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A REVISION OF THE GENUS PTERNANDRA (MELASTOMATACEAE)

J. F. MAXWELL

Botanic Gardens, Singapore

ABSTRACT

Pternandra (Melastomataceae) is revised; the genus Kibessia is reduced to synonymy, as it differs only in one structural detail (the calyptate calyx). Fifteen species and two varieties are recognized in this revision, of which two species (P. angustifolia and P. crassicalyx) are new. Two taxa are retained at the rank of variety for the first time (P. azurea var. cordata (Korth.) Maxwell, and P. galeata var. elmeri (Merr.) Maxwell). Thirteen previously described taxa of Pternandra and Kibessia are here reduced to synonymy. Descriptions, morphological discussion, key to taxa, illustrations of some taxonomically important features, and photographs of some type specimens have been included.

INTRODUCTION

Revived interest in the Malaysian flora and the Flora Malesiana project subsequent to the end of World War II has greatly increased both the quantity and quality of herbarium specimens available for research. This has certainly been true for Pternandra (including Kibessia), and both prompted and facilitated the completion of this revision. Nonetheless, the present paper is not really an attempted definitive treatment. The Philippine and New Guinean materials are still not satisfactory and work remains to be done in collecting as well as interpreting these plants in the eastern part of the Malay Archipelago. However, it is hoped that this paper will resolve some of the taxonomic confusion that has plagued both foresters and botanists working with Pternandra since the time of William Jack (1820). Comments on, additions to, and critiques of this revision will be greatly welcomed by the author.

Acknowledgements: Prof. Hsuan Keng (National University of Singapore) provided a constant source of advice and criticism, and Dr. Chang Kiaw Lan (Curator, Herbarium of the Botanic Gardens, Singapore) graciously cooperated in my work by permitting me to study and borrow the Gardens’ Herbarium specimens. In the period May—July 1977 I visited the Rijksherbarium, Leiden, Netherlands, a trip arranged by Drs. R. Geesink, who also arranged my accommodation; thanks are due both to him and his wife, Dia Geesink M. D., for their hospitality and help. I wish also to thank Prof. Dr. C. Kalkman, Dr. C. G. G. J. van Steenis, Dr. R. C. Bakhuizen van den Brink, Dr. W. Vink, and especially Dr. H. Sleumer and Dr. J. F. Veldkamp at Leiden for preparing the Latin diagnoses in this paper. Dr. D. G. Frodin (University of Papua New Guinea) and Dr. M. G. Manuel (formely of the University of Malaya) read the manuscript and offered several constructive comments which have been incorporated herein. I am especially grateful to Dr. B. C. Stone (University of Malaya) for editing the manuscript and for his continued interest in my research. For access to specimens I am indebted to the Keepers and Curators of the Herbarium, Royal Botanic Gardens, Kew; the Herbarium of the National Botanic Garden, Brussels; the Herbarium of the University of Utrecht, Netherlands; and for loans of several type specimens to the British Museum (Natural History) and the University of Florence. In addition, Mrs. Chirayupin Chandraprasong formerly of the Herbarium, Department of Agriculture, Bangkok (BK) and Dr. Tem Smitinand of the
Royal Thai Forest Herbarium (BKF) kindly made available materials for study. Mr. Jumali Kafrawi (National University of Singapore herbarium technician) kindly redrew several floral diagrams and Mrs. Lucia Sunderaj Krueger completed plates 5, 8, 9 and 13.

HISTORY OF THE GENUS _PTERNANDRA_

_Pterandra_ (Greek _ptera_ = heel; _aner, andros_ = 'man) was established by Jack in 1822 with the type species _P. coerulescens_. The generic name refers to the heel-like extension of the anther connective. Jack’s type material originated from Penang. In 1828, De Candolle described _Kibessia_ on the basis of _Melastoma azurea_ Bl. _Kibessia_ is distinguished by the presence of a calyx cap and setose, often branched, bristles on the calyx tube and cap. _Ewyckia_ was described by Blume in 1831, with _E. cyanea_ as type species. This was listed immediately after _Kibessia_ and differs in having a truncate calyx which is obscurely 4-lobed, and a much smoother tessellate calyx pattern. Apparently Blume was unaware of Jack’s publication since _P. coerulescens_ and _E. cyanea_ are essentially the same (there is no calyx cap and the calyx pattern is tessellate).

In 1849 Blume established two more genera which are considered to be synonyms of _Pterandra_. The first, _Rectomitra_, based on _Ewyckia galeata_ Korth., differs from _Ewyckia_ in having a calyx cap which splits into several lobes and a verrucose to tuberculate calyx pattern. Blume obviously considered the ornamentation of the calyx tube more important than the cap in his generic distinctions, otherwise he would have placed _E. galeata_ in _Kibessia_. The second, _Macroplacis_, based on _Kibessia cordata_ Korth., was distinguished on the basis of vegetative characters from _Kibessia_; the floral features of this species and of _K. azurea_ (Bl.) DC. are the same.

Naudin (1852) reduced _Pterandra_ to _Ewyckia_, but maintained _Kibessia_, _Rectomitra_, and _Macroplacis_ as distinct genera. The last genus to be described on the basis of a _Pterandra_ specimen was _Apteuxis_ Griff. (1854), based on a Burmese plant which Griffith named _A. trinervis_. Miquel (1855) considered _Pterandra_ and _Rectomitra_ as synonyms of _Ewyckia_, but maintained _Kibessia_ and _Macroplacis_. Bentham and Hooker (1865) recognized _Pterandra_ and reduced _Rectomitra_ and _Macroplacis_ to synonyms of _Kibessia_.

Triana (1871) maintained _Pterandra_, _Kibessia_, and _Rectomitra_, but combined _Ewyckia_ with _Pterandra_ and _Macroplacis_ with _Kibessia_. The bases for his generic distinctions were thus: _Pterandra_ — no calyx cap; _Kibessia_ — calyx cap falling off as a unit; _Rectomitra_ — calyx cap splitting into several lobes. Kurz (1877) accepted _Pterandra_ and listed only _P. coerulescens_ Jack and _P. capitellata_ Jack for his account of the Burmese forest flora. C. B. Clarke (1879) recognized both _Pterandra_ and _Kibessia_ in his account of the Melastomataceae in the Flora of British India, including three species of _Pterandra_ (all from the Indian subcontinent) and four species of _Kibessia_ (all from the Malay Peninsula). Of the latter, two are now regarded as synonyms of _P. coerulescens_. _Kibessia simplex_, as described by Clarke, is not Korthals’ species but is _P. echinata_ Jack; _K. pubescens_ Decne. and _K. acuminata_ Decne. are also now regarded as _P. echinata_; and _K. tuberculata_ (Korth.) HK. f. ex Cl. is a distinct species now called _P. tuberculata_ (Korth.) Nayar (1978). Thus, in Clarke’s treatment only three species of _Pterandra_ continue to be recognized, and only _P. coerulescens_ Jack is found in India. Clarke correctly reduced Griffith’s _Apteuxis trinervis_ to _Pterandra coerulescens_. Clarke distinguished _Pterandra_ from _Kibessia_ by its lack of a calyx cap, small cymes, and smooth calyx pattern. Clarke’s treatment does not include any taxa of _Ewyckia_, _Rectomitra_, or _Macroplacis_, so no information on the status or relationships of those taxa is present either.
Baillon (1890) was the first botanist to combine *Kibessia* and *Pternandra*, but Cogniaux (1891), in his monograph of Melastomataceae, continued to distinguish these two genera, although he combined *Rectomitra* with *Kibessia*. Cogniaux divided *Kibessia* into three sections, based on *Kibessia sensu stricto* (*Eukibessia* Cogn.), *Rectomitra* (as Sect. *Rectomitra* (Bl.) Cogn.), and *Macroplacis* (as Sect. *Macroplacis* (Bl.) Cogn.). Krasser (1893), in a treatment based on Cogniaux, kept both *Kibessia* and *Pternandra*.

In King’s (1900) treatment of the Malayan Melastomataceae, three species of *Pterandra* (*P. coerulescens*, with three varieties; *P. echinata*, and *P. griffithii* King) were recognized. Merrill (1921) enumerated four Bornean species of *Pterandra* and twelve Bornean species of *Kibessia*; among these sixteen species twelve are maintained in the present account as distinct taxa.

In Ridley’s (1922) *Flora of the Malay Peninsula* six species of *Pterandra* were recorded, one of which (*P. galeata* (Korth.) Ridl.) had been included in *Kibessia* by Cogniaux. Mansfield (1925) kept *Kibessia* and *Pterandra* as distinct genera in his list of three taxa found in New Guinea. Burkill (1935), in his recombination of *Kibessia azurea* Bl. to *Pterandra azurea* (Bl.) Burk., also noted that *Kibessia* DC. should be reduced to a synonym of *Pterandra* Jack.

In the latest work on Malesian Mealstomataceae, Bakhuizen v. d. Brink (1943, 1943–5) also maintained both *Pterandra* and *Kibessia* on the traditional basis. He discusses nine species and two varieties of *Kibessia*, and one species and two varieties of *Pterandra*. Of these, seven species are now still regarded as distinct. The varieties in *Kibessia* are not now kept; neither are the varieties in *Pterandra*.

Corner (1952) in his book *Wayside Trees of Malaya* lists *Pterandra* only, including 3 species.

Backer and Bakhuizen v. d. Brink (1963) in the *Flora of Java* list one species, *P. azurea* (Bl.) Burk., and indicate in a footnote that they consider *Kibessia* as a synonym of *Pterandra*.

Nayar (1978) transferred 18 taxa of *Kibessia* to *Pterandra*. Unfortunately, the overall value of the publication is dubious since most of the nomenclatural changes were made without any discussion. Of Nayar’s new combinations only seven are herein considered as denoting distinct taxa, including *Pterandra cogniauxii* Nayar, a new name for *Kibessia korthalsiana* Cogniaux. Nine other recombined names are herein reduced to synonyms. *Pterandra ledermannii* (Mansf.) Nayar is a dubious species with close affinities to *P. rostrata* (Cogn.) Nayar. In my research studies at Leiden, Kew, and the British Museum, I did not notice any of Nayar’s annotation labels on the relevant specimens of *Pterandra*. Nayar proposed a new species, *Pterandra moluccana* which, however, is based on a specimen in poor condition, that is unquestionably a species of *Medinilla*. This specimen, at Leiden, does not have a calyx calyptra or 8 equal stamens without appendages, as specified in Nayar’s description. *Pterandra moluccana* thus will become a synonym under *Medinilla* when revisional work on that genus is carried out. Finally it may be noted that *Pterandra ‘birtella’* in Nayar’s paper should be *P. hirtella* (Cogn.) Nayar.

**GENERIC CIRCUMSCRIPTION OF PTERANDRA**

Since there is but one real structural difference which can be used to separate *Kibessia* from *Pterandra*, that is the presence of a calyptra or calyx cap in the former
and its absence in the latter, an assessment of the importance of this character is required and will determine the taxonomic result. In my opinion, this is not a feature that merits generic distinction, nor should genera be separated on any single, isolated feature. In the present treatment, therefore, Kibessia is submerged in Pternandra, the latter name, being the oldest, thus being the correct name for this genus.

CONSTITUTION OF THE GENUS PTERNANDRA.

In this paper 15 species (with 2 varieties) of Pternandra are described, of which two are newly proposed (P. angustifolia Maxw. and P. crassicalyx Maxw., both from Borneo). Thirteen names are reduced to synonymy, four herbarium (in scheda) names are de-valued, and one species attributed to Kibessia, and four species originally placed in Pternandra, are removed to other genera. Three taxa (species) remain dubious, and a fourth could not be evaluated herein because of unavailability of material for study.

TAXONOMIC TREATMENT

Pternandra Jack


Apteuxis Griffith, Notul. 4 (1854) 672.
Maxwell: *Pterandra* (Melastomataceae)

Trees to 25 m tall, diameter to 75 cm, less frequently shrubs. Upper branches cylindric, angled, or winged; glabrous or pilose. Leaves opposite; blades chartaceous to coriaceous, simple, entire, lanceolate to suborbicular, acute to acuminate, at base narrowed, rounded, or cordate, 3–5-nerved from base, nerves sunken above, raised and tapering below, intramarginal nerve thin, often merging with margin in apical part of blade; petiole usually flattened; interpetiolar line or ridge distinct; stipules none. Inflorescence umbellate, cymose, paniculate, or nearly sessile and glomerulate, few to many-flowered, from leafless or leafy nodes or terminal. Calyx tube campanulate, with an external pattern (tessellate, umbonate, verrucose, or echinate plates, or setose appendages which are barbed to branched); margin truncate and minutely 4-cusped, or with a distinct calyx cap with or without tubercles or setae, which either falls off as one piece or splits into 2–4 lobes. Petals 4, imbricate to the right, usually broad-ovate to suborbicular, acute, at base truncate, thick or thin, glabrous. Stamens 8, equal, glabrous, with flattened filaments and dolabrid form to oblong, laterally flattened anthers with antrorse aestivation, the connective thickened, straight, eglandular, usually with a minute spur near the filament. Stigma subcapitate to cylindric, 4-grooved or lobed; style slender; ovary 4-locular, placenta parietal, ovules numerous. Fruit a berry, campanulate-truncate, urceolate, or globose; the exocarp tessellate or echinate. Seeds numerous, flattened, quadrangular-rhombic, glossy tan or light brown.

Type species: *Pterandra coerulescens* Jack

From other genera of Melastomataceae, this genus is distinguished by its woody habit, tessellate to echinate calyx tube, calyptra or calyx cap in most species, small and only minutely appendaged anthers, 4-locular ovary, and many-seeded fruit. The characteristic leaf venation pattern (3–5 basal nerves) is usually a good field character, but confusion on this basis with other plants such as *Rhodamnia* (Myrtaceae), *Cinnamomum* (Lauraceae), and *Strychnos* (Loganiaceae), or with *Memecylon* of the same family, is possible. *Strychnos*, however, is a genus of which the species are mostly woody climbers.

MORPHOLOGY

*Habit*. — Of the 17 taxa discussed herein, there are nine which consist exclusively of trees, the remainder are either trees or shrubs. Species which are constantly or noticeably arboreal are: *P. coriacea, P. galeata, P. hirtella, P. tuberculata*. I have seen four taxa in the field (*P. coerulescens, P. echinata, P. galeata*, and *P. tuberculata*), but data on the other taxa has been gleaned from herbarium label notes. All taxa are interstitial but one species, *P. cogniauxii*, has apparently the capacity to grow as an epiphyte, as noted on two specimens. *P. echinata*, though usually recorded as a tree, has twice been recorded as a climber; however in Singapore I have seen this only in tree form. Certain taxa, as follows, attain a considerable height and trunk diameter: *P. azurea* may reach 30 m and 75 cm; *P. galeata* var. *elmeri*, 20 m and 45 cm; and *P. tuberculata*, 20 m and 50 cm. Buttresses are common in larger individuals and the bole is usually straight with a wide crown.

*Bark and wood*. — Typically the outer bark is thin (0.25 – 1 mm) with longitudinal fissures or craks, is smooth, and peels off in narrow strips. In colour it ranges from grey-brown to blackish, often mottled with various dark shades. The inner bark is 0.5 – 2 mm thick, variable in pigmentation, white, reddish-brown, greenish-yellow, or dark red. The wood is hard and usually yellowish or brownish. Browne (1955) gives some useful information on the general features and wood anatomy.

*Branchlets*. — These are useful in identification, especially vegetative material; they are either terete or flattened and grooved on two faces, or quadrangular below the upper
node and tapering to a terete condition, or quadrangular entirely, or even 4-winged, with membranous undulate wings on the angles. Older branchlets and branches of all taxa are terete and ungrooved, and without angles or wings.

The following taxa have entirely terete, cylindrical internodes: *P. crassicalyx*, *P. galeata* var. *elmeri*, and *P. teysmanniana*.

Five taxa have branchlets which are usually flattened and grooved, or are somewhat quadrangular below the upper node: *P. cogniauxii*, *P. coriacea*, *P. galeata* var. *galeata*, *P. multiflora*, and *P. rostrata*.

Two taxa have quadrangular internodes: *P. echinata*, with the angles extending fully from one internode to the next, and *P. gracillis*, with the internode flattened and grooved on two faces below the upper node. In *P. hirtella*, the branchlets are basically quadrangular but the angles are slightly winged.

Two taxa have distinctly winged branchlets: *P. azurea* var. *cordata* and *P. tessellata*.

There are six taxa with pubescent branchlets (*P. azurea*, both var. *azurea* and var. *cordata*, *P. crassicalyx*, *P. echinata*, *P. hirtella*, and *P. tessellata*). All other taxa have glabrous branchlets. *P. echinata* can be distinguished from all other taxa solely on the basis of its 4-angled and pubescent branchlets.

The branchlet epidermis is thin, smooth, brownish or blackish, and may peel off (e.g. *P. coerulescens*, *P. multiflora*) leaving a smooth, tan undersurface. The wings of the branchlets in those taxa with this feature are fragile and may break off on the lower older part of the stems, leaving an interrupted series of irregular ridges, all of which however eventually fall off, leaving smooth, cylindrical, glabrous internodes. The upper internodes are usually flattened, but fill out to cylindrical form in age. Articulation zones at the base of the petiole tend to coalesce and may be mistaken for stipular scars. Branch tips with very young leaves show this feature clearly. The second node usually has a distinct interpetiolar ridge or line.

*Leaves.* — Usually these are simple, entire, glabrous or finely puberulent, 3–5-nerved (except *P. angustifolia*, 1-nerved) and may be chartaceous to coriaceous in texture. There is always a pair of intramarginal nerves. Secondary venation is pinnate in plan from each main nerve and is visible except in a few cases (the taxa with thickened leaf blades, e.g. *P. coerulescens* and *P. galeata* var. *elmeri*). In shape the blades range from lanceolate to suborbicular; the apex from rounded to acute, and the base from acute to cordate. The petiole is usually flattened; it is glabrous except in those five taxa which have pubescent branchlets.

Some taxa are recognizable from their leaves: *P. cogniauxii*, with 5 main nerves and a cordate base; *P. coriacea*, with small, coriaceous blades; *P. teysmanniana*, with blades glaucous beneath; etc. The leaves of *P. echinata*, *P. azurea* var. *azurea*, and *P. azurea* var. *cordata* are very similar. Also those of *P. galeata*, *P. coerulescens*; and *P. rostrata*, *P. tuberculata*; and *P. crassicalyx* and *P. hirtella* are similar.

*Inflorescences.* — *P. coerulescens* has a wide range of structural variation in the inflorescence, but most other taxa have definite inflorescence forms. That of *P. multiflora* is distinct in having the largest, most complex panicle (to 5 ramifications). Some specimens of *P. coerulescens* may have inflorescences branched to the 4th degree, but
most are less branched. Shortening of the ultimate axes result in a cyme-like or umbelli-form appearance in some specimens of *P. tessellata* and *P. coerulescens*. In most taxa the inflorescences are cymose and 3- or 1-flowered. Solitary flowers occur in *P. azurea*, *P. hirtella*, and *P. rostrata*. In *P. echinata* such a transition may be seen, with the cymes ranging from 9- to 3-flowered, or even 1-flowered. Some species have the inflorescence condensed glomerulate, with few or solitary flowers, e.g. *P. angustifolia*, *P. cogniauxii*, *P. galeata*, and *P. gracilis*.

Most species possess axillary inflorescences from leafy nodes, but in *P. cogniauxii*, *P. galeata* var. *elmeri*, and *P. multiflora*, the nodes are leafless and thus the inflorescences are ramuline. In *P. coriacea* the inflorescence axes are flattened and grooved, in *P. rostrata* also but quadrangular, and in *P. azurea*, *P. echinata*, and *P. multiflora* they are clearly quadrangular. All axes are glabrous except in the five taxa with pubescent branchlets. The bracteoles and bracts are paired, connate, sheathing, and usually persistent. Only those of *P. echinata* are manifest or variable enough to be of taxonomic importance.

**Calyx.** — In both flowering and fruiting material the calyx provides the most distinct differences between the taxa. The structure of the calyx tube and the nature of the calyx margin has allowed the taxonomic discrimination or, in contrast, the synonymous status, of most of the taxa herein treated.

In *P. galeata* the calyx is urceolate and in the same species the variety *elmeri* is campanulate. It may be ornamented externally with a distinctive pattern of 4-angled flat or umbonate scales (tessellate pattern); or conical tubercles (tuberculate pattern); or with flattened or cylindrical appendages (echinate pattern) which may be entire or branched and glabrous or pubescent. *P. coerulescens* always shows the tessellate pattern; this also appears, sometimes, in *P. galeata*, which however can be distinguished by the urceolate form of the calyx. The umbonate-tessellate pattern occurs in *P. crassicalyx* and *P. tessellata*, while a more extreme form (conical-tuberculate) is common in e.g. *P. cogniauxii*, *P. rostrata*, and *P. tuberculata*. In *P. coriacea* and *P. teysmanniana*, for example, the pattern nearer the pedicel is umbonate-tuberculate but the gradual elongation of the umbo in the more distal scales reaches, at the margin, results in an echinate pattern. A more distinctly echinate pattern, with appendages longer than wide, is common to many taxa, though the shape of the appendage varies from setiform, as in *P. azurea* and *P. hirtella* (setae often branched) to flattened in *P. angustifolia* and *P. echinata* (appendages entire). In *P. azurea* var. *cordata* the appendages are both flattened and branched.

The calyx margin is truncate, completely in *P. coerulescens* and *P. multiflora*. The remaining 15 taxa have a calyx cap, or at least minute calyx lobes. Five taxa have a smooth calyx cap which ultimately splits into 2, 3, or 4 persistent lobes: *P. cogniauxii*, *P. galeata*, both varieties, *P. teysmanniana*, and *P. tuberculata*. The remaining taxa have a smooth calyx cap (*P. crassicalyx* and *P. rostrata*) or one with appendages near the middle (*P. azurea*, *P. hirtella*) which falls off as a unit at the time of petal expansion. Thus the mature flowers of these taxa appear to have a truncate (i.e. lobeless) calyx. Examination of buds is necessary to determine the difference, a crucial matter e.g. in distinguishing *P. multiflora* from *P. coerulescens*. In *P. tuberculata* the calyx is 4-lobed, a characteristic feature, and in *P. rostrata* the calyx is calyptrate, thus enabling distinction of these quite similar species.

