |
| 4 | 52 | 144 | 56 | 2.6 |
| 4 | 55 | 106 | 72 | 1.5 |
| 4 | 56 | 104 | 39 | 2.7 |
| 4 | 58 | 126 | 71 | 1.8 |
| | Total | 2253 | 1090 | |
| | Mean | 102.4 | 49.5 | 2.1 |

**Appendix 2**. Distribution of Species In Forest Types (FT)

(All 62 Clusters, with 5 in Ft2, 35 in Ft3 and 22 in FT4)

(At end of list, Z=trees with collected leaf specimens but could not be identified in the herbarium, ZU=trees for which we failed to collect leaf specimens & could not be identified)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 1. | *Acronychia porteri* Hook. f. | 0 | 9 | 11 | 20 |
| 2. | *Actinodaphne glomerata* (Bl.) Nees | 0 | 1 | 0 | 1 |
| 3. | *Actinodaphne malaccensis* Hook. f. | 0 | 3 | 2 | 5 |
| 4. | *Actinodaphne pruinosa* Nees | 0 | 6 | 2 | 8 |
| 5. | *Adenanthera bicolor* Moon | 0 | 10 | 14 | 24 |
| 6. | *Adinandra dumosa* Jack | 95 | 312 | 29 | 436 |
| 7. | *Aglaia exstipulata* (Griff.) Theob. | 0 | 0 | 1 | 1 |
| 8. | *Aglaia leucophylla* King | 0 | 1 | 0 | 1 |
| 9. | *Aglaia maingayi* (Hiern) King | 0 | 0 | 6 | 6 |
| 10. | *Aglaia malaccensis* (Ridl.) Pannell | 0 | 0 | 6 | 6 |
| 11. | *Aglaia odoratissima* Bl. | 0 | 0 | 2 | 2 |
| 12. | *Aglaia rubiginosa* (Hiern) Pannell | 0 | 0 | 2 | 2 |
| 13. | *Aglaia* sp. | 0 | 0 | 1 | 1 |
| 14. | *Aidia wallichiana* Tirv. | 0 | 13 | 4 | 17 |
| 15. | *Alangium nobile* (Clarke) Harms | 0 | 0 | 2 | 2 |
| 16. | *Albizia splendens* Miq. | 0 | 1 | 2 | 3 |
| 17. | *Alphonsea maingayi* Hook. f. & Thoms. | 0 | 0 | 5 | 5 |
| 18. | *Alseodaphne bancana* Miq. | 0 | 0 | 6 | 6 |
| 19. | *Alseodaphne intermedia* kosterman | 0 | 0 | 1 | 1 |
| 20. | *Alstonia angustifolia* Wall. ex A. DC. | 19 | 39 | 6 | 64 |
| 21. | *Alstonia angustiloba* Miq. | 1 | 3 | 2 | 6 |
| 22. | *Anisophyllea griffithii* Oliv. | 0 | 0 | 1 | 1 |
| 23. | *Anisoptera megistocarpa* Sloot. | 0 | 1 | 6 | 7 |
| 24. | *Antidesma coriaceum* Tul. | 0 | 2 | 2 | 4 |
| 25. | *Antidesma cuspidatum* M.A. | 1 | 2 | 10 | 13 |
| 26. | *Antidesma neurocarpum* Miq. | 0 | 0 | 1 | 1 |
| 27. | *Antidesma salicinum* Ridl. | 0 | 0 | 1 | 1 |
| 28. | *Aphanomyrtus skiophila* (Duthie) Valeton | 0 | 1 | 0 | 1 |
| 29. | *Aporusa ?nervosa* | 0 | 4 | 1 | 5 |
| 30. | *Aporusa ?penanqensis* | 0 | 0 | 1 | 1 |
| 31. | *Aporusa benthamiana* Hook. f. | 0 | 3 | 6 | 9 |
| 32. | *Aporusa bracteosa* P. & H. | 0 | 0 | 3 | 3 |