Internally the calyx shows 8 lines and 8 grooves corresponding in which the anthers lie in the bud state. These correspond with the extraovarial chambers found in some other genera of this family, i.e. those of the tribes *Dissochaeteae* and *Oxysporeae*. 
Corolla. — The four petals are equal, symmetrical, usually broad-ovate to sub-orbicular, acute, and truncate at the base. They are usually thin with visible veins (P. gracilis) or thicker with indistinct or invisible veins (e.g. P. coerulescens). As taxonomic features the petals are not especially useful and are often lacking in herbarium specimens.

Stamens. — These are 8, glabrous, equal, with smooth, flat filaments in all taxa of Pternandra. In contrast to most other genera of Melastomataceae, Pternandra has very reduced and unspecialized anthers, similar in many ways to those of Astronia and (some) Memecylon. The anthers are usually dolabriform, i.e. axe-shaped, or oblong, bilocular (each opening by a longitudinal slit), and with a thickened, non-glandular connective which often bears a spur near the filament. The stamens appear to be rather uniform in the genus and are not very important in taxonomy.

Gynoecium and fruit. — They ovary is inferior, 4-locular; the style slender, glabrous, and the stigma subcapitate to cylindrical, at first 4-grooved and twisted, later 4-lobed. The placentation is parietal, with numerous ovules (Fig. 1). The fruit is a berry, which tends to retain its younger shape with a thickened, gritty pericarp and contains many flattened, quadrangular-rhombic or cuneate seeds. In P. galeata the fruit (unlike the floral calyx) is urceolate, but in all other taxa the fruit shape is pretty uniform. Seed morphology, however, may play a promising taxonomic role and should be investigated more thoroughly.

DISTRIBUTION

P. coerulescens and P. echinata var. pubescens (Decne.) King occur in Thailand, the former known from Chang Island in Trat Province, the latter (which is indistinguishable from var. echinata) from throughout the southern peninsular part of Thailand. In the Malay Peninsula and Singapore, four taxa occur: P. coerulescens, P. galeata, P. tuberculata, and P. echinata—the latter is apparently restricted to the Malay Peninsula and the Riouw Archipelago. Ten taxa appear to be endemic to Borneo: P. cogniauxii, P. gracilis, P. galeata var. elmeri, P. teysmanniana, are uncommon; P. azurea var. cordata, and P. rostrata are common in Borneo, but also occur in Sumatra and Java, the latter also in New Guinea. P. coerulescens, P. galeata s.s.; and P. tuberculata range from W. Malaysia to New Guinea. Much more collecting must be done in Sumatra, Celebes, Moluccas, and New Guinea to determine more precisely the taxa of Pternandra which they include.

In terms of relative abundance I have adopted five crude but suggestive categories:

RARE: 
P. angustifolia, P. coriacea, P. galeata var. elmeri, P. tessellata, P. teysmanniana

NOT COMMON: 
P. azurea var. cordata, P. cogniauxii, P. crassicalyx, P. gracilis, P. hirtella, P. multiflora

COMMON: 
P. azurea var. azurea, P. galeata var. galeata, P. tuberculata

VERY COMMON: 
P. echinata, P. rostrata

MOST COMMON: 
P. coerulescens.
Fig. 1. *Pterandra echinata* Jack ovary, x-section, showing parietal placentae and ovules. Drawn from Maxwell 76-757.
KEY TO THE TAXA OF *PTERNANDRA*

1. Calyx tube with setose to echinate scales which are distinctly longer than wide.

2. Scales branched near the tip, especially those near the calyx margin; calyx cap or lobes tuberculate to echinate near middle.

3. Blades mostly narrowed or sometimes rounded, never cordate, at base; petiole at least 3 mm long.

4. Branchlets and blades beneath densely red-brown pilose, the pubescence persistent; blades 9–17 cm long, 4.5–8 cm wide, coriaceous ............................................. (12) *P. hirtella* (Cogn.) Nayar

4. Branchlets glabrous at maturity; nerves minutely pilose beneath near petiole, glabrescent; blades generally thinner, smaller than as above ............................................. (2) *P. azurea* (Bl.) Burk. var. *azurea*

3. Blades rounded and usually cordate at base; petiole up to 2 mm long ........ (3) *P. azurea* var. *cordata* (Korth.) Maxw.

2. All scales entire; calyx cap with or without tubercles or appendages.

5. Blades with 3 main nerves and 2 intramarginal nerves.


7. Scales flattened, never barbed; cap without tubercles or appendages. ........ (8) *P. echinata* Jack

7. Scales setose, the upper ones often barbed; cap with tubercles. ............... (2) *P. azurea* (Bl.) Burk. var. *azurea.*


8. Blades coriaceous, glaucous beneath, generally drying grey to whitish; inflorescence axes 1–1.5 cm long; cap without tubercles. .............................. (6) *P. coriacea* (Cogn.) Nayar

8. Blades chartaceous, green beneath; inflorescence axes less than 5 mm long; cap with setose to echinate appendages. .................. (11) *P. gracilis* (Cogn.) Nayar

5. Blades with 1 main nerve and 2 intramarginal nerves. ........................ (1) *P. angustifolia* Maxw.

1. Calyx scales tessellate, umbonate, verrucose, tuberculate; usually wider than long.

9. Scales tessellate or slightly umbonate near the margin.
10. Blades cordate at base, 5-nerved, 13–26 cm long, 7–13 cm wide; inflorescence mostly from behind the leaves. (4) *P. cogniauxii* Nayar

10. Blades narrowed or rounded at base, 3-nerved; inflorescence mostly from leafy nodes; blades usually smaller than as above.

11. Calyx cap or lobes distinct; fruit urceolate or campanulate

12. Calyx tube and cap c. 0.25 mm thick, cap splitting into 4 persistent lobes; fruit urceolate, the pericarp to 0.5 mm thick.

13. Blades subcoriaceous to coriaceous; calyx tessellate. (9) *P. galeata* (Korth.) Ridl. s.s.

13. Blades thick coriaceous; calyx umbonate to tuberculate. (10) *P. galeata* var. *elmeri* (Merr.) Maxw.

12. Calyx tube and cap c. 1.5 mm thick, cap falling off in one piece; fruit campanulate truncate, pericarp c. 1.5 mm thick. (7) *P. crassicalyx* Maxw.

11. Calyx cap not developed; fruit globose.

14. Inflorescence 7–75 mm long; petals white, blue, or purple. (5) *P. coerulescens* Jack


9. Scales umbonate, verrucose, or tuberculate near the margin.

15. Branchlets distinctly sinuate-winged. (15) *P. tessellata* (Stapf) Nayar

15. Branchlets cylindric.

16. Blades subcoriaceous to coriaceous; cap smooth or tuberculate.

17. Blades broadly rounded to cordate at base, 5-nerved; inflorescences mostly from behind the leaves; cap tessellate to tuberculate. (4) *P. cogniauxii* Nayar

17. Blades narrowed to rounded at base, 3-nerved; inflorescences mostly from leafy nodes; cap smooth.

18. Inflorescence glomerulate, primary axes c. 1 mm long; pedicels 1–2 mm long; calyx tube 3–4 mm long; petals thin; fruit urceolate; leaf blades to 5 x 3 cm, petiole 1.5–2.5 mm long. (16) *P. teysmanniana* (Cogn.) Nayar
18. Inflorescence umbellate, cymose, or of solitary flowers; primary axes and pedicels generally over 2 mm long; calyx tube 4–6 mm long; petals thick; fruit campanulate, truncate; blades at least 6.5 cm long, 3 cm wide; petiole 2–8 mm long.

19. Cap splitting into 4 lobes; primary and secondary inflorescence axes puberulous .................................................. (17) *P. tuberculata* (Korth.) Nayar

19. Cap falling off in one piece; primary and secondary axes glabrous.

20. Inflorescence axes 1.5–2 mm thick; mature calyx 6 mm long, 5 mm wide; leaf blades 6.5–21 cm long, 3–10 cm wide, drying light or dark brown beneath ................................................ (14) *P. rostrata* (Cogn.) Nayar

20. Inflorescence axes to 1 mm thick; mature calyx 4.5 x 4 mm; blades 4.5–6.5 cm long, 2.5–4 cm wide, usually drying greenish to yellowish beneath ................................................ (6) *P. coriacea* (Cogn.) Nayar


21. Cap tuberculate; blades drying brownish or olive-green; inflorescence axes glabrous. .................................................. (11) *P. gracilis* (Cogn.) Nayar

21. Cap smooth; blades drying blackish to brown; inflorescence axes pilose ............ .................................................. (17) *P. tuberculata* (Korth.) Nayar

LIST OF TAXA IN *PTERNANDRA*

4. *P. cogniauxii* Nayar — Borneo, endemic.
11. *P. gracilis* (Cogn.) Nayar — Borneo, endemic.
12. *P. hirtella* (Cogn.) Nayar — Sarawak, endemic.
14. *P. rostrata* (Cogn.) Nayar — Borneo and Sumatra; one collection from New Guinea.
15. *P. tessellata* ( Stapf) Nayar — Borneo, endemic.
17. *P. tuberculata* (Korth.) Nayar — W. Malaysia, Riouw Archipelago, Sumatra, Borneo, New Guinea.

1. *Pternandra angustifolia* Maxw., *sp. nov.*

_Rami cylindrici glabri, epidermide brunnescenti, deglubescenti; folia membranacea, glabra lanceolata acuminata, basi acuta, uninervia, nervis intramarginalibus tenuibus exceptis, lamina 55–75 mm longa, 12.5–20 mm lata, petiolis 1–2 mm longis. Inflores-
Maxwell: *Pterandra* (Melastomataceae)

scentia solitaria, axillaris, reducta uniflora, glabra, axi primario c. 5 mm longo, nodis 2, pedicello c. 1 mm longo, calycis tubus echinatus glaber c. 4 mm longus; calyptra mammiformis laevis glabra tenuis apice acuminatus, minutissime 2–4-dentato. Fructus ignotus.

Type: SARAWAK: Gunung Santubong, hillside, heath forest, alt. c. 200 m, *Haron 21444* (L, holotype; isotypes in A, K, BO, KEP, MEL, and SING). Fig. 2.

Small tree. Upper branchlets cylindric, smooth, glabrous, c. 1 mm thick, epidermis drying brown and peeling off leaving a smooth, tan coloured surface on older branchlets and branches. Blades subcoriaceous, glabrous, lanceolate, acuminate at the tip (acumen 1–1.5 cm long), narrowed at the base; uninerved, midnerve sunken above, raised and tapering below; intramarginal nerves faint, 1–2 mm from the margin and merging with it in the upper part of the blade; secondary venation pinnate, c. 10–20 pairs, obscure above, obscure to invisible below; 5.5–7.5 cm long, 1.25–2 cm wide, drying grey-green above, brown below. Petioles 1–2 mm long, c. 1 mm thick, glabrous. Inflorescences of solitary flowers from leafy nodes, axes slightly flattened, glabrous. Bracts and bracteoles lanceolate, acute, c. 1 mm long, glabrous. Primary axes c. 5 mm long, with two nodes, c. 0.5 mm thick at the base, pedicels c. 1 mm long. Calyx tube campanulate, densely covered with glabrous, entire, echinate appendages with are shortest near the pedicel (c. 1 mm) and longest (c. 2 mm) near the margin, c. 4 mm long, 4 mm wide, pale green with a magenta hue near the base, drying brown; calyx cap mammiform, acute and 2–4 apiculate at the tip, smooth, thin, glabrous, 4–5 mm long, dehiscence unknown but probably splitting into several pieces. Bud petal imbricating to the right, broadly ovate, acute at the tip, truncate at the base, thickened with thinner margins, venation invisible, c. 3.5 x 3.5 mm. Filaments c. 1 mm long; anthers c. 2 mm long. Stigma in bud cylindric, 4-grooved, c. 1 mm long; style c. 5 mm long, glabrous. Fruit not seen.

*Pterandra angustifolia* Maxw. is readily distinguished from all other species of *Pterandra* by its small, narrow blades which have a prominent midrib and two faint intramarginal nerves. All other species of *Pterandra* have 3 or 5 nerves in addition to a pair of intramarginal ones. The echinate calyx tube and smooth cap strongly resemble *P. echinata* Jack; however the latter species is easily recognized by its thin, 3-nerved, pilose blades; large bracts, and pilose, angled branchlets.

I have chosen the epithet *angustifolia* so that the most obvious distinguishing feature of this species is indicated. *P. angustifolia* is in no way related to *Kibessia angustifolia* Bl. which is probably the same as *P. echinata* Jack (q.v.). Fortunately Nayar, in his relentless pursuit of botanical fame, overlooked a possible recombination of *K. angustifolia* to *Pterandra* in his recent uncritical paper (Bull. Bot. Surv. India 17 (1978) 51). Fortunately, this oversight is insignificant when one considers all the confusion that Nayar has created in his infuriating and inept meddling in the Melastomataceae.

Fig. 2. A: calyx; B: bud petal; C: stamen.

Distribution:

**Borneo**

* Sarawak — Gunung Santubong: Haron 21444 (holotype L, isotypes: K, SING, SAN, A, BO, KEP, MEL) on a hillside of a heath forest at an altitude of c. 200 m.
Fig. 2. *Pterandra angustifolia* Maxw. A-C: Haron 21444 (holotype).

var. *azurea*.

Tree up to 30 m tall with a diameter up to 75 cm, often shrubby. Bark finely fissured, soft, c. 0.5 mm thick, flaking and peeling off in strips 1–3 cm wide, brown; inner bark brown to light yellowish, 2 mm thick; wood yellowish. Branchlets 4-angled, minutely puberulous, glabrescent, brown-blackish when dry, peeling and cracking with a sinuate-alate appearance, rapidly falling off leaving a cylindric, smooth branch drying grey-tan, 1–2 mm thick, nodes flattened. Blades chartaceous to subcoriaceous; lanceolate, elliptic, or ovate; acuminate at the tip (acumen up to 1.5 cm long), narrowed and slightly decurrent at the base; immature blades minutely puberulous, especially below, becoming glabrous, glabrous above; prominently 3-nerved from the base, nerves sunken above, prominently raised and tapering below, lateral nerves slightly thinner, minutely puberulous near the base below, glabrescent; intramarginal nerve faint, c. 1 mm from the margin; secondary venation pinnate from each of the 3 main nerves, c. 20–30 pairs from each, slightly raised below; 6.5–15 cm long, 3–6 cm wide, drying dark brown or olive-brown above, lighter brown below. Petioles flattened, 2–4 mm long, 1.5–2 mm wide, at first minutely puberulous, later glabrescent. Inflorescences from leafy nodes, frequently terminal; flowers solitary or in 3-flowered cymes; axes 4-angled, minutely puberulous, glabrescent, 10–30 mm long. Bracts lanceolate, acute, 1–1.5 mm long, minutely puberulous. Primary axes 5–20 mm long with 1 or 2 nodes, c. 1 mm thick; secondary axes not developed (solitary flowers) or up to 8 mm long; pedicels 3–6 mm long, slightly longer and thicker in fruit. Calyx tube campanulate, densely covered with minutely puberulous bristles, which are often curved or hooked, simple or branched, or with flattened, triangular, mostly barbed scales which are shorter near the pedicel and longer and usually more barbed near the margin; bristles and scales often mixed together, longest ones 4 mm long and 1 mm wide at the base; scales and bristles not or obscurely barbed in bud; margin truncate, thickened, at maturity 8–10 mm long, 8 mm wide, minutely puberulous throughout, glabrous with 16 internal lines; calyx cap conical, acute, c. 5 mm long, distinctly tuberculed or with slender, frequently curved, spines near the middle, minutely puberulous throughout, falling off as a unit, pale green. Petals slightly thickened, broadly ovate to suborbicular, obtuse to acute at the tip, broadly narrowed and truncate at the base, margins thinner, c. 5 mm long, 5 mm wide, glabrous, pale pink, blueish-pink, or dark blueish. Filaments flattened, c. 5 mm long; anthers c. 2 mm long. Stigma cylindrical, at first 4-grooved, later 4-lobed, 2.5–3 mm long. Style slender, 6–8 mm long, glabrous.
Fruit campanulate, truncate, bristles and/or scales frequently slightly more developed, internal lines distinct, style often persisting; 8–10 mm long, 9–12 mm wide, minutely puberulous externally; areolus glabrous; exocarp green then pale yellow, turning red, and finally purplish when ripe; pericarp c. 1 mm thick, gritty. Seeds numerous, flattened, rhombic-rectangular, glossy tan-khaki, c. 0.75 mm long.

Vernacular: siri siri (Tawau District, Sabah), siren siren (Tambunan District, Sabah), polok (Iban); Java (Soend.): ipis koelit, ki boeroej, ki djambe, ki djeboeg.

Pternandra azurea (Bl.) Burk. var. azurea is easily distinguished from all other taxa of Pternandra by the usually barbed calyx scales and acute blade bases. P. azurea var. cordata (Korth.) Maxw. has more persistent, sinuate-aleate wings on the branches and cordate blades; and P. echinata. Jack has thinner, pilose blades and branches, entire calyx scales, and lacks tubercles on the calyx cap.

The two type specimens of K. simplex (Korthals s.n., from Borneo) at Leiden are, unfortunately, in poor condition with only one small bud remaining on one sheet, while the other collection is vegetative. Miquel, in his original description of this species, merely included a few words about the leaves and that the calyx has simple setae with a sub-nude cap. The bud specimen of the type collection is very immature and has simple bristles. The branches, blades, and inflorescences of this collection of P. simplex match those of the type specimens of P. azurea. In fact, I have not been able to distinguish the two species vegetatively. P. azurea, according to Blume, has branched bristles on the calyx and it is fortunate that the types of this species at Leiden are well preserved, since I have been able to get a good idea about these two species. Blume notes for K. simplex that the bristles are rarely branched. In addition to the numerous collections examined by Bakhuizen f. at Leiden plus the many other newer collections of this species at Leiden, I have been able to see that these two species are the same.

Included among the specimens of this species that I have studied, the bristles on calyx range from almost all being entire, entire below and branched near the margin, and nearly all branched. The appendages range from setose to linear and in a few collections the scales are flattened and triangular. There is also individual variation in the degree of branching and in many specimens this appears to be a factor related to the maturity of the flowers. Examples of some collections with almost entirely simple, setose appendages include: Nahar 12700 and Luang 22383 (both from Sarawak) and Cockburn & Saikeh 70033 (from Sabah). Some collections with branched bristles near the margin are: Kostermans 7039, and Nooteboom & Chai (from Borneo); the latter collection also has some calyx specimens that are all simple, thus there is variation in the nature of the bristles even on the same plant. Finally, some collections with flattened, branched scales include: Winkel 1415 (from Java), DeVries 107 (from Sumatra); with Clemens 21565, and Luang 21874 (both from Sarawak).

Transitional situations are common where there are simple and branched scales, therefore there is nothing substantial that can be used to distinguish the two species on all herbarium sheets. The petals and anthers from the few collections with mature flowers that I have seen are the same, regardless of the nature of the calyx appendages. More evidence lies in the development of the calyx bud which always appears to have simple bristles when young. Maturity of the flowers also involves the development of the bristles or scales, with the fruit having the most distinct appendages. Two sheets, Clemens 29367 (Sabah), and Paie 28437 (Sarawak) have buds identical to the one on the type specimen of K. simplex and also include more mature buds with immature and mature fruit that
have distinctly branched, and a few flattened, appendages. These more mature flowers and fruits are identical to those on the type collections of *P. azurea*.

There is good reason to consider *K. simplex* as a synonym of *P. azurea* since not only is the former species poorly defined, but it is extremely difficult to distinguish from the latter. With the numerous variant intermediates, including Elmer 21310 (Sabah) — type of *K. acuminatissima* Merr. — which has fruits covered with simple bristles except near the margin where they are more flattened and branched; it is clear that *P. azurea* is variable in the calyx ornamentation and that this factor cannot be determined unless mature flowers and fruits are available.

King considered *Kibessia simplex* Korth. as a synonym of *P. echinata* Jack, however the two taxa are easily distinguished by the calyx appendages and the absence of spines on the cap of *P. echinata*.

*Kibessia azurea* (Bl.) DC. var. *subalata* (Bl.) Miq. is clearly the same as *P. azurea* and does not merit distinction as a separate taxon. The holotype of this variety (Korthals s.n., from Sumatra) does indeed have winged branches which appear sinuate-alate due to the peeling off of the epidermis. Beccari 688 (from Sumatra) shows all stages of peeling from a smooth, cracked, sinuate-alate, to completely lost epidermis. The branches with the epidermis lost are cylindric and are identical to those branches on the type collections of *K. simplex* and *P. azurea*, plus most of the other collections of these two species at Singapore and Leiden which have already lost their epidermis.

The calyx bristles in these specimens with an intact or peeling epidermis are almost all entire (e.g. Lampangi 24078, Gibot 31294, and Brand 24547 (all from Borneo); to flattened and branched (e.g. the holotype of the variety), Beccari 688, and Paiie 28331 (from Sarawak). This not only shows that var. *subalata* is based on an inconsistent characteristic, but also that these bristles are found on specimens that could be referred to both *K. simplex* and *K. azurea*.

Waitez s.n., from Gunong Rantau, Kalimantan, the holotype of *Kibessia simplex* Korth. var. *oblunga* Bl., has an abnormal inflorescence without flowers or fruits. From the branches and leaves I think that the specimen is more like *P. azurea* rather than *P. coerulescens* Jack as Bakhuizen f. indicates.

Nayar (1978), in an entirely cursory attempt to change as many taxa of *Kibessia* to *Pternandra* as possible, renamed *Kibessia simplex* Korth. as *Pternandra borneaensis* Nayar. Nayar obviously never examined any authentic material of *K. simplex* Korth. otherwise he might not have renamed this taxon since it is the same as *P. azurea* var. *azurea*. *Pternandra simplex* (Korth.) Baill., which Nayar assumed was a distinct taxon, is not based on *Kibessia simplex* Korth. Nayar of course, did not comment on *P. simplex* (Korth.) Baill. since this would have required more than a superficial attempt at taxonomic research which he apparently prefers to conscientiously avoid.

Baillon’s (1880) illustrations of *Pternandra simplex* (Korth.) Baill. are certainly not based on *Kibessia simplex* Korth. since the diagrams show the calyx with a tessellate and smooth pattern, not bristly as in *P. azurea*. The figures (37 and 38) are referable to *P. rostrata* (Cogn.) Nayar, the most likely choice, or *P. tessellata* (Stapf) Nayar. The combination *Pternandra simplex* (Korth.) Baill. is a valid recombination, thus Nayar’s *Pternandra borneaensis* Nayar is a superfluous name.
Distribution:

**Lingga Archipelago**

**Pulau Lingga** — Pasir Pandjang: Bunnemeyer 6900.

**Sumatra**

Asahan — Loemban Ria: Boeia 7985.