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 33. | *Aporusa frutescens* Bl. | 0 | 2 | 1 | 3 |
| 34. | *Aporusa miqueliana* M.A. | 0 | 2 | 0 | 2 |
| 35. | *Aporusa nervosa* Hook. f. | 0 | 1 | 2 | 3 |
| 36. | *Aporusa penangensis* (Ridl.) Airy Shaw | 0 | 4 | 1 | 5 |
| 37. | *Aporusa symplocoides* (Hook. f.) Gage | 0 | 6 | 2 | 8 |
| 38. | *Aquilaria malaccensis* Lamk. | 2 | 18 | 12 | 32 |
| 39. | *Archidendron clypearia* (Jack) I. Niels | 34 | 16 | 3 | 53 |
| 40. | *Archidendron ellipticum* (Bl.) Niels. | 0 | 0 | 1 | 1 |
| 41. | *Archidendron globosum* (B1.) Niels. | 0 | 2 | 1 | 3 |
| 42. | *Ardisia colorata* Roxb. | 0 | 0 | 1 | 1 |
| 43. | *Arthrophyllum diversifolium* Bl. | 1 | 3 | 2 | 6 |
| 44. | *Artocarpus ?kemando* | 0 | 1 | 0 | 1 |
| 45. | *Artocarpus anisophyllus* Miq. | 0 | 1 | 3 | 4 |
| 46. | *Artocarpus dadah* Miq. | 0 | 8 | 4 | 12 |
| 47. | *Artocarpus fulvicortex* Jarrett | 0 | 0 | 1 | 1 |
| 48. | *Artocarpus heterophyllus* Lamk. | 0 | 2 | 0 | 2 |
| 49. | *Artocarpus integer* (Thunb.) Merr. | 0 | 3 | 1 | 4 |
| 50. | *Artocarpus kemando* Miq. | 0 | 1 | 8 | 9 |
| 51. | *Artocarpus lanceifolius* Roxb. | 0 | 0 | 1 | 1 |
| 52. | *Artocarpus lowii* King | 0 | 2 | 1 | 3 |
| 53. | *Artocarpus nitidus* Trec. | 1 | 6 | 5 | 12 |
| 54. | *Artocarpus rigidus* B1. | 2 | 32 | 19 | 53 |
| 55. | *Artocarpus scortechinii* King | 0 | 1 | 0 | 1 |
| 56. | *Baccaurea ?sumatrana* | 0 | 0 | 1 | 1 |
| 57. | *Baccaurea hookeri* Gage | 0 | 0 | 2 | 2 |
| 58. | *Baccaurea kunstleri* King ex Gage | 0 | 0 | 1 | 1 |
| 59. | *Baccaurea maingayi* Hook. f. | 0 | 0 | 1 | 1 |
| 60. | *Baccaurea minor* Hook. f. | 0 | 0 | 1 | 1 |
| 61. | *Baccaurea parviflora* (M.A.) M.A. | 0 | 2 | 4 | 6 |
| 62. | *Baccaurea racemosa* (Reinw.) M.A. | 0 | 1 | 2 | 3 |
| 63. | *Baccaurea reticulata* Hook. f. | 0 | 0 | 1 | 1 |
| 64. | *Baccaurea sumatrana* M.A. | 0 | 3 | 5 | 8 |
| 65. | *Beilschmiedia kunstleri* Gamble | 0 | 0 | 1 | 1 |
| 66. | *Beilschmiedia madang* B1. | 2 | 9 | 15 | 26 |
| 67. | *Bhesa paniculata* Arn. | 0 | 12 | 13 | 25 |
| 68. | *Bhesa robusta* (Roxb.) Ding Hou | 0 | 2 | 2 | 4 |
| 69. | *Blumeodendron ?tokbrai* | 0 | 0 | 1 | 1 |
| 70. | *Blumeodendron tokbrai* (B1.) J.J. Smith | 0 | 1 | 10 | 11 |
| 71. | *Bouea oppositifolia* (Roxb.) Meisn. | 0 | 0 | 1 | 1 |
| 72. | *Brackenridgea hookeri* (Planch.) A. Gray | 0 | 1 | 1 | 2 |
| 73. | *Buchanania arborescens* (B1.) B1. | 0 | 0 | 1 | 1 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 74. | *Buchanania sessifolia* B1. | 1 | 1 | 2 | 4 |
| 75. | *Calophyllum ?ferrugineum* | 0 | 11 | 8 | 19 |
| 76. | *Calophyllum ?rufigemmatum* | 0 | 1 | 0 | 1 |
| 77. | *Calophyllum dispar* P.F. Stevens | 0 | 0 | 1 | 1 |
| 78. | *Calophyllum ferrugineum* Ridl. | 0 | 107 | 11 | 118 |
| 79. | *Calophyllum lanigerum* Miq. v.*austrocoriaceum* (T.C. Whitmore) P.F. Steven | 0 | 5 | 1 | 6 |
| 80. | *Calophyllum macrocarpum* Hook. f. | 0 | 0 | 1 | 1 |
| 81. | *Calophyllum pulcherrimum* Wall. ex Choisy | 1 | 151 | 7 | 159 |
| 82. | *Calophyllum rigidum* Miq. | 0 | 2 | 0 | 2 |
| 83. | *Calophyllum rubiginosum* Hend. & Wyatt-Smith | 0 | 13 | 1 | 14 |
| 84. | *Calophyllum rufigemmatum* Hend. & Wyatt-Smith | 0 | 12 | 0 | 12 |
| 85. | *Calophyllum sundaicum* P.F. Stevens | 0 | 2 | 0 | 2 |
| 86. | *Calophyllum tetrapterum* Miq. | 1 | 23 | 35 | 59 |
| 87. | *Calophyllum teysmannii* Miq. | 0 | 24 | 11 | 35 |
| 88. | *Calophyllum wallichianum* Planch. & Tr. v. *incrassatum* (Hend. & Wyatt-Smith) P.F. Stevens | 0 | 20 | 5 | 25 |
| 89. | *Campnosperma auriculatum* (B1.) Hook. f. | 22 | 93 | 19 | 134 |
| 90. | *Campnosperma squamatum* Ridl. | 1 | 38 | 7 | 46 |
| 91. | *Canarium ?grandifolium* | 0 | 0 | 1 | 1 |
| 92. | *Canarium grandifolium* (Ridl.) Lam | 0 | 0 | 1 | 1 |
| 93. | *Canarium littorale* B1. | 0 | 11 | 12 | 23 |
| 94. | *Canarium patentinervium* Miq. | 0 | 0 | 9 | 9 |
| 95. | *Canarium pilosum* Benn. | 0 | 1 | 1 | 2 |
| 96. | *Canthium glabrum* B1. | 0 | 1 | 0 | 1 |
| 97. | *Carallia brachiata* (Lour.) Merr. | 0 | 9 | 13 | 22 |
| 98. | *Castanopsis megacarpa* Gamble | 0 | 0 | 2 | 2 |
| 99. | *Castanopsis nephelioides* King ex Hook. f. | 0 | 0 | 1 | 1 |
| 100. | *Castanopsis schefferiana* Hance | 0 | 0 | 3 | 3 |
| 101. | *Castanopsis wallichii* King ex Hook. f. | 1 | 2 | 1 | 4 |
| 102. | *Cheilosa malayana* (Hook.f.) Corner ex Airy Shaw | 0 | 0 | 1 | 1 |
| 103. | *Chisocheton patens* B1. | 0 | 0 | 2 | 2 |
| 104. | *Chisocheton pentandrus* (Blanco) Merr. | 0 | 0 | 3 | 3 |
| 105. | *Chisocheton sarawakanus* (C. DC.) Harms | 0 | 3 | 0 | 3 |
| 106. | *Cinnamomum iners* Reinw. ex B1. | 0 | 8 | 4 | 12 |
| 107. | *Cleistanthus sumatranus* (Miq.) M.A. | 0 | 0 | 2 | 2 |
| 108. | *Clerodendron laevifolium* B1. | 0 | 0 | 1 | 1 |
| 109. | *Cocos nucifera* L. | 0 | 1 | 0 | 1 |
| 110. | *Cratoxylum ?maingayi* | 0 | 0 | 2 | 2 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 111. | *Cratoxylum arborescens* (Vahl) Bl. | 1 | 8 | 2 | 11 |
| 112. | *Cratoxylum cochinchinense* (Lour.) Bl. | 0 | 1 | 0 | 1 |
| 113. | *Cratoxylum formosum* (Jack) Dyer | 0 | 9 | 6 | 15 |
| 114. | *Cratoxylum maingayi* Dyer | 0 | 7 | 0 | 7 |
| 115. | *Croton laevifolius* Bl. | 0 | 0 | 1 | 1 |
| 116. | *Crypteronia griffithii* Clarke | 0 | 0 | 2 | 2 |
| 117. | *Cryptocarya ferrea* Bl. | 0 | 0 | 4 | 4 |
| 118. | *Cryptocarya impressa* Miq. | 0 | 0 | 3 | 3 |
| 119. | *Cryptocarya rugulosa* Hook. f. | 0 | 0 | 4 | 4 |
| 120. | *Ctenolophon ?parvifolius* | 0 | 0 | 2 | 2 |
| 121. | *Ctenolophon parvifolius* Oliv. | 0 | 0 | 4 | 4 |
| 122. | *Cyathocalyx ramuliflorus* (Maingay ex Hook. f. & Thoms.) Scheff. | 0 | 31 | 22 | 53 |
| 123. | *Cyathocalyx ridleyi* (King) Sinclair | 0 | 16 | 7 | 23 |
| 124. | *Dacryodes costata* (Benn.) Lam | 0 | 2 | 3 | 5 |
| 125. | *Dacryodes laxa* (Benn.) Lam | 0 | 0 | 1 | 1 |
| 126. | *Dacryodes rostrata* (Bl.) Lam | 0 | 2 | 5 | 7 |
| 127. | *Dacryodes rugosa* (Bl.) Lam | 0 | 1 | 5 | 6 |
| 128. | *Decaspermum fruticosum* J.R. & G. Forst. | 7 | 1 | 1 | 9 |
| 129. | *Dehaasia incrassata* (Jack) Kostermans | 1 | 2 | 0 | 3 |
| 130. | *Dialium ?maingayi* Baker | 0 | 0 | 1 | 1 |
| 131. | *Dialium ?platysepalum* | 0 | 0 | 1 | 1 |
| 132. | *Dialium indum* L. v. *bursa* (de Wit) Rojo | 0 | 1 | 1 | 1 |
| 133. | *Dialium platysepalum* Baker | 0 | 1 | 6 | 7 |
| 134. | *Dillenia grandifolia* Wall. ex Hook. f. & Thoms. | 0 | 3 | 2 | 5 |
| 135. | *Diospyros ?ridleyi* Bakh. | 1 | 0 | 0 | 1 |
| 136. | *Diospyros buxifolia* (Bl.) Hiern | 0 | 0 | 3 | 3 |
| 137. | *Diospyros lanceifolia* Roxb. | 0 | 3 | 4 | 7 |
| 138. | *Diospyros maingayi* (Hiern) Bakh. | 0 | 0 | 4 | 4 |
| 139. | *Diospyros pilosanthera Blanco v. oblonga* (Wall. ex G. Don) Ng | 0 | 0 | 2 | 2 |
| 140. | *Diospyros* sp. 1 | 0 | 1 | 0 | 1 |
| 141. | *Diospyros styraciformis* King & Gamble | 0 | 2 | 7 | 9 |
| 142. | *Diplospora malaccensis* Hook. f. | 0 | 1 | 3 | 4 |
| 143. | *Dipterocarpus apterus* Foxw. | 0 | 0 | 1 | 1 |
| 144. | *Dipterocarpus cornutus* Dyer | 0 | 0 | 5 | 5 |
| 145. | *Dipterocarpus grandiflorus* Blanco | 0 | 0 | 15 | 15 |
| 146. | *Dipterocarpus sublamellatus* Foxw. | 0 | 2 | 14 | 16 |
| 147. | *Drypetes pendula* Ridl. | 0 | 1 | 0 | 1 |
| 148. | *Durio griffithii* (Mast.) Bakh. | 0 | 0 | 5 | 5 |
| 149. | *Durio singaporensis* Ridl. | 0 | 2 | 4 | 6 |
| 150. | *Dyera costulata* (Miq.) Hook. f. | 0 | 14 | 33 | 47 |
| 151. | *Dysoxylum cauliflorum* Hiern | 1 | 9 | 22 | 32 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 152. | *Dysoxylum densiflorum* (Bl.) Miq. | 0 | 0 | 1 | 1 |
| 153. | *Dysoxylum excelsum* Bl. | 0 | 0 | 1 | 1 |
| 154. | *Dysoxylum flavescens* Hiern | 0 | 0 | 1 | 1 |
| 155. | *Elaeocarpus ferrugineus* (Jack) Steud. | 2 | 37 | 4 | 43 |
| 156. | *Elaeocarpus floribundus* Bl. | 0 | 1 | 0 | 1 |
| 157. | *Elaeocarpus masterii* king | 18 | 46 | 4 | 43 |
| 158. | *Elaeocarpus nitidus* Jack v.*salicifolius* (King) Ng | 0 | 14 | 11 | 25 |
| 159. | *Elaeocarpus palembanicus* (Miq.) Corner | 0 | 1 | 0 | 1 |
| 160. | *Elaeocarpus petiolatus* (Jack) Wall. | 1 | 17 | 2 | 20 |
| 161. | *Elaeocarpus rugosus* Roxb. | 0 | 6 | 0 | 6 |
| 162. | *Elaeocarpus stipularis* Bl. | 6 | 0 | 1 | 7 |
| 163. | *Endospermum diadenum* (Miq.) Airy Shaw | 4 | 7 | 5 | 16 |
| 164. | *Enicosanthum* sp. 1 | 0 | 0 | 2 | 2 |
| 165. | *Eugenia ?microcalyx* | 0 | 2 | 4 | 6 |
| 166. | *Eugenia ?nigricans* | 0 | 3 | 0 | 3 |
| 167. | *Eugenia ?pseudosubtilis* King | 0 | 2 | 0 | 2 |
| 168. | *Eugenia cerina* Hend. | 0 | 6 | 1 | 7 |
| 169. | *Eugenia chlorantha* Duthie | 0 | 4 | 1 | 5 |
| 170. | *Eugenia cumingiana* Vidal | 0 | 6 | 3 | 9 |
| 171. | *Eugenia duthieana* King | 0 | 1 | 3 | 4 |
| 172. | *Eugenia filiformis* Duthie v.*clabimyrtus* (Koord. & Valet.) Hend. | 0 | 3 | 2 | 5 |
| 173. | *Eugenia glauca* King | 1 | 33 | 3 | 37 |
| 174. | *Eugenia grandis* Wight | 2 | 65 | 3 | 70 |
| 175. | *Eugenia longiflora* (Presl) F.-Vill. | 37 | 29 | 4 | 70 |
| 176. | *Eugenia microcalyx* Duthie | 22 | 16 | 22 | 60 |
| 177. | *Eugenia muelleri* Miq. | 0 | 1 | 0 | 1 |
| 178. | *Eugenia nemestrina* Hend. | 0 | 12 | 3 | 15 |
| 179. | *Eugenia ngadimaniana* Hend. | 0 | 4 | 6 | 10 |
| 180. | *Eugenia nigricans* King | 0 | 10 | 10 | 20 |
| 181. | *Eugenia oblongifolia* Duthie | 0 | 4 | 1 | 5 |
| 182. | *Eugenia pachyphylla* kurz | 0 | 2 | 1 | 3 |
| 183. | *Eugenia papillosa* Duthie | 0 | 0 | 1 | 1 |
| 184. | *Eugenia pauper* Ridl. | 0 | 16 | 1 | 17 |
| 185. | *Eugenia pendens* Duthie | 0 | 0 | 2 | 2 |
| 186. | *Eugenia polyantha* Wight | 0 | 3 | 2 | 5 |
| 187. | *Eugenia ridleyi* King | 0 | 4 | 12 | 16 |
| 188. | *Eugenia spicata* Lamk. | 0 | 1 | 0 | 1 |
| 189. | *Eugenia subdecussata* Duthie | 0 | 5 | 2 | 7 |
| 190. | *Eugenia tumida* Duthie | 0 | 0 | 3 | 3 |
| 191. | *Euodia glabra* (Bl.) Bl. | 13 | 1 | 4 | 18 |
| 192. | *Eurya acuminata* DC. | 0 | 1 | 5 | 6 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 193. | *Eurycoma longifolia* Jack | 0 | 0 | 2 | 2 |
| 194. | *Fagraea fragrans* Roxb. | 1 | 9 | 7 | 17 |
| 195. | *Fahrenheitia pendula* (Hassk.) Airy Shaw | 0 | 0 | 1 | 1 |
| 196. | *Ficus glandulifera* (Wall. ex Miq.) King | 1 | 0 | 1 | 2 |
| 197. | *Ficus kerkhovenii* Val. | 0 | 0 | 1 | 1 |
| 198. | *Ficus lamponga* Miq. | 1 | 1 | 1 | 3 |
| 199. | *Galearia fulva* (Tul.) Miq. | 0 | 1 | 0 | 1 |
| 200. | *Galearia maingayi* Hook. f. | 0 | 1 | 1 | 2 |
| 201. | *Ganua kingiana* (Brace) Van Den Assem | 0 | 0 | 5 | 5 |
| 202. | *Ganua motleyana* (De Vr.) Pierre ex Dubard | 0 | 0 | 4 | 4 |
| 203. | *Garcinia atroviridis* Griff. & T. Anders. | 0 | 0 | 2 | 2 |
| 204. | *Garcinia eugeniaefolia* Wall. ex T. Anders. | 0 | 88 | 8 | 96 |
| 205. | *Garcinia forbesii* King | 0 | 0 | 5 | 5 |
| 206. | *Garcinia griffithii* T. Anders. | 0 | 6 | 1 | 7 |
| 207. | *Garcinia maingayi* Hook. f. v. *stylosa* King | 0 | 1 | 0 | 1 |
| 208. | *Garcinia nervosa* Miq. | 0 | 0 | 1 | 1 |
| 209. | *Garcinia parvifolia* (Miq.) Miq. | 4 | 213 | 40 | 257 |
| 210. | *Garcinia scortechinii* King | 0 | 0 | 3 | 3 |
| 211. | *Gardenia griffithii* Hook. f. | 0 | 0 | 1 | 1 |
| 212. | *Gardenia tubifera* Wall. | 0 | 0 | 3 | 3 |
| 213. | *Gironniera ?nervosa* | 0 | 0 | 1 | 1 |
| 214. | *Gironniera nervosa* Planch. | 11 | 60 | 47 | 118 |
| 215. | *Gironniera parvifolia* Planch. | 0 | 1 | 20 | 21 |
| 216. | *Gironniera subaequalis* Planch. | 0 | 2 | 8 | 10 |
| 217. | *Glochidion superbum* Baill. | 1 | 1 | 0 | 2 |
| 218. | *Gluta wallichii* (Hook. f.) Ding Hou | 0 | 5 | 19 | 24 |
| 219. | *Gnetum gnemon* L. | 0 | 0 | 1 | 1 |
| 220. | *Gonystylus confusus* Airy Shaw | 0 | 10 | 5 | 15 |
| 221. | *Gonystylus maingayi* Hook. f. | 0 | 0 | 2 | 2 |
| 222. | *Gordonia ?singaporiana* Wall. ex Ridl. | 0 | 1 | 0 | 1 |
| 223. | *Gordonia multinervis* King | 1 | 11 | 0 | 12 |
| 224. | *Grewia blattaefolia* Corner | 0 | 1 | 8 | 9 |
| 225. | *Guioa pleuropteris* (B1.) Radlk. | 0 | 1 | 0 | 1 |
| 226. | *Guioa pubescens* (Z. & M.) Radlk. | 0 | 18 | 2 | 20 |
| 227. | *Gymnacranthera bancana (Miq.)* Sinclair | 0 | 0 | 1 | 1 |
| 228. | *Gymnacranthera farquhariana* (Hook. f. & Thoms.) Warb. | 0 | 1 | 12 | 13 |
| 229. | *Gymnacranthera forbesii* (King) Warb. | 0 | 6 | 0 | 6 |
| 230. | *Gynotroches axillaris* B1. | 8 | 107 | 46 | 161 |
| 231. | *Helicia petiolaris* Benn. | 0 | 2 | 1 | 3 |
| 232. | *Heritiera ?javanica* B1. | 0 | 0 | 2 | 2 |
| 233. | *Heritiera elata* Ridl. | 0 | 0 | 2 | 2 |
| 234. | *Heritiera borneensis* (Merr.) Kostermans | 0 | 1 | 2 | 3 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 235. | *Heritiera simplicifolia* (Mast.) Kostermans | 0 | 0 | 3 | 3 |
| 236. | *Hevea brasiliensis* (Willd. ex A. Juss.) M.A. | 0 | 17 | 0 | 17 |
| 237. | *Hopea griffithii* Kurz | 0 | 0 | 11 | 11 |
| 238. | *Hopea mangarawan* Miq. | 0 | 0 | 10 | 10 |
| 239. | *Horsfieldia crassifolia* (Hook. f. & Thoms.) Warb. | 0 | 0 | 2 | 2 |
| 240. | *Horsfieldia polyspherula* (Hook. f. emend. King) J. Sinclair | 1 | 12 | 18 | 31 |
| 241. | *Horsfieldia sucosa* (King) Warb. | 0 | 2 | 6 | 8 |
| 242. | *Horsfieldia superba* (Hook. f. & Thoms.) Warb. | 0 | 0 | 1 | 1 |
| 243. | *Horsfieldia wallichii* (Hook. f. & Thoms.) Warb. | 0 | 0 | 2 | 2 |
| 244. | *Hymenaea courbaril* L. | 0 | 1 | 0 | 1 |
| 245. | *Ilex cymosa* B1 | 1 | 10 | 0 | 11 |
| 246. | *Ilex macrophylla* Hook.f. | 0 | 1 | 0 | 1 |
| 247. | *Irvingia malayana* Oliv. & Benn. | 0 | 0 | 1 | 1 |
| 248. | *Ixonanthes icosandra* Jack | 0 | 30 | 35 | 65 |
| 249. | *Ixonanthes reticulata* Jack | 9 | 38 | 11 | 58 |
| 250. | *Jackiopsis ornata* (Wall.) Ridsdale | 0 | 0 | 1 | 1 |
| 251. | *Kibara coriace* (B1.) Tul. | 0 | 0 | 1 | 1 |
| 252. | *Kibatalia maingayi* (Hook. f.) Woodson | 0 | 1 | 3 | 4 |
| 253. | *Knema communis* Sinclair | 0 | 2 | 6 | 8 |
| 254. | *Knema conferta* (King) Warb. | 0 | 3 | 1 | 4 |
| 255. | *Knema curtisii* (King) Warb. v. *paludosa* J. Sinclair | 0 | 3 | 2 | 5 |
| 256. | *Knema furfuracea* (Hook. f. & Thoms) Warb. | 0 | 0 | 1 | 1 |
| 257. | *Knema hookeriana* (Wall. ex Hook. f. & Thoms.) Warb. | 0 | 1 | 3 | 4 |
| 258. | *Knema intermedia* (B1.) Warb. | 5 | 6 | 5 | 16 |
| 259. | *Knema latericia* Elm. | 0 | 4 | 3 | 7 |
| 260. | *Knema laurina* (B1.) Warb. | 0 | 1 | 6 | 7 |
| 261. | *Knema malayana* Warb. | 0 | 2 | 8 | 10 |
| 262. | *Koompassia malaccensis* Maingay ex Benth. | 0 | 4 | 12 | 16 |
| 263. | *Kopsia singapurensis* Ridl. | 0 | 0 | 1 | 1 |
| 264. | *Lansium domesticum* Correa | 0 | 0 | 1 | 1 |
| 265. | *Licania splendens* (Korth.) Pranc e | 0 | 18 | 1 | 19 |
| 266. | *Lindera lucida* (B1.) Boerl. | 6 | 4 | 0 | 10 |
| 267. | *Lithocarpus ?ewyckii* | 0 | 0 | 1 | 1 |
| 268. | *Lithocarpus bennettii* (Miq.) Rehd. | 0 | 0 | 2 | 2 |
| 269. | *Lithocarpus conocarpus* (Oudem.) Rehd. | 0 | 1 | 1 | 2 |
| 270. | *Lithocarpus encleisacarpus* (Korth.) A. Camus | 0 | 3 | 4 | 7 |
| 271. | *Lithocarpus ewyckii* (Korth.) Rehd. | 1 | 7 | 11 | 19 |
| 272. | *Lithocarpus lucidus* (Roxb.) Rehd. | 0 | 3 | 6 | 9 |
| 273. | *Lithocarpus sundaicus* (B1.) Boerl. | 0 | 12 | 1 | 13 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 274. | *Litsea accedens* (B1.) Boerl. | 0 | 3 | 2 | 5 |
| 275. | *Litsea castanea* Hook. f. | 0 | 3 | 7 | 10 |
| 276. | *Litsea costalis* (B1.) Kostermans | 0 | 0 | 2 | 2 |
| 277. | *Litsea elliptica* B1. | 1 | 67 | 33 | 101 |
| 278. | *Litsea erectinervia* Kostermans | 0 | 1 | 4 | 5 |
| 279. | *Litsea ferruginea* B1. | 0 | 1 | 1 | 2 |
| 280. | *Litsea firma* Hook. f. | 3 | 59 | 10 | 72 |
| 281. | *Litsea grandis* Hook. f. | 5 | 18 | 3 | 26 |
| 282. | *Litsea maingayi* Hook. f. | 0 | 0 | 2 | 2 |
| 283. | *Litsea ridleyi* Gamble | 0 | 0 | 10 | 10 |
| 284. | *Litsea robusta* B1. | 0 | 0 | 2 | 2 |
| 285. | *Lophopetalm multinervium* Ridl. | 0 | 0 | 5 | 5 |
| 286. | *Lophopetalum wightianum* Arn. | 0 | 1 | 3 | 4 |
| 287. | *Macaranga conifera* (Zoll.) M.A. | 141 | 45 | 5 | 191 |
| 288. | *Macaranga gigantea* (Rchb. f. & Zoll.) M.A. | 4 | 5 | 0 | 9 |
| 289. | *Macaranga hypoleuca* (Rchb. f. & Zoll.) M.A. | 0 | 1 | 0 | 1 |
| 290. | *Macaranga lowii King* ex Hook. f. | 0 | 0 | 8 | 8 |
| 291. | *Macaranga triloba* (Bl.) M.A. | 8 | 11 | 4 | 23 |
| 292. | *Madhuca korthalsii* (Pierre) Lam | 0 | 0 | 1 | 1 |
| 293. | *Madhuca malaccensis* (Clarke) Lam | 0 | 1 | 0 | 1 |
| 294. | *Madhuca sericea* (Miq.) Lam | 0 | 1 | 8 | 9 |
| 295. | *Magnolia candolii* (B1.) H. Keng | 0 | 0 | 6 | 6 |
| 296. | *Magnolia elegans* (B1.) H. Keng | 0 | 1 | 0 | 1 |
| 297. | *Mallotus penangensis* M.A. | 0 | 1 | 9 | 10 |
| 298. | *Manqifera foetida* Lour. | 0 | 0 | 1 | 1 |
| 299. | *Mangifera griffithii* Hook. f. | 0 | 0 | 18 | 18 |
| 300. | *Mangifera indica* L. | 0 | 1 | 0 | 1 |
| 301. | *Mangifera subsessilifolia* Kostermans | 0 | 0 | 1 | 1 |
| 302. | *Maranthes corymbosa* B1. | 0 | 1 | 0 | 1 |
| 303. | *Mastixia trichotoma* B1. | 0 | 0 | 2 | 2 |
| 304. | *Melanochyla auriculata* Hook. f. | 0 | 0 | 3 | 3 |
| 305. | *Melanochyla caesia* (B1.) Ding Hou | 0 | 0 | 2 | 2 |
| 306. | *Meliosma lanceolata* B1. *v. lanceolata* | 0 | 0 | 1 | 1 |
| 307. | *Meliosma simplicifolia* (Roxb.) Walp. | 0 | 0 | 1 | 1 |
| 308. | *Memecylon edule* Roxb. | 0 | 0 | 1 | 1 |
| 309. | *Memecylon floridum* Ridl. | 0 | 2 | 0 | 2 |
| 310. | *Memecylon lilacinum* Z. & M. | 0 | 0 | 1 | 1 |
| 311. | *Memcylon megacarpum* Furtado | 0 | 1 | 5 | 6 |
| 312. | *Memecylon paniculatum* Jack | 0 | 0 | 1 | 1 |
| 313. | *Mezzettia parviflora* Becc. | 0 | 1 | 2 | 3 |
| 314. | *Microdesmis caseariifolia* Planch. | 0 | 0 | 2 | 2 |
| 315. | *Monocarpia marginalis* (Scheff.) Sinclair | 0 | 2 | 1 | 3 |
| 316. | *Mussaendopsis beccariana* Baill. | 0 | 0 | 14 | 14 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 317. | *Myrica esculenta* Buch.-Ham. | 0 | 6 | 2 | 8 |
| 318. | *Myristica ?guatteriifolia* A. DC. | 0 | 0 | 1 | 1 |
| 319. | *Myristica ?lowiana* | 0 | 0 | 1 | 1 |
| 320. | *Myristica ?maingayi* | 0 | 0 | 2 | 2 |
| 321. | *Myristica cinnamomea* King | 0 | 0 | 8 | 8 |
| 322. | *Myristica elliptica* Hook. f. & Thoms. | 0 | 0 | 5 | 5 |
| 323. | *Myristica iners* B1. | 0 | 0 | 1 | 1 |
| 324. | *Myristica lowiana* King | 0 | 0 | 2 | 2 |
| 325. | *Myristica maingayi* Hook. f. | 0 | 2 | 2 | 4 |
| 326. | Myristicaceae 1 | 0 | 0 | 1 | 1 |
| 327. | Myristicaceae 2 | 0 | 1 | 0 | 1 |
| 328. | Myristicaceae 3 | 0 | 1 | 0 | 1 |
| 329. | *Nauclea officinalis* (Pierre ex Pitard) Merr. & Chun | 0 | 1 | 0 | 1 |
| 330. | *Neesia synandra* Mast. | 0 | 2 | 0 | 2 |
| 331. | *Neolitsea ?zeylanica* | 0 | 1 | 0 | 1 |
| 332. | *Neolitsea zeylanica* Merr. | 0 | 0 | 1 | 1 |
| 333. | *Neoscortechinia kingii* (Hook. f.) P. & H. | 0 | 0 | 2 | 2 |
| 334. | *Nephelium cuspidatum* B1. v. *eriopetalum* (Miq.) Leenh. | 0 | 2 | 2 | 4 |
| 335. | *Norrisia maior* Soler. | 0 | 0 | 1 | 1 |
| 336. | *Norrisia malaccensis* Gardn. | 0 | 0 | 1 | 1 |
| 337. | *Nothaphoebe umbelliflora* (B1.) B1. | 0 | 11 | 23 | 34 |
| 338. | *Ochanostachys amentacea* Mast. | 0 | 3 | 3 | 6 |
| 339. | *Osmelia philippina* (Turcz.) Benth. | 0 | 1 | 5 | 6 |
| 340. | *Palaquium ?rostratum* | 0 | 0 | 1 | 1 |
| 341. | *Palaquium hexandrum* (Griff.) Baill. | 0 | 0 | 7 | 7 |
| 342. | *Palaquium microphyllum* King & Gamble | 0 | 5 | 1 | 6 |
| 343. | *Palaquium obovatum* (Griff.) Engl. | 0 | 15 | 5 | 20 |
| 344. | *Palaquium rostratum* (Miq.) Burck | 0 | 13 | 8 | 21 |
| 345. | *Palaquium* sp.1 | 0 | 0 | 13 | 13 |
| 346. | *Palaquium xanthochymum* (De Vr.) Pierre | 0 | 1 | 9 | 10 |
| 347. | *Parartocarpus bracteatus* (King) Becc. | 0 | 0 | 2 | 2 |
| 348. | *Parinari oblongifolia* Hook. f. | 0 | 0 | 1 | 1 |
| 349. | *Parishia maingayi* Hook. f. | 0 | 4 | 8 | 12 |
| 350. | *Parkia speciosa* Hassk. | 0 | 4 | 4 | 8 |
| 351. | *Payena lucida* (G. Don) DC. | 0 | 0 | 1 | 1 |
| 352. | *Payena obscura* Burck | 0 | 4 | 1 | 5 |
| 353. | *Pellacalyx axillaris* Korth. | 0 | 0 | 5 | 5 |
| 354. | *Pellacalyx saccardianus* Scort. | 0 | 3 | 0 | 3 |
| 355. | *Pentace triptera* Mast. . | 0 | 0 | 5 | 5 |
| 356. | *Pertusadina eurhyncha* (Miq.) Ridsdale | 0 | 1 | 21 | 22 |
| 357. | *Phoebe grandis* Merr. | 0 | 0 | 1 | 1 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 358. | *Pimeleodendron griffithianum* (M.A.) Benth. | 0 | 2 | 4 | 6 |
| 359. | *Pithecellobium jiringa* (Jack) Prain | 0 | 2 | 0 | 2 |
| 360. | *Planchonella maingayi* (Clarke) van Royen | 0 | 1 | 2 | 3 |
| 361. | *Ploiarium alternifolium* (Vahl) Melchior | 2 | 4 | 0 | 6 |
| 362. | *Polyalthia ?hookeriana* King | 0 | 1 | 0 | 1 |
| 363. | *Polyalthia glauca* (Hassk.) Muell. | 0 | 0 | 11 | 11 |
| 364. | *Polyalthia jenkensii* (Hook. f. & Thoms.) Hook.f. & Thoms. | 0 | 0 | 1 | 1 |
| 365. | *Polyalthia macropoda* King | 0 | 0 | 2 | 2 |
| 366. | *Polyalthia rumphii* Merr. | 0 | 1 | 2 | 3 |
| 367. | *Polyalthia sumatrana* (Miq.) Kurz | 0 | 0 | 2 | 2 |
| 368. | *Pometia pinnata* Forst. f. *alnifolia* | 0 | 0 | 14 | 14 |
| 369. | *Popowia fusca* King | 0 | 3 | 5 | 8 |
| 370. | *Popowia pisocarpa* (B1.) Endl. | 0 | 0 | 1 | 1 |
| 371. | *Porterandia anisophylla* (Jack ex Roxb.) Ridl. | 4 | 29 | 14 | 47 |
| 372. | *Pouteria malaccensis* (Clarke) Baehni | 0 | 9 | 15 | 24 |
| 373. | *Prunus arborea* (B1.) Kalkm. | 0 | 1 | 1 | 2 |
| 374. | *Purnus polystachya* (Hook. f.) Kalkm. | 1 | 29 | 42 | 72 |
| 375. | *Pseudoeugenia singaporensis* King | 0 | 0 | 1 | 1 |
| 376. | *Psydrax sp.* 10 of Wong (1989) | 0 | 26 | 5 | 31 |
| 377. | *Psydrax sp.* 11 of Wong (1989) | 0 | 1 | 0 | 1 |
| 378. | *Pternandra coerulescens* Jack | 0 | 3 | 4 | 7 |
| 379. | *Pternandra echinata* Jack | 2 | 47 | 15 | 64 |
| 380. | *Pyrenaria acuminata* Planch. ex Choisy | 0 | 0 | 2 | 2 |
| 381. | *Rhodamnia cinerea* Jack | 258 | 1217 | 165 | 1640 |
| 382. | *Sandoricum beccarianum* Baill. | 0 | 0 | 1 | 1 |
| 383. | *Sandoricum koetjape* (Burm. f.) Merr. | 0 | 1 | 1 | 2 |
| 384. | *Santiria ?griffithii* | 0 | 1 | 0 | 1 |
| 385. | *Santiria apiculata* Benn. | 0 | 0 | 4 | 4 |
| 386. | *Santiria griffithii* (Hook. f.) Engl. | 0 | 11 | 23 | 34 |
| 387. | *Santiria laevigata* B1. | 0 | 8 | 19 | 27 |
| 388. | *Santiria rubiginosa* B1. | 0 | 3 | 5 | 8 |
| 389. | *Santiria tomentosa* B1. | 0 | 7 | 4 | 11 |
| 390. | Sapotaceae? 1 | 0 | 0 | 1 | 1 |
| 391. | *Sarcotheca griffithii* (Planch. ex Hook. f.) Hall. f. | 0 | 0 | 3 | 3 |
| 392. | *Sarcotheca laxa* Knuth v. *sericea* (Ridl.) Veldk. | 0 | 0 | 1 | 1 |
| 393. | *Scaphium macropodum* (Miq.) Beumee ex Heyne | 1 | 0 | 5 | 6 |
| 394. | *Scleropyrum wallichianum* (Wight & Arn.) Arn. | 0 | 1 | 0 | 1 |
| 395. | *Scorodocarpus borneensis* Becc. | 2 | 1 | 6 | 9 |
| 396. | *Shorea bracteolata* Dyer | 0 | 1 | 2 | 3 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 397. | *Shorea curtisii* Dyer ex King | 0 | 0 | 3 | 3 |
| 398. | *Shorea gibbosa* Brandis | 0 | 1 | 5 | 6 |
| 399. | *Shorea gratissima* Dyer | 0 | 0 | 4 | 4 |
| 400. | *Shorea leprosula* Miq. | 0 | 1 | 6 | 7 |
| 401. | *Shorea macroptera* Dyer | 0 | 6 | 12 | 18 |
| 402. | *Shorea ovalis* B1. | 0 | 3 | 2 | 5 |
| 403. | *Shorea parvifolia* Dyer | 0 | 3 | 4 | 7 |
| 404. | *Shorea pauciflora* King | 0 | 4 | 9 | 13 |
| 405. | *Shorea platycarpa* Heim. | 0 | 0 | 2 | 2 |
| 406. | *Sindora coriacea* Maingay ex Prain | 0 | 2 | 2 | 4 |
| 407. | *Spathodea campanulata* P. Beauv. | 0 | 3 | 0 | 3 |
| 408. | *Stemonurus scorpioides* Becc. | 0 | 0 | 1 | 1 |
| 409. | *Sterculia ?shillinglawii* F.V. Muell. | 0 | 1 | 0 | 1 |
| 410. | *Sterculia cordata* B1. | 0 | 0 | 1 | 1 |
| 411. | *Sterculia edelfetii* F.v. Muell. | 0 | 0 | 1 | 1 |
| 412. | *Sterculia macrophylla* Vent. | 0 | 0 | 2 | 2 |
| 413. | *Sterculia parviflora* Roxb. | 0 | 2 | 1 | 3 |
| 414. | *Sterculia rubiginosa* Vent. | 0 | 0 | 2 | 2 |
| 415. | *Streblus elongatus* (Miq.) Corner | 6 | 14 | 15 | 35 |
| 416. | *Strombosia ceylanica* Gardn. | 0 | 1 | 39 | 40 |
| 417. | *Strombosia javanica* B1. | 0 | 3 | 13 | 16 |
| 418. | *Styrax benzoin* Dryand. | 1 | 1 | 1 | 3 |
| 419. | *Swintonia schwenkii* (T. & B.) T. & B. | 0 | 0 | 1 | 1 |
| 420. | *Symplocos adenophylla* Wall. ex G. Don | 0 | 1 | 0 | 1 |
| 421. | *Symplocos fasciculata* Zoll. | 0 | 0 | 1 | 1 |
| 422. | *Symplocos rubiginosa* Wall. ex DC. | 0 | 1 | 0 | 1 |
| 423. | *Tarenna costata* (Miq.) Merr. | 1 | 0 | 0 | 1 |
| 424. | *Tarenna mollis* (Wall. ex Hook. f.) B.L. Robinson | 0 | 0 | 1 | 1 |
| 425. | *Tarenna odorata* (Roxb.) B.L. Robinson | 0 | 1 | 0 | 1 |
| 426. | *Teijsmanniodendron ?holophyllum* (Baker) Kostermans | 0 | 0 | 1 | 1 |
| 427. | *Teijsmanniodendron coriaceum* (Clarke) Kostermans | 0 | 0 | 6 | 6 |
| 428. | *Terminalia subspathulata* King | 0 | 0 | 1 | 1 |
| 429. | *Ternstroemia penangiana* Choisy | 0 | 0 | 1 | 1 |
| 430. | *Timonius wallichianus* (Korth.) Valeton | 27 | 188 | 61 | 276 |
| 431. | *Triomma malaccensis* Hook. f. | 0 | 0 | 3 | 3 |
| 432. | *Tristaniopsis merguensis* (Griff.) Wilson & Waterhouse | 0 | 0 | 1 | 1 |
| 433. | *Turpinia sphaerocarpa* Hassk. | 0 | 2 | 0 | 2 |
| 434. | *Vatica ?ridleyana* | 0 | 0 | 1 | 1 |
| 435. | *Vatica maingayi* Dyer | 0 | 0 | 5 | 5 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 436. | *Vatica ridleyana* Brandis | 0 | 3 | 12 | 15 |
| 437. | *Vitex pinnata* L. | 1 | 6 | 1 | 8 |
| 438. | *Xanthophyllum ?affine* | 0 | 1 | 0 | 1 |
| 439. | *Xanthophyllum affine* Korth. | 0 | 2 | 14 | 16 |
| 440. | *Xanthophyllum amoenum* Chodat | 0 | 1 | 1 | 2 |
| 441. | *Xanthophyllum ellipticum* Korth. | 1 | 2 | 3 | 6 |
| 442. | *Xanthophyllum eruhynchum* Miq. | 0 | 3 | 2 | 5 |
| 443. | *Xanthophyllum griffithii* Hook. f. ex Benn | 0 | 0 | 1 | 1 |
| 444. | *Xanthophyllum obscurum* Benn. | 0 | 0 | 2 | 2 |
| 445. | *Xanthophyllum stipitatum* Benn. | 0 | 0 | 3 | 3 |
| 446. | *Xanthophyllum vitellinum* (Bl.) Dietr. | 0 | 8 | 6 | 14 |
| 447. | *Xerospermum noronhianum* Bl. | 0 | 1 | 3 | 4 |
| 448. | *Xylopia caudata* Hook. f. & Thoms. | 0 | 8 | 2 | 10 |
| 449. | *Xylopia ferruginea* (Hook. f. & Thoms.) Hook. f. & Thoms. | 0 | 44 | 4 | 48 |
| 450. | *Xylopia ferruginea* v.oxyantha (Hook. f. & Thoms.) Sinclair | 0 | 14 | 0 | 14 |
| 451. | *Xylopia fusca* Maingay ex Hook. f. & Thoms. | 0 | 0 | 1 | 1 |
| 452. | *Xylopia magna* Maingay ex Hook. f. & Thoms. | 0 | 0 | 1 | 1 |
| 453. | *Xylopia malayana* Hook. f. & Thoms. | 0 | 8 | 10 | 18 |
| 454. | Z01 | 0 | 0 | 1 | 1 |
| 455. | Z02 | 0 | 2 | 0 | 2 |
| 456. | Z03 | 0 | 1 | 1 | 2 |
| 457. | Z04 | 0 | 1 | 0 | 1 |
| 458. | Z05 | 0 | 1 | 0 | 1 |
| 459. | Z06 | 0 | 0 | 2 | 2 |
| 460. | Z07 | 0 | 0 | 2 | 2 |
| 461. | Z08 | 0 | 1 | 0 | 1 |
| 462. | Z09 | 0 | 0 | 1 | 1 |
| 463. | Z10 | 0 | 0 | 1 | 1 |
| 464. | Z11 | 0 | 0 | 1 | 1 |
| 465. | Z12 | 0 | 0 | 2 | 2 |
| 466. | Z13 | 0 | 0 | 1 | 1 |
| 467. | Z14 | 0 | 0 | 1 | 1 |
| 468. | Z15 | 0 | 0 | 1 | 1 |
| 469. | Z16. | 0 | 1 | 1 | 1 |
| 470. | Z17. | 0 | 1 | 2 | 3 |
| 471. | Z18. | 0 | 0 | 1 | 1 |
| 472. | Z19. | 0 | 0 | 1 | 1 |
| 473. | Z20. | 0 | 1 | 0 | 1 |
| 474. | Z21. | 0 | 0 | 1 | 1 |
| 475. | Z22. | 0 | 1 | 0 | 1 |
| 476. | Z23. | 0 | 0 | 1 | 1 |

Appendix 2 (Continued)

| | SPECIES | No. of Individuals | | | |
|---|---|---|---|---|---|
| | | FT 2 | FT 3 | FT 4 | Total |
| 477. | Z24. | 0 | 0 | 1 | 1 |
| 478. | Z25. | 0 | 0 | 1 | 1 |
| 479. | Z26. | 1 | 0 | 0 | 1 |
| 480. | Z27. | 0 | 4 | 0 | 4 |
| 481. | ZU01. | 0 | 0 | 1 | 1 |
| 482. | ZU02. | 0 | 0 | 1 | 1 |
| 483. | ZU03. | 0 | 0 | 1 | 1 |
| 484. | ZU04. | 0 | 0 | 1 | 1 |
| 485. | ZU05. | 0 | 0 | 1 | 1 |
| 486. | ZU06. | 0 | 1 | 0 | 1 |
| 487. | ZU07. | 0 | 1 | 0 | 1 |
| 488. | ZU08. | 0 | 1 | 0 | 1 |
| 489. | ZU09. | 0 | 0 | 1 | 1 |
| 490. | ZU10. | 0 | 0 | 1 | 1 |
| 491. | ZU11. | 0 | 0 | 1 | 1 |
| 492. | ZU12. | 0 | 0 | 1 | 1 |
| 493. | ZU13. | 0 | 1 | 0 | 1 |
| 494. | ZU14. | 0 | 1 | 0 | 1 |
| 495. | ZU15. | 0 | 0 | 1 | 1 |
| 496. | ZU16. | 0 | 0 | 1 | 1 |
| 497. | ZU17. | 0 | 0 | 1 | 1 |
| 498. | ZU18. | 0 | 1 | 0 | 1 |
| 499. | ZU19. | 0 | 1 | 0 | 1 |
| TOTAL | | 823 | 4386 | 2253 | 7462 |

# Embryology and Seed Development in the Winged Bean, *Psophocarpus tetragonolobus*

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## Abstract

In *Psophocarpus tetragonolobus* (L.) DC the anther is tetrasporangiate. Its wall development usually conforms to the Dicotyledonous type but occasionally to the Basic type. Simultaneous cytokinesis in microsporocytes results in tetrahedral microspore tetrads. The mature pollen grains are triporate and 2-celled with a reticulate exine. The mature ovule is campylotropous, bitegmic and crassinucellate. The micropyle is zig-zag and formed by both the integuments. The embryo sac development follows the monosporic Polygonum type. Fertilization is porogamous and triple fusion precedes syngamy. The endosperm development is of the Nuclear type and free-nuclear endosperm haustoria develop in both the micropylar, and chalazal parts. The first two divisions of the zygote are transverse producing a linear 4-celled proembryo, but the subsequent divisions are in various planes. At the early globular stage of the embryo, the suspensor cells become hypertrophied and haustorial. In mature seed, the inner integument remains 2 or 3 layered, but the outer becomes 15-30 layers and is particularly massive around the micropyle. The thick-walled palisade cells of the seed coat are derived from the outer epidermis of the outer integument, while all the other layers remain parenchymatous.

## Introduction

*Psophocarpus tetragonolobus* (L.) DC., the winged bean, is a perennial climber of the tribe Phaseoleae of the legume subfamily Papilionoideae. The geographical origin of the species is uncertain with Africa (where all the other five species of the genus are indigenous), India, South East Asia (particularly Indonesia, where there are numerous local names for the plant), and Papua New Guinea having been suggested variously as possible places of origin (Hymowitz and Boyd, 1977). Hymowitz and Boyd (1977) themselves favoured a Papua New Guinea origin and stated that "it would be difficult to find another high rainfall-adapted tropical legume crop with as many desirable characteristics as *Psophocarpus tetragonolobus.*" Virtually all parts of the plant are edible. Besides the unripe fruits, which are popular as a green vegetable, the leaves, flowers, seeds and tuberous roots are consumed as well. The protein and oil content (37% and 18% respectively) of the seeds compares favourably with that of soybeans, and even the leaves, flowers, pods and tubers have protein levels of 10-15% (Abbiw, 1990). The plants are also considered as a valuable source of green fodder and manure. Detailed embryological information, which might be useful in any attempts to improve this crop of considerable potential, has so far been lacking.

## Materials and Methods

Flowering and fruiting materials of suitable ages were collected between 1990 and 1992 from glasshouse-grown plants at the Department of Botany, University of New England. These were fixed in FPA (formalin-propionic acid- 70% ethyl alcohol - 5:5:90 v/v) and stored after 48 hr in 70% ethyl alcohol. Following standard procedures of microtechnique (Sass, 1958), the specimens were embedded in Paraplast, sectioned, and stained in safranin and fast green. Permanent slides were made after dehydration in an ethyl alcohol series, treatment with Histoclear (a xylene substitute), and mounting in Eukitt.

## Observations

### Anther:

The anther is tetrasporangiate (Fig. 1A). Hypodermal archesporial cells in each sporangium divide periclinally to form the primary parietal and primary sporogenous cells (Fig 1B). The latter divide repeatedly in various directions and differentiate into microsporocytes. The primary parietal cells divide periclinally to form the outer and inner secondary parietal cells. Usually, only the outer secondary parietal cells continue further divisions whereas the inner do not (Fig. 1D). The derivatives of the outer secondary parietal cells constitute the endothecium and the two middle layers while the inner secondary parietal cells directly develop into the tapetum. Occasionally the inner secondary parietal cells also show mitosis (Fig. 1C) suggesting that although the anther wall formation usually conforms to the Dicotyledonous type (Davis, 1966), the Basic type may also occur. Rarely, the cells of a middle layer may further divide resulting in a third middle layer (Fig. 1E). The tapetum is secretory; its cells remain uninucleate and develop one or two large vacuoles before meiosis occurs in the microsporocytes (Fig.1F,G). The mature anther wall, lying under the single-layered epidermis, consists of one layer each of endothecium and tapetum and 2 or 3 middle layers lying in between.

At the time of meiosis, the microsporocytes become ensheathed in callose. Simultaneous cytokinesis accompanies meiosis (Fig. 1H-J) and the resultant microspore tetrads are tetrahedral (Fig. 1G, K). Different stages of development, ranging from late prophase to the microspore tetrad phase, can be observed within the same flower bud. In addition, different microsporangia of the same anther may exhibit different stages of development though usually all microsporocytes within a single sporangium show synchrony. However, in one instance while the microsporocytes in the lower part of the sporangium were at the late prophase stage, those in the middle were at diakinesis, and in the upper part they were at metaphase I.