Benkoelen — de Voogd 1143; Mt. Singlang: Schiffner 2309.

**Borneo. Sabah** — Anap, Bukit Mersing: Sibat 21874, 22383; Bombari: Gibot 18595; Dallas: Clemens 29367, 30350; Merotai Besar: Gibot 31294, 31310; Mt. Kinabalu: Chew, Corner, Stainton 7; Sipitang, Ulu Moyah: Wood 16663; Tawao: Elmer 21310 (*Kibessia acuminatissima* Merr., isotype L); Ulu Sg. Kinabatangan: Gibot 32947; Ulu Sungai Serudong: Aban 31163; Tenom-Kamabong-Katabu Track: Cockburn & Saikeh 70033; Tambunan, Trusmadi For. Res.: Mikil 31450; Ulu Sungai Danum: Cockburn 85032; 


**Kalimantan** — Amai Ambil: Hallier 3113; Balikapapan (Gunong Beratus): Kostermans 7507; Gunong Rantau: Waitz sn (*Kibessia simplex* Korth. var. oblonga Bl., holotype L); Gunong Sahasi, Belajan River: Forman 428; Gunong Sakoeambang: Korthals sn (*Kibessia simplex* Korth., holotype L); Gunong Singgalang: Korthals sn (*Kibessia azurea* Bl. var subalata (Bl.) Miq., holotype L); W. Koetai, Kombeng: Endert 5192; Kutei: Kostermans 5535; near L. Petah: Endert 3195; near Mt. Kemul: Endert 3622; Mangapu, Singkulirang: Walsh 715; Mt. Kenepai: Hallier 1763; Nunukan Island: Kostermans 9043; Miejer 2252, Paymans 7; Tanjong Bangko: Kostermans 7039; exact location unknown: Winkler 2321.

**Java** — Djakarta, Batavia-Bantam: van Steenis 11193; Batavia, Gunong Paniisan: van Steenis 2328; Gunong Pangerango: Blume sn (*Kibessia azurea* Bl., holotype L); Leugkong District: Kostermans 23820; Mt. Salak: Hochreutiner 761 (*Kibessia azurea* Bl. var. typica Hochr., L); Palak: Danser 2481.

Tree 2–10 m tall, diameter up to 12 cm, or a shrub; outer bark smooth, grey-brown, wood light yellow. Branchlets distinctly 4-angled and typically undulate winged, minutely puberulous, 1.5–2 mm thick; epidermis brown, peeling and flaking off leaving irregular and scattered remnants of the angles and wings; older branches without the epidermis, smooth, cylindric, glabrous, drying greyish to khaki-tan. Blades chartaceous to subcoriaceous, lanceolate, elliptic, to ovate; acuminate at the tip (acumen 1–1.5 cm long), broadly rounded and shallowly (1–2 mm) cordate at the base; 3- nerves from the base, nerves sunken above, raised and tapering below; intramarginal nerves thin, c. 1 mm from the margin; secondary venation pinnate from each of the 3 main nerves, c. 30–40 pairs, slightly raised below; glabrous above, minutely puberulous on the nerves below; green above, pale green below; drying olive-green to dark brown above, lighter brown below; 7–12 cm long, 3–6 cm wide. Petioles c. 2 mm long, flattened, blades appearing sessile, minutely puberulous, c. 1.5 mm thick. Flowers solitary from leafy nodes or in a terminal 3-flowered umbel; axes 4 -angled, minutely puberulous, c. 1 mm thick; bracts lanceolate, acute at the tip, c. 1.5 mm long, minutely puberulous; primary axes 5–8 mm long with usually 1 node, secondary axes not developed or up to 5 mm long, pedicels 5–8 mm long. Calyx tube campanulate, densely covered with setose to flattened bristles which are shorter and simple or barbed in the lower half, longest (2–3 mm) and branched near the margin, minutely puberulous; 6 mm long, 5 mm wide, green; calyx cap conical, acute, with 1 or several whorls of simple, barbed, or branched appendages, minutely puberulous, falling off in one piece, c. 5 mm long. Petals slightly thickened, broadly ovate to suborbicular, acute and often mucronate at the tip, broadly narrowed at the base, c. 7–8 mm long, 8–9 mm wide, purple or lilac. Filaments flattened, c. 2 mm long, yellow; anthers with a thickened bulge on the connective near the filament; stigma cylindric, slightly twisted to the right, 4-grooved and later 4- lobed, c. 2 mm long, yellow. Style slender, c. 6 mm long. Fruits campanulate, truncate, scales persisting, c. 8 mm long, 10 mm wide; areolus glabrous, internal lines distinct; pericarp c. 1 mm thick, gritty. Seeds numerous, cuneate-quadrangular, flattened, c. 1 mm long, glossy khaki-tan.

In general, the distinction between var. *cordata* and var. *azurea* is distinct viz. the former has rounded to cordate blades, shorter petioles, and branchlets with more persistent epidermal remnants in a sinuate-alate form. Ultimately, however, the epidermis falls off leaving a smooth, greyish to khaki-tan surface common to both taxa.

As far as I can determine from the limited number of mature flowers available; the petals, anthers, stigma, and fruits of var. *cordata* are the same as those of var. *azurea*. There is less variation in the shape of the calyx appendages in var. *cordata* than in var. *azurea*, and in young buds of several specimens of var. *cordata* (e.g. Boeaa 9363, de Wilde & de Wilde-Duyffjes 12829 (both from Sumatra), and Korthals s.n. (from Java)) are indistinguishable from those on the type collections of *K. simplex* and *P. azurea*. The branching of the scales occurs with the development of the flowers, and after flowering and with mature fruit these appendages are readily observed.

There are some specimens, e.g. Reinwardt s.n., and Bunnemeyer 3443 (both from Sumatra) that have some blades rounded or slightly cordate at the base and others that are narrowed. Bakhuizen f. identified both of these collections as *K. cordata*, however a distinction between the two taxa here is difficult to determine. The petioles in both specimens are short, thus I tend to agree with Bakhuizen f. in his identifications.

Var. *cordata* is structurally very close to *P. hirtella* (Cogn.) Nayar which has acute blade bases, cylindric to somewhat angled (not winged) branches, and is covered with a reddish-brown tomentum. Vegetatively var. *cordata* is very similar to *P. tessellata* (Stapf)
Fig. 3. *Pterandra azurea* (B1.) Burk. var. azurea - A: Endert 3195; B: Luang 21736; C, D, E: Mikil 31450; F, G: Luang 22383; H: Luang 21874; I: Kostermans 9043; J: Ashton 19923.
Fig. 4. *Pternandra azurea* (Bl.) Burk. var. *cordata* (Korth.) Maxw. - A-D: de Wilde & de Wilde-Duyfjes 12829; E, F: Batten-Pooll sn (Sobiga, Sumatra).
Plate 1. *Pternandra azurea* (Bl.) Burk. var. *cordata* (Korth.) Maxw. This is the holotype of *Kibessia tetraperta* Miq. which Bakhuizen f. reduced to a synonym of *Kibessia cordata* Korth. in 1943. *K. cordata* was recombined by Baillon in 1880 as *Pternandra cordata* (Korth.) Baill. and has been given varietal status in this revision. Photo: Rijksherbarium, Leiden.
Nayar which has tessellate or tuberculate calyx scales. The winged branches and cordate blades of both taxa are quite similar, however the intramarginal nerve in the latter species is usually more prominent and often the venation appears to be 5-nerved. Furthermore, the calyx cap in *P. tessellata* is smooth or has minute tubercles and the blades are usually glabrous below.

Fig. 4. A, B: calyx; C: mature petal; D, E: stamens; F: stigma.

Plate 1. Holotype of *Kibessia tetraptera* Miq.

Distribution: (specimens examined in addition to those cited by Bakhuizen f., 1943 and 1943–45, p. 317)

**Simatua** Aek Moente, Asahan: Boeea 9363; Gunung Leuser: de Wilde & de Wilde-Duyfjes 12829; Gunung Malintang: Korthals sn (holotype U); Kapoeas: Teysmann 8655; Loemban Ria, Asahan: Boeea 7604; Pajakumbua: Meijer & Vermeulen 5401; Palembang: Dumas 1576; Pargam Biran, Asahan: Boeea 5739; Siberut Island: Boden-Kloss 14558; near Sobaiaga: Batten-Pool sn; Taram: Meijer 6716, 6799; Tapanoeli: Opper Angkola: Junghuhn sn (*Kibessia tetraptera* Miq., holotype U, isotype L); W. Indragiri: Meijer 4311.

**Borneo Sarawant** — Bergark: Haviland 107; Penkulu: Haviland 173.

**Kalimantan** — Gunong Kenepai: Hallier 1601.


Shrub (epiphytic or hanging) up to 5 m tall, diameter up to 4.5 cm, or a tree up to 5 m tall with a diameter of up to 7 cm. Bark c. 0.25 mm thick, grey to light brown; inner bark c. 0.5 mm thick, white; branching nearly down to the base of the plant. Branchlets somewhat flattened and grooved on two faces below the upper node, becoming cylindric below, glabrous, c. 2–2.5 mm thick; epidermis brownish, flaking off and leaving a smooth, greyish surface. Blades subcoriaceous, glabrous, narrowly to broadly ovate, acuminate at the tip (acumen 1–1.5 cm long), broadly rounded and usually shallowly (2–5 mm) cordate at the base; distinctly 5-nerved from the base, nerves sunken above, prominently raised and tapering below, lateral nerves less prominent than the mid-vein, the two peripheral veins merging with margin in the upper 1/4 of the blade; intramarginal nerves thin, c. 1 mm from and merging with the margin in the lower 1/3 of the blade; secondary venation pinnate from all 5 main veins, c. 20–30 pairs, distinct above, slightly raised below, anastomosing and reticulate; drying brownish with an olive hue above, brown below; 14–20 cm long, 5.5–10 (12) cm wide near the base. Petioles flat-
tended, glabrous, 1.5–3 mm long, 3–4 (6) mm wide. Inflorescences mostly from behind the leaves, often on branches up to 1.5 cm thick, or in the axils of the lowest leaves, glabrous, solitary or fascicled often on raised tubercles; axes cylindric, smooth, c. 0.75 mm thick. Bracts lanceolate to ovate, acute, c. 1–1.5 mm long. Primary axes 1–7, with one or less commonly two nodes, 2–3 mm long, elongating 1 or 2 mm in fruit; pedicels 1–3 mm long, elongating to 5 mm in fruit. Calyx tube campanulate-cyathiform, glabrous, c. 4.5 cm high, 3–4 mm wide, densely covered with tuberculate scales which are thicker near the margin, red; glabrous inside with 16 fine vertical lines; cap dome-shaped, splitting into 4 thin, broadly triangular, persistent lobes, each 5 mm long, 3.5 mm wide, covered with thick tubercles externally, smooth inside, reflexed at maturity. Petals (ex Cogniaux and Bakh. f.) obovate, obtuse, 3–3.5 mm long, 2.5 mm wide, pink, white, or whitish-purple. Filaments flattened, 2.5–3 mm long, whitish; anthers hatchet-shaped, inappandicate, 2.5 mm long, 1 mm wide, yellow. Stigma 4-lobed, c. 1 mm long, whitish-purple. Style slender, 7–9 mm long, glabrous, often persisting in fruit, white. Fruits urceolate, nearly smooth or sparsely tuberculate near the base, scales elongate, diamond-shaped, not or slightly umbonate, more tessellate near the rim and neck, 7–8 mm long, 7–8 mm wide, glabrous, pinkish-red, maroonish, and finally purplish when ripe; areolus 4–5 mm wide, smooth or with several faint lines, and glabrous inside; calyx lobes persisting; pericarp c. 0.5 mm thick. Seeds numerous, flattened, rhombic-cuneate, quadrangular, c. 0.75 mm long, glossy light brown.

Habitat: primary forests, secondary scrub.

Vernacular: puloh (Iban), timbers burung (Banjar-Malay) seri seri (Utan), pura saie (Bidayuh).

_Pternandra cogniauxii_ Nayar is easily distinguished from all other taxa of _Pternandra_ by its relatively large, 5-nerved, cordate blades; solitary or fascicled flowers from behind the leaves; and the urceolate fruit with a nearly smooth or slightly umbonate pattern and persistent, tuberculate calyx lobes. The fruit resembles that of _P. galeata_ (Korth.) Ridl. in basic shape, however the scales in _P. galeata_ are tessellate throughout, while in _P. cogniauxii_ the pattern is more raised; also the calyx lobes in _P. galeata_ are smooth on both sides.

Bakhuizen f. notes that _Kibessia elmeri_ Merr. is similar to this species, however his opinion seems to be based entirely on Merrill's comment at the end of the original description. This species, in my opinion, is _P. galeata_ var. _elmeri_ (Merr.) Maxw.

Due to confusion on the part of previous authors, it has been necessary to establish a new name for this species. The original name, _Ewyckia cordata_ Korth. (described from material collected by Korthals, s.n., in Borneo, and maintained in the Lieden collection) cannot be used because it is a later homonym of _K. cordata_ Korth. (now _P. azorea_ (Bl.) Burk. var. _cordata_ (Korth.) Maxw.). Cogniaux, realizing this, changed the name to _K. korthalsiana_ Cogn. Unfortunately, _P. korthalsiana_ (Miq.) Triana (based on _Ewyckia korthalsiana_ Miq. (Fl. Ind. Bat. Suppl. I (1860) 321) is not a proper name for this species since, in my opinion, it is the same as _P. tuberculata_ (Korth.) Nayar (specifically _P. griffithii_ King). Cogniaux and Bakhuizen f. both placed it under _P. coerulescens_ Jack. In any case, the epithet _korthalsiana_ cannot be used for any other species of _Pternandra_ since _P. korthalsiana_ was validly published by Triana, even though it is a completely different species from _K. korthalsiana_ Cogn. The epithet _cogniauxii_ was selected in an effort to clear the confusion and misunderstanding in this literature and various herbaria concerning this species. _P. cogniauxii_ Nayar, as far as I can determine, is endemic to Borneo. This species has been named in honour of Celestin Alfred Cogniaux (1841...
Fig. 5. *Pternandra cogniauxii* Nayar - A, D: Haviland (=174)B; B, C: Mamit 33396.
1916), a French botanist, who published a comprehensive monograph on the Melastomataceae in 1891.

Fig. 5. A: calyx with calyptra; B: calyx with split calyptra; C: stamen; D: fruit.

Distribution:

**Borneo. Sabah** — Beaufort: Cuadra 1363; Mt. Dulit: Richards 2562; Mt. Kinabalu: Clemens 26355, 26873.

**Sarawak** — Bau: Purseglove 4457; Bukit Temudok, Simanggang: Anderson T29; Kampong Sadir: Mamit 33396; Kota For. Res.: Chai & Paie 31104; Penkalan Ampat: Haviland sn in 1889; Rajang River, Kapit: Jacobs 5457; Statut, Padawan: Mamit 29829; Ulu Dapoi, Tinjar: Paie 23054; exact location unknown: Haviland (=174) B.

**Kalimantan** — Gunong Rantau: Korthals sn (Ewyckia cordata Korth., holotype L); Ingaran: Nooteboom 1328; W. Koetai: Endert 2659, 2931, 4970; Mentawir, Balikpapan: Sauvour K5, 133; Mt. Rikai: Hallier 1308; Mt. Trusmadi: Nooteboom 1474; Tarakan: Meijer 2537; exact location unknown: Korthals sn (L).


Tree up to 20 m tall with a diameter up to 90 cm; less frequently a shrub up to 5 m tall. Bark grey, greyish-red, brown, smooth, finely fissured, thin; slash inner bark fibrous,
light brown, very thin; cambium white; sapwood cream to yellow, very hard. Branchlets cylindric, smooth 1–2 mm thick, brown to blackish when dry; epidermis peeling off of older branches, leaving a smooth brown surface. Blades extremely variable in texture, size, and shape; chartaceous, subcoriaceous, to coriaceous; lanceolate and acute at both ends; elliptic to ovate, acute or obtuse at the tip and narrowed or rounded at the base; or very broadly ovate to suborbicular with acute tips and in most specimens of this sort slightly narrowed to rounded at the base; 3-nerved from the base, nerves sunken above, raised and tapering to the tip below; intramarginal nerves thinner, 1–6 mm from the margin, arching to the tip; secondary venation pinnate from each of the 3 main nerves, obscure to prominent, anastomosing and reticulate; smallest blades 5–8 cm long, 2–3 cm wide; largest ones 18–25 cm long, 11–15 cm wide; dark green above, green to yellow-green below; drying dark brown to blackish or sometimes olive green above, brown to khaki-green below; entirely glabrous. Petioles flattened, 5–10 mm long, 1–3 mm wide, glabrous. Inflorescences extremely variable in size and branching; glomerulate, cymose, to paniculate; c. 7 mm to 7.5 cm long, glabrous, few to many-flowered; a.es flattened with a groove on each narrow side, green; primary axes 1–3, mostly from leaf axils or on swollen leafless nodes (common in specimens with large, coriaceous blades), 0.75–2.0 mm wide at the base, c. 1 mm – 6 cm long with 1–5 nodes, each primary, etc. node subtended by a pair of ovate, acute, and often slightly keeled connate bracts, 0.5–1 mm long, persistent; smooth or with a reticulate pattern of flattened or slightly raised polygonal plates in a tessellate pattern; secondary axes not developed or up to 2.5 cm long, tertiary axes none or up to 7 mm long, 4th axes not developed or up to 4 mm long, pedicels 1–4 mm long, solitary on the tips of each ultimate ramification. Calyx campanulate, tube with a tessellate, less frequently umbonate to somewhat tuberculate pattern; truncate or with 4 minute cusps on the margin; smooth internally and without lines or ridges; 2.5–4 mm long, 3–3.5 mm wide; green, drying brown to black. Petal buds conical, lobes imbricating to the right, c. 3 mm long; mature petals thick with thinner margins, broadly ovate to suborbicular, acute to mucronate at the tip, rounded or slightly clawed at the base, reflexed at maturity, 2–6 mm long, 2–4 mm wide; white, lilac, or blue; margins white to purple. Filaments flattened, 2–4 mm long, often flexed or curved at maturity, violet; anthers inflexed in bud, then elevating with their dorsal surfaces at 90° to the filament, thus forming a flat topped ring about the style, finally becoming erect (180° to the filament) with the locules facing the style, c. 2–3 mm long, c. 1 mm wide, yellow or violet. Stigma clavate-cylindric, c. 1 mm long, yellow. Style slender, straight, 4–7 mm long; fruiting axes often elongating a few mm and becoming thicker. Fruits subglobose (slightly wider than long, and when immature appearing somewhat urceolate) or globose, 4–6 mm diameter, capped by the thinner margin of the calyx, areolus 2–3 mm wide, style often persisting; exocarp in immature fruit tessellate, becoming obscured or nearly smooth with maturity; green or yellow-green then purple when ripe, drying black; pericarp c. 0.25 mm thick. Seeds numerous, flattened rectangular-square, c. 1 mm long, 0.5 mm wide, glossy tan.

*Pterandra coerulescens* Jack is easily distinguished from all other species of *Pterandra* by the truncate calyx (no calyx cap), tessellate pattern on the calyx tube and fruit, and subglobose to globose fruits. *P. multiflora* Cogn. has similar flora features, but has a much larger inflorescences and yellow petals. *P. coerulescens* is often confused with *P. galeata* (Korth.) Ridl., however the latter species has a calyx cap which splits into 4 persistent calyx lobes and urceolate fruit.

Vernacular: cursed shade, lidah katak, sial menahun, pakot bonnot paya, sial menan, nipsis kulit, kayu kuku bami (Malacca), mempoyang (Selangor); sireh sireh (Borneo Malay), puloh (Iban), kalombayng (Dusun), sari sari (Brunei), dulang dulang (Kedayan), ubah meskalak (Sarawak); memeteng (Sumatra); New Guinea: mereiie (Arfak), merie (Sidei).
Delimiting the range of variation of this species has never satisfied many botanists, thus numerous species and varieties have been described as being distinct from Jack's original description. For the Malay Peninsula King includes four varieties (including the typical variety), while Ridley considered all four of them as distinct species. Bakhuizen f. lists all of these taxa under three varieties (including the typical variety) of *P. coerulescens*.

King notes that the species is very variable and that some specimens are intermediate between varieties. From the large collection of *P. coerulescens* in the Singapore and Leiden herbaria it is quite obvious that the variation in the size of the leaves, length of the inflorescences, and number of flowers confirms King’s observation. The variation is so complex, and in many collections impossible to delimit, that I have decided to include all related taxa as synonyms of *P. coerulescens*; thereby giving the species an extremely wide range of variation in the leaves and inflorescence. This idea is completely justified by the gradation of these variable characteristics in specimens from Thailand to New Guinea. It is also necessary to note that none of these taxa are based on any structural features and that the flowers and fruits of all the specimens examined are essentially the same.

*Pternandra coerulescens* Jack var. *jackiana* (Walp.) Cl. has short cymes (primary axes 5—10 mm) with few flowers. Sessile or shortly peduncled (3 mm) inflorescences with larger leaves (11—25 cm long, 9—15 cm wide) have been separated as var. capitellata (Jack) King. Finally, specimens with a large, branching, many-flowered inflorescence with many rudimentary leaves have been designated as var. *paniculata* (Miq.) King. This variety is based on a specimen which has an abnormal (witches broom) inflorescence. While there are many specimens in the Singapore and Leiden collections which can be definitely placed in one of these varieties, there are many other collections which include characteristics of two varieties, or are intermediate between them.

For the specimens with large leaves (aff. var. *capitellata*) there is Moysey & Kiah 33638 which has a subsessile inflorescence (primary axes 1—2 mm with 2—3 flowers per axis); Sinclair 39635 has longer axes (5—10 mm) and more flowers (aff. var. *jackiana*); and Ridley s.n. (Province Wellesley, June 1890) has a larger inflorescence which can be considered as the typical variety (*sensu* Bakh. f.). From these three specimens it is clear that the size of the leaves cannot be correlated with the length of the inflorescence, *vice versa* and that var. *capitellata* includes characteristics shared by the original limits of the other varieties.

Another series linking these varieties includes Suppiah 14820, which has the axes ranging from 4—7 mm long; Murdoch 263, 8—20 mm, and T. & P. 76 (2676) with the axes 6—8 mm long. The leaves of all three of these collections are small (7—9 cm long, 3—4 cm wide), except with T. & P. 76 (2676) which also has large var. *capitellata*-like leaves.