The microspore walls are formed by furrowing and the microspores are initially isolated from each other by callose (Fig. 1J,K). Dissolution of callose releases individual microspores into the sporangium by which time a thin exine and incipient pores become evident (Fig. 1L). At this stage, the tapetum is still intact though large vacuoles appear in the cells and the cytoplasm appears sparse. By then all but one of the middle layers disintegrate. The uninucleate microspore enlarges, the exine thickens, and its nucleus migrates to the periphery of a large central vacuole, giving the microspore the characteristic signet-ring appearance. Next the tapetum also degenerates while the cells of the endothecium enlarge and become radially elongated. The microspore undergoes mitosis to form the 2-celled pollen grain. In the anther wall fibrous thickenings appear in the endothecium and the single persistent middle layer still remains distinct (Fig. 1M). By the time the microspores become mature pollen grains, the tapetum and the remaining middle layer completely break down leaving only the fibrous endothecium and the epidermis, the cells of which accumulate brownish-staining crystals (Fig. 1N). The mature pollen grains are triporate, 2-celled, and show a reticulate exine.

**Ovule:**

Mature ovules are campylotropous, bitegmic and crassinucellate. Ovular primordia, 10-18 in number, are initiated as homogeneous hemispherical protuberances from the marginal placenta (Fig. 2A). All the ovules in an ovary develop synchronously. The primordia begin to undergo curvature even before the integuments arise and finally assume the campylotropous form (Fig. 2A-C).

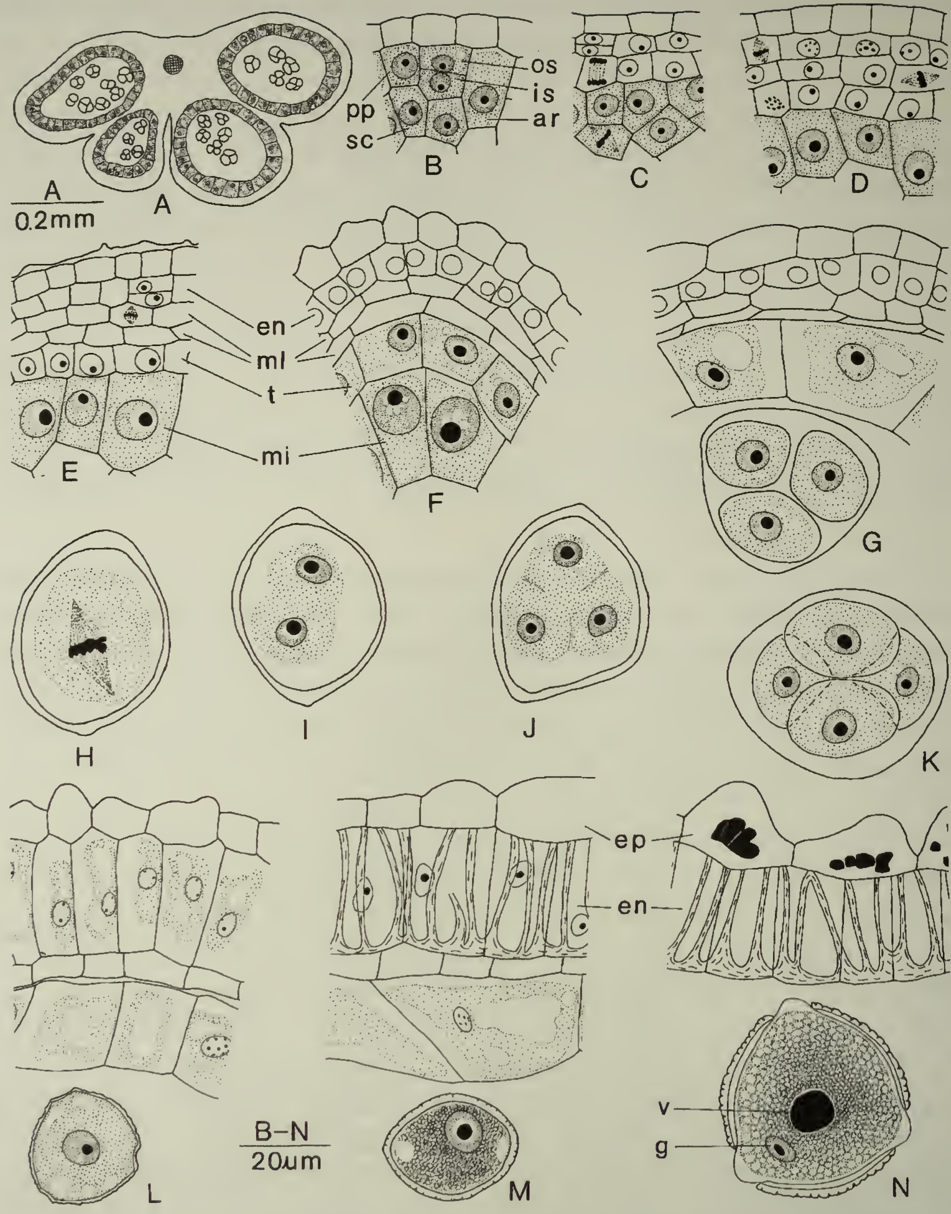


**Fig. 1.** ***Psophocarpus,* anther wall and pollen development.** All cross sections of anther. *A,* tetrasporangiate anther with pollen tetrads; *B-E,* stages in anther wall development; *F,* microspore mother cells and wall layers; *G,* anther wall at pollen tetrad; *H-K,* microsporogenesis; *L,M,* differentiation of the mature anther wall and pollen; *N,* anther wall and mature 2-celled pollen. (*ar,* archesporial cell; *en,* endothecium; *ep,* epidermis; *g,* generative nucleus; *is,* inner secondary parietal cell; *mi,* microsporocyte; ml, middle layer; *os,* outer secondary parietal cell; *sc,* sporogenous cell; *t,* tapetum; *v,* vegetative nucleus).

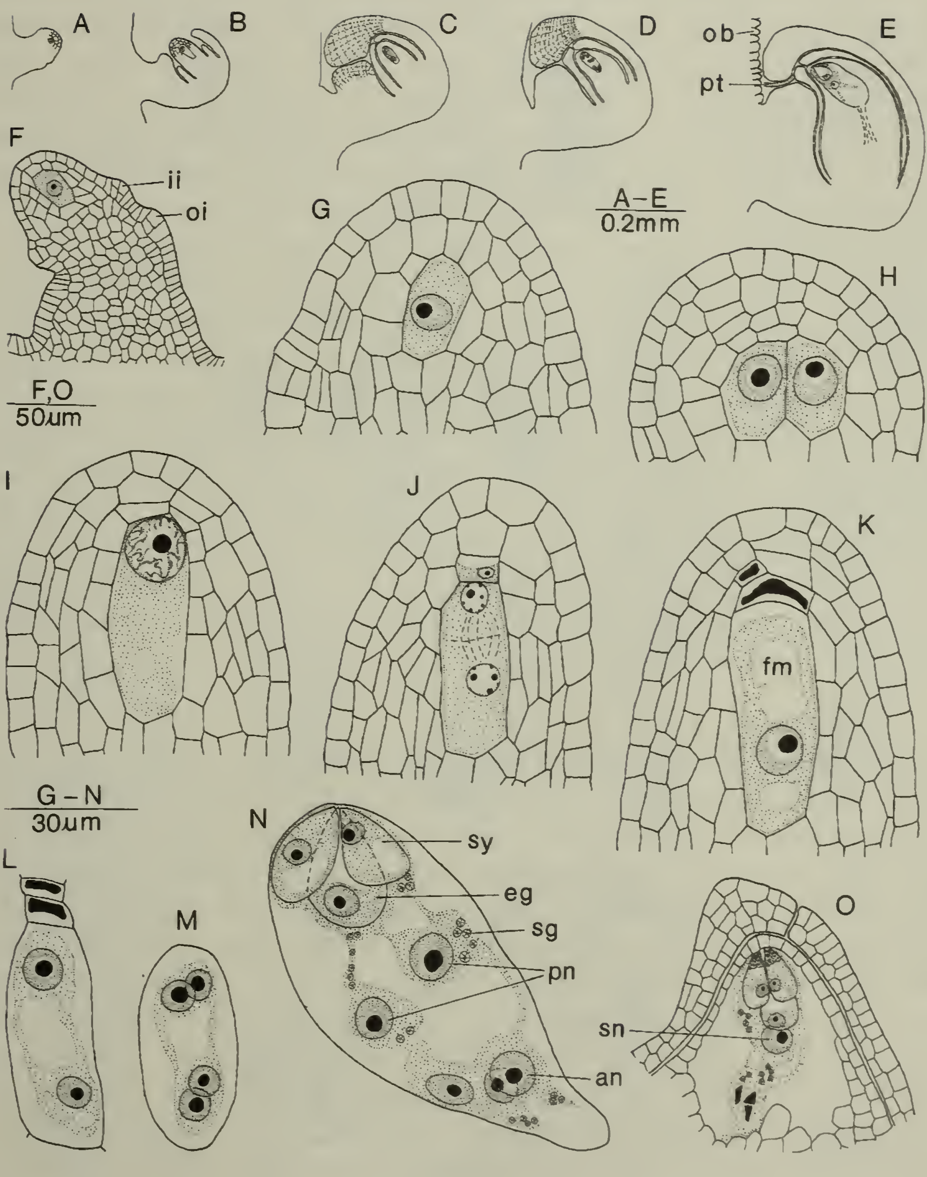


**Fig. 2. *Psophocarpus,* ovule and embryo sac development**. All longitudinal sections of ovule. *A-D,* stages in ovule development; *E,* pollen tube entering ovule; *F,* initiation of the inner and outer integuments; *G,* a single sporogenous cell; *H,* twin sporogenous cells; *I,* megasporocyte; J, megasporogenesis; *K-M,* megagametogenesis; *N,* mature female gametophyte; *O,* degeneration of antipodals in the female gametophyte. (*an,* antipodal; *eg,* egg; *fm,* functional megaspore; *ii,* inner integument; *ob,* obturator; *oi,* outer integument; *pn,* polar nuclei; *pt,* pollen tube; *sg,* starch grains; *sn,* secondary nucleus; *sy,* synergid).

Both integuments differentiate simultaneously from the nucellus at the sporogenous cell stage (Fig. 2F). However, the development of the inner integument is slower than that of the outer so that at the megasporocyte stage the outer integument of 3 layers encloses the inner integument of 2 or 3 layers and the nucellus (Fig. 2B). The outer integument continues to grow rapidly and completely envelops the nucellus at the end of megasporogenesis while the inner reaches only half its length. By the 2-nucleate stage of the female gametophyte, the inner integument, which is still 2 or 3 cells thick, reaches the micropyle while the cells of the outer integument undergo periclinal and anticlinal divisions in the micropylar part so that it becomes 8-10 cells thick at the tip (Fig. 2C). As the ovule matures, the tip of the outer integument continues to show repeated divisions to form a massive structure of 13-20 layers of cells, growing towards the funiculus and covering the inner integument and the micropylar end of the nucellus. As a consequence, the micropyle becomes zig-zag with the exostome surrounded by the outer integument and the endostome bounded on all sides by the inner integument of 2 or 3 layers of cells (Fig. 2D). Starch grains accumulate in the cells of the outer and inner integuments in the region surrounding the micropyle.

Usually one of the hypodermal cells differentiates into the archesporium which divides periclinally to form a primary parietal cell and a sporogenous cell (Fig. 2G). A single instance of twin sporogenous cells was observed (Fig. 2H). As the cytoplasm becomes denser and the nucleus enlarges, the sporogenous cell becomes the megasporocyte while the primary parietal cell divides giving rise to 2 or 3 nucellar layers above it (Fig. 2I). Cytokinesis following the first meiotic division produces a dyad, of which only the lower member undergoes meiosis II. Thus a linear triad is formed at the end of meiosis (Fig. 2J). The smaller upper dyad cell degenerates simultaneously with the middle megaspore, leaving only the chalazal megaspore to continue development (Fig. 2K). After three successive nuclear divisions a mature eight-nucleate female gametophyte is formed (Fig. 2L-N); its development thus conforming to the monosporic Polygonum type. As the female gametophyte matures, an egg flanked by two synergids - each with a filiform apparatus - differentiates at the micropylar end, the polar nuclei migrate toward the funicular side of the female gametophyte and the antipodals are organised in the chalazal region (Fig. 2N). Soon after formation, the two polar nuclei fuse into a large secondary nucleus which becomes located just below the egg (Fig. 2E,O).

During its development the female gametophyte rapidly increases in size at the expense of the nucellar tissue, especially at the sides and in the

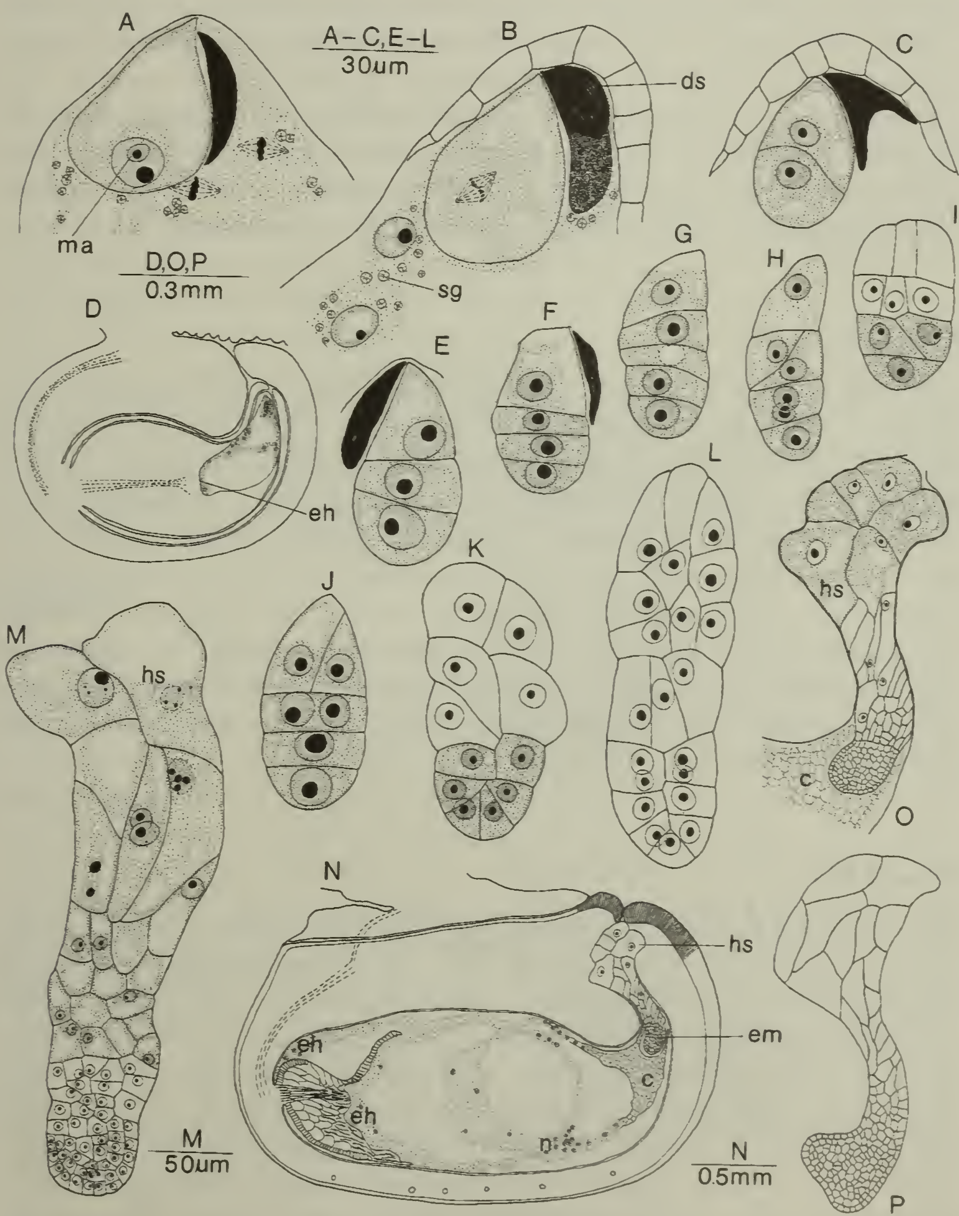


**Fig. 3.** ***Psophocarpus,*** **embryo development.** All longitudinal sections of seed. *A,* division of endosperm nucleus before syngamy; *B,C,* division of zygote; *D,* linear 4-celled proembryo and nuclear endosperm showing beginning of endosperm haustoria; *E-M,* stages in the development of globular embryo, note the extensive haustorial suspensor; *N,* section of whole seed showing globular embryo and endosperm haustoria; *O,* globular embryo; *P,* early heart-shaped embryo. (*c,* cellular endosperm; *ds,* degenerating synergid; *eh,* endosperm haustorium; *em,* embryo; *hs,* haustorial suspensor; *ma,* male gamete; *n,* endosperm nuclei; *sg,* starch grains).

micropylar region. Hence the mature female gametophyte is bordered by the inner integument on the sides, the single-layered nucellar epidermis at the micropylar end, and the hypostase in the chalazal region. An endothelium is not differentiated. Starch grains are first deposited in the nucellar epidermis at the 4-nucleate female gametophyte stage. They become abundant in not only the two integuments but also the mature female gametophyte (Fig. 2N,O) and persist even after fertilisation.

**Fertilisation**:

Pollen tubes grow along the placenta towards the nucellus through the micropyle (Fig. 2E, 4A). The epidermal cells of the placenta become papillate, assume a glandular appearance, and possibly act as a a pollen tube guide. The entry of the pollen tube is porogamous and through one of the synergids; the other synergid degenerates soon after fertilization. One male gamete fuses with the secondary nucleus to form the primary endosperm nucleus whereas the second enters the egg but does not immediately fuse with its nucleus. The two nuclei within the egg remain separate while the primary endosperm nucleus divides to form free endosperm nuclei (Fig. 3A). Syngamy occurs after the formation of eight endosperm nuclei.

**Endosperm:**

The development of the endosperm is of the Nuclear type. Just before the primary endosperm nucleus divides, the embryo sac enlarges significantly and large starch grains accumulate, particularly in the micropylar region. At least the first three mitotic divisions are synchronous. The free nuclei, resulting from repeated divisions, mainly occupy the micropylar region and along the periphery of the enlarging endosperm in the vicinity of the funiculus (Fig. 3D). At the 16 nucleate stage of the endosperm, the zygote divides (Fig. 3B). At the time of a linear proembryo there are about 60 endosperm nuclei. As the proembryo develops, the number of free nuclei continues to increase rapidly.