Cantley 2948 and Ridley 2009b have the short var. *jackiana* kind of inflorescence, while with Haniff 367 the axes (in fruit) are c. 2 cm long – intermediate between var. *jackiana* and Ngadiman 34652 which could easily be included as the typical variety due to the relatively large inflorescence. The leaves of all four of these sheets are the same (6—9.5 cm long, 4—5 cm wide, and of similar texture). Finally, Kiah 37737 is few-flowered with the primary axes c. 1 mm long which contrasts remarkably with Kiah 32429 which has the large, branching inflorescence of the typical variety. The branches and leaves on these two sheets are identical.
The type collection of *Ewyckia cyanea* Bl. (Moluccas) at Leiden has relatively thin and narrow blades with short inflorescences. The type specimens of *E. latifolia* Bl. (Borneo) have slightly thicker and larger blades with identical inflorescences. It is quite obvious that the two taxa are the same. From the limited number of collections available, all the specimens of *P. coerulescens* s.s. from the Moluccas and Celebes have relatively thin, narrow *E. cyanea*-type blades. New Guinea has collections with both *E. cyanea* and *E. latifolia*-type leaves. This is also true in Borneo, Sumatra, the Malay Peninsula, and Thailand where both are common. In many collections the thicker blades of *E. latifolia* and short inflorescences are intermediate with those of what Bakhuizen f. considers the typical variety of *P. coerulescens*, i.e. the inflorescences are larger. Haviland (=2203)Y (Borneo), Singh 1079 (Johore, W. Malaysia), and Smitinand 5659 (SE. Thailand) are some examples which illustrate that var. *cyanea* (including *E. latifolia*) cannot always be distinguished from typical *P. coerulescens*.

*E. latifolia* Bl. var. *membranacea* Bl. (Borneo) has larger and thinner blades, but otherwise does not differ from *E. latifolia*. Var. *membranacea* is matched by specimens with both large and small blades, e.g. Amir 35638 (Sabah), which links it to *E. cyanea*.

The blades and small inflorescences of *E. latifolia* merge with the typical variety through Sanusi 5327 (Sarawak), and Mikil 37737 (Sabah) which are intermediate in the size of the inflorescences. The blades are of both the thin and thicker types.

The collections from Sumatra also show that there is much variation of *P. coerulescens* and that the numerous taxa that have been split from it can not always be distinguished or even properly defined. Soepadmo 134 links *E. latifolia* and *E. cyanea* with Torojes 3835, which has a long inflorescence; and Alston 14331, which has a short inflorescence. The variability of the leaves and inflorescences of the Sumatran material is the same as that for Borneo; thus there is considerable mixing of traits in many collections, while in others it is true that they match the various varieties that other authors have described.

The very large blades of *P. coerulescens* from the Malay Peninsula, which usually have a very short (var. *capitellata*) inflorescence, are not common in Borneo and I have not found any in the collections from the Celebes and New Guinea. These larger blades, as noted above, merge with smaller and thinner blades, which have small or large inflorescences and could be identified as var. *cyanea* or the typical variety.

Several collections, e.g. Hou 537 and 545, Paie 26926, and Brooke 10640 (all from Sarawak) have small, thick blades with indistinct secondary venation; and short inflorescences (var. *capitellata*) appear to be distinct from all other variants of *P. coerulescens*. These specimens can be linked to *E. latifolia* and the typical variety through other specimens with various combinations of thinner blades (Bunnemeyer 7504, from the Lingga Archipelago) or larger inflorescences (Soepadmo 134, Sumatra).

The gradation of the specimens from the Malay Peninsula and the Malay Archipelago is quite striking, and from the examples noted above there is no doubt in my mind that there is no solid basis for maintaining any of the taxa which have been split from *P. coerulescens*. I have attempted to sort all the specimens according to leaf shape and size and length of the inflorescence. As a result many groups include a bewildering assemblage of contrasting characteristics, i.e. the variation of the leaves and inflorescence is so mixed that it is virtually impossible to group many sheets beyond an individual basis.
As far as flowers are concerned there is some variation in the size and ornamentation of the calyx and length of the filaments; and shape of the petals; but the shape of the anthers and features of the stigma and style appear to be nearly the same. King notes that 3 or 4 anthers are imperfect, however in all of the flowers (including a liquid collection, Maxwell 77–23, from Singapore) dissected all 8 of the stamens are of the same shape and size.

The calyx in most specimens is ornamented with flat, smooth, tessellate plates. This feature does not correlate in any way with leaf or inflorescence characteristics. In some other specimens the ornamentation is of raised warts which appear umbonate or even slightly tuberculate; and again, specimens in the Singapore and Leiden collections with this type of pattern have variable leaf and inflorescence sizes. Symington & Kiah 28774 has a var. capitellata inflorescence and Maxwell 77–23 a larger one that could easily be considered as the typical variety; the blades in the former are rather thin and narrow (aff. E. cyanea), while in the latter they are coriaceous and considerably wider (typical variety). The calyx is umbonate-tuberculate in both specimens.

A smooth, tessellate pattern is found in Ridley s.n. (Province Wellesley, June 1890) and the specimen could easily be considered as being the typical variety; and with Moysey & Kiah 33638 (var. capitellata), both with large leaves, and in the small-leaved specimen collected by Suppiah (14820) which has a var. jackiana style inflorescence. Thus, the tessellate calyx pattern is common to specimens of all the varieties.

In general, however, many of the var. paniculata specimens have a warty or tuberculate pattern and these have been properly identified as P. tuberculata (Korth.) Nayar. In other specimens with the abnormal inflorescence the calyx pattern is tessellate (P. coerulescens). Sometimes the pattern is extremely variable and inconsistent, that is leaf, inflorescence, and calyx characteristics do not form a clear series in which correlation of these traits is possible. In at least one specimen, Henderson 10012, (inflorescence = var. capitellata) both the smooth and raised patterns are found.

One exceptional specimen, Derry 1159, has a tuberculate calyx very much resembling P. tuberculata, but the absence of a calyx cap and the anthers distinguish this as P. coerulescens. The inflorescence is rather large and, as far as this trait is concerned, is easily included as the typical variety. This particular specimen and several others were incorrectly annotated by Furtado (Herb. Sing.) as K. tuberculata since the tuberculate pattern of many is similar to this species. Dissection of flowers to examine the stamens and presence of a calyx cap is necessary in order to distinguish many of these specimens.

I do not agree with Bakhuizen f. in reducing Kibessia simplex Korth. var. oblonga Bl. to a synonym of P. coerulescens. The holotype of the variety (Teysmann s.n., from Borneo) lacks buds, but the leaves suggest close affinities with P. azurea (Bl.) Burk. and thin-bladed specimens of P. tuberculata.

Bakhuizen f. also reduced Kibessia angustifolia Bl. to a synonym of P. coerulescens. The holotype (Waitz s.n., from Borneo) is without flowers or fruits, but the angled branches; and thin, narrow leaves strongly resemble those of P. echinata Jack. These vegetative parts are, in contrast to the puberulous indumentum of P. echinata, entirely glabrous.

The holotype of Ewyckia paniculata Miq. at Utrecht (Teysmann s.n., from Bangka Island) has abnormal inflorescences in which the axes and bracts are larger than normal
and frequently with deformed buds. The holotype has some normal buds and these are identical to those of many typical specimens of *P. coerulescens* Jack. I am certain of this since the deformed buds lack calyx lobes or a calyx cap. Wallich cat. 4080, which Bentham named as *P. paniculata* Benth. ex Cl. also has abnormal inflorescences similar to those of *P. paniculata* (Miq.) Triana — the latter being reduced by Cogniaux to a synonym of the former, and both species to *P. coerulescens* Jack by Bakhuizen f. King considered *P. paniculata* Benth. ex Cl. as an abnormal form of *P. coerulescens* Jack. Ridley was of the opinion that *P. paniculata* Benth. ex Cl. is a form of *P. griffithii* King with a large, abnormal inflorescence. While the branches and leaves of the two respective type specimens are similar, the flowers do not match. The calyx tube of *P. griffithii* King is tuberculose and there is a distinct cap which splits into 4 lobes. In *P. paniculata* Benth. ex Cl. the calyx tube is tessellate and there is no cap. *P. griffithii* King is, therefore, not related to, while *P. paniculata* Benth. ex Cl. is identical to *P. coerulescens* Jack. *P. griffithii* King is, in my opinion, the same as *P. tuberculata* (Korth.) Nayar.

Furtado annotated several specimens in the Singapore collection as *Pterandra coerulescens* Jack var. *membranacea* (Bl.) Furt. with the added comment that the taxon is the same as var. *cyanea* (Bl.) Cogn. These specimens have the short var. *jackiana* inflorescence, however the blades range in texture from subcoriaceous (Ridley 12113) to coriaceous (Ridley 6217, 2009b). The leaves are all of the smaller (c. 8–12 cm long, 4–8 cm wide) size. As with all the other varieties described for *P. coerulescens*, var. *membranacea* (Bl.) Furt. is neither distinct nor constant and, therefore, should be combined with all other varieties of this species into a single taxon.

*Ewyckia cyanea* Bl. predates *E. latifolia* Bl. var. *membranacea* Bl. and along with the fact that Furtado's new combination was never published, and is therefore invalid, var. *membranacea* (Bl.) Furt. should be ignored.

*Ewyckia korthalsiana* Miq., which Cogniaux considered the same as *P. capitellata* and a synonym of var. *cyanea* by Bakhuizen f., is more closely related to *P. tuberculata* (Korth.) Nayar (specifically *P. griffithii* King). As the holotype of *E. korthalsiana* is without flowers or fruits, it is difficult to determine its exact relationship with *P. coerulescens* and *P. tuberculata*. Miquel's original description, however, indicates that the calyx is 4-dentate with an areolate-verruculose pattern. This is good evidence to support my belief that it is actually a synonym of *P. tuberculata*.

A specimen collected by Ledermann (s.n., from New Guinea) labeled *Memecylon oligoneuron* var. *maluense* Mansf. in the Singapore collection is definitely *P. coerulescens* Jack with a short inflorescence. Mansfield's short description of this variety fits the specimen quite well, thus I am assuming that this specimen represents the taxon even though I have not seen the type specimen (Ledermann 7007).

Fig. 6  A: inflorescence; B: flower bud; C: mature petal; D: stamen.

Plate 2. Holotype of *Ewyckia paniculata* Miq.

**Distribution:**

**Hainan** — Hung Mo Shan: Tsang & Fung 18034 (not seen, q.v. Merrill (1934) and Li (1944)).

**Thailand. Trat:** Chang Island: Klong Haat Sy Dang — Maxwell 74425, Klong Nayom — Kerr 6827, 6828A; Takum: Kerr 17869.

**Chumpon** — sine. coll. 46.
Fig. 6. *Pternandra coerulescens* Jack - A-D: Sinclair 39635.
**Surat Thani** — Kaw Pa-Ngan: Put 758; Langsuan, Tako: Put 1696; Nawng Wai: Kerr 12270; Tung Luang: Kerr 12510.

**Puket Island** — Haniff 367.

**Nakorn Sithammarat** — Ban Natawn: Kerr 15650; Ban Plien: Kerr 15654; Tung Song, Ban Pa Prek: Rabil 192.

**Satun** — Lakshnakara 346; Teratao Island: Kerr 14166.

**Songkla** — Hat Yai: Kerr 13538, Pradit 232; Natawee: Rabil 71, 91.

**Narathiwat** — Bacho: B. Sangkhachand 141; Kao Re Chow, Toh Moh: Lakshnakara 744; Nikomwang: Prayad 431.

**W. Malaysia Kedah** — Bukit Enggau: Everett 13752; Bukit Perak: Everett 13695; Bukit Sama Ganjah: Baba 21483; Bukit Selambau: Meh 8989; Gunong Bongau: Harun 17710; Gunong Jerai: Meh 9040, 10160; Inchong Estate: Spare 3806; Kedah Peak: Ridley sn, June 1893; Kochummen 16327, Stone, Mahmod, Sharif 8539; Langkawi Is.: Haniff 15527; Mukim Sik: Dolman 21512; Pantai Acheh: Symington 37382; Pantai Chichak: Meh 10182, Sungei Batu Asah: Ridley 15527; Sungei Rohan: Arshad 18029, Symington 20875; Ulu Muda For. Res.: Bray 11508; Ulu Tawar Res.: Meh 12569; sine loc.: Meh 21891.

**Wellesley** — Kriaui: Ridley 2009b, sn in June 1890; Nibong Tebal: Curtis 3470.

**Penang** — van Balgooy 2412; I. H. Burkill 382, 3303; Chelliah 98142; Corner sn at Balek Palu; Curtis 67, 879, sn at Government Hill; Muka Head: B. & K. Bremer 1770; Penang Hill: King sn on 22 Aug. 1879, Nur 1235, Patt sn, Ridty sn in Dec. 1895 and Jan. 1921, Selvaraj 99671, Shukor 104, Sidek 232, Sinclair 39033, H. Singh & Samsuri 196, Stone 6352; sine loc.: Wallich 4077 (neotype K), 4079, 4080, ? Wallich 3143; Shimizu et al. 12969, 13160; Flippance sn on 27 Oct. 1932.


**Kelantan** — Bukit Baka, Machang: Shah & Shukor 3192; Chabang Tongkat: Suppiah 10988; Kemahang: Whitmore 8884; Sungei Mering: Ng 5483; Sungei Perias: Whitmore 4109.

**Trengganu** — Bauk For. Res.: Chan 16878, Whitmore 3942; Kemaman, Ulu Bendoong: Corner 30026; Kemaman: Corner sn on 22 June 1932; Sekayu: Loh 13466, Shing 13553; Sungei Loh: Cockburn 10720, 10735; Sungei Pelong: Suppiah 14815, 14820; Ulu Brang: Moysey & Kiah 33638, 33834; Ulu Sungei Trengganu: Cockburn 8499, 10552; Kemaman, north of Sungei Ayam: Whitmore 20183.


Malacca — Batang: Derry 1159; Bukit Bruang: Derry 14; Chabau: Alvins 2249; Jus: Derry 15; Pengkalan Balak: Derry 31; Pulau Jarak: Seimund 78, 1142; Selandar For. Res.: I. H. Burkill 1356; Sungei Udang: Alvins 20, Holmberg 863; Tebong: I. H. Burkill 1334; sine loc.: Alvins 74, 648, 1151, 1284; Cuming 2316; Griffith 2273, sn; Maingay 801 (1212), 802 (1508).


Singapore — Baker sn on 4 Nov. 1917; Cantley 2948, sn; Corner sn in July 1933; Hultett 320; Jumali 4414; Kiah 37737; Maxwell 77–23, 77–138; Ngadiman 34652, 34683, 36487; Nur sn on 30 Sept. 1915; Ridley 279, 2004, 6217, sn on 10 Feb. 1898, sn in May 1905, sn in 1911; Sinclair 39635; Keng & Jumali 4043, Ahmad 1366, 1464, Hill 1135.

Riouw Archipelago — Neth. Ind. For.: Serv. 27671, 28613, 30001, 30029, 30089.

Lingga Archipelago — Bunnemeyer 7025.

Borneo Sabah — Bayong, Mempakul: Tandum 4117; Binoni, Papar: Mikil 37737; Bukit Kuku, Sandakan: Meijer 20560; Bukit Padang, Jesselton: Meijer 19942, Tikau 33732; Gunong Dajak: Aet 200; Hindian For. Res., Beaufort: Singh 24384; Kibilo, Sandakan: Valera 1870; Lumat, Beaufort: Cuadra 1336, Kadir 1690; Lupak, Beaufort: Bunaar 25836, Kinted 15889; Meruba, Beaufort: Karim 80300; Sandakan: Amir 35638, Ampuria 32628, Creagh sn, Elleh 35596, Elmer 20194, Kadir 393, 3569; Puasa 4183; Sepilof For. Res.: Charlington 20853, Patrick 42922; Subuga: Sam 34678; Sionggau: Brain 1291; Sungei Kapur: Meijer 22904, Singh 22883; Tawao: Elmer 20839, 21622.


Kalimantan — Bengkoka: Balajadia 2841, Shea & Minjulu 76132; Doessoen Lands: Korthals sn (Ewyckia latifolia Bl. var. membranacea Bl., holotype L); Gunong Pamattan: Korthals sn (Ewyckia latifolia Bl., holotype L); E. Kutei: Kostermans 5429; W. Koetai: Endert 1545; Loa Dajanana, Samarinda: Kostermans 6706; Lubak Duaya: Meijer 23636; Maslah For. Res.: Kruhoff 4021; Mensalong: Melegrito 2506; Mt. Kenepai: Hallier 1630; Nununkan Island: Kostermans 9021, 9128; Meijer 2366; Pembilangan: Amdjah 804; Sam Pajau: Aet 661; Samarinda: Reksodiharjo 101; Sampit: Kostermans 4709; Soengai Kenepai, Hallier 2159; Sungei Menubar: Kostermans 5083; Sungei Susuk: Kostermans 5637; Tapang Padai: Omar 68; Tarakan Island: Meijer 2469; exact location unknown: Winkler 2249, 2408.

Celebes — Manado: Eyma 3399, 4020; Moena: Neth. Ind. For. Serv. 21607.

Moluccas — W. Ceram: Kuswata & Soepadmo 212; Soela Island: Neth. Ind. For. Serv. 28834, 29817; sine loc.: Zippel sn (Ewyckia cyanea Bl., holotype L).

New Guinea — Babo: Aet 690; Beriat: Schram 6007; Versteegh 4900; Daswa: Brass 5959; Hollandia: Neth. Ind. For. Serv. 5715, 25715; Ingembit: Henty, Ridsdale, Galore 31810; Ridsdale, Henty, Galore 31929; Reksodiharjo 291, 343; Job Is.: Schram 14915; Laem Morobe: Hartley 11913; Oriomo River: McVeigh 8292; Sepik-Gebiet: Ledermann 6536; 7788; Sidai: Koster 6784; Schram 1743; Sorong: Pleyte 704; Wersars: Versteegh 4969; sine loc.: Ledermann sn (Memecylon oligoneuron Bl. var. maluense Mansf., isotype ? SING) (Ledermann 7007, type, not seen).

Australia, Queensland — Bamaga, Torres Strait: Hyland 3990.
Plate 2. *Pternandra coerulescens* Jack. *Ewyckia paniculata* Miq. is based on a specimen with an abnormal (witches broom) inflorescence described by Miquel in 1860 which Triana renamed as *Pternandra paniculata* (Miq.) Triana in 1871. Bentham provided the name *Pternandra paniculata* Benth. in the Wallich Catalogue (no. 4080) in 1831 which was not validly published until 1879 by Clarke as *P. paniculata* Benth. ex C. King reduced this species to a synonym of *P. coerulescens* Jack in 1900, while Ridley considered *P. paniculata* a synonym of *P. griffithii* King (=*P. tuberculata* (Korth.) Nayar). King's opinion has been confirmed in this revision. This is the holotype of *Ewyckia paniculata* which was collected by Teysmann on Bangka Island in 1871. Photo: Rijksherbarium, Leiden.

Tree up to 10 m tall with a diameter up to 60 cm. Bark smooth, thin, dark brown; inner bark yellowish; sapwood light brown; heartwood dark brown. Branchlets slightly flattened, becoming cylindric, 1–1.5 mm thick, epidermis dark brown, flaking and peeling off leaving a smooth, tan coloured surface. Blades subcoriaceous, glabrous, elliptic to ovate, acuminate at the tip (acumen c. 5 mm long), acute to somewhat rounded and decurrent (1–2 mm) at the base; 3-nerved from the base, nerves sunken above, prominently raised and tapering below; intramarginal nerves frequently appearing as a second set of basal nerves (thus 5-nerved), but thinner and parallel, 1–1.5 mm away from the margin; secondary venation pinnate from the 3 main nerves, c. 20 pairs, anastomosing and reticulate; 4.5–6.5 cm long, 2.5–4 cm wide; glaucous below when fresh; drying dark brown to olive-green above, grey-whitish or grey-greenish to light brown below. Petioles flattened, 2–5 mm long, 1–1.5 mm wide, glabrous. Inflorescences from leaf axils, composed or solitary flowers and or 3-flowered cymes, up to 1.5 cm long; axes obscurely 4-angled to cylindric, glabrous. Bracts and bracteoles lanceolate, acute, c. 1 mm long. Primary axes solitary or clustered, 2–4 mm long, with 1 or 2 nodes; secondary axes not developed in solitary flowers, in the cymes 3–4 mm long, pedicels 2–3 mm long in the cymes, 5–8 mm long with solitary flowers, usually puberulous. Calyx tube campanulate, 4 mm long, 3 mm wide, covered with entire, glabrous projections which are unbonate to tuberculate in the lower part, longer and more echinate near the margin; cap conical, acuminate, smooth, glabrous, 4–5 mm long, 3–4 mm wide, falling off in one piece. Petals broadly ovate, 7–8 mm long, 6–8 mm wide, thin, white to very pale mauve, reflexed at maturity. Filaments flattened, 3–3.5 mm long; anthers usually with a small extension of the connective near the filament, 2–2.5 mm long. Stigma subcapitate to cylindric, grooved, c. 1 mm long. Style slender, 7–9 mm long. Fruits urceolate, with a tessellate to triangular-echinate pattern, 7–8 mm long, 6–7 mm wide, green then turning purple when ripe. Seeds numerous, flattened, quadrangular-cuneate, smooth, glossy tan coloured, c. 1 mm long.

Habitat: lowland swamp forests, peat swamps

Vernacular: ubah pandang (Malay)

*Pternandra coriacea* (Cogn.) Nayar is easily distinguished from all other species by its relatively small, glaucous blades; solitary and short inflorescence axes; and the umbonate to triangular calyx scales which are never barbed.

*Pternandra teysmanniana* (Cogn.) Nayar differs from *P. coriacea* in having thick coriaceous, 5-nerved blades with an obtuse to rounded tip, and fascicled to subsessile flowers. *P. coriacea* is in many respects similar to *P. tuberculata* (Korth.) Nayar in leaf size and texture, inflorescence, calyx pattern, and fruits. *P. tuberculata*, however, has a calyx cap which splits into 4 lobes and leaves which often become considerably larger than any collections of *P. coriacea* that I have seen. *P. rostrata* (Cogn.) Nayar differs in having thicker inflorescence axes, larger flowers with an acute to rostrate cap, and larger leaves.

*P. coriacea* is only known from Borneo and is apparently a relatively rare species. More collections are desired in order to understand this species more completely.

Fig. 7. A: calyx; B: mature petal; C: stamen.

Plate 3. Lectotype of *Pternandra coriacea* (Cogn.) Nayar.
Fig. 7. *Pterandra coriacea* (Cogn.) Nayar - A, C: Beccari 3324 (lectotype); B: Haviland (=972)B.
Plate 3. Pterandra coriacea (Cogn.) Nayar, lectotype at Florence. Cogniaux listed two syntypes for this species, both of which were collected by Beccari in Sarawak. This collection was chosen as the lectotype for this revision. Cogniaux queried the name "Kibessia glauca Triana" in his note on this specimen which, as far as I can determine, is an in scheda name. Photo: Rijksherbarium, Leiden.
Distribution:

Borneo. Sarawak — Garai: Haviland sn (548) in 1891; Kuching: Haviland =972B, 1753; Lake Kwang: Forest Department Sarawak 2606; Marop: Beccari 3164 (syntype FI), 3324 (lectotype FI, isoelectotypes K, P); Naman For. Res., Sibu: Ahmad 14335, Anderson 3361/3; Sungei Mas: Bujang 20878.

Brunei — Liang: van Niel 4621; Ulu Sigei: Brunig 1006.

7. Pterandra crassicalyx Maxw., sp. nov.

Ramuli cylindrici, furfuracei, epidermise in sicco brunnescenti, deglutenti. Folia subcoriacea oblonga rarius elliptica 75—150 mm longa, 30—75 mm lata, acuminata, basi sive acuta, secus que petiolum decurrente, sive rotunda, supra fusciscentia usque nigrescentia, infra (sicco) brunnescentia, subtriplinervis, nervis furfuraceis, glabrescentibus, intramarginalibus tenuioribus; petiolis 40—60 mm longis furfuraceis glabrescentibus. Inflorescentia axillaris, terminalisve, 15—40 mm longa, rhachi floribus solitariis vel 3-umbellatis, quadrangularibus vel cylindricis, furfuraceis. Bractae lanceolatae, 15—50 mm longae acutae. Pedicelli 2—3.5 mm longi. Calyx late campanulatus tesselatus vel umbonatus 6 mm longus, 8 mm latus, 1.5 mm crassus, furfuraceus; calyptra tholiformis glabra laevis 7 mm longa, 1.5 mm crassa, tota integre decidua. Petala in alabastro crassa, late rhombica, 6 mm longa, 8 mm lata, acuta. Fructus campanulatus truncatus, pericarpio 1.5—2 mm crasso.

Type: SARAWAK: Kapit, Bukit Raya, Au 23944 (L, holotype; isotypes: K, SING, SAN, A, BO, KEP, MEL, MOSC, FHO, CGE, P, SAR). Fig. 8.

Tree 5—12 (23?) m tall, diameter up to 15 cm. Bark smooth, soft, light grey-green or light to dark brown, often mottled; inner bark thin, red, cambium red, sapwood white to yellow-pink. Branchlets slightly flattened below the upper node, cylindric below, epidermis drying dark brown, nearly glabrous or minutely brown furfuraceous, usually peeling off on the second internode leaving a smooth, glabrous, grey-khaki surface when dry, 1.5—2 mm thick; nodes slightly swollen. Blades subcoriaceous, oblong, less frequently elliptic, acuminate at the tip (acumen up to 1 cm long), somewhat rounded or acute and decurrent at the base; 3-nerved from the base, nerves sunken above, raised and tapering below, intramarginal nerves thin, c. 1 mm from the margin, disappearing in the upper part of the blade; secondary venation pinnate from each main nerve, c. 15—20 pairs, anastomosing and reticulate; glabrous above, glabrous or red-brown furfuraceous on the nerves below; 7.5—15 cm long, 3—7.5 cm wide, drying dark brown to blackish, frequently with a greyish hue, above; brown below. Petioles 4—6 mm long, 3 mm wide, glabrous or red-brown furfuraceous. Inflorescences from leaf axils or terminal, 1.5—4 cm long; flowers solitary or in 3-flowered umbels; axes slightly 4-angled to cylindric, red-brown furfuraceous. Bracts and bracteoles lanceolate, acute, 1.5—5 mm long, red-brown furfuraceous. Primary axes solitary (3) 8—22 mm long with 1 or 2 nodes, 0.5—1.5 mm thick at the base; secondary axes not developed in solitary flowers, or up to 5 mm long, pedicels 2—3.5 mm long. Calyx campanulate, with a tesselate to umbonate pattern of scales which are smaller near the pedicel and longest about the margin, minutely furfuraceous, mature buds 6 mm long, 8 mm wide, 1.5 mm thick, purple; cap dome-shaped, smooth, glabrous, 7 mm long, 1.5 mm thick, falling off in one piece, pale pink. Bud petals imbricating to the right, broadly rhombic, acute and often asymmetric at the tip, truncate at the base, thick with thinner margins where the venation is visible, 6 mm long, 8 mm wide, light violet, light blue, to purple. Filaments in bud c. 2 mm long, flattened,
Fig. 8. *Pterandra crassicalyx* Maxw. - A: Au 23944 (holotype); B, C, D: Wright & Othman 32303; E: Ampuria 32707.
white; anthers in bud c. 2 mm long, connective with a minute spur near the filament. Stigma in bud cylindric, twisted to the right, 2.5 mm long, very light violet when mature; style slender, 4 mm long is bud. Mature fruits campanulate, truncate, 9–10 mm long, 10–12 mm wide, with a tessellate to umbonate pattern, scales often widely spaced, margin truncate, areolus c. 7 mm wide, internal lines distinct, stigma often persisting, epidermis red or violet, drying dark brown; pericarp 1.5–2 mm thick, gritty. Seeds numerous, flattened, quadrate-cuneate, c. 0.75 mm long, glossy tan coloured.

Vernacular: sireh-sireh, siri siri; puloh (Iban), empulis (Iban).

*Pternandra crassicalyx* Maxw. is readily distinguished from all other species of *Pternandra* by its large, thick, tessellate to umbonate calyx tube; large, thick, and smooth cap; and the thick pericarp. *Pternandra tuberculata* (Korth.) Nayar has generally smaller, glabrous leaves and flowers, and a calyx cap which splits into 4 lobes. *Pternandra rostrata* (Cogn.) Nayar has similarly shaped fruits, however the calyx and fruit patterns are umbonate to tuberculata; with a thinner, more acute cap.

The red-brown indumentum on the branchlets, blades (only in some specimens), and inflorescences recall that of *P. hirtella* (Cogn.) Nayar, however the latter differs greatly in having setose, branched calyx appendages; a setose cap, and entirely different fruits.

Fig. 8. A, calyx; B: mature petal; C: stamen; D: stigma; E: fruit.

Distribution:

**Borneo. Sabah** — Beaufort: Mikil 28089; Beaufort Hill: Madius 49299; Keningan District, Crocker Range: Ag. Nordin 85971; Kinabakan District, Tangkulap Kechil: Madani 33239; Mt. Kinabalu: Chew, Corner, Stainton 7; Papar: Lajangah 32197; Tawau District, Kalabakan: Gibot 30582.


Tree up to 20 m tall with a diameter (dbh) up to 60 cm, bole straight, infrequently a shrub or climber (probably incorrect). Bark smooth, finely fissured, thin; grey, yellow-brown, brown-grey, brown-black; inner bark brown, red, orange; wood yellow, white. Branchlets distinctly and often sharply 4-angled or slightly 4-winged, becoming cylindrical with age; nearly glabrous to densely, but minutely, pilose with red-brown, less commonly light yellowish, hairs; becoming glabrous or not with age; 1.5—2.5 mm thick; nodes slightly thicker, with a distinct interpetiolar, stipule-like ridge in an inverted “U”-shape and uniting the angles on the internodes, becoming thickened with age. Blades thin, lanceolate to elliptic, acuminate at the tip (acumen 1—1.5 cm long) narrowed and decurrent for a few mm or somewhat rounded at the base; 3-nerved from the base, nerves sunken above, raised and tapering below; intramarginal nerves very faint, 0.5—1 mm from the margin, loopig; secondary venation pinnate from each main nerve, anastomosing and reticulate; glabrous above, glabrous to densely, but minutely (especially on the 3 main nerves) pilose with red-brown, less frequently light yellowish, hairs; 7—12 cm long, 2.5—4.5 cm wide; dark green above, green to green-brown below; drying brownish to dark olive-green above, lighter brown to light olive-green below. Petioles flattened and grooved, 3—6 mm long, 1 mm thick; glabrous to densely, but minutely pilose as the branchlets and blades. Inflorescences varying from solitary flowers to cymes with 3—9 flowers (i.e. umbel with 3 flowers or simple cyme with 5—9 flowers), (2)3—6 cm long, from leaf axils and often terminal; axes quadrangular, sparsely to densely pilose as described above with the branchlets, etc., 1—1.5 mm thick; green, drying brown or tan; primary axis solitary, 1—2 cm long with 2—3 nodes; secondary axes not developed, thus the flowers are solitary; or present as 3 axes, each with one flower, i.e. appearing as an umbel, or cymose with the middle axis having tertiary axes, each with one flower (inflorescence 5-flowered); 1—1.5 mm long; maximum development as a 9-flowered inflorescence with each secondary axis having 3 tertiary axes, each terminated by one flower; tertiary axes 7—14 mm long; pedicels 4—8 mm long. Bracts of the inflorescence and individual ramifications extremely variable in size, ranging from linear-lanceolate-ovate to elliptic-broadly ovate; generally acute to acuminate at the tip, narrowed at the base, distinctly 3-nerved, thin, glabrous to pilose as the branchlets, leaves, etc.; 5—20 mm long, 2—9 mm wide, green, drying dark brown or olive-greenish; persisting in fruit. Calyx tube campanulate, acutely tuberculate near the pedicel, becoming echinate near the margin with triangular, obtuse to acuminate Appendages, 2—5 mm long, frequently twisting or curling; minutely papilllose throughout; tube 6—7 mm long; 7—8 mm wide, smooth internally with 16 slightly raised lines opposite and alternating with the filaments, green; calyx cap acute to acuminate, 6—8 mm long, 6—8 mm wide at the base, usually minutely papilllose throughout, green; falling off as a unit with the expansion of the petals. Petals thick, broadly ovate to oblong, truncate to broadly rounded with an acute to acuminate cusp at the tip; broadly narrowed at the base; 5—13 mm long, 3—9 mm wide, erect to spreading at maturity, blue, whitish-lilac, white. Filaments thick, flattened with a slightly raised ridge on one side, c. 2 mm wide, 3—4 mm long, whitish-lilac; bud anthers introrse, i.e. dorsal surface facing the style, later becoming horizontal, i.e. dorsal surface facing the style, later becoming horizontal, i.e. dorsal surfaces in a flat plane 90°
to and encircling the style, later becoming erect, i.e. dorsal surfaces and locules parallel to the style; subreniform, at first with the flap-like margins of the connective near the filament folded down, later becoming erect forming a flat, ovate, obtuse crest, 1–1.5 mm long; without other projections; 3–3.5 mm long, 2–2.5 mm wide; connectives yellow, locules reddish. Stigma cylindric, often slightly twisted to the left, 2.5–5 mm long, c. 1 mm thick, persisting in fruit, yellowish. Style 5–9 mm long, whitish. Fruits sub-globose (slightly wider than high) or globose, 7–10 mm high, 8–15 mm wide; areolus 6–9 mm diameter, internal ridges obscure to distinct; appendages on the calyx tube, especially near the margin, up to 9 mm long; epidermis green and turning pale yellow, purplish when ripe, brown-tan when dry; pericarp 1–1.5 mm thick, gritty. Seeds numerous, flattened, rhombic-quadrangular, c. 0.75 mm long, testa glossy tan.

Habitat: primary and secondary forests
Vernacular: kayu kaki kura (Temuan in Selangor), lemak ketam (Kedah), pako anun and sial-mi-na-on (Malacca), mempoyan and serri menaan (Pahang), sial menaon and sial menahun, cursed shade (Selangor and Pahang).

*Pterandra echinata* Jack is easily distinguished from *P. tuberculata* (Korth.) Nayar by the former having larger flowers and fruits, minutely pilose branchlets and undersides of the chartaceous blades, and the distinctly echinate appendages near the margin of the calyx tube in both flower and fruit.

In addition to obvious differences in flower morphology, *P. azurea* (Bl.) Burk. has similar branchlets which, however, tend to crack and peel at the angles leaving a sinuate-alate apperance, and less pubescent baldes.

King notes that *P. echinata* has a truncate calyx with 4 narrow, acuminate teeth. All the specimens with flowers of this species in the Singapore collection, including some that he collected himself in Singapore, have a distinct calyx cap, or in those specimens where the cap has fallen off and in fruiting specimens, the calyx tube is truncate and without any teeth. It is possible that King mistook some of the external, echinate appendages for calyx lobes.

Other authors have not agreed on the exact status of *P. echinata* Jack. The species was considered a synonym of *K. azurea* (Bl.) DC. by Moritzi (in Zollinger’s Syst. Verz. (1845–46) p. 11), and identical to *K. simplex* Korth. by Cogniaux (Boerlage, Handl. Fl. Ned. Ind. I (1891) 1108). Burkill (Kew Bull. (1935) 319) considered the species as being *P. azurea* (Bl.) Burk. Bakhuisen f. (1943, 1943–45) was of the opinion that *P. echinata* Jack is allied to *P. coerulescens* Jack and that the former “is an up to now unknown species of that genus.” Finally, Merrill (J. Arn. Arbor. 33 (1952) 241) suspected that the species is *K. azurea* (Bl.) DC.

After having examined specimens of these species and having seen living material of *P. echinata* it is quite apparent that the description of *K. acuminata* Deene. corresponds with *P. echinata*. It is certain that *K. acuminata* is not the same as *K. azurea* (Bl.) DC., *K. simplex* Korth., or *P. coerulescens* Jack. Clarke (Fl. Brit. Ind. II (1879) 552) and Cogniaux list specimens collected by Walker (304) and Mainay (804) (both from Singapore) as representative of *Kibessia acuminata* Deene. Both specimens are unquestionably *P. echinata*. King also notes that *K. acuminata* is not distinct and subsequently reduced it to *P. echinata*. I fully agree with his treatment. Bakhuisen f. considered *K. acuminata* Deene. as a distinct species and listed two collections after his description viz. Bunnemeyer 6424, which is *P. echinata*, and Hallier 3113, which is *P. azurea* (Bl.) Burk. var. *azurea*.
Maxwell: *Pterandra* (Melastomataceae)

There is considerable justification, therefore, in assuming that Jack's short description: "pedunculis axillaribus terminalibusque, calyxis ovarisque echinatus" matches the most salient characteristics — the echinata calyx tube — of the specimens that I have identified as *P. echinata* Jack.

*Kibessia cupularis* Decne. in Deessert's Icones is identical to *P. echinata*, thus confirming the opinions of Cogniaux and King on the synonymy of the former with the latter species.

I have not hesitated to reduce *P. echinata* Jack var. *pubescens* (Decne.) King to a synonym of *P. echinata* Jack since the pubescence of the branchlets, leaves, and axes of the inflorescences vary considerably. No distinction can be made between those specimens that are glabrous or slightly pilose and those which have "much minute rusty pubescence". King also had his doubts about the distinction of this variety and comments that Wallich did not accept this variety and considered it as being "true" *P. echinata* Jack.

Ridley designated *P. echinata* Jack var. *bracteata* Ridl. on the basis of "large, ovate-lanceolate, persistent bracts". Indeed, there are several specimens, in addition to the types of the variety (Ridley, sn, from Bukit Panjang, Singapore), e.g. Spare 1045, King & Jamali 6298, Maxwell 76-757; that have these kind of bracts. However, some of the older collections including, King s.n. (Singapore, 7 September 1879), Curtis 270, Hullett 661, and Ridley 9189 have bracts similar to the isotype. In fact, Curtis 270 is annotated "*P. echinata* var. *pubescens* King". Considering the fact that there are specimens with either intermediate sized bracts (Goodenough 2010 from Singapore, and Lambok 2723 from Rompin, Pahang) or have both small and large bracts on the same specimen (often the same inflorescence) (C. F. Kedah 20788 from Gunong Jerai, Kedah; Santiago sn, from Kepong; and I. H. Burkill 446, from Malacca) it is quite possible that King did not consider the larger bracts as being unusual. His description merely indicates "... flowers with one or more pairs of curved, linear-oblong bracteoles". Both Ridley and Bakhuizen f. did not include descriptions of the bracts of this species, thus I am uncertain of the size limits for the typical variety.

I feel that there is no good reason to maintain var. *bracteata* Ridl. as distinct from the typical variety of *P. echinata* Jack since there are some specimens that cannot be definitely distinguished. As far as all other structural and vegetative features are concerned, var. *bracteata* does not differ from those specimens with small bracts.

It is interesting to note that all specimens of *P. echinata* Jack from Singapore and most of the collections from Johore have large bracts. Specimens from southern Thailand to Johore mostly have smaller bracts. Craib does not record var. *bracteata* Ridl. for Thailand. It is not surprising, therefore, that four of the specimens with intermediate or mixed-sized bracts come from north of Johore and the other from Singapore since the centers of distribution probably include the northern part of the Malay Peninsula for small bracts and Singapore — Sumatra for large bracts. Ridly also notes that the distribution of var. *bracteata* includes Singapore, Sumatra, and Java, however I have not seen any specimens of this species from the latter locale. It is probable that *P. echinata* may be found in Sumatra.

The holotype of *Kibessia*? *angustifolia* Bl. at Leiden (Waitz s.n., from Borneo) merely consists of a short branch and a few leaves. These branches are 4-angled and the blades are thin and narrow. These parts differ from *P. echinata* in being entirely glabrous, otherwise they are indistinguishable. This species is not, as Bakhuizen f. claims, the same as *P. coerulescens* Jack.
Fig. 1. Ovary, x-section.

Fig. 9. A: inflorescence and leaf; B: flower; C: mature petal; D: mature stamen.

Plate 4. A and B: flowers; C: branchlet with mature fruits; D: mature trunk and bark.

Distribution:

Thailand. Nakorn Sithammarat, Thung Song: Geesink & Santitsuak 5362; Trang, Khao Chong: Phusomsaeng 58; Satun, Klawng Ton: Kerr 14575; Songkla, Klawng Yai: Kerr 15884; Pattani, Betong: Kerr 7430; Narathiwat, Waeng: B. Sangkhachand 853; Toh Moh, Kao Re Chaw: Lakshnakara 737.


Penang — Curtis 270, = 270 in Sept. 1890 and March 1892; Ridley sn on 9 July 1890; Wallich Cat. 4078 (neotype K), 4078A (P. echinata Jack var. pubescens (Decne.) King, lectotype K).

Perak — Gunong Bubu For. Res.: Everett 13962, Suppiah 11933; Larut: King's collector 3518, 3578; Chan 13195, Everett 13581 at Maxwell's Hill; Taiping: Wray 2354; sine loc.: Kunstler 87; Scortechini 1643, 1894 (1824?).


Trengganu — Bukit Langut For. Res.: Suppiah 11430; Bukit Rambai: Loh 13418.

Selangor — Batu Tiga: Mahamet sn in April 1890; Berembun near Bukit Tangga: Ismail 104877; Bukit Kulu: Goodenough 10604; Bukit Lassong For. Res.: Kochummen 93466; Kepong: Ng 118166, Santiago sn; Klang Gates: Hume 7077; Petaling Jaya: Woods 145; Rawang: Kloss sn; Semangkok: Ridley sn; Sungei Buloh: H. M. Burkill & Shah 1033, 1095; Ulu Gombak: Carrick 1482 (2412), Hume 8873; Ulu Langat: Gadoh Umbai 880, 1361, 1769; Weld's Hill: Cubitt 811.

Pahang — Benka Road: Soh 15089; Chini For. Res.: Bray 11632; Everett 14559; Gunong Benom, Ulu Krau: Ismail 97845; Whitmore 3153; Gunong Tapis: Cockburn 10907; Lepar For. Res.: Suppiah 108979; Lubok Paku: Ngadiman 16122; Raub: I. H. Burkill & Haniff 16241, 16868; Sohadi 14715; Rompin: Lambok 2723; Taman Negara, Latah Berkoh: Keng, Wee, & students 3; Sungei Tahan: Kiah 31912; Tahan Woods: Whitmore 4788; Taman Negara: Everett 14456; Shah & Shukor 2672; Ulu Tembeling: Henderson 22130.


Malacca — Batang: Derry 17; Bukit Bruang: Curtis =270 in May 1900, Goodenough 1346; Bukit Sedaman For. Res.: Holttum 9672; Kesang Batu: Hervey 2010b; Selundun; Alvins 249; Surgei Baru For. Res.: I. H. Burkill sn on 13 Feb. 1914; Sungei Ujong:
Fig. 9. *Pternandra echinata* Jack - - A: I. H. Burkill & Haniff 16808; B, C, D: Maxwell 76-757.
Alvins 2148; sine loc.: Alvins 586, 727, 1246, sn; Cuming 2337; Griffith 2272, sn: Maingay 803 (1213).

**Johore** — Bukit Pakat: Ridley sn in 1900; Bukit Tangga Tujoh: Shah, Ahmad, Noor, 2057; Castlewood: Ridley 9189; Endau: Singh (& Samsuri) 1028; Gunong Lambak: Whitmore 15547; Gunong Panti: Bain 6015, Chan 17667; Gunong Pulai: Maxwell (observed); Kota Tinggi: T. & P. 648 (3248); Kuala Palong For. Res.: Everett 14272; Mt. Ophir: Shah & Ahmad 3658; Pulau Tinggi: I. H. Burkill sn in June 1915; Dungei Tukong Estate: Spare 1045.

**Singapore** — Anderson 62; Cantley 184, 2900; Goodenough = (Ridley) 352, 2010; Gilliland 5075; Hardial 624; Henderson 1372; Hullett 661; Kasim 577; Keng & Jumali 522, 3071 (K242), 6298; King sn on 7 Sept. 1879; Maingay 804 (3333); Maxwell 76—757; Panki 769; Ridley 352, sn at Bukit Panjang (P. echinata Jack var. bracteata Ridl. (holotype K, isotype SING); Walker 304; Botanic Gardens: Noor sn on 26 April 1921, Nur sn on 24 April 1921 and 19 Nov. 1929, Furtado sn on 19 Nov. 1929, Desmakh sn on 10 Sept. 1921; Hill 1103; Ahmad 1442; Ali sn at Bukit Timah on 18 April 1974.