A tubular coenocytic haustorium develops from the upper end of the endosperm on the side of the funiculus. It grows towards the chalazal nucellar tissue causing many of the cells to degenerate (Fig. 3D, 4B). The narrow haustorium, with a sac-like tip, is discernible at the linear proembryo stage and becomes very distinct by the early globular stage. As the embryo develops, the haustorium grows in between the inner integument and the nucellus (Fig. 3N). In addition, the chalazalmost free-nuclear part of the endosperm also shows haustorial activity. Both haustoria remain free-nuclear throughout the life of the endosperm.

The main body of the endosperm remains completely free-nuclear until the early globular embryo stage. The number of nuclei counted at this stage was 658 with 274 situated mainly in the micropylar quarter of the endosperm and showing either mitotic metaphase or anaphase. The remaining occur as free nuclei mostly along the periphery of the endosperm. Cell-formation in the endosperm begins from the micropylar region and proceeds towards the chalazal part at the late globular embryo stage (Fig. 4C). By now, because of the breakdown of the nucellus, the endosperm is completely surrounded by the inner integument except at the chalazal region where a butt of the nucellus persists until the cotyledons differentiate in the embryo. The endosperm is almost totally consumed by the embryo in the mature seed and the reserve foods are transferred to the cotyledons.

**Embryo:**

The zygote enlarges and divides after the formation of 16 nuclei in the endosperm (Fig. 3B). The first division is transverse forming an apical cell and a basal cell after which both further divide transversely to form a linear 4-celled proembryo (Fig. 3C, E, F). The next division may be transverse in one of the cells forming a linear 5-celled proembryo (Fig. 3G); or vertical and oblique in one or more cells (Fig. 3H-K). Subsequent oblique divisions result in the early globular embryo while the derivatives of the basal cell continue to divide in an irregular and variable manner to produce the cells of the suspensor (Fig.3K, L). The suspensor cells become hypertrophied and elongate significantly, extending from the embryo sac into the erstwhile endostome and finally touching the outer integument (Fig. 3M-O). By the heart-shaped stage of the embryo (Fig. 3P), the endosperm is mostly used up. The massive suspensor eats into the integuments and apparently assumes a major, if not the sole, responsibility for the continued nutrition of the embryo.

**Seed:**

The fertilised female gametophyte undergoes gross enlargement at the expense of cells in the micropylar part of the nucellus so that only 7 or 8 nucellar epidermal cells eventually persist. The cells of the inner integument divide anticlinally and undergo radial elongation. Meanwhile, the endosperm haustoria rapidly disorganise and destroy the chalazal nucellus which is gradually resorbed, thus increasing the size of the endosperm. At the linear 4-celled stage of the proembryo, the endosperm is bordered by the inner integument along half its length (Fig. 3D); while by the late globular embryo stage the entire length

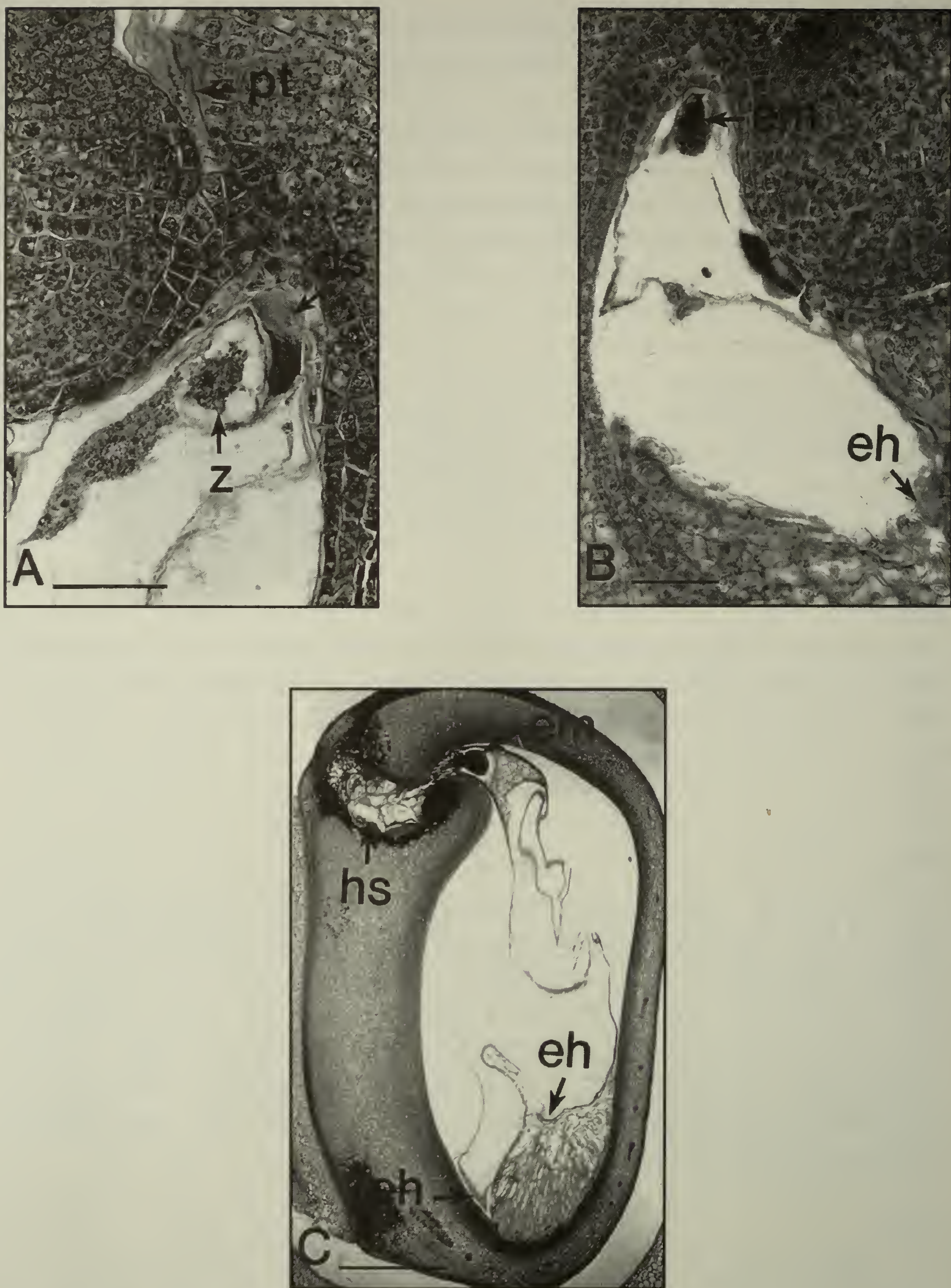


**Fig. 4.** ***Psophocarpus*, longitudinal sections of seeds**. *A,* division of zygote with degenerating synergid and pollen tube at the micropyle; *B,* linear 4-celled proembryo with nuclear endosperm forming haustorium; *C,* globular embryo with haustorial suspensor and endosperm haustoria. (*ds,* degenerating synergid; *eh,* endosperm haustorium; *em*, embryo; *hs,* haustorial suspensor; *pt,* pollen tube; *z,* zygote. Scale: *A,B* = 40mm; *C* = 0.5mm).

except the chalaza is lined by the inner integument (Fig. 3N). Throughout this development the inner integument continues to divide anticlinally to expand its length but remains 2 or 3 cells thick. The outer integument, on the other hand, becomes 15-30 layers thick through both anticlinal and periclinal divisions and is particularly massive around the micropylar region (Fig. 4C). Further, the outer epidermal cells of the outer integument divide anticlinally, the resultant cells elongate, lose their nuclei and differentiate into a palisade tissue of thick-walled columnar cells. The cells below the epidermis remain parenchymatous (Fig. 4C) without showing the differentiation of a layer of hour-glass cells as in certain other legumes.

## Discussion

Dicotyledonous type of anther wall development was the only type recorded in the family (Davis, 1966; Prakash, 1987) until the present report of the occasional presence of the Basic type as well. Besides the secretory tapetum of uninucleate cells, the anther wall occasionally shows three middle layers which is one layer more than that reported in the other members of the family (Prakash, 1987). The morphology of the ovule and its development reaffirm the earlier observations on the family (Prakash, 1987; Prakash and Chan, 1976; Prakash and Herr, 1979). The female gametophyte development conforms to the monosporic Polygonum type, which seems to be a common feature throughout the Leguminosae - except for members of the Australian endemic papilionoid tribe Mirbelieae which exhibit a variety of novel patterns (Cameron and Prakash, 1993). Also, the antipodals are normal in *P. tetragonolobus* unlike certain Australian genera of the tribes Indigofereae, Bossiaeeae and Mirbelieae which possess giant antipodals (Cameron and Prakash, 1990). An instance of twin sporogenous cells has been observed; and this too is known in the family (Rembert, 1969b; Prakash, 1987). Presumably only one sporogenous cell continues development because twin female gametophytes, which have been recorded in certain other members of the family, have never been found in the present material. Often, during megasporogenesis, the second division of the micropylar dyad is arrested and a triad is formed as in *Cassia* (Rembert, 1969a), and *Vicia villosa* (Rembert, 1969b). An integumentary endothelium, which occurs in many other members of the family (Prakash, 1987), does not seem to differentiate in any member of the tribe Phaseoleae. However, an endothelium of nucellar origin has been reported in *Phaseolus aconitifolius* (Deshpande and Bhasin, 1974).

The egg nucleus fuses with the male gamete only after the division of the primary endosperm nucleus. This delayed syngamy has been described in one other legume i.e., *Acacia leucophloea* (Ugemuge,1982), in which it is achieved after the formation of four endosperm nuclei. As in all other legumes studied so far, the endosperm is of the Nuclear type and it becomes cellular only after several hundred free nuclei are formed. The presence of a chalazal haustorium which remains free-nuclear even after cell-formation had occurred in the micropylar half of the endosperm is known in several legumes (Johri and Garg, 1959) including *Atylosia*, *Glycine*, *Teramnus* (Rau, 1953) *Canavalia*, *Hardenbergia violacea*, *Kennedia rubicunda* and *Vandasia retusa* (Cameron, 1988) of the tribe Phaseoleae. However, in *Psophocarpus* there is an additional tubular lateral haustorium which also remains coenocytic. The zygote divides when there are 16 free endosperm nuclei as has also been reported in *Acacia leucophloea* (Ugemuge,1982).

As in many other groups of the Leguminosae (Lersten, 1983), in Phaseoleae also the morphology of the suspensor is variable; from being filamentous in species of *Erythrina* (McNaughton, 1976) to massive in *Phaseolus*. Cameron (1988) found a short suspensor in *Glycine clandestina, Hardenbergia violacea* and *Kennedia rubicunda* but a long, filamentous, uniseriate suspensor of inflated cells in *Canavalia*. However, unlike *P. tetragonolobus*, in most species the suspensor is contained wholly within the endosperm.

The pattern of embryogeny in *Psophocarpus tetragonolobus* is essentially similar to that in *Glycine* (Ho, 1963; Souèges, 1949). The structure of the seed coat is similar to that described for the family by Corner (1951, 1976) who believed that the functioning of the exposed surface as a protective layer suggests a primitive construction. However, unlike certain other members of the family (Corner, 1976; Prakash and Chan, 1976), a layer of hour glass cells is not distinguished in the mesophyll of the winged bean seed.

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# *Carallia brachiata* cv. Honiara, a Beautiful Fastigiate Ornamental Tree

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*Carallia* is an inland genus of the mainly mangrove family Rhizophoraceae. The genus extends from Madagascar to the Solomon Islands and has *c.* 10 species (Hou, 1958), eight of them in Malesia. *Carallia brachiata* occurs throughout the Asian range of the genus. It is a common, but never abundant, rather nondescript tree of lowland tropical rain forest, reaching 50 m tall.

In a few villages of the Solomon Islands and in the capital Honiara there occurs an exceptionally beautiful fastigiate form of *C. brachiata,* with weeping limbs and the crown shape of the Lombardy Poplar *(Populus nigra* cv. Italica) of Europe, see Fig. 1. This form reaches 18 m tall and 25 cm bole diameter but is usually smaller. Numerous fruits are produced at frequent intervals and germinate easily.

The trees planted in Coronation Gardens, Honiara, came from Auki District, Malaita, where the form is reputed to occur wild. A tree seen at Lodomae village, north Kolombangara, is reputed to be grown from Choiseul seeds.

Several attempts to export this fine tree by G.F.C. Dennis, doyen of horticulture in the Solomons, have all failed. But of 25 seeds from a tree in his garden in Honiara, collected on 2 February 1986 by one us (TCW) and planted in Singapore on 12 February 1986 by WYK all but one germinated between 7 March and 28 March 1986. From this batch of seedlings six trees have now been planted out along Cheang Hong Lim St. and twelve trees along Cross St. in the Central Business District of Singapore, on very poor compacted soil. These were 8 m tall in July 1994, (Fig. 2) and they bore copious young fruit. Three previous attempts to germinate seeds from separate fruitings failed, but recently the Singapore Botamic Gardens managed to collect seeds and germinate them successfully. The seedlings are now being nurtured for planting out at a later date.

**Fig. 1.** *Carallia brachiata* cv. *Honiara* in Coronation Gardens, Honiara, Solomon Islands, 1964, with John Sore.

Herbarium specimens of this form are identical to typical *C. brachiata* and in his *Flora Malesiana* revision Hou (1958) gave it no taxonomic recognition. We believe this elegant fastigiate tree has high potential as a wayside tree, and that now a small population exists in Singapore, the form should be grown as a superior replacement or supplement to the other introduced fastigiate tree *Polyalthia longifolia* cv. Pendula.

To give identity to this form we propose the cultivar name Honiara.

**Carallia brachiata** (Lour.) Merr. cultivar **Honiara**

Differs from the wild tree in its tall, narrow columnar habit with pendulous branches. Representative herbarium collections (all seen at SIN): Solomon Islands: Honiara, Coronation Gardens: BSIP 503, 3 Aug. 1962, Forester collector; BSIP 7870, 23 Feb 1967, G.F.C. Dennis. Kolombangara, Lodomae village: BSIP 4413, 26 July 1964, T.C. Whitmore, 'dautoli'.

The seedlings of typical *C. brachiata* are described by Burger (1972). Our observations concur except that the cultivar has entire, not serrate cotyledons (Fig.3). Ng (1991-2) illustrated seed (Fig. 466B) and seedling (Fig. 768) of the typical form. These are also similar to the cultivar but Ng noted germination occurred between 52 and 106 days, much slower than we observed. Our cultivar very soon develops weeping branches (Fig.4), and grows rapidly in height (4 mo 15 cm, 5 mo 25 cm, 7 mo 40 cm, 10 mo 60 cm).

A second batch of the 1986 seed lot, sent to the Forest Research Institute of Malaysia, failed to germinate. It seems likely from this and the earlier failures that the seeds soon lose viability, perhaps due to desiccation, i.e. they are recalcitrant *sensu* Roberts (1973).

## Acknowledgements

We thank Mr G.F.C. Dennis for the seeds and Mdm. Ohn Set for caring for the seedlings and then arranging their planting out. The journey to re-measure permanent sample forest plots in the Solomons which made this enterprise possible was funded by the National Geographic Society of Washington DC, USA.

**Fig. 2.** *Carallia brachiata* cv. *Honiara* as a street tree in Singapore, July 1994.

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**Fig. 3.** Young seedlings showing cotyledons with entire margins.

**Fig. 4.** Seedling at 10 months age, 65 cm tall, scale marked every 30 cm.

# The Angiosperm Flora of Singapore Part 2
# PHILYDRACEAE

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## *Philydrum* Banks & Sol. ex Gaertn

Fruct. sem. pl. 1 (1788) 62, t. 16; Ridl., Fl. Malay Penins. 4 (1924) 347; Skottsb., Bull. Jard. bot. Etat Brux. ser. 3, 13: (1933) 111; Skottsb., Fl. Males. ser. 1, 4:1(1948) 5.

Erect, perennial, caespitose herbs with a short rhizome. *Leaves* densely rosulate, equitant, 2-ranked; linear, fleshy, parallel-veined, sheathing at base. *Inflorescence* a simple or paniculate terminal spike; scape 1 m or longer, with few cauline leaves gradually replaced by alternate bracts. *Flowers* bisexual; zygomorphic; sessile, solitary in axil of spathaceous bracts; bracts enclosing flower buds, reflexed at anthesis, later embracing the fruit; perianth corolline, 4-segmented, 2-seriate, persistent as fruit cover, yellow, 2 outer tepals larger, adaxial and abaxial respectively, 2 inner tepals smaller, lateral; stamen single, filament flattened, adnate with base of inner and adaxial tepals, anther dorsifixed, 2-loculate, spirally twisted, extrorse, opening lengthwise by slits, pollen grains in tetrads, staminodes cuneate, acute, shorter than fertile stamen; ovary single, superior, 3-loculate, with parietal placentation, ovules many per locule, anatropous; style simple. *Fruit* a persistent triangular-oblong loculicidal capsule with 3 valves. *Seeds* with corona and spirally-striate testa, many per locule; embryo straight.

Distribution - Monotypic genus, occurring in South Japan, Taiwan, South-East China, Indo-China, Malay Peninsula, Guam, South New Guinea and North, East and South-East Australia (Hamann, 1966a). *P. lanuginosum* is reported to be extinct in Singapore (Keng, 1987) but was previously collected in Bedok.

Ecology - *P. lanuginosum* occurs in freshwater ponds, marshes and ricefields at low altitudes in its natural range (Skottsberg, 1948).

Uses - *P. lanuginosum* has no known economic importance.


**Fig. 1.** ***Philydrum lanuginosum*** Banks & Sol. ex Gaertn. a. Habit. b. Flower with one lateral tepal removed. c. Flower with carpel and adaxial tepal removed. d. Stamen, with spirally twisted anthers. e. Carpel. f. Ovary (transverse section), with parietal placentation. g. Seed, with spirally striate testa. [a. H.N. Ridley 5907 (SING); b.-g. drawn from fresh material. Scale bars: a = 2 cm, b - e = 2 mm; f = 1 mm; g = 0.25 mm.] Del. R.J. Nicholls.

Notes - The most comprehensive account of the Philydraceae is by Hamann (1966a), who studied various aspects of taxonomic relevance, including morphology, anatomy and embryology. The embryology has been the subject of considerable research (Hamann, 1963, 1966a, 1966b; Kapil and Walia, 1965), and has assisted with the clarification of the phylogenetic relationships of the family. Similarities are apparent with the Pontederiaceae and Haemodoraceae, although a relationship with the Burmanniaceae has also recently been suggested.