**Riouw Archipelago.** Pulau Dompak: Bunnemeyer 6424.

**Borneo.** sine loc.: Waitz sn (aff.) (Kibessia angustifolia Bl., holotype L).


var. galeata

Tree 7—22 m tall with a diameter up to 30 cm. Bark smooth, pinkish to pale brown, shallowly fissured and rugose, 0.5 mm thick; inner bark pale brown, 2 mm thick; wood pale brown. Branchlets flattened at and 1—2 mm below the upper node, otherwise cylindric, smooth, 1—2 mm thick, upper nodes 3—4 mm wide. Blades subcoriaceous to coriaceous, elliptic to ovate, acuminate at the tip (acumen 0.5—1.5 cm long), narrowed and decurrent for a few mm at the base; prominently 3-nerved from the base, veins sunken above, raised and tapering below; intramarginal nerves very faint, 0.5—1.5 mm from the margin, looping; secondary venation pinnate, distinct but faint from each of the 3 main nerves, anastomosing and reticulate; 9—14 cm long, 3.5—8 cm wide, drying brown on both surfaces in thinner leaves, olive-tan in thicker ones. Petioles flattened, 3—5 mm long, 1.5—3 mm wide, shorter and broader in thicker leaves. Inflorescences glomerulate, often from thickened nodes behind the leaves, c. 1 cm long, several to many -flowered; primary axes 1—5 mm long, secondary axes not developed or up to 1 mm long, pedicels usually solitary on the tip of each ultimate axis, 1—2 mm long. Bracts connate and sheathing, ovate, acute at the tip, c. 1 mm long. Calyx tube campanulate, ornamented with flat or slightly raised (tessellate, umbonate, to slightly verruculose) polygonal plates outside, smooth with 16 vertical lines internally, c. 4 mm long, 3—3.5 mm wide;
clayx cap dome-shaped, apiculate, splitting into 2 or 4 persistent lobes, each c. 2.5 mm long, 3 mm wide, smooth and without scales or plates on both surfaces. Petals thick, broadly ovate to suborbicular, broadly rounded and acute at the tip, tapering to a broad base, 3 mm long, 4 mm wide, reflexed at maturity, blue to pinkish-white. Anthers sub- re

lobes, at

longer

leaves,

and

ger

Pternandra

however

Pternandra
galeata

(Porph.) Ridl. var. galeata is easily separated from specimens of Pternandra coerulescens Jack with short inflorescences by the presence of a calyx cap and the 1–2 mm long neck on the fruits. P. galeata differs from P. tuberculata (Korth.) Nayar by having a shorter inflorescence and tessellate, never tubercled, calyx tube, and urceolate fruits. P. cogniauxii Nayar has similar fruits, but has 5-nerved, cordate blades and a tuberculate calyx tube and lobes.

Vernacular: lidah batak, lagis pukuan hutang, kemasulan, pasoeian.

According to the original description, Kidessia galeata (Korth.) Cogn. var. pluriflora Mansf. merely differs from var. galeata in having many flowers which are mostly in groups of 3, ovate buds, and conical calyx caps. From the specimens of P. galeata in the Singapore and Leiden collections, this variety is not distinct and falls within the range of variation for var. glaeata.

It should be noted that there are one or two primary axes in variety pluriflora (Ledermann 8585, from New Guinea) from the leaf axils, each c. 1 mm long, with 2 or 3 secondary axes each c. 3 mm long, and pedicels c. 1.5 mm long. The ovate, acute bracts at each node are about 1 mm long and persistent. The inflorescence in this specimen has longer axes than specimens from the Malay Peninsula and Borneo. In respect to the leaves, inflorescence, and calyx pattern var. pluriflora resembles P. coerulescens Jack, however the presence of a distinct cap and lobes immediately distinguishes P. galeata from the latter.

The two isotypes of P. forbesii E. G. Baker at Leiden (Forbes 3219, from Sumatra) are unquestionably the same as P. galeata since the fruits are distinctly urceolate. This collection was determined as K. galeata Cogn. by Hallier in 1916.

Fig. 10. A: inflorescence; B: flower; C: mature petal; D: stamen; E: mature infructescence.

Distribution:

W. Malaysia Pahang — Auwik River: Burn-Murdoch 196; Endau, Rompin: Mahamud 15506; Pianggu, Endau: Evans sn.


Fig. 10. *Pternandra galeata* (Korth.) Ridl. var. *galeata* - - A-D: Corner sn, Sungei Sedili, Johore on 27 March 1932; E: Maxwell 78-260.
Borneo. Sabah — Keningau: Cockburn 73016.

Brunei — Ulu Damit: Ashton 932.


Kalimantan — Balikpapan: Kostermans 4456, Neth. Ind. For. Serv. 24637 (aff.); Bandjermasin: Korthals sn (holotype L, isotype L), Motley 200; Berau: Kostermans 21540; Danau Menjeban: Main 2162; Ioa Haur, Samarinda: Kostermans 6868, 9916; W. Koetai: Neth. Ind. For. Serv. 29231; Kuala Kuajan, Sampit: Kostermans 4721, 8066; Lampt: Buwalda 7935; Mentawir, Balikpapan District: Kostermans 9706; Pelawan Besar, Sangkoelirang: Walsh 748.

New Guinea — Manikiong: Koster 1212 (aff.); Sepik-Gebiet: Ledermann 8585 (Kibessia galeata (Korth.) Ridl. var. pluriflora Mansf., isotype L); Vogelkop Peninsula: van Royen 4006 (aff.); Warsamson Valley, Sorong: Schram 12887; Western District, Kiunga: Katik 46796.


Tree up to 20 m tall with a diameter up to 45 cm. Bark smooth to scaly, brown, peeling off in 1 mm long strips; inner bark pale white-brown, 2 mm thick, white near the cambium; sapwood white. Branchlets cylindric, smooth, c. 3 mm thick, drying tan to blackish. Blades thick coriaceous, glabrous, broadly ovate, acuminate at the tip (acumen c. 1 cm long), broadly rounded and slightly decurrent at the base; 3-nerved from the base, nerves sunken above, raised and tapering below; intramarginal nerves thin, 1–2 mm from the margin, disappearing in the upper part of the blade; secondary venation distinct, pinnate from each main nerve, anastomosing and reticulate; 12–16 cm long, 8–10 cm wide; drying olive-greenish to brown above, greenish to light brown (black in juvenile blades) below. Petioles 8–10 mm long, 3–4 mm thick, glabrous. Inflorescences in fascicles from leafy or leafless nodes, of 3–5 flowered cymes c. 1 cm long or of solitary flowers; axes glabrous, slightly flattened. Bracts and bracteoles ovate, acute at the tip, 1–1.5 mm long, persistent. Primary axes up to 5 mm long with 1–2 nodes, secondary axes usually not developed, pedicels 0.5–0.75 mm long. Calyx campanulate, glabrous, with a tessellate or slightly umbonate pattern, scales smaller near the pedicel, largest near the margin; 4–5 mm long, 4–5 mm wide; cap dome-shaped, smooth and glabrous, splitting into 4 triangular lobes each c. 4 mm long, falling off as the petals mature. Bud petals broadly ovate to suborbiculate, obtuse to acute at the tip, narrowed and truncate at the base, thickened, venation faint, white. Bud filaments flattened, c. 2 mm long; bud anthers 2–2.5 mm long. Stigma c. 1 mm long. Style slender c. 5 mm long in bud, elongating to 8 mm in fruit. Fruits urceolate, 7–8 mm long, 7–9 mm wide, tessellate, areolus 3–4 mm wide; white, drying brown to blackish; pericarp c. 0.5 mm thick. Seeds numerous, flattened, rhombic-quadrangular-cuneate, c. 0.75 mm long, glossy tan to light brown.

Kibessia elmeri Merr., which Merrill placed in section Macroplacis Cogn. where the calyx cap opens into 4 lobes and the anthers lack a connective spur, is similar to P. galeata var. galeata in the structure of the inflorescence, calyx pattern, petals, and fruits. In several specimens of P. galeata, e.g. Kostermans 9916, from Kalimantan, the calyx splits into 4 lobes and the anthers have a small spur near the filament. Elmer 21337, an isotype of K. elmeri, has only a few loose buds and immature fruits, and the anthers are too
Fig. 11. *Pternandra galeata* (Korth.) Ridl. var. *elmeri* (Merr.) Maxw. - A-C: Elmer 21337 (isotype).
immature to determine whether or not such a spur is present. Singh 30042, from Sabah, has leaves which match Elmer 21337, and also has one inflorescence with some loose fruits which are urceolate and have a tessellate pattern. These fruits match those of several specimens of P. galeata, e.g. Soepadmo 29 (Sumatra) and Paie 15589 (Sarawak), however these two specimens have smaller and thinner blades which do not resemble those of var. elmeri. I still have not seen mature flowers of var. elmeri, however from the specimens available it is apparent that var. elmeri is very closely related to P. galeata due to the tessellate calyx pattern, cap which splits into 4 lobes, and the urceolate fruits. Important differences between the two taxa include the larger, thicker blades, and the larger and more branched inflorcescences of var. elmeri.

The generally larger inflorcescences of var. elmeri are identical in structure to some specimens of P. rostrata (Cogn.) Nay. with large leaves, e.g. Hose 462 (Sarawak); and Kadir 2726, Singh 22369 (both from Sabah); however the latter taxon differs in usually having thinner blades, umbonate to tuberculate calyx tube pattern, calyx cap which falls off in one piece, and campanulate-truncate fruits.

- Pternandra congniauxii Nayar, the type of section Macroplacis Cogn. (Kibessia korthalsiana Cogn.), is similar in the splitting of the calyx cap and urceolate fruits, but differs in having a tuberculate calyx pattern and 5-nerved, cordate blades.

Referable here is a vegetative specimen collected by the Neth. Ind. Forest Service (16214, from Kalimantan) which has leaves similar to those of var. elmeri. This specimen also resembles large-leaved collections of P. coerulescens Jack which often has nearly sessile or shortly cymose inflorcescences. P. coerulescens is easily distinguished by its lack of a calyx cap and globose fruits.

Nayar's recombination of Kibessia elmeri Merr. to Pternandra was done without having seen any relevant material, thus P. elmeri (Merr.) Nayar is merely another indication of Nayar's inability to do critical botanical research.

Fig. 11. A: calyx; B: stamen; C: fruit.

Distribution:


Kalimantan — central Kutei: Kostermans 10325; W. Koetai: Neth. Ind. For. Service 16214 (aff.).


Shrub 2–5 m tall or a tree up to 10 m high, diameter up to 15 cm. Bark smooth, pale grey-brown, outer and inner bark brownish, cambium pale whitish, sapwood brownish. Brachlets 4-angled, frequently flattened and grooved on two faces below the upper node, c. 1 mm thick, glabrous (rarely setose); epidermis light brown, peeling off leaving
Holotype

Maxwell: Pternandra (Melastomataceae) 55

a smooth, cylindric, glabrous khaki-tan coloured surface when dry. Blades chartaceous, glabrous, lanceolate to elliptic, acuminate at the tip (acumen c. 1 cm long), narrowed and decurrent for 1–2 mm at the base; 3-nerved from the base, nerves sunken above, prominently raised and tapering below; intramarginal nerves thin, c. 1 mm from the margin; secondary venation pinnate from each of the 3 main nerves, c. 20–30 pairs, anastomosing and reticulate; drying brownish, often with an olive hue, above; lighter brown below; 5–15 cm long, 2.5–5 (8) cm wide. Petioles flattened, glabrous, 3–4 mm long, 1–2 mm wide. Inflorescences of solitary flowers or in clusters, from leaf axils; primary axes 1–3 mm long with one or two nodes, each with one pedicel, pecicels c. 1 mm long. Bracts ovate, acute, up to 1 mm long; axes and bracts glabrous. Calyx tube campanulate, glabrous, densely tuberculate in the lower part, appendages becoming longer (up to 1 mm), thicker, and often somewhat flattened (muricate to narrowly echinate) in the upper half, especially near the margin; 3–5 mm long, 4–5 mm wide, pink to red; cap dome-shaped, rounded at the tip, glabrous, 4-grooved, c. 1.5 mm long, up to the middle provided with appendages similar to those about the margin, splitting into 4 persistent, triangular, acute lobes, each c. 1.5 mm long. Petals thin, glabrous, broadly ovate to suborbicular, broadly rounded at the tip, clawed at the base, c. 4 mm long, 3 mm wide; filaments flattened, 2–4 mm long; anthers c. 2 mm long, 1 mm wide, pale pink. Stigma oblong, cylindric, c. 1 mm long, 4-lobed, yellow. Style slender, 5–8 mm long, elongating to 10 mm after flowering, pale pink. Fruits globose, appendages similar to those in flower, often less densely spaced or nearly smooth with little trace of the scales, 6–8 mm wide, orange turning red; calyx lobes persisting, green or yellow; pericarp c. 0.2 mm thick. Seeds numerous, rectangular-quadrat, often flattened, c. 1 mm long, glossy khaki-tan coloured.

Habitat: primary, frequently dipterocarp, forests
Vernacular: puloh (Iban).

Pternandra gracilis (Cogn.) Nayar is easily distinguished from all other taxa of Pternandra by its solitary flowers on each primary axis, axes which are never more than 5 mm long, tuberculate-echinate calyx tube, cap which also has appendages and splits into 4 persistent lobes; and the chartaceous, glabrous blades which are narrowed at both ends.

Pternandra tuberculata (Korth.) Nayar is sometimes confused with this species, but the former has larger and longer inflorescences, larger flowers with an umbonate to tuberculate pattern, smooth cap, thicker blades, and larger fruits.

Clemens 21580, from Sarawak, differs from all other specimens of P. gracilis examined in having black, minutely setose branches. The leaves and fruits are identical to those of other specimens of P. gracilis.

Fig. 12. A, B: calyx; C: Mature petal; D: stamen; E: immature fruit.

Plate 5. Holotype of Pternandra gracilis (Cogn.) Nayar.

Distribution:

Borneo. Sabah — Gunong Balapau: Richards 2414; Gunong Lumaku: Nooteboom 1176; Lumat, Beaufort: Madani 35095; Mt. Kinabalu: Carr 26691; Chew, Corner, Stainton 97, 1201; Clemens 28071, 29592, 31285, 32134, sn in May 1933; Mt. Trusmadi: Nooteboom 1368; Sungei Tuban: Ashton 18371; Usun Arau: Asah ak Luang 22684.
Fig. 12. *Pterandra gracilis* (Cogn.) Nayar - A, C, D: Beccari 3172 (holotype); B: Ashton 18371; E: Ashton 720.
Plate 5. *Pterandra gracilis* (Cogn.) Nayar, holotype at Florence, which was collected by Beccari in Sarawak in March 1867. Photo: Rijksherbarium, Leiden.

Sarawak — Bukit Iju: Luang 23248; Bukit Mentagai: Luang 23263; Bukit Salong, Kapit: Paie 25858, 25862; Gat, upper Rejang River: Clemens 21580; Lanko Battu: Beccari 3172 (holotype (4244) FI; isotypes (4244A) FI, BR).


   Tree up to 12 m tall, diameter up to 15 cm. Outer bark smooth, thin, very dark grey to black, longitudinally cracked; inner bark dark red; wood moderately hard, sapwood pale yellow, heartwood darker and staining reddish after exposure. Branchlets 4-angled, sometimes narrowly undulate-winged, densely red-brown pilose, c. 2 mm thick, epidermis flaking off leaving a smooth, cylindrical, glabrous, tan-khaki coloured surface. Blades subcoriaceous to coriaceous, elliptic to ovate, acuminate at the tip (acumen 0.5–1.5 cm long); narrowed, less frequently rounded, and shortly (1–2 mm) decurrent at the base; 3-nerved from the base, nerves sunken above, prominently raised and tapering below; intramarginal nerves thin, 1–1.5 mm from the margin, sometimes giving the blades a 5-nerved appearance at the base; secondary venation pinnate from each of the 3 main nerves, c. 15–25 pairs, slightly raised below, anastomosing and reticulate; blades glabrous above, sparsely to densely red-brown pilose, especially on the main nerves, below; 9.5–20 cm long, (3) 4.5–8.5 cm wide, dark green above, paler beneath, glossy on both sides, drying olive-brownish to dark brown above, brown below. Petioles flattened, 4–8 mm long, 2–3 mm wide, densely red-brown pilose. Inflorescences of solitary flowers from leafy nodes or in terminal, 3-flowered umbels; axes 4-angled, densely red-brown pilose. Bracts and bracteoles lanceolate, acute at the tip, 4–7 mm long, 1–2 mm wide, densely red-brown pilose, persistent. Primary axes 0.5–1.5 cm long, 1.5–2 mm thick, solitary flowers with 2–4 nodes, the umbels with one node; secondary axes not developed in solitary flowers or up to 4 mm long, pedicels 2–4 mm long. Calyx tube campanulate, 6–8 mm long, 5–7 mm wide, densely covered with setaceous bristles which are shorter and simple near the base and longest (2–3 mm) and barbed near the rim, frequently curved or hooked, densely red-brown pilose; calyx cap conical, acuminate, c. 6–7 mm long, 5–7 mm wide, with a whorl of bristles near the middle; densely red-brown pilose throughout; falling off as a single unit, often remaining attached to one side of the rim in fruit, up to 1.5 cm long. Mature flowers not seen. Bud petals slightly thickened, broadly ovate, acute at the tip, truncate at the base, 6–7 mm long, 5–6 mm wide, margin thinner, white. Bud anthers inappendiculate, c. 2 mm long, 1 mm wide, pale mauve; filaments flattened. Stigma cylindric, slightly twisted to the right, later splitting into 4 lobes, 2.5 mm long. Style slender, c. 6 mm long, glabrous, elongating to 12 mm in fruit. Fruits subglobose, truncate, covered with pilose bristles, 8–10 mm long, 11–13 mm wide, areolus 7–8 mm wide, internal lines distinct, 16, glabrescent; exocarp greenish, reddish, then dark violet when ripe; pericarp c. 1.5 mm thick, gritty. Seeds numerous, flattened, rectangular-cuneate, glossy khaki-tan.

Habitat: primary lowland forests

Vernacular: merkatak (Kuching, Sarawak); puloh, pulu (Iban)

Fig. 13. A: calyx; B: anther; C: stigma.
Fig. 13. Pterandra hirtella (Cogn.) Nayar. A: Ridley 12281; B, C: Carrick & Enoch 349.
As far as the basic structure of the inflorescence and calyx bristles are concerned, *P. hirtella* closely resembles *P. azurea* (Bl.) Burk. var. *azurea* and var. *cordata* (Korth.) Maxw. There are several specimens at Singapore and Leiden of both varieties of *P. azurea* which have setose bristles which are mostly unbranched (e.g. Endert 3195. Kostermans 9043, and Nahar 12700 – all from Borneo); however with other specimens of *P. azurea* there is considerable variation in the density, branching, and thickness of the calyx appendages. The bristles in *P. hirtella* are constant, i.e. the lower part of the calyx tube consists mostly of curved and barbed appendages, while those near the margin are branched. This species is quite constant in its characteristics and I have seen that it differs little in pubescence, leaf texture and shape, and the flowers.

*P. hirtella* is easily distinguished from all other species of *Pternandra* by its dense, red-brown pubescence which persists on the branches, blade undersurfaces, petioles, inflorescence axes, flowers, and fruits. The fruits differs from that of *P. azurea* in being subglobose to truncate, rather than campanulate and truncate. The blades in *P. hirtella* are also larger and thicker than in *P. azurea*.

Cogniaux (1891) lists two syntypes for this species viz. de Vriese sn and Beccari 17 – both from Borneo. I have not seen de Vriese’s specimen which Cogniaux indicates is at Leiden, however Beccari 17, at Florence, was examined on loan and has been designated as the lectotype of *Pternandra hirtella* (Cogn.) Nayar.

**Distribution:**

*Borneo Sarawak* – Bako National Park: Ashton 17815; Carrick & Encoh 349; Purseglove 5043; Batu Anam: Dauk & Tachun 35601, 35604; Bukit Empan Ra’a, Serian: Paie 28069; Bukit Iju, Ulu Arip, Balingian: Luang 23610; Gunong Santubong, Kuching: Bujang 13698; Kuching: Banyeng & Sibat 24913; Beccari 17 (lectotype, FI); Haviland sn on 14 April 1893; Lambir Forest, Miri: Morshidi 24090; Penkulu Ampat: Haviland 175; Sampadi For. Res.: Paie 27694; Santubong, Kuching: Ridley 12281; Santulang: Ridley sn in Jan. 1918; Selang For. Res., Kuching: Paie 8452; Semengoh For. Res., Kuching: Anderson 14643, 26854; Bojeng 14643; Brain 5368; Brown 2290; Galau 15703; Setapuk For. Res., Kuching: Bojeng 9304; Sundu: Bishop (Hose) & Haviland 230 (inflor. abnormal); Sungei Sabal, Tapang, Serian: Sinclair 10277; Ulu Kakus, Anap: Haron 29993; Ulu Kuyong, Anap: Chai 19317.

13. **Pternandra multiflora** Cogn. in DC., Monogr. Phan. 7 (1891) 1104; Merrill, J. Str. Br. Roy. As. Soc. 86 (1921) 452.

Tree up to 15 m tall with a diameter up to 1 m. Bark smooth, grey or mottled with brown; inner bark greyish to yellow, sapwood greyish-brown. Branchlets flattened and deeply grooved on the flattened faces, often 4-angled, becoming cylindric, 1.5–2 mm thick, epidermis brown to black, peeling off leaving a tan-khaki coloured surface; nodes flattened and swollen. Blades subcoriaceous, glabrous, elliptic to ovate, acuminate at the tip (acumen 1–1.5 cm long), narrowed and frequently shortly decurrent at the base; prominently 3-nerved from the base, nerves sunken above, prominently raised and tapering below; lateral veins less prominent than the midvein; intramarginal nerves thin, 1–2 mm from the margin; secondary venation pinnate from each of the 3 main nerves, c. 15–25 pairs equally prominent on both surfaces, slightly raised, anastomosing and prominently reticulate; 12–22 cm long, 5.5–7.5 cm wide; drying olive-brown above, brown below. Petioles flattened, 5–10 mm long, 2–3 mm wide. Inflorescences paniculate from behind the leaves and on thicker branches, 15–30 cm long, very loose and open, many-flowered; axes grooved near the nodes, otherwise 4-angled, smooth, glabrous,
Fig. 14. *Pternandra multiflora* Cogn. - A-D: Purseglove 5149; E: Brain 5369.
drying dark brown to blackish; primary axes generally solitary at each node, less frequently paired, 10—25 cm long with 3—5 nodes; secondary axes 2 or 4 from each node of the primary axis, peripheral axes less developed, 3—8 cm long with 1—3 nodes; 3d axes c. 1—2.5 cm long, 4th 5—10 mm, 5th not developed or up to 4 mm long, pedicels 1—2 mm long. Bracts and bracteoles lanceolate, acute, 0.5—2 mm long. Calyx tube campanulate-cyathiform, scales few, tessellate to umbonate, rather large, often indistinct giving a rugose texture, 2.5—3 mm long, 2 mm wide, smooth and glabrous; internally with faint lines, margin often appearing 4-lobed with the extension of 4 large scales alternating with 4 smaller ones at the margin, pale yellow. Petals yellow, ovate to sub-orbicular, broadly rounded at the tip, broadly rounded and truncate to broadly clawed at the base, 1.5—2 mm long, 1.5—2 mm wide, thin with visible venation. Filaments flattened, c. 1.5 mm long, 0.5 mm wide; anthers c. 1 mm long, yellow, connective thick, often papillose, ridge-like with a short spur extending beyond the filament. Stigma capitate, 4-grooved, c. 0.75 mm long. Style somewhat flattened, slender, 5—6 mm long. Fruits (sub)globose, truncate with remnant scales at the tip, tessellate-rugose and minutely lepidote externally, 5—8 mm diameter; areolus 4 mm wide, style often persisting, exocarp ripening orange to light brown, drying khaki-tan; pericarp c. 0.2 mm thick. Seeds numerous, rhombic-cuneate-quadrangular, c. 0.5 mm long, tan to light brown, glossy.

Pternandra multiflora Cogn. is easily distinguished from all other species of Pternandra, especially P. coerulescens Jack, by its long, complex, many-flowered inflorescence; tessellate to umbonate calyx pattern, and absence of a cap. The yellow petals and fruits also appear to be distinct. The closest species is P. coerulescens which has smaller inflorescences; thick white, blue, or purple petals; and fruits which dry black.

Cogniaux notes in his description that the fruits of P. multiflora are shallowly 4-grooved (leviter 4-sulcata), however I have not seen this character on any of the fruiting specimens of this species in the Singapore or Leiden collections.

Fig. 14. A: inflorescence; B: flower; C: mature petal; D: stamen; E: fruit.

Distribution:

Borneo Sabah — Beaufort District: Madani 35246; Beaufort Hill: Mikil 31979; Sun Suran Trail, Penampang District: Mikil 37755.

Sarawak — Bukit Lambar, Miiri: Luang & Nulong 24446; Gunong Matang, Kuching: Chai 19758; Kuching: Bojeng 9428; Lambir Forest, Miiri: Morshidi 22892; Lebang For. Res., Bintulu: Paie 15836; Limbang, Kunaeng: Haviland 68 (544); Matang: Becari 1551 (lectotype Fl), 2981 (syntype Fl); Haviland sn on 24 Aug. 1888; Miiri: Dan 1907 (S1458), Hose 598; Miiri River: Hose 71; Niah River, Miiri District: Wright 29135; Pelagus For. Res.: Chai 33177; Penkulu Ampat: Haviland 476; Selang For. Res.: Paie 8484; Semengoh For. Res.: Brain 3569; Sungei Tau: Purseglove 5149; Tegora: Haviland 2019; exact location unknown: native collector 1139 (distribution Manila).


Tree 8–15 m tall, diameter up to 25 cm, or a shrub up to 3 m tall; buttressed in older individuals. Bark smooth, grey-brown, thin, finely fissured; inner bark red-brown, thin; sapwood pale yellow. Branchlets cylindrical, often somewhat flattened or obscurely 4-angled below the upper node, 1.5–2.5 mm thick, smooth, drying grey to brownish. Blades subcoriaceous to coriaceous, glabrous, elliptic to ovate (often broadly so), acuminate at the tip (acumen 0.5–1 cm long), narrowed or broadly rounded and usually decurrent at the base; prominently 3-nerved from the base, nerves sunken above, raised and tapering below; intramarginal nerves faint, 1–2 mm from the margin, disappearing in the upper half of the blade; secondary venation pinnate from each main nerve, conspicuous, anastomosing and reticulate; 6.5–21 cm long, 3–10 cm wide; dark, often glossy, green above; green below; drying dark brown to olive-brown above, brown to tan-brown or with a greenish hue below. Petoioles flattened, 2–8 mm long, 1.5–4 mm thick, glabrous. Inflorescences of axillary or terminal cymes of 3 or of solitary flowers, 1–2.5 cm long, axes somewhat flattened to 4-angled, glabrous; primary axes usually several from leaf axils, with 1–3 nodes, solitary flowers generally having two nodes and two pairs of bracts as the secondary axes have not developed, c. (1) 5–10 mm long; secondary axes not developed or 3–5 mm long; pedicels (0.5) 1–3 mm long. Bracts and bracteoles lanceolate to ovate, acute, 1–2 mm long, persistent, green. Calyx tube campanulate, ornamented with raised tubercules (umbonate to tubercululate), glabrous, 4–6 mm long, 3–5 cm wide at maturity; cap conical, thick, acute to rostrate, falling off in one piece, 3–8 mm long, 4–5 mm wide; green; tube smooth and obscurely 16-lined internally, lines opposite and alternating with the filaments. Petals thick, broadly ovate to suborbicular, often asymmetric, broadly rounded and apiculate at the tip, shortly clawed at the base, 6–8 mm long, 8–10 mm wide, reflexed at maturity, lilac. Filaments flattened, 3–4 mm long, lilac; anthers subreniform, connective with a dorsal extension near the filament, c. 2 mm long, yellow. Stigma clavate-cylindric, 1–2 mm long, yellow. Style 5–6 mm long, whitish, elongating to about 10 mm and persisting in fruit. Fruits campanulate, truncate at the top, 7–9 mm long, 10–12 mm wide, areolus 7–9 mm wide, internal ridges and lines distinct; exocarp green, umbonate to distinctly tubercululate; pericarp c. 1.5 mm thick, gritty. Seeds numerous, rectangular-quadrate, often appearing cuneate, c. 1.0 mm long, testa glossy tan.

Vernacular: nipsis kulit, tahi kerlan, talinga basing (Brunei), sandi-sandi (Dusun-Kina-batangan).

Pterandra rostrata is very variable in the size and texture of the leaves, pattern on the calyx tube and fruits, and shape of the calyx cap. This species differs from P. tuberculata (Korth.) Nayar which has a more slender and more branched inflorescence, and a short calyx cap which splits into 4 lobes. The leaves of the two species are usually indistinguishable.

The type collection of P. rostrata (Beccari 979, from Sarawak) has a rostrate calyx cap which apparently falls off in one piece. Other specimens with a rostrate cap, e.g. Haviland 972, Kadir 2726, and Gansau 46311; vary in the size and texture of the leaves, and length of the inflorescences. The calyx pattern ranges from umbonate to tubercululate and in many other collections several different patterns can be found on the same specimen, that is umbonate, verruculose, and tubercululate patterns. These patterns do not correlate with the size or shape of the leaves.
**Pterandra verrucosa** Merr. has the same leaves as Beccari 979, and with the few loose fruits on paratype specimens (Ramos 1191, from Sabah), Merrill’s description of the inflorescence and comparison with many specimens of *P. rostrata* at Singapore and Leiden, I cannot find any constant differences between the two taxa. Mature flowers are sparse, and from the internal structures from buds I cannot make any distinctions either.

The isotype of *P. affinis* Merr. (Elmer 21478, from Sabah) has leaves which could easily be confused with several specimens of *P. galeata* (Korth.) Ridley, but the loose fruits have a tuberculate pattern. Although the shape of these fruits is urceolate, as with *P. galeata*, the specimen is actually *P. rostrata*. Confirming evidence lies in the fact that many immature fruits of *P. rostrata* are urceolate with a verrucose to tuberculate pattern (not tessellate as with *P. galeata*) and in some specimens, e.g. Gansau 46311, fruits identical to Elmer 21478 plus buds with a rostrate cap are on the same specimen. Aside from the fact that the pattern on the fruits differ, the presence of a cap which falls off in one piece (in contrast to the caps which split into 4 lobes with *P. galeata*) is sufficient proof for me to consider *Kibessia affinis* as a synonym of *P. rostrata*.

Several collections from Borneo (e.g. Meijer 37999, Gibot 60613, Mikil 38496, Latangah 33144, etc.) collected at elevations above 1300 m. have much smaller leaves and more obtuse calyx caps than most other specimens of *P. rostrata* that I have seen. These specimens will require further study with more flowering and fruiting material in order to determine their exact taxonomic status. I have included them in this section since they do not resemble any other species of *Pterandra* that I have studied.

*Kibessia affinis* Merr., *K. verrucosa* Merr., and *K. tuberculata* var. *grandifolia* Bakh. f. are, in my opinion, all synonyms of *P. rostrata*. Even with type material of all these taxa, deciding on their true taxonomic status has been difficult since these specimens are, in general, not only incomplete, but also in poor condition. Reconstructing various aspects of each one of them has been by comparison with other specimens at Singapore and Leiden which match each type, plus the original descriptions.

All of these taxa have shortly cymose (up to 2 cm) inflorescences; campanulate calyx tubes with umbonate to verrucose scales; smooth and acute to rostrate caps; thick and broadly ovate to suborbicular (often asymmetric) petals; and campanulate fruits with a truncate apex and an umbonate to verruculose pattern. The different taxa have leaves which vary in size and, combined with the various stages of flower or fruit development for each specimen, has resulted in considerable taxonomic confusion.

The isotype of *K. affinis* (Elmer 21478, from Sabah) has several fruits in various stages of development, most of which are slightly constricted below the margin giving a somewhat urceolate appearance. The pattern on these fruits is identical to that on the only mature fruit (which is crushed) included with Rutten 537 – the holotype of var. *grandifolia*. The fruits of Ramos 1191, a paratype of *K. verrucosa*, differ slightly in being more umbonate and less verrucose, and are not, at least in most fruits, urceolate, i.e. there is little, if any, construction below the margin. There are, however, some fruits with Ramos 1191 which match those of *K. affinis*.

Merrill notes that *K. affinis* is closely related to (Kibessia) *Pterandra galeata* (Korth.) Ridley, however the latter species is easily distinguished by its tessellate to somewhat umbonate calyx pattern, and the distinctly urceolate fruits (neck 1–2 mm) with a much smoother pattern, and often with persistent calyx lobes.
Griffith 2272/1 has a few calyx specimens which have identical scales to those of var. grandifolia. The leaves on the two sheets show a transition from small \( P. \) griffithii to moderately large (var. grandifolia). As noted above, the mature fruits of var. grandifolia the same as those of \( K. \) affinis which also has individual variations which match those of \( K. \) verrucosa. The shape and venation of the blades in all of these taxa are essentially the same. Large blades with prominent venation of \( K. \) verrucosa are matched by those of var. grandifolia, which are slightly smaller; then progressively smaller leaves from \( K. \) affinis, \( P. \) griffithii, and \( P. \) tuberculata.

It is obvious from other collections in Singapore and Leiden that all of these taxa are the same since many specimens with small to large leaves have buds, flowers, or fruits which match those fragments from one or more of the type collections discussed above. In other words, these taxa have been described from individual specimens which were collected at a particular stage in the development of the individual flower or fruit. By comparing specimens collected in other stages of maturity, it is obvious that leaf size is not a constant factor since all specimens can be linked by the distinct calyx pattern and by the truncate fruits.

Fig. 15. A–F: G: mature petal; H: stamen.

**Distribution:**

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<th>Sumatra</th>
<th>Exact location unknown: Beccari 179.</th>
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**Brunei** – Bukit Lambir: Ashton 37, Fuchs 21297.
Fig. 15. *Pterandra rostrata* (Cogn.) Nayar - A, G: Haviland 972; B, H: Hose 462; C: Kadir 2726; D: Jacobs 5302; E: Siranggol S1101; F: Brooke 10010.
**Sarawak** — Bettoton: Boden-Kloss 19057, Kloss 19027; Bukit Mentagai: Luang 22821; Entoyut River, Baram District: Hose 462; Gat, upper Rejang River: Clemens 21564, 21575; Gunong Mulu, Baram: Paie 15091; Gunong Rara For. Res.: Chow 75670; Gunong Sahari: Forman 498; Kuching: Haviland 972; Lawas: Brooke 10010; Lema’as For. Res.: Chong 33666; Long Kerangan, Barma District: Tong 34998; Matang: Haviland 176; Miri River, Baram District: Hose 653; Mt. Matang: Clemens 20937; Mt. Singglio: Haviland =176; Piningiao: Becarri 979 (holotype Fl); Puman Besar: Geh & Samsuri 708; Rejang River, Kapit District: Jacobs 5302; Semengoh For. Res., Kuching: Ghazali & Asah 13662; Sungei Ukong, Miri: Haromy 21395; Ulu Mujong, Balleh: Ashton 13975; Ulu Sungei Bukong: Benang 24406, Luang 24454; Ulu Sungei Mamut Bakong, Miri: Luang 24377; Ulu Sungei Sekaloh, Miri: Luang 27855, Wright 29129; Ulu Tubau: Ashton 17717; exact location unknown: Becari 301.

**Kalimantan** — Amai Ambit: Hallier 3208; Batu Pondong, Sangkoelirang District: Kostermans 13664; Berau: Kostermans 21573; Boeloengan Beraoe: Rutten 537 (Kibessia tuberculata (Korth.) Hk. f. ex Cl. var. grandifolia Bakh. f., (holotype U); Gunong Ketapong, Sangkoelirang: Walsh 443; Hunukan: Meijer 2148; Indonesia Islands: Kostermans 21115; W. Koetai: Endert 2596, 4980; Liang Gagang: Hallier 2736; Loa Djanan, Sama-rinda: Kostermans 6440; Muara Muntai Kutei: Meijer 496; Soengai Sambas: Hallier 1082; Sungei Wain, Balikapan: Kostermans 4154, 4238.

**New Guinea.** Sepikgebiet: Ledermann 8717a (aff.) (Kibessia ledermannii Mansf., isotype SING).


Shrub or tree 3—12 m tall, diameter up to 15 cm. Branchlets distinctly 4-undulate-winged, minutely pilose, 1—1.5 mm thick, epidermis dark brown when dry, flaking off (including wings) leaving a smooth, cylindrical, glabrous, tan-khaki coloured surface. Blades chartaceous to subcoriaceous; lanceolate, elliptic, to ovate; acuminate at the tip (acumen up to 10 mm long), broadly rounded and shallowly (1—2 mm) cordate at the base; prominently 3-nerved from the base, intramarginal nerves 1—2 mm from the margin, less prominent, but often giving the blades a 5-nerved appearance; nerves sunken above, prominently raised and tapering below; secondary venation pinnate from each of the 3 main nerves, c. 20 pairs, slightly raised below, reticulate; juvenile blades puberulous on the main nerves near the petiole, adult ones glabrous; drying olive-brown to blackish above, lighter brown below, very brittle; 7.5—12 cm long, 3—5.5 cm wide. Petioles c. 2 mm long, c. 2 mm thick, at first minutely puberulous, later glabrous. Inflorescences from leaf axils, often terminal, composed of solitary flowers or 2—3-flowered umbels; axes flattened, minutely puberulous, c. 1 mm thick. Bracts and bracteoles lanceolate, acute, c. 1.5 mm long, minutely puberulous; primary axes 6—15 mm long, secondary axes not developed (solitary flowers) or up to 10 mm long; pedicels 3—5 mm long. Calyx tube campanulate, covered with tessellate-umbonate-tuberculare scales, lower ones smaller and flatter increasing in size and projection to the margin where they are triangular-tuber-culate; 4—5 mm long, 4—5 mm wide, minutely puberulous, glabrescent, green; calyx cap conical, acuminate, larger buds with a few minute tubercles in the middle, smaller ones smooth, minutely puberulous throughout, falling off as one piece. Bud petals broadly ovate, acute at the tip, narrowed to the truncate base, 5—6 mm long, 7—8 mm wide, thick, lilac-blue to dark red-violet. Bud filaments flat, c. 1 mm long, inapplicable, c. 2 mm long, yellow. Bud stigma 4-lobed, c. 1.5 mm long; style c. 4 mm long. Fruits
Fig. 16. *Pterandra tessellata* (Stapf) Nayar - A-E: Haviland 1383 (isotype).
campanulate, truncate, scales flatter and more tessellate, triangular and erect near the margin, glabrous, areolus with conspicuous lines; style persisting, 8–9 mm long, 10–12 mm wide, green, drying dark brown to black; pericarp c. 1 mm thick, gritty. Seeds numerous, flattened, quadrangular-cuneate, glossy khaki-tan, c. 0.75 mm long.

Vegetatively, with its sinuate-winged branchlets and cordate blades, this species resembles P. azurea (Bl.) Burk. var. cordata (Korth.) Maxw., however there are differences which include the setose and often branched calyx scales of the latter. Immature buds of P. tessellata frequently resemble those of P. rostrata (Cogn.) Nayar when the tubercles on the cap are not apparent. The rostrate tip and calyx scales are also similar.

The calyx scales of P. tessellata also resemble those of P. tuberculata (Korth.) Nayar, however the cap in that species is without any trace of tubercles. Unfortunately, flowering material of P. tessellata is sparse, thus I cannot be certain of the morphology of the mature internal flower parts. Stapf notes that his species is close to Kibessia simplex Korth. (=P. echinata Jack) and to Curtis 953 from Penang which is a syntype of P. griffithii King (=P. tuberculata). P. tessellata differs in many significant ways from P. echinata Jack, e.g. the length of the scales, winged branchlets, shape and pubescence of the leaves, etc.

P. tessellata appears to be a distinct species without any intermediate forms linking it to other species. More material, especially flowers, is required to better understand the species.

Stapf lists the type collection as being Haviland 1303 from Koung, Tampassuk River, Mt. Kinabalu, Sabah; however I believe that the actual number is 1383 since specimens of this species in the Singapore, Leiden, and Kew collections collected by Haviland at this locality in 1892 are labeled as K. tessellata Stapf. I have not seen Haviland 1303 in any collections of Melastomataceae that I have studied.

Fig. 16. A, B: calyx; C: bud petal; D: stamen; E: fruit.

**Distribution:**


**Kalimantan** — Central East, W. Koetai: Endert 2961, 4561.


Tree (other field notes lacking). Branchlets cylindric, glabrous, 1.5 mm thick, drying blackish; upper nodes flattened, c. 3 mm thick. Blades coriaceous, glabrous, elliptic, ovate, to obovate, rounded at the tip, narrowed to rounded at the base; 3-nerved, veins sunken above, raised and tapering below; intramarginal nerves invisible; secondary venation pinnate, reticulate, distinct above, invisible to obscure below; 3–5 cm long, 1.5–3
cm wide, drying greenish to brown above, tan to lighter brown below. Petioles 1.5—2.5 mm long, 1.5—2 mm thick, glabrous. Inflorescences glomerulate, on tubercles from leaf axils or just below them, many-flowered, glabrous; primary axes usually several per axil, c. 1 mm long, each with a solitary pedicel 1—2 mm long. Bracts and bracteoles ovate, acute, 0.5—1 mm long, glabrous. Calyx campanulate, glabrous, pattern closely tuberculate in the lower part, with larger and longer tubercles near the margin; 3—4 mm long, 2.5—3 mm wide; cap conical, acute, glabrous, smooth, thin, c. 2.5 mm long, splitting into several (4?) caducous lobes. Petals broadly ovate, acute at the tip, narrowed and truncate at the base, thickened with thinner margins where the venation is visible, 3—5 mm long, 2—2.5 mm wide. Filaments flattened, 2 mm long; anthers 2—2.5 mm long, 1 mm wide, with a connective spur near the filament; stigma cylindric, 1 mm long. Style slender, 3—4 mm long, elongating to 6 mm in fruit. Fruits urceolate, 5 mm long, 5 mm wide, pattern tessellate to slightly umbonate, exocarp drying brown; pericarp c. 0.2 mm thick. Seeds numerous, flattened, cuneate-quadrangular, 1—1.25 mm long, glossy brown.

The relatively small (the smallest for the genus), thick, blades with a rounded tip; fascicled inflorescences, small flowers, and urceolate fruits with a tessellate pattern distinguish this apparently rare species from all others.

The inflorescences and fruits are similar to those of P. galeata (Korth.) Ridl. and P. cogniauxii Nayar, however the former has a tessellate pattern on the calyx and the latter is easily recognized by its large, cordate, 5-nerved blades. Pterandra teysmanniana is not, as Bakhuizen f. notes under Kibessia pachyphyllum, related to kibessia acuminata Deene., which is, in my opinion, related to Pterandra echinata Jack. The calyx pattern of K. acuminata is more tuberculate to echinate and is probably and underdeveloped form of P. echinata where the scales are flattened-echinate.

Kibessia pachyphyllum Bakh. f., only known from the type collection, is undoubtedly identical to P. teysmanniana. The holotype of the former (Hallier 2223, from Kalimantan) is without inflorescences or fruits, however comparison of its leaves and buds with those of two collections of P. teysmanniana confirms its synonymy. Bakhuizen f. did not describe K. teysmanniana in his monograph. Nayar’s recombination of K. pachyphyllum Bakh. f. to Pterandra was done without having examined any relevant material, thus indicating his failure to contribute to or understand the taxonomy of Pterandra.

Fig. 17: A: inflorescence; B, C: calyx; D: mature petal; E: stamen.
Plate 6. Holotype of Pterandra teysmanniana (Cogn.) Nayar.

Distribution:

Borneo Kalimantan — Mdjang: Teysmann 8165 (holotype FI, isotype BR); Sei Kenepai Singang: Hallier 2223 (Kibessia pachyphylla Bakh. f., holotype L, isotype BO); Soengai Djemila: Hallier 2247; exact location unknown: Jaheri 1893.
Fig. 17. *Pternandra teysmanniana* (Cogn.) Nayar - A, D, E: Teysmann 8165 (holotype); B, C: Hallier 2223 (*Kibessia pachyphyllum* Bakh. f., holotype).
Plate 6. *Pterandra teysmanniana* (Cogn.) Nayar, holotype at Florence. Collected by and named after J. E. Teysmann (1808-1882), a Dutch botanist who collected extensively in the Malay Archipelago. This specimen is from Borneo and was collected in 1876. Photo: Rijksherbarium, Leiden.