**1. *P.lanuginosum* Banks & Sol. ex Gaertn**

Fruct. sem. pl. 1 (1788) 62,t. 16; Ridl., J. Straits Br. R. Asiat. Soc. 33 (1900) 169; Ridl., Mat. Fl. Malay Penins. 2 (1907) 110; Ridl., Fl. Malay Penins. 4 (1924) 347; Skottsb., Bull Jard. bot. Etat Brux. ser. 3,13 (1933) 111; Skottsb., Fl. Males. ser. 1, 4:1(1948) 5; M.R. Hend., Malayan Wild Flowers, Monocotyledons (1954) 192; H. Keng, Gdns' Bull., Singapore 39 (1987) 123; I.M. Turner, K.S. Chua & H.T.W. Tan, J. Singapore Nat. Acad. Sci. 18 & 19 (1990) 79; I.M. Turner, Gdns' Bull., Singapore 45 (1993) 188.

*Leaves* 40-80 cm long (including basal sheath), glabrous, thick, aerenchymatous; sheath 14-30 by 1-1.5 cm. *Inflorescence* 20-60 cm long; scape slender, terete, glabrate below, villous towards the flowers; bracts ovate to subulate, 2-10 by 0.75-1 cm, woolly on abaxial side, short-acuminate to attenuate. *Flowers* with thin perianth, outer tepals 10-15 by c. 10 mm, many-veined, long villous outside, the upper with 2 stronger veins and bidentate, acute, margins inflexed, inner tepals spathulate, c. 8 by 2 mm, membranous, 3-veined, with base hairy outside; stamen c. 9 mm long, glabrous, anther ± spherical; ovary densely long-woolly; style glabrous; stigma broad-triangular, long-papillose. *Fruit* 9-12 by 4-5 mm. *Seeds* dark reddish-brown, bulb-shaped, c. 1 mm long; n = 8 (Hamann, 1966a) and 2n = 16 (Briggs, 1966).

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# The Angiosperm Flora of Singapore Part 3
# PLANTAGINACEAE

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## Plantago L.

Sp. pl. (1753) 112; Gen. pl. ed. 5 (1754) 52; Ridl., J. Straits Br. R. Asiat. Soc. 33 (1900) 125; Ridl., Fl. Malay Penins. 2 (1923) 225; M.R. Hend., Malayan Wild Flowers, Dicotyledons (1959) 268; H. Keng, Gdns' Bull., Singapore 36 (1983) 111; H. Keng, Concise Flora of Singapore (1990) 140; I.M. Turner, K.S. Chua & H.T.W. Tan., Journal of the Singapore National Academy of Science 18 & 19 (1990) 80; I.M. Turner, Gdns' Bull., Singapore 45 (1993) 189.

Annual or perennial herbs, rarely small shrubs. *Leaves* simple; usually spirally arranged; lamina venation parallel, margin entire or toothed; petiole forming a sheath at the base; exstipulate. *Inflorescence* spicate or capitate; axillary; pedunculate; bracts persistent. *Flowers* 4-merous; unisexual or bisexual; regular; calyx lobed or deeply cleft; corolla scarious, lobes imbricate in bud; stamens as many as and alternating with corolla lobes, filaments long, anthers 2-loculate, exserted, versatile, opening by longitudinal slits; ovary single, superior, usually 2-loculate, placentation axile, ovules, with an integument several cells thick, 1 to many per locule; style 1, bifid. *Fruit* a circumscissile capsule, dehiscing transversally with the top segment falling off as a lid. *Seeds*, with a translucent testa, 1 or more per locule; endospermous.

Distribution - The genus *Plantago*, with about 250 species (Mabberley, 1990), is naturally distributed in Europe and temperate Asia. According to Holm *et* al. (1977), the widespread introduction of *P. major* and *P. lanceolata*, to various parts of the world has resulted in the almost cosmopolitan distribution of the genus; both species are found in all continents, except the Antarctic and Arctic. Man has played a prominent role in the widespread distribution of this genus. Only *Plantago major* occurs in Singapore.

Ecology - Mostly weeds of disturbed areas such as agricultural land, wasteland, cultivated ground, roadsides, and open fields. Allard (1965) regarded *P. lanceolata* as one of the 12 most successful naturally growing


**Fig. 1: Plantago major** L. a. Habit. b. A segment of the inflorescence showing a flower and a flowering bud. c. Longitudinal section of flower. d. 'Exploded'view of the cie=rcumscissile capsule. [K. S. Chua 413]

colonizing plants. *P. major* and *P. lanceolata* are among the world 's most noxious weeds (Holm *et al.,* 1977).

Uses - When soaked in water, the seeds of some species produce copious mucilage which are medicinal (Burkill, 1966). The testa ('husk') of several species, notably *P. ovata*, *P. psyllium* and *P. indica*, are prepared by the pharmaceutical industry and widely used as a bulk laxative (Leung, 1980) and remedy for chronic diarrhoea. The husk mucilage is also used as a thickener in some food products.

### 1. *Plantago major* L.,

Sp. pl. (1753) 112; Ridl., J. Straits Br. R. Asiat. Soc. 33 (1900) 125; Ridl., Fl. Malay Penins. 2 (1923) 225-226; M.R. Hend., Malayan Wild Flowers, Dicotyledons (1959) 268; H. Keng, Gdns' Bull., Singapore 36 (1983) 111; H. Keng, Concise Flora of Singapore (1990) 140; I.M. Turner, K.S. Chua & H.T.W. Tan, J. Singapore Nat. Acad. Sci. 18 & 19 (1990) 80; I.M. Turner, Gdns' Bull., Singapore 45 (1993) 189.

*P. asiatica* L.

Perennial herb. *Leaves* simple; in a radical rosette; lamina broadly ovate to narrowly lanceolate, 3-22 by 1-22 cm, with 5-9 longitudinal veins, glabrous or pubescent, apex rounded, obtuse or acute, margin entire, shallowly or deeply toothed, base abruptly narrowed; petiole 1-25 cm long. *Inflorescence* an upright spike, 10-30 cm long; peduncle 4-50 cm long, terete or shallowly ribbed, glabrous or pubescent; bracts 1-3.25mm long. *Flowers* greenish-white, bisexual; calyx lobes oval, oblong, obtuse or acute, 1.25-2 mm long, margin scarious; corolla lobes spreading, 1-1.5 mm long; style 4-6 mm long. *Fruit* ovoid, 3-4 mm long. Seeds brown or black, oblong, 1 by 0.75 mm, rugose, 4-21 per locule.

Distribution - Singapore: widely distributed and locally common; Nee Soon Swamp Forest, Kent Ridge, Dover Crescent, Punggol, Tanglin, etc.

Ecology - *P. major* can be found as a naturalized weed in disturbed areas such as wasteland, public car parks, gardens and lawns. The plant is remarkable in its ability to adapt to a wide range of growing conditions. In Singapore, *P. major* can be found growing in periodically-mown lawns, in waterlogged areas beside drains, and in cracks in concrete pavements. In Europe and Morocco, *P. major* has been found growing in regions of 2,000 metres a.s.l. Its most northerly location is Spitsbergen, a Norwegian island at latitude 77 °N (Sagar and Harper, 1964). The wide distribution of the plant has led Holm et al. (1977) to suggest that its "habitat is probably not restricted by climate." Being of temperate origin, the plant's adaptability and tolerance to adverse growing conditions are severely tested in the low altitude and equatorial climate of Singapore. Holm *et al.* (1977) mentioned that *P. major* is rarely a troublesome weed in the equator as the tropical heat and competition from the taller and more vigorous-growing plants help to keep *P. major* under control. The mature plants of *P. major* flower and fruit frequently throughout the year. Ridley (1930) noted that the seeds are wind-dispersed.

Uses - According to Burkill (1966), *P. major* was originally introduced from China for use as a medicine for diarrhoea and dysentery and for the seeds in making jelly, while the leaves are occasionally eaten as a vegetable. He also added that the Malays use the plant in the treatment of cough, dysentry and gonorrhea.

Notes - *P. major* is extremely variable in form. Backer (1965) stated that "they might be taken for different species, were it not that they are connected by series of intergrades." For a key to the numerous varieties and taxa of *Plantago major*, see Pilger (1937).

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# A Botanical Survey of Pulau Jong, Singapore

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## Abstract

A botanical survey of Pulau Jong of the Republic of Singapore, a 0.6 ha island off the south coast of Singapore Island, recently found at least 38 native vascular plant species which are listed here. Previous botanical records for the island are also collated to bring the recorded number of species now to 52. The contemporary flora is dominated by beach and secondary forest species. The slight change in the species composition and decline in number compared to observations made by Holttum (1925) are typical of the random fluctuations seen in small island floras.

## Introduction

Pulau Jong is an island within the Republic of Singapore. Its vascular plant flora was described by Holttum (1925) in some detail. More recent records include collections made by J. Sinclair in 1950 and Johnson (1977) who probably quoted Holttum (1925). It was chosen for a botanical survey because it is relatively untouched largely owing to its reputation of being haunted (Brooke 1925), its very steep terrain, small area and lack of water, all of which would make it extremely difficult for settlement. It would thus be interesting to examine the flora in detail after a lapse of about 70 years. This survey is also part of the on-going Angiosperm Flora of Singapore Project

## Site

Pulau Jong (N1° 12' 56.2", E 103° 47' 18.2") is a small, dome-shaped island (Fig. 1) of about 0.6 ha (Resource Centre, Ministry of Information and the Arts 1994) lying off the south coast of Singapore Island, surrounded by Pulau Bukum to the north-west, Pulau Sakeng to the south-west and Pulau Sebarok to the south-east (Fig. 5). *Jong*, is Malay for junk and is probably an allusion to the silhouette of the island being similar to that type of vessel. The island is generally undisturbed and activities of man are hardly evident. Brooke (1925) mentioned that half a dozen tombstones were found near the water's edge when he visited the island and a rusty, still-standing flagpole was found by us at the summit of the island which is 23.4 m in altitude.

Geologically, the island is the type locality of the Jong Facies and "contains alternating beds of roundstone conglomerate and sandstone, and less frequently, beds of mudstone" (Anonymous, 1976).

Although there are no records of the climate for the Island, it would be very similar to that for mainland Singapore which has an equatorial climate with uniformly high temperatures, humidity and rainfall year-round (Chia and Foong, 1991).

## Methods

All the specimens cited in Table 1 as "Collected Recently" were obtained by a team of five researchers who made a thorough survey of the island on 13 Nov 1992. These collections were made into herbarium sheet specimens which were identified largely by comparison with named specimens in the Herbarium, Singapore Botanic Gardens (SING). Nomenclature follows those of Turner, Chua and Tan (1990) and Turner (1993). Voucher specimens of all the species reported were deposited in the Herbarium, Department of Botany, The National University of Singapore (SINU) and replicates when available, distributed to other herbaria, mostly to SING. A survey of specimens from previous collections found in SING and SINU was also made to compile an historical list of species found on Pulau Jong.

## Results and Discussion

The species that were recorded in the past and more recently are given in Table 1. Found recently were a total of 38 vascular plants comprising nine ferns, two gymnosperms and 27 angiosperms. All can be considered native species.

From herbarium sheet labels, Holttum had made some collections of the species he mentioned in his 1925 paper. Collection dates were 9 Jun, 11 Jun and 13 Jul 1924. Sinclair also made collections on 22 Sep 1950. From the survey of past collections and literature, the total number of vascular plants including those recently collected is 52 with 13 ferns, two gymnosperms and 37 angiosperms.

The Pulau Jong flora is approximately 1.5% of the total flora for the Republic of Singapore in about 0.0009% of the area. The species list is made up largely of beach and secondary forest elements with some mangrove species.

Most of the species are common with some exceptions considered endangered, vulnerable or rare in the Singapore context according to Turner *et al.* (1994). A few trees of *Podocarpus polystachyus* at the highwater mark were observed. This is an endangered species with only a few other individuals known in Singapore from Kampong Mandai Kechil and Sentosa (Tan, Turner and Chua, 1994; Turner *et al.*, 1994). One treelet of *Pongamia pinnata* which has a conservation status of vulnerable (Turner *et al.*, 1994) was seen. Another taxon currently found on the island and categorized as vulnerable is *Pteridium caudatum* ssp. *yarrabense* (Wee, 1994). *Schefflera elliptica*, a rare species, which Keng (1990) noted to be probably extinct, has now been rediscovered here as well as in Pulau Ubin (Turner *et al.*, 1992). *Gnetum microcarpum*, a rare species in Singapore (Turner *et al.*, 1994), said to be of the rain forest (Markgraf, 1951), was growing well in a few locations on the island climbing on trees almost to the sea edge and bearing many strobili in seed. There were many fully blooming individuals of the rare *Tarenna fragrans* (Turner *et al.*, 1994). This species is probably absent on the mainland but also seen in Pulau Ubin (Turner *et al.*, 1992). Other recently collected species considered to be rare according to Turner *et al.* (1994) include *Ficus globosa*, *Memecylon edule* and *Xylocarpus granatum*. In view of the significant number of species classified endangered, vulnerable or rare, the island is worth conserving as it is one of the few localities for these species.

The flora has changed from that which Holttum (1925) described. Of the sea shore plants he mentioned, *Desmodium umbellatum*, *Heritiera littoralis*, *Hibiscus tiliaceus*, *Intsia bijuga* (called *Afzelia retusa* by Holttum), *Premna corymbosa* (*Premna integrifolia*), *Pterocarpus indicus* and *Sonneratia griffithii* are now extinct. Found too was a seedling of the mangrove-dwelling *Xylocarpus granatum* which was not previously recorded by Holttum (1925).

The slopes of the island have changed little in species composition (Figs. 2 and 3). The extant species are very similar to those mentioned by Holttum (1925) except for the extinction of *Commersonia bartramia* (*Commersonia platyphylla*). *Eugenia spicata* and *Eugenia grandis* are much more plentiful than described by Holttum (1925). At the more rocky areas, patches of *Davallia* species (Fig. 3) and *Dicranopteris linearis* (Fig. 2) occur between the beach forest areas. *Davallia solida* was collected by Holttum (1925) but we collected only *Davallia denticulata*. As both species occur in this type of habitat and are very similar, it is quite possible that in both our cases, one could easily overlook the presence of the other.

The vegetation of the summit of the island (Fig. 4) has changed considerably. Holttum (1925) described it as being quite open, mostly covered by bracken fern (probably *Pteridium caudatum* ssp. *yarrabense*) and the grass, *Eriachne pallescens* with stunted bushes of *Melastoma malabathricum* (*Melastoma*

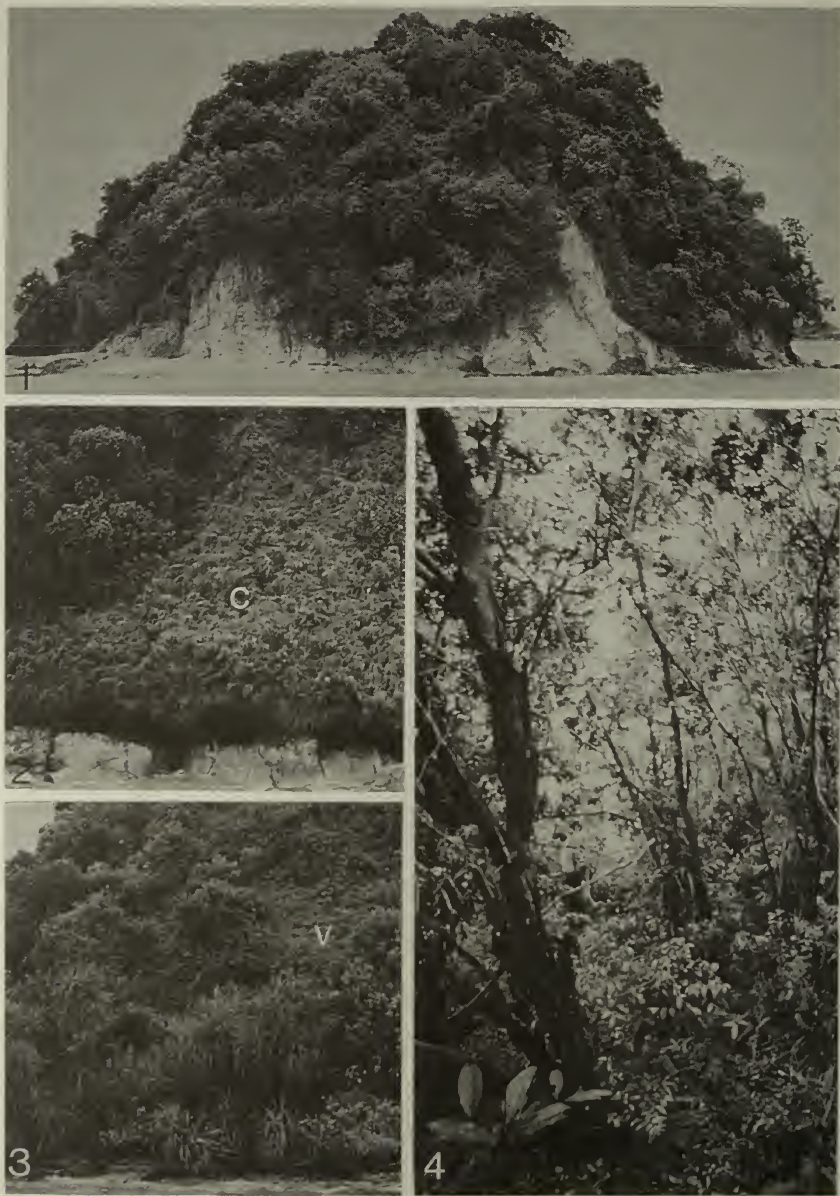


**Fig. 1.** View of Pulau Jong from the east-south-east. Most of the island is covered by beach forest.

**Fig. 2.** Patch of *Dicranopteris linearis* (c) growing to the edge of the sea.

**Fig. 3.** *Pandanus odoratissimus* plants in the foreground with a patch of *Davallia species* (v) behind.

**Fig. 4.** Beach forest at the summit of Pulau Jong. The tallest trees are about 8 m in height. I.M. Turner is seen about centre.

*polyanthum*). Currently, the summit has mostly a dense growth of trees and is similar in species composition to the slopes with small patches of *Dicranopteris linearis* in the few open areas. Most of the trees are *Eugenia spicata* with lesser numbers of *Eugenia grandis* and *Myrica esculenta.* This cover of trees has occurred contrary to the predictions of Holttum (1925) who felt that the high exposure and drainage of the summit area would not be conducive to growth of taller vegetation. The tallest trees at the summit and slopes are about 8 m in height.

The extant species of epiphytes and lithophytes are similar to those found by Holttum (1925). The pigeon orchid plants (*Dendrobium crumenatum*) however, appeared to be on the verge of extinction with a few tiny, half-dried individuals on the rocks almost at the sea edge, growing with *Pyrrosia lanceolata.*

The present vegetation of the island consists of patches of beach forest with patches of *Davallia* species (Fig. 3) or *Dicranopteris linearis* (Fig. 2) in the open areas with poorer or no soil. Presumably, in time, with the build up of soil, the whole island will become covered with beach forest.

The ten newly recorded species may have either been overlooked by Holttum (1925) who had stated that the 41 vascular plant species he noted "is probably by no means all that are present", or, they may have since arrived by various means.

The two newly recorded ferns, young plants of *Acrostichum speciosum* and *Vittaria ensiformis* have wind-dispersed spores. Ridley (1930) has noted that *Xylocarpus granatum* (called *Carapa moluccensis* by Ridley) has corky, buoyant seeds which are sea-dispersed. Ridley (1930) quoting H.B. Guppy has noted that the legumes of *Pongamia pinnata* (*Pongamia glabra*) are buoyant and can float for months in the sea. He also mentioned that *Derris trifoliata* (*Derris uliginosa*) has similar fruits and dispersal mode.

The other species are probably bird-dispersed as their fruits are of the colours Ridley (1930) listed, that attract birds. Ridley (1930) noted that seeds of *Gnetum* species are mostly dispersed by birds but may be dispersed by water and have been seen in sea-drift. *Gnetum microcarpum* has pink, ripe seeds which are probably bird-dispersed. *Arthrophyllum diversifolium* (*Arthrophyllum ovalifolium*) is probably bird-dispersed (Ridley, 1930). *Breynia reclinata* has slightly fleshy, red capsules and red is the most attractive colour to birds (Ridley, 1930). *Memecylon edule* has fleshy, black berries when ripe and black is the third most attractive colour to birds (Ridley, 1930). Lastly, *Ficus globosa* which


**Fig. 5.** Maps of Singapore and Pulau Jong. In the bottom map, the contour lines are at 5 m intervals. This map is based on the 1:2,500 topographic map published by the Chief Surveyor, Singapore, 1970 and by courtesy of the Chief Surveyor, Singapore.

has a 1.5 cm diameter fruit may be bird or bat-dispersed like many other members of its genus.

The 16 species which have become extinct, may have become so for any of the factors including a lack of adaptation to the island habitat, the 'founder principle', greater susceptibility to random non-adaptive changes in genomes because of the small population size, biological interactions between species, currently present such as competition or co-evolutionary effects (Cox and Moore, 1985). The slight decline in number of species, extinction of some and the immigration of others are typical of the random fluctuations of small island floras.

Holttum (1925) mentioned that he found *Pterocarpus indicus* and *Morinda citrifolia* on the island. *Morinda citrifolia* was also found in the recent survey. In view of the relatively untouched nature of the island, in all probability *Pterocarpus indicus* was, and *Morinda citrifolia* is, growing naturally. Turner, Chua and Tan (1990) and Turner (1993) omitted *Pterocarpus indicus* from their lists of Singapore vascular plants because it was not considered a native or naturalised species but one that is only cultivated and *Morinda citrifolia* was considered an alien species. Whitmore (1972) commented that *Pterocarpus indicus* occurs naturally "in coastal areas and tidal creeks along the east coast of Johor(e) and the Rompin district of Pahang" in Peninsular Malaysia. It thus seems very possible that this species also occurs naturally in Singapore which is immediately south of Johore. Sinclair had also collected a specimen of *Pterocarpus indicus* on 22 Sep 1950 at Pulau Sakeng (Specimen - J. Sinclair *SFN 39009*). Although Pulau Sakeng is close to Pulau Jong, it has been inhabited even before the founding of Singapore by the British, so whether that tree from which the specimen was taken, was cultivated, cannot be ascertained. To confuse issues further, this species was introduced as a street tree so the vast majority of trees in Singapore have been planted. Wong (1989) described *Morinda citrifolia* to be "cultivated in villages and wild on lowland and rocky coasts' so the specimens on Pulau Jong are likely to be wild plants. This species is difficult to designate as native or alien because it is cultivated as well as occurs naturally.

**Acknowlegements**

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**Table 1**. The vascular plants of Pulau Jong.

This list includes those mentioned by Holttum (1925), Johnson (1977) and collections made by Holttum, J. Sinclair and us. The specimens and nomenclature of Holttum and Sinclair were redeterminded and updated, respectively.

| S/No. | Species | Holttum (1925) | Johnson (1977) | Collected Recently | Specimen |
|---|---|---|---|---|---|
| | **PTERIDOPHYTA** | | | | |
| | **Blechnaceae** | | | | |
| 1. | *Blechnum orientatle* L. | + | + | - | R.E.Holttum s.n. 11 Jun 1924 |
| | **Davalliaceae** | | | | |
| 2. | *Davallia denticulata* (J. Burm.) Mett. | - | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 16 |
| 3. | *Davallia solida* (G. Forst.) Sw. | + | + | - | R.E. Holttum s.n. 9 Jun 1924 |
| 4. | *Humata heterophylla* (Sm.) Desv. | + | + | - | R.E. Holttum s.n. 9 Jun 1924 |
| | **Gleicheniaceae** | | | | |
| 5. | *Dicranopteris linearis* (Burm.f.) Underw. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 27 |
| | **Hypolepidaceae** | | | | |
| 6. | *Pteridium caudatum* (L.) Maxon ssp. *yarrabense* (Dommin) Parris | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 31 |
| | **Nephrolepidaceae** | | | | |
| 7. | *Nephrolepis biserrata* (Sw.) Schott | + | + | + | R.E. Holttum s.n. 13 Jul 1924; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 19 |
| | **Polypodiaceae** | | | | |
| 8. | *Phymatosorus scolopendria* (Burm.f.) Pic. Serm. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 17 |
| 9. | *Pyrrosia lanceolata* (L.) Farw. | + | + | + | R.E. Holttum s.n. 9 Jun 1924; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 11 |
| 10. | *Pyrrosia piloselloides* (L.) M.G. Price | + | + | - | R.E. Holttum s.n. 13 Jul 1924 |

| S/No. | Species | Holttum (1925) | Johnson (1977) | Collected Recently | Specimen |
|---|---|---|---|---|---|
| | **Pteridaceae** | | | | |
| 11. | *Acrostichum speciosum* Willd. | - | - | + | K.S.Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 20 |
| | **Schizaeaceae** | | | | |
| 12. | *Lygodium microphyllum* (Cav.) R.Br. | + | + | + | R.E. Holttum s.n. 13 Jul 1924; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 13 |
| | **Vittariaceae** | | | | |
| 13. | *Vittaria ensiformis* Sw. var. *ensiformis* | - | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 45 |
| | **PINOPHYTA** | | | | |
| | **Gnetaceae** | | | | |
| 1. | *Gnetum microcarpum* Blume f. *microcarpum* | - | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 28; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 38 |
| | **Podocarpaceae** | | | | |
| 2. | *Podocarpus polystachyus* R.Br. ex Endl. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 26 |
| | **MAGNOLIOPHYTA** | | | | |
| | **Araliaceae** | | | | |
| 1. | *Arthrophyllum diversifolium* Blume | - | - | + | K.S.Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 42 |
| 2. | *Schefflera elliptica* (Blume) Harms | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 34 |
| | **Asclepiadaceae** | | | | |
| 3. | *Dischidia major* (Vahl) Merr. | + | - | - | Nil |

| S/No. | Species | Holttum (1925) | Johnson (1977) | Collected Recently | Specimen |
|---|---|---|---|---|---|
| | **Euphorbiaceae** | | | | |
| 4. | *Breynia reclinata* (Roxb.) Hook.f. | - | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 22 |
| 5. | *Macaranga heynei* I.M. Johnst. | + | - | + | R.E. Holttum s.n. 11 Jun 1924 |
| | **Goodeniaceae** | | | | |
| 6. | *Scaevola taccada* (Gaertn.) Roxb. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 6 |
| | **Gramineae** | | | | |
| 7. | *Eriachne pallescens* R.Br. | + | - | + | R.E. Holttum s.n. 13 Jul 1924; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 9 |
| 8. | *Imperata cylindrica* (L.) P.Beauv. var. *major* (Nees) C.E. Hubb. ex C.E.Hubb. & R.E. Vaughan | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 12 |
| | **Leguminosae** | | | | |
| 9. | *Dalbergia candenatensis* (Dennst.) Prain | + | - | + | R.E. Holttum s.n. 13 Jul 1924; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 35 |
| 10. | *Derris trifoliata* Lour. | - | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 7 |
| 11. | *Desmodium umbellatum* (L.) DC. | + | - | - | R.E. Holttum s.n. 11 June 1924 |
| 12. | *Intsia bijuga* (Colebr.) Kuntze | + | - | - | R.E. Holttum s.n. 13 Jul 1924; J. Sinclair SFN 39001 |
| 13. | *Pongamia pinnata* (L.) Pierre | - | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 39 |
| 14. | *Pterocarpus indicus* Wild. | + | - | - | Nil |
| | **Liliaceae** | | | | |
| 15. | *Dianella ensifolia* (L.) DC. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 18 |

| S/No. | Species | Holttum (1925) | Johnson (1977) | Collected Recently | Specimen |
|---|---|---|---|---|---|
| | **Malvaceae** | | | | |
| 16. | *Hibiscus tiliaceus* L. + | - | - | Nil | |
| | **Melastomataceae** | | | | |
| 17. | *Melastoma malabathricum* L. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M.Turner & J.W.H. Yong JONG 40 |
| 18. | *Memecylon edule* Roxb. var. *edule* | - | - | + | J. Sinclair SFN 39004;<br>K.S. Chua, B.C Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 1;<br>K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 43 |
| | **Meliaceae** | | | | |
| 19. | *Xylocarpus granatum* J.König | - | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 3 |
| | **Moraceae** | | | | |
| 20. | *Ficus globosa* Blume | - | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 41 |
| 21. | *Ficus grossularioides* Burm.f. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 25 |
| | **Myricaceae** | | | | |
| 22. | *Myrica esculenta* Buch.-Ham. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 23 |
| | **Myrtaceae** | | | | |
| 23. | *Eugenia grandis* Wight | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 29;<br>K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turuer & J.W. Yong 33. |
| 24. | *Eugenia spicata* Lam. | + | - | + | R.E. Holttum s.n. 11 Jun 1924<br>K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 24 |

| S/No. | Species | Holttum (1925) | Johnson (1977) | Collected Recently | Specimen |
|---|---|---|---|---|---|
| | **Orchidaceae** | | | | |
| 25. | *Dendrobium crumenatum* Sw. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 44 |
| | **Pandanaceae** | | | | |
| 26. | *Pandanus odoratissimus* L.f. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 21 |
| | **Rubiaceae** | | | | |
| 27. | *Gynochthodes sublanceolata* Miq. | + | - | + | R.E. Holttum s.n. 11 Jun 1924; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 2 |
| 28. | *Morinda citrifolia* L. | + | - | + | R.E. Holttum s.n. 11 Jun 1924; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 10; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 36 |
| 29. | *Morinda umbellata* L. | + | - | + | R.E. Holttum s.n. 11 Jun 1924; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 32 |
| 30. | *Tarenna fragrans* (Nees) Koord. & Valeton | + | - | + | R.E. Holttum s.n. 13 Jul 1924; J.Sinclair SFN 39005; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 4; K.S. Chua, B.C Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 5; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 37 |
| | **Sapindaceae** | | | | |
| 31. | *Guioa pleuropteris* (Blume) Radlk. | + | - | + | R.E. Holttum s.n. 11 Jun 1924; J. Sinclair SFN 39003; K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 15 |

| S/No. | Species | Holttum (1925) | Johnson (1977) | Collected Recently | Specimen |
|---|---|---|---|---|---|
| | **Sonneratiaceae** | | | | |
| 32. | *Sonneratia alba* Sm. | + | - | - | Nil |
| | **Sterculiaceae** | | | | |
| 33. | *Commersonia bartramia* (L.) Merr. | + | - | - | R.E. Holttum s.n. 13 Jul 1924 |
| 34. | *Heritiera littoralis* Dryand. ex Aiton | + | - | - | Nil |
| | **Theaceae** | | | | |
| 35. | *Adinandra dumosa* Jack | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 30 |
| | **Verbenaceae** | | | | |
| 36. | *Premna corymbosa* (Burm.f.) Rottler & Wild. | + | - | - | Nil |
| 37. | *Vitex pinnata* L. | + | - | + | K.S. Chua, B.C. Soong, H.T.W. Tan, I.M. Turner & J.W.H. Yong JONG 8 |

# Notes on the Flora of Malaya: New Records, Overlooked Records and some Nomenclatural Clarification

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**Abstract**

*Browallia americana* L., *Persicaria nepalensis* (Meisn.) H. Gross, *Sonchus oleraceus* L. and *Verbena bonariensis* L. must be added to the flora of Malaya, being established as weeds in the highlands. *Ranunculus cantoniensis* DC. is recorded for the first time for Malaya. *Mitracarpus hirtus* (L.) DC. is probably also an established member of the weed flora of the lowlands. *Desmodium obcordatum* (Miq.) Kurz is native to the far north of Peninsular Malaysia. *Alsomitra macrocarpa* (Blume) M. Roem. was not included in earlier Malayan floras, but has been collected from the lowland forests of several states in the Peninsula. Two species of *Maclura* occur in Malaya. *Begonia perakensis* var. *rotundata* Irmsch. is reduced to the type variety of the species. *Phrynium pubinerve* Blume is the correct name for the widespread lowland forest maranta referred to previously as *Phrynium malaccense* Ridl. or *Phrynium capitatum* Willd.

## Introduction

Whilst working on the compilation of a checklist of the vascular plants of Malaya (Peninsular Malaysia and Singapore) I have come across a number of records of species native or naturalized that have either not been published before, or have been published rather obscurely making it unlikely that any but the extremely persistent would come across the record. The purpose of this paper therefore, is to list these new or overlooked records and also to attempt to clarify a few nomenclatural problems in the flora.

## New Weed Records from the Highlands

A high proportion of the new or overlooked records are weedy species that have become naturalized around the hill resorts in the Peninsula. I have not been able to find earlier records of their presence in the Malay Peninsula in the literature for some. Others appear only in Stone's *Summit Flora of Gunung Ulu Kali* (Stone, 1981) which is not easy to obtain.

***Browallia americana* L. [Solanaceae]**

Stone (1981 p. 144) reports this species as being naturalized on the summit zone of Gunung Ulu Kali in the Genting Highlands. I have also seen it growing as a weed of tea in the Cameron Highlands. A description of this blue-flowered herb is given by Backer and Bakhuizen van der Brink (1965 p. 482). This species is originally from South America but is now naturalized in the palaeotropics.

***Persicaria nepalensis* (Meisn.) H. Gross [Polygonaceae]**

This species has probably been accidently introduced into the Cameron Highlands from the Himalayan region. It was first collected in the Boh Plantations by Md. Nur (*SFN 32847*) on 3 April 1937. J. Sinclair collected it in two localities the Cameron Highlands in August of 1956. The species is described in Backer and Bakhuizen van den Brink (1963 p. 222) and figured in van Steenis (1972 plate 41-8) under the synonym *Polygonum nepalense* Meisn.

***Ranunculus cantoniensis* DC. [Ranunculaceae]**

I was surprised to see a buttercup growing on a grassy roadside verge in Tanah Rata, Cameron Highlands. A visit to Kew allowed me to identify my collection [I.M. Turner *94-31*] as *Ranunculus cantoniensis* DC., a species widespread in temperate and subtropical Asia. A single collection from one small patch of plants is not sufficient to confirm naturalization of the species, but it seems likely that this species will eventually be added to the list; the first *Ranunculus* for Malaya.

***Sonchus oleraceus* L. [Compositae]**

This softly-spiny yellow-flowered composite is now quite a common weed of cultivation around the towns of the Cameron Highlands. Native to temperate Eurasia, the earliest Malayan collection (in SING) was that of J. Sinclair (*9959*) made on 4 November 1958 at the junction of Batu Brinchang Road and Sungei Palas Tea Estate Road. For a detailed description see Backer and Bakhuizen van den Brink (1965 p. 435).

***Verbena bonariensis* L. [Verbenaceae]**

Stone (1981 p. 150) reported this plant from Gunung Ulu Kali. It has been collected a number of times from the Cameron Highlands also (e.g.

H.M. Burkill *2869*, J. Sinclair *9931*). It appears to persist readily as an escape from cultivation as an ornamental herb. A detailed description is given by Yeo (1990 p. 105).

## New Records from the Lowlands

A few species found in the lowlands also appear to have been overlooked:

### *Desmodium obcordatum* (Miq.) Kurz [Leguminosae]

A twining subshrub with characteristic obcordate leaves, placed in the monotypic genus *Hegnera* by Schindler but now generally treated within *Desmodium sensu stricto*. I have seen three collections from Peninsular Malaysia. The earliest (M.R. Henderson, *SFN23079*) was made on 22 Nov 1929 from Gua Nangka in Perlis. Two others come from rubber estates in Kedah. Ohashi (1973) cites the distribution of this species as Indochina, South Sumatra and Java, so its presence in the driest parts of northern Peninsular Malaysia is not unexpected.

### *Mitracarpus hirtus* (L.) DC. [Rubiaceae]

This small herb appears to have become naturalized from tropical America. There are three collections in SING by J. Sinclair of this species from near Kepong in Selangor (*SFN40076*), Telok Paku Road, Singapore (*10768*) and the Scudai River in Johore (*10825*). All apparently from open dry sandy sites. Inspection of such sites in other places may reveal this species elsewhere in Malaya. Detailed descriptions are given by Verdcourt (1976 under the synonym *M. villosus* (Sw.) DC., and 1989). It is now a pantropical weed which originated from tropical South America.

### *Alsomitra macrocarpa* (Blume) M. Roem. [Cucurbitaceae]

Reid (1953), in a short article, noted the presence of this cucurbitaceous vine in the lowland forests of Peninsular Malaysia. There are collections in SING from Pahang, Negri Sembilan and Johore. The plant is remarkable for its football-sized fruits which contain winged seeds. The fruits, or at least the empty fruit shells, are featured in Davison (1988 p. 127) being used as playthings by kampung kids in Johore. Winged seeds, probably of this species, are shown gliding down through a rain-forest canopy in Borneo in a spectacular film sequence in the BBC *The Private Life of Plants* series.

## *Maclura* in the Malay Peninsula

In an annotated key to genera of the Moraceae in Malaya, Kochummen (1978 p. 120) states that *Maclura amboinensis* Blume is only one native species belonging to this genus. Ridley (1923) also included only one species referable to *Maclura*. This was *Cudrania javensis* Tréc., which is a synonym of *Maclura cochinchinensis* (Lour.) Corner. Kochummen cites *Cudrania javensis sensu* Ridley as a synonym of *Maclura amboinensis* but I wondered whether Ridley might have actually correctly identified at least some of the Malayan material. Revisions of the genus (Corner, 1962; Berg, 1986) do not contain any specific reference to *Maclura cochinchinensis* in Malaya, but inspection of material in SING showed that both species are present. *Maclura amboinensis* Blume is a spiny climber of hill and montane forest collected from Perak and Pahang. *Maclura cochinchinensis* (Lour.) Corner is a small tree found in Perlis, Kedah and Penang with a majority of collections from limestone sites.

## The varieties of *Begonia perakensis* King

In his monograph of *Begonia* in the Malay Peninsula, Irmscher (1929) described two varieties of *Begonia perakensis* King. However, he made no allusion to any type variety for the species. In describing the species, King referred to three specimens of Kunstler's, numbers *10338*, *10506* and *10951*. Irmscher included *10338* in the list of specimens of his variety *rotundata* and he rejected Kunstler *10566* from *Begonia perakensis*. I imagine that King's *10506* is the same as Irmscher's *10566* but typographical errors have occured somewhere. The third syntype given by King is not mentioned by Irmscher. Thus there is a strong case for regarding var. *rotundata* as the type variety of *Begonia perakensis*, a conclusion that would become incontravertible if Kunstler *10338* were declared the lectotype of *Begonia perakensis*. As I have not seen this specimen I refrain from lectotypification, but provisionally I reduce var. *rotundata* to the type variety.

***Begonia perakensis*** King, J. Asiat. Soc. Bengal. Pt. 2 Nat Hist. 71 (1902) 64 var. ***perakensis***

*Begonia perakensis* var. *rotundata* Irmsch., Mitt. Inst. Allg. Bot. Hamburg 8 (1929) 129.

var. ***conjungens*** Irmsch., Mitt. Inst. Allg. Bot. Hamburg 8 (1929) 129

## The correct name for *Phrynium capitatum*

In his monograph of Malayan Marantaceae Holttum (1951) used the name *Phrynium capitatum* Willd. for the common lowland forest maranta. Recently, Suresh and Nicolson (1986) have shown that *Phrynium capitatum* Willd. is an illegitimate name. They go on to provide a new name in *Phrynium* for the oldest combination available for this species *Pontederia ovata* L.; the new name being necessary as *Phrynium ovatum* was already occupied by a species decribed by Nees and Martelli in 1823. Suresh and Nicolson's new name, *Phrynium rheedei*, would be the correct one for the species if no other valid combinations in *Phrynium* existed for it. However, it appears that the species is widespread and at least two earlier combinations are available. The oldest being *Phrynium pubinerve* Blume as given below:

***Phrynium pubinerve*** Blume, Enum. Pl. Javae (1827) 38; Back. & Bakh.f., Fl. Java 3 (1968) 79; Noltie, Fl. Bhutan 3(1) (1994) 214.

*Pontederia ovata* L., Sp. Pl. (1753) 288. *Phrynium rheedei* Suresh & Nicolson, Taxon 35 (1986) 355.

*Phrynium capitatum* Willd., Sp. Pl. 1 (1797) 17, nom. illeg. Holttum, Gdns' Bull. Sing. 13 (1951) 287.

*Phrynium malaccense* Ridl., J. Str. Br. R. Asiat. Soc. 32 (1899) 180.

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# Additions to the Flora of Singapore, II.

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## Abstract

Seven species of vascular plants not previously reported for the flora of the Republic of Singapore are listed in this paper. Three of these, the epiphytic orchid *Bulbophyllum gusdorfii* J.J.Sm., the icacinaceous liana *Iodes cirrhosa* Turcz. and the leguminous sea-shore shrub *Sophora tomentosa* L., are apparently overlooked native species. The other four, the sedge *Cyperus difformis* L., the fern *Pteris semipinnata* L. and the leguminous shrubs *Macroptilium lathyroides* (L.) Urban and *Sesbania cannabina* (Retz.) Poir., are naturalized exotic species.

The Republic of Singapore has a native and naturalized vascular plant flora containing some 2,500 species (Turner, 1993). Despite fairly intensive botanical inventory for more than a century it is still possible to find additions to the flora. These are either overlooked native species or exotics that have become naturalized after accidental or deliberate introduction. In this paper we list seven new records.

### 1. *Bulbophyllum gusdorfii* J.J.Sm. [Orchidaceae]

An epiphyte of forest trees consisting of a horizontally creeping rhizome bearing ovoid, slightly four-angled pseudobulbs up to 2.5 cm long, each with a single coriaceous, oblanceolate-obovate leaf which can reach 16.5 by 3.5 cm in size. The pinkish scape arises from the base of the pseudobulb, and is from 7 to 9 cm long. At the tip of the scape, the 6-8 flowers are found in an umbel-like arrangement. Each flower has a dorsal sepal and about equal-sized lateral petals. The lateral sepals are joined for almost all their upper edges, are up to 26 mm long and 8 mm at the widest point, and are pale yellow flushed purple at the base. The identification was confirmed from a plant (K.S. Chua et al., *NRS1683*, 29 Apr. 1993) collected from a fallen branch in the forest to the north of MacRitchie Reservoir near Thompson Ridge and grown until it flowered at the National University of Singapore.

*Bulbophyllum gusdorfii* has been reported from Selangor, Pahang and Johore in the Malay Peninsula, as well as from Sumatra and possibly the Philippines (Seidenfaden & Wood, 1992).

2. ***Cyperus difformis* L. [Cyperaceae]**

A small annual, about 50 cm tall, with tufted stems, well-developed but weak, leaves and reddish fibrous roots. The inflorescence is simple or compound. It is made up of 5-9 spreading primary branches of up to 4 cm long, often bearing shorter secondary branches radiating from their tips. Each branch or branchlet ends in a spike consisting of a globose head of up to 40 spikelets stellately arranged.

A specimen (K.S. Chua *1059*, 11 Oct. 1994) of *Cyperus difformis* was recently collected from a clump of sedges in a patch of waterlogged open ground beside the road in Lim Chu Kang. Ridley (1925) reported that *Cyperus difformis* was rare in the Malay Peninsula, occurring as a weed in the ricefields of Kelantan. Elsewhere it is widespread across the Tropics and Subtropics of the Old World, being found from southern Europe and Africa to Australia, but in Malesia is only common on Java (Kern, 1974). Expanses of waste land in Singapore appear to have favoured the establishment of weedy species, such as this one, endemic to more seasonal tropical climates.

3. ***Iodes cirrhosa* Turcz. [Icacinaceae]**

A liana with woody stems to 8 cm in diameter climbing with the aid of tendrils. The simple leaves are roughly ovate and hairy beneath. The tiny yellowy-white flowers are borne in much-branched lax cymes to 15 cm long. The fruits are red drupes about 1.5 cm long. In Singapore the first record of this species is a specimen (I.M. Turner et al. *NRS0026*, 1 Apr. 1992) collected from the margin of the Nee Soon Swamp Forest near Seletar Reservoir Park. The species is found over a wide area of both the Malay Peninsula and Malesia (Sleumer, 1971), so it does not seem unlikely that it is native to Singapore.

4. ***Macroptilium lathyroides* (L.) Urban [Leguminosae]**

The phasey bean or kacang batang is a small shrub reaching about 1.5 m tall. In the open it remains erect but among other plants the young branches may twine round adjacent stems allowing the plant to climb. The leaves are trifoliate with ovate-lanceolate to elliptic leaflets. The "dried blood" red flowers are borne in racemes up to 15 cm long with a 40 cm peduncle. The narrow pods are more or less cylindrical, about 10 cm long and given to abrupt dehiscence.

This species, native to Tropical America, has been used quite widely in the Tropics as a forage legume (Jones & 't Mannetje, 1992) and probably arrived in Singapore as an escape from an agricultural trial somewhere in the region. It has been observed in a number of localities in Singapore, seemingly preferring open sandy sites, particularly newly reclaimed land. Collections include: Ali Ibrahim *95* (25 Jun 1987) from reclaimed land at Marina South, I.M. Turner *93-12* (17 Jan 1993) from reclaimed land at Marina East and K.S. Chua et al. *SB 3063* (13 Oct 1993) from Sungei Buloh Nature Park, along roadsides at the Lim Chu Kang boundary.

5. ***Pteris semipinnata*** **L. [Pteridaceae]**

A terrestrial fern with fronds 30-40 cm long. The fronds are pinnate; the terminal pinna being deltoid with lateral lobes incised close to the rachis. The 4-7 pairs of subopposite lower pinnae are sessile with lobes along their lower margins. The edges of the pinnae are minutely and irregularly toothed. The pale brown spores are produced from sori running round the margins of the fertile fronds.

*Pteris semipinnata* was first collected in Singapore by J. Sinclair in 1950 (*SFN 39124*) on Pulau Brani. The field note on the herbarium sheet describes the locality as a clayey slope near the jetty and declares the fern to be common in that site. More recently this species has been collected from Labrador Park at the base of a *Eugenia grandis* tree (I.M. Turner *92-50,* 23 Aug. 1992) and from a similar habitat in Mount Faber Park (I.M. Turner *93-2*, 1 Jan. 1993). Holttum (1968) noted that it had not been recorded south of Malacca in the Malay Peninsula, and was commonest in the more seasonal North East, where it was often found in light shade around towns and villages. It occurs across Indochina and southern China (Tagawa & Iwatsuki, 1989). It would seem likely therefore, given the thorough plant collecting that has taken place in Singapore, that *Pteris semipinnata* has undergone a recent range extension. It appears to be a species that is suited to the park habitat and development has favoured its establishment in new areas.

6. ***Sesbania cannabina*** **(Retz.) Poir. [Leguminosae]**

An erect shrub to 4 m in height, found growing in wasteland and newly cleared areas. The branches are characteristically held more or less horizontally and bear paripinnate leaves. The flowers, borne in axillary racemes, have yellow petals streaked with brown. The slender, straight to curved, legumes may be up to 20 cm long. This species appears to have spread across Singapore in the last 15 years or so and has now been recorded from areas as various as Boon Lay Way, Bukit Batok Road, Hindhede Drive, Marina East and Turut Track (collections include K.S. Chua & H.T.W. Tan *353* and K.S. Chua and I.M. Turner *655*).

*Sesbania cannabina* is probably native to Australia and parts of Malesia, but has become established across the Old World Tropics including Africa (Gillet, 1963).

7. ***Sophora tomentosa* L. [Leguminosae]**

A sea-shore shrub to 5 m tall characteristically with most parts more or less covered with a dense grey silky tomentum. The pinnate leaves possess 5-9 opposite pairs plus a terminal leaflet and are up to 30 cm long. The bright yellow flowers are borne in racemes up to 30 cm long. These give rise to pods which look like short strings of black beads because of constrictions between each seed in the pod.

*Sophora tomentosa* is a pantropical coastal plant (Rudd, 1980). In the Malay Peninsula it is common on the East Coast but on the west found only north of Lumut in Perak (Corner, 1988). There are no earlier records of this species from Singapore, yet it was recently collected (Turner et al. *LAZ 36*, 29 June 1993) on Pulau Sakijang Pelepah (Lazarus Island) where a single bush was found growing on the rocky southern shore of the island. It seems that it is a resident species that has eluded detection by earlier Singapore-based botanists. Seed was collected from the plant and successfully germinated in the Department of Botany, The National University of Singapore. It is hoped to establish the young plants at various suitable localities in Singapore to expand the population of this attractive native plant.

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# Book Reviews

## Flora of Australia Volume 49 : Oceanic Islands 1.

Pp xxiii + 681. 1 black-and-white photograph, 16 colour plates (63 colour photographs), 3 maps, 1 coloured and 41 line drawings. Australian Government Publishing Service, Canberra, 1994. ISBN 0 644 29384 5 (pbk.). Price $A 54.95 (paperback), $A 64.95 (hardcover). Available by mail from AGPS Mail Order Sales, GPO Box 84, Canberra ACT 2601, Australia.

Though listed as Volume 49, this first volume on the flora of Australia's Oceanic Islands came one year after the second volume (Volume 50), covering Part 2 of Oceanic Islands, was published. It covers Norfolk Island and Lord Howe Island in the Tasman Sea. Written almost entirely by Mr Peter Green, formerly a botanist at the Royal Botanic Gardens, Kew, this volume includes 136 families, 455 genera and 706 species and subspecific taxa.

The layout of the book is excellent and the descriptions are brief but diagnostic. The clever use of different font and type sizes is easy on the eyes and enables the reader to use the book with ease. Keys to the families, genera and species are clear and well set-out.

The separate checklists of plants in Norfolk Island and Lord Howe Island in the introductory chapter are very useful. Endemic and naturalised species listed are marked with different symbols to allow readers a quick survey of the flora at the specific level.

The inclusion of a glossary towards the end of the book is most welcome for readers who are not specialists. This is one of the useful features in Flora of Australia and should set the trend for modern flora writing.

There are a few minor errors and omissions in the book. The colour photograph of Fig. 21 (p. xxi) appears to be inverted while those of Fig. 11 (p. xviii) and Fig. 58 (p. 283) would look more natural sideways. It would have been useful to include a list of illustrations and photographs. About 63% of the families covered are illustrated with line drawings though I feel that more could have been incorporated.

In the Locality Map (fig. 32), the name Vanuatu should be adopted rather than New Hebrides. This is more so when Vanuatu is mentioned in the text (p. 2), The name New Hebrides could have been included under parenthesis to inform readers who are familiar with it.

On page 2, it is stated that the degree of endemism of vascular plants in Norfolk and Lord Howe Islands is 44.9 %. This percentage of endemism should actually be 43.2 considering there are 149 endemics in the 345 indigenous species. This is a very high percentage of endemism for these islands with a total area of about 51.2 sq. km. The explanation of the specific epithet for *Ricinus communis* has been omitted. The genus *Sanseviera* on p. 523, 525 and 676 should be spelt as *Sansevieria*.

Despite these minor errors and omissions, I have no reservation in recommending this book to anyone interested in the flora or even the geography, climate, physical features and history of human habitation of these two islands. Considering the amount of time and effort put into the preparation of this book and the excellent production, not forgetting the impeccable editing, the cost is very reasonable.

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## Rattans

Dransfield, J. & Manokaran, N. (eds.), 1993. Plant Resources of South-East Asia (PROSEA) No. 6. Pudoc Scientific Publishers, Wageningen. 1993. 137pp. ISBN 90-220-1057-0. Hardbound. Dfl. 120.00. Available from, PROSEA Foundation Publication Office, Wageningen Agricultural University, P.O. Box 341, 6700 AH Wageningen, The Netherlands. For developing countries a cheap paper edition (about US$ 10.00) is available from, PROSEA Network Office, P.O. Box 234, Bogor 16122, Indonesia.

This is the sixth volume from PROSEA, an international programme on the documentation of information on plant resources of Southeast Asia. This volume by 17 contributors provides details on 23 species and one genus of rattan that are commercially important or have potential to be so. Another 105 less important species are briefly discussed. It is not an identification manual; keys are not provided.

Over virtually all of Southeast Asia the use of rattan in village life is ubiquitous and significant. Traditional cultures would not be the same without rattan. This product has also contributed to the building of cities in this part of the world as the required binding material for wooden scaffoldings. Several loops of rattan strips at each junction and joint, hold together massive scaffoldings. A demonstration of its toughness and high coefficient of friction?

The first part of the book is a concise introduction to the subject. It covers a wide range of topics including, origin and geographical distribution, uses, history of the rattan trade, morphology, growth and development, ecology, exploitation of wild resources, cultivation and research priorities and development. It is made clear that serious rattan research in response to a rapidly diminishing natural resource dates back only 15 years. This perhaps is the cause for unclear statements in the text. For example in the bottom paragraph of page 34, "There may be little control over the collection of rattans from the wild in many countries." Is there any doubt that there is little control? In the bottom paragraph on page 35, after saying that large-diameter canes have to be cured with a hot oil mixture, the sentence continues, ....." this treatment is said to make the canes durable by removing gums, resins and water." Yet on page 52 it is quite clearly stated (by a contributor) that this curing is to protect the canes from attack by staining fungi and the powder-post beetle. In the bottom paragraph on page 36 it is stated that, "Even where licences are issued and royalties paid to forest departments, there is evidence to suggest that harvesting is carried out with little thought for sustainability." The author of this is overly optimistic to expect that because licences are issued and royalties collected, the licensee will do something about sustainability (one is reminded about the logging industry). In any case it is expressed that the basic data required for understanding possible rates of harvest of wild populations are still being compiled (top paragraph on page 37).

Less explicable are slips in the citations. On page 16 there is reference to Brown (1941-1943), in the literature listing this is Brown (1951-1957). The years for some of the citations in the text (pages 34, 37 & 38) are absent; neither are these references listed in the literature. However, overall, the introduction is useful and very interesting.

Part Two, the main part of the book, is an alphabetical treatment of major species. All available information (some species have little) seems to have been neatly summarized under the following headings; vernacular names, origin and geographical distribution, production and international trade, properties, description (or sometimes, botany), growth and development, other botanical information, ecology, propagation and planting, husbandry, diseases and pests, harvesting, yield, handling after harvest, genetic resources, breeding, prospects, and literature. Although the contents emphasize cultural practices and handling of the product, the botanical description of each species is detailed and accompanied by a good quality quarter-page line drawing showing all important parts.

Part Three of the book treats the minor species alphabetically. Information for each species appears under these headings; vernacular names, distribution, uses, and observations (which normally include notes on the botany, distribution and ecology).

The literature is listed in three different places: after each species in Part Two, where, as if emphasizing that these are important species, the reference is spelled out in full; at the end of Part Three where the references are numbered and only the numbers are cited after each species entry; and at then end of the book under the heading, "Literature." In this final list not all items found in the first two parts appear.

This is a useful addition to the growing literature on this important resource. The availability of a cheaper, "developing country" edition is most welcome, especially as this edition, though with a soft cover, appears identical in the paper, binding and printing to the hardbound one. The editors and editorial staff have done a marvellous job creating a uniform product from the contributions of so many.

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