Tree up to 20 m tall with a maximum diameter of 50 cm. Bole straight, not buttressed; outer bark 0.5 mm thick, grey to brown with many shallow fissures, smooth and peeling off; inner bark white, wood yellowish. Branchlets terete, smooth, glabrous, drying blackish, c. 2 mm thick, nodes flattened and swollen, c. 4 mm wide. Blades subcoriaceous to coriaceous, glabrous, broadly lanceolate to broadly ovate, acuminate at the tip (acumen 6–10 mm long), narrowed and decurrent or rounded to cordate at the base; 3-nerved from the base, nerves sunken above, raised and tapering below; secondary venation pinnate, c. 15–20 pairs, reticulate; 5.5–12 (19) cm long, 3–6 (9.5) cm wide, dark green above, green below; drying olive to blackish above, tan to dark brown below. Petioles 4–5 mm long, 1–2 mm wide, glabrous. Inflorescences cymose, from leaf axils, less commonly leafless nodes, often terminal, 1–2.5 cm long, several to many flowers per axil; axes 4-angled, puberulous. Bracts and bracteoles lanceolate to ovate, obtuse to acute at the tip, 2–3 (5) mm long, larger ones concave, minutely puberulous. Primary axes 1 to several per axil, 4–20 mm long, with 1–3 nodes, up to 1 mm thick; secondary axes 2–4 mm long, pedicels 2–3 mm long. Calyx campanulate, 4–5 mm long, c. 4 mm wide, green, covered with minutely puberulous, often appressed, tubercles which are shorter near the pedicel and longest (c. 2 mm) near the rim; cap mammiform, papillose-puberulous, smooth, c. 2 mm long, splitting into 4 triangular lobes. Bud petals imbricating to the right, when mature thickened, broadly ovate to suborbicular, acute at the tip, truncate at the base, 4–5 mm long, 4–5 mm wide, lilac. Filaments flattened, c. 2 mm long, lilac; anthers c. 2 mm long, yellow. Stigma 4-lobed, c. 2 mm long, yellow. Style slender, glabrous, 4–5 mm long, whitish. Fruits campanulate, truncate at the margin, 7–8 mm long, 7–8 mm wide, pattern umbrella-verruculose; exocarp grey-green, drying black. Seeds numerous, flattened, cuneate-quadrangular, c. 0.5 mm long; testa glossy tan.

The type collection of *P. tuberculata* (Korthals s.n., from Sumatra) has some inflorescences and young buds. From the descriptions of this species it is apparent that it has a calyx cap which splits into 4-lobes. The leaves of the type material match those on Griffith 2272/1 — which is the lectotype of *P. griffithii*. This specimen and the syn-type collection (Curtis 953) have buds and mature flowers. The nature of the calyx cap and inflorescence is different from those of *P. rostrata* which has shorter, thicker, and glabrous flowering axes; an acute to rostrate cap which falls off in one piece; and generally larger blades. This last point has many exceptions, e.g. Koster 1481, from New Guinea, has leaves larger than the type collection of *P. rostrata* (Beccari 979); and Meijer 37999 (*P. rostrata*) which has leaves smaller than Griffith 2272/1. I have not been able to separate the two species on the basis of vegetative characters since the leaves vary considerably for each.
The type collections of *P. griffithii* are probably the same as *P. tuberculata*. I have attempted to construct an idea of *P. tuberculata* using *P. griffithii* as a basis. Cogniaux and Bakhuizen f. adopted this approach and considered *P. griffithii* King as a synonym, however Ridley combined *P. griffithii* with *P. paniculata* Benth. ex Cl. which is based on a specimen with an abnormal, witches broom inflorescences. I agree with King and Bakhuizen f. in considering *P. paniculata* Benth. ex Cl. as a synonym of *P. coerulescens* Jack. Another possibility is that the two species are different and that *P. coriacea* (Cogn.) Nayar is the same as *P. tuberculata*. The basic problem lies in trying to determine what the nature of *P. tuberculata* really is.

The blades of the type collection of *P. tuberculata* closely resemble those of Beccari 3164 and 3324 — both types of *P. coriacea*. The leaves on these collections are always small, in contrast to those of *P. griffithii* which often become rather large. The basic structure of the inflorescences of *P. tuberculata*, *P. griffithii*, and *P. coriacea* are similar and the only distinction I can find between the taxa lies with the calyx cap which falls off as a unit in *P. coriacea*. It is due to the nature of the cap plus its small leaves that I have followed Cogniaux in considering *P. coriacea* distinct from *P. tuberculata*. Both species are uncommon and more flowering and fruiting material are needed to fully understand these taxa.

The holotype of *Ewyckia korthalsiana* Miq. at Utrecht (Teysmann sn, from Bangka Island) is without flowers or fruits, however there are two short parts of two inflorescences remaining. *E. korthalsiana* is written on the original label and on another more recent tag *P. capitellata* Jack is noted. The primary axes on this specimen are between 8 and 10 mm long, thus they are longer than the maximum (3 mm) generally considered for *P. capitellata*. Bakhuizen f., therefore, included *E. korthalsiana* under *P. coerulescens* Jack var. *cyanea* (Bl.) Bakh. f. Cogniaux, however, included it under *P. capitellata*. Since the specimen lacks flowers and fruits I cannot be absolutely certain that it is *P. coerulescens*.

The blades and remnants of the two inflorescences on this specimen, in my opinion, more closely resemble Griffith 2272/1 — which is the lectotype of *P. griffithii* King. The shape, texture, and colour of the dry leaves match, and the inflorescence axes are more like those of *P. griffithii* than of *P. coerulescens*. Miquel's original description indicates that the calyx is "obtuso-4-dentatus, areolato- verruculosus". This is not a feature of *P. coerulescens* which has a truncate calyx with a tessellate or somewhat umbonate pattern. Teysmann's specimen, from its general appearance, more closely resembles several other collections of *P. tuberculata* than *P. coerulescens* which tends to dry black.

Wray 1994, lectotype of *Pternandra griffithii* var. *cordata*, has slightly cordate blades. However, this feature is only developed on some blades and in others the indentation is more like that of an auricle. Most specimens of *P. tuberculata* in the Singapore and Leiden collections have acute bases, but some of the blades in Robinson & Kloss 6148 are rounded, and in fact look like some of the blades in Wray 1994. The texture of the blades in Wray 1994 is very similar to many specimens of *P. tuberculata* (Ridly s.n. from Biodi Tepah, Nov. 1908 — which has rounded blades, and Nauven 35879). Some of the blades in these specimens are broadly rounded and some appear to be almost cordate. The distinction of var. *cordata*, in my opinion, does not merit a separate taxon, therefore I have united it with *P. tuberculata*.

Maxwell 77—22, from Singapore, differs from all other flowering specimens of *P. tuberculata* that I have seen in having a thin, mammiform cap which falls off in one piece. The collection in all other respects matches other collections of *P. tuberculata*.
Fig. 18. *Pterandra tuberculata* (Korth.) Nayar - A, G: Buwalda 6239; B, E: Griffith 2272/1 (*Pterandra griffithii* King, lectotype); C, D: Maxwell 77-22; F: Koster 1481.
Fig. 18. A, B: calyx; C: calyptra; D: petal; E: stamen; F: style in bud; G: mature style.

Plate 7. Holotype of *Pternandra tuberculata* (Korth.) Nayar.

Plate 8. Lectotype of *Pternandra griffithii* King.

Distribution:

**W. Malaysia. Kedah** — Serdang: Nauen 35879; sine loc.: Meh 17863.

**Penang** — Curtis 453 (syntype *P. griffithii* King var. *cordata* King, not seen), 953 (syntype *P. griffithii* King), 2784, 2786, sn in June 1890.


**Trengganu** — Ulu Brang: Moysey & Kiah 33646 (abnormal).

**Selangor** — Batu Tigai: Ridley 11936; Genting Highlands Rd., 9th mile: Kochummen 023063; Semangkok Forest Reserve: Chan 13270.

**Malacca** — sine loc.: Griffith 2272/1 (*P. griffithii* King, lectotype K).

**Singapore** — Ahmad 1054, 1365; Anderson 63, Maxwell 77–22; Ridley 3918, 4729.

**Riouw Archipelago.** Bukit Tanjong: Buwalda 6239.

**Sumatra. West Coast** — Gunong Koerintgi: Korthals sn (*Ewyckia tuberculata* Korth., holotype L); Kuala Belilas: Buwalda 6693.


**Borneo Sabah** — Sosopodon: Mikil 38499.

**New Guinea** Ilolo: Streimann & Kairo 26184; Japen Island: Koster 11178; Kaloal: Koster 1481.

18. ABNORMAL AND UNIDENTIFIED *PTERNANDRA*.

There are several collections of *Pternandra* in the Singapore and Leiden herbaria that have abnormal inflorescences with witches broom deformities or are vegetative (Plate 2). With many of these specimens I am reasonably certain as to their identities (indicated by aff.) however with others I cannot be absolutely certain what species they are. Since the vegetative characteristics of *P. echinata* Jack and *P. azurea* (Bl.) Burk. are often similar I have, in most instances, been able to sort these specimens on the basis of collecting locale, that is *P. echinata* is mostly restricted to the Malay Peninsula and *P. azurea* to the Malay Islands. A more difficult problem lies with abnormal or vegetative collections of what closely resembles *P. coerulescens* Jack and *P. tuberculata* (Korth.) Nay. from the Malay Peninsula, and these two species plus *P. galeata* (Korth.) Ridl. and *P. rostrata* (Cogn.) Nay. from the Malay Islands. The branchlets and leaves of these four species
Plate 7. Holotype of *Pternandra tuberculata* (Korth.) Nayar at Leiden. This species was originally described by Korthals in 1844 as *Ewyckia tuberculata* Korth, and was recombined by Blume as *Rectomitra tuberculata* (Korth.) Bl. in 1849. It was changed to *Kibessia tuberculata* (Korth.) Hk. f. ex Cl. in 1879 and finally to *P. tuberculata* (Korth.) Nayar in 1978. Photo: Rijksherbarium, Leiden.
Plate 8. Lectotype of Pternandra griffithii King at Kew which has been reduced to a synonym of P. tuberculata (Korth.) Nayar in this revision. Pternandra griffithii King, from Malacca, was named by King in 1900 in honour of William Griffith (1810-1845), a British surgeon-botanist, who collected extensively and published detailed accounts of the flora of British India and the Malay Peninsula. Photo: Rijksherbarium, Leiden.
often resemble each other, therefore without flowers or fruits I have not ventured
to guess what species these specimens are. Hopefully collectors will take notice of
abnormal _Pterandra_ inflorescences and make an effort to collect normal specimens from
the same tree so that future workers can study the degree and variability of such de-
formities which can be positively identified.

In several specimens, e.g. Ridley 391 (8?); Ridley sn, from Bdoi Tapah, Perak in
November 1908; Nauen 35879; and Moysey & Kiah 33646; the inflorescences are abnormal
in that they are 8–15 cm long, with a few rudimentary leaves and enlarged, lanceolate,
acuminate bracts which often resemble the leaves; and with or without a few, often de-
formed, flowers. These specimens, in my opinion, are _P. tuberculata_ (Korth.) Nay. since
what I can see of the calyx resembles this species more than that of _P. coerulescens_
Jack.

Ridley was of the opinion that _P. paniculata_ (Miq.) Triana is a paniculatd form of
_`P. griffithii`_ King where the inflorescence is “abnormal or converted into a nass of small
leaves, with a few abnormal flowers intermixed.” Bakhuizen f. considered _P. paniculata_
as a synonym of the typical variety of _P. coerulescens_ Jack. Moreover, he notes that
_P. paniculata_ is based on a specimen with a witches broom deformity of the inflo-
rescence. Apparently this abnormal condition affects both _P. coerulescens_ and _P. tubercu-
lata_, however it is extremely difficult to tell the species apart without normal flowers or
fruits.

The calyx tube in some specimens, e.g. Kostermans 13664 (Borneo) and others with
this abnormal inflorescence, is tuberculata with a distinct and smooth cap. These speci-
mens are most likely _P. rostrata_ or _P. tuberculata_.

Other specimens, e.g. Teysmann sn, from Bangka Island — the holotype of
_`P. (Ewyckia) paniculata`_ (Miq.) Triana; Winkler 2408, Haviland =177 (both from Borneo)
and others have a tessellate calyx and no cap. These collections are clearly _P. coerulescens_
Jack.

_Kibessia simplex_ Korth. var. _oblonga_ Bl. (Mus. Bot. Lugd.-Bat. I:1 (1849) 9) is
described from a specimen (Waitz sn, from Borneo) which has an abnormal inflorescence
which resembles those of _P. azurea_ and _P. coerulescens_. Unfortunately, the specimen
lacks buds, thus I cannot be absolutely certain of what species it really is; however from
the leaves and branches var. _oblonga_ more closely resembles the type collections of
_P. azurea_ (Bl.) Burk. and _Kibessia simplex_ Korth. — which I consider a synonym of the
former. I do not agree with Bakhuizen f. in reducing var. _oblonga_ to a synonym of
_P. coerulescens_ Jack.

_Craib_ (F1. Siam. Enum. I:4 (1931) 702) notes that several collections of _P. coeru-
lescens_ Jack from southern Thailand have abnormal inflorescences. He also indicates that
several species of _Diospyros_ (Ebenaceae) and _Maesa_ (Myrsinaceae) are also affected in
this manner.

Specimens Examined

_W. Malaysia._ Kedah — Kedah Peak: Robinson & Kloss 6148.

_Penang._ — I. H. Burkill 6145 (aff. 5).

_Perah._ — Ayer Larut: Wray sn; Dindings: H. M. Burkill & Shah 185 (aff. 5); Pangkor:
Ridley sn; sine, loc.: Scortechini 248, sn.

Maxwell: _Pterandra_ (Melastomataceae) 79
Singapore – Murton 92 (aff. 8), Ridley sn at Chan Chu Kang.


Borneo. Sarawak – Bukit Lambir, Baram District: Chew 961; Segan For. Res.: Wright 27105; Sungei Lebang, Bintulu: Ashton 16299.


Sine Loc.: Boerlage 6688 (aff. 2).

APPENDIX


2. Pterandra discolor Cogn. in DC., Monogr. Phan. 7 (1891) 1194. An isotype at Brussels, Balansa 1145, from Tonkin, is Rhodaninia dumetorum (DC.) Merr. & Perry, of the Myrtaceae.


4. Kibessia galeata var. latifolia Ohwi, Bot. Mag. Tokyo 57 (1943) 18. The type (Kanehira & Hatusima 13146, New Guinea) has not been seen.


6. Pterandra parasitica Finl. & Wall. (Wall. cat. 4086A) is Pogonanthera pulverulenta (Jack) Bl.

7. Kibessia celebica Koord., Fl. van Celebes II (1898) 466 is Medinilla myrtiformis (Naud.) Triana.

8. Pterandra simplex (Korth.) Baill., Hist. Pl. 7 (1880) 24, f. 32, 33. The two figures cited do not represent this species (the correct name of which is Pterandra azurea var. azurea) and it is most likely that they were based on P. rostrata (Cogn.) Nayar or perhaps P. tessellata (Stapf) Nayar.


This species, from New Guinea, supposedly differs from P. coriacea (Cogn.) Nayar in having larger leaves, shorter pedicels; and smaller, flatter calyx tubercles. P. coriacea also has glaucous blade undersurfaces which dry whitish to greyish, and are more ovate and less lanceolate-elliptic than those of P. ledermannii. The tubercles in P. coriacea are more acute and in P. ledermannii more flattened and hexagonal.

I believe that P. ledermannii is closer to P. rostrata (Cogn.) Nayar, however I cannot be certain of this until more New Guinea material becomes available. Mansfield lists Ledermann 8717a, which I have examined at Singapore, as possibly being equal to the
Holotype: Ledermann 8711 — which I have not seen. The collection at Singapore consists of a few flowering axes and one flower bud. The calyx pattern and the thickened, acuminate cap, which apparently falls off in one piece, resemble *P. rostrata* more than any other taxon. It is definitely not *P. tuberculata* (Korth.) Nayar or *P. glaceta* (Korth.) Ridl. var. *galeata* both of which have caps have caps that split into four lobes.

Nayar, without having examined any authentic material of *Kibessia ledermannii* Mansf., merely transferred this species to *Pterandra* without any discussion. Needless to say, such pseudo-academic pursuits, however beneficial to their author, merely create more unnecessary confusion and certainly detract from one’s taxonomic credibility — and in the case of Nayar, an already dubious one.

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Sam 21797 (14), 34678 (5)  
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Santiago sn, Kepong, Selangor (8)  
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Yakup 11209 (9)
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sine coll. 46 (Chumpon, Thailand) (5)
A REVISION OF THE GENUS *TETRADIUM* (RUTACEAE)

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ABSTRACT

The genus *Tetradium*, which has traditionally been placed in the synonymy of the rutaceous genus *Euodia*, consists of nine species and is distributed from the Himalayas east to Japan and south to Java and Sumbawa. The genus is described and its taxonomic history and relationships to other genera are discussed. The nine species are keyed, described, and their interrelationships discussed. New combinations are made for the names of seven species, and one species, *Tetradium sumatranum*, is described as new.

Among the Rutaceae of the southeast Asian-Pacific region is a group of trees and shrubs that is distinctive in having opposite, pinnately compound leaves in combination with terminal inflorescences, follicular fruits, and seeds that remain attached in the dehisced follicle. These plants were first described in 1790 when Loureiro based the genus *Tetradium* on a Vietnamese species, *Tetradium trichotomum* Lour. Although Loureiro's description of this plant was reasonably adequate and a representative specimen was lodged at the British Museum, the identity of *Tetradium* in the Rutaceae was not definitely established until the publication of the first volume of Bentham and Hooker's *Genera Plantarum* (1862). In the meantime, Sprengel (1824) transferred *Tetradium trichotomum* to the simaroubaceous genus *Brucea* J. F. Mill., DeCandolle (1825) recognised *Tetradium* as a distinct genus and placed it between *Brucea* and *Ailanthus* Desf., while Jussieu (1825) and Endlicher (1840) listed it in the Rutaceae as an insufficiently known genus. Also during this period, three additional genera, *Philagonia* Bl., from Java, *Boymia* A. Juss., from mainland China, and *Megabotrya* Hance ex Walpers, from Hong Kong, were based on plants that are congeneric with *Tetradium trichotomum*.

Bentham and Hooker placed *Tetradium*, along with *Philagonia*, *Boymia*, and *Megabotrya*, in the synonymy of the genus *Euodia* J. R. & G. Forst. They were essentially followed in this by Engler (1896, 1931), in the standard major work on the southeast Asian-Pacific Rutaceae, who treated *Tetradium* as a section of *Euodia* and listed *Philagonia*, *Boymia*, and *Megabotrya* in its synonymy. This is a remarkably conservative treatment, considering the morphologic differences between the type species of *Euodia*, *Euodia hortensis* J. R. & G. Forst., from the New Hebrides, and the plants typifying *Tetradium*, *Philagonia*, *Boymia*, and *Megabotrya*, but its correctness has apparently never been questioned.

In connection with the present study I have examined type or otherwise authentic specimens of nearly all of the 200 or so species that have been placed in *Euodia sensu* Engler, and it is evident that those with opposite, pinnately compound leaves and follicular fruits with persistent seeds form a natural group around the type species of *Tetradium* and stand well apart, morphologically, from a group of species centered around the type species of *Euodia*. It is also evident that the majority of the species that have been placed in *Euodia* in this classification are more correctly placed in the genus *Melicope* J. R. & G. Forst. than in either *Tetradium* or *Euodia*. 

In view of this, the formulation of a more natural classification of these species reinstating *Tetradium* (including *Philagonia*, *Boymia*, and *Megabotrya*) at the rank of genus and redefining *Euodia* and *Melicope*. These three genera are thus characterized as follows:

**Tetradium.** Leaves opposite, pinnately compound; inflorescences terminal or terminal and from the axils of the uppermost pair of leaves; flowers unisexual, 4–5-merous; stamens the same number as petals; carpels 1- or 2-ovulate; fruits follicular; seeds shiny, smooth, remaining attached in the dehisced follicle. Nine species; distributed from the Himalayas east to Japan and south to Java and Sumbawa.

**Euodia.** Leaves opposite, trifoliolate or unifoliolate; inflorescences axillary; flowers bisexual, 4-merous; stamens the same number as petals; carpels 2-ovulate; fruits follicular; seeds more or less dull and roughened, discharged when the follicle dehisces. About six species; distributed from New Guinea and northeastern Australia east to Samoa.

**Melicope.** Leaves opposite, trifoliolate, unifoliolate, or simple; inflorescences axillary, lateral, or rarely (only in a few species from Madagascar) terminal; flowers bisexual or unisexual, 4-merous; stamens the same number or twice as many as the petals; carpels 2-ovulate; fruits follicular to capsular; seeds shiny, smooth, remaining attached in the dehisced fruit. Probably about 150 species; distributed from Madagascar to India and southern China, throughout Malesia, Micronesia, Melanesia, and Polynesia to the Society Islands, and south to southeastern Australia and New Zealand.

Of the species that are considered here to belong in the genus *Melicope*, the flowers of those that were misplaced in *Euodia* are 4-staminate whereas those of the type species of *Melicope*, *Melicope ternata* J. R. & G. Forst., from New Zealand, and the 50 or so species that center around it, morphologically, are 8-staminate. This is the only consistent difference between these plants and it is clearly not a sign of generic distinctness, as has traditionally been thought, because it cuts across many lines of obvious relationships between species.

The main differences between *Tetradium*, *Euodia*, and *Melicope*, as these genera are interpreted here, are given in the following key:

Seeds more or less dull and roughened, discharged when the follicle dehisces; leaves trifoliolate or unifoliolate; inflorescences axillary...................... *Euodia*

Seeds shiny, smooth, remaining attached in the dehisced fruit.

Leaves pinnately compound; inflorescences terminal or terminal and from the axils of the uppermost pair of leaves...................... *Tetradium*

Leaves trifoliolate, unifoliolate, or simple; inflorescences axillary, lateral, or rarely terminal....................................................... *Melicope*

(*Euodia* and *Melicope* are being revised. The necessary nomenclatural changes for species of *Melicope* that were originally described in *Euodia* will be made in a future publication.)

Besides the distinguishing characters noted above, *Tetradium* differs from *Euodia* and
Melicope in having strong sexual dimorphism in the gynoecium. In its carpellate flowers the carpels are contiguous, forming a 4- or 5-lobed ovary, whereas in its staminate flowers the rudimentary carpels are divergent, finger-like structures which are about as long as the functional carpels. There is no similar dimorphism in Euodia or in Melicope. The flowers of the former are always bisexual and, in species of the latter with unisexual flowers, the non-functional gynoecium is merely a reduced replica of the functional gynoecium.

Strikingly similar sexual dimorphism to that found in Tetradium is exhibited by the genus Phellodendron Rupe. (Rutaceae), which consists of about eight species and is distributed from southwestern China northeast to southeastern U.S.S.R. and Japan and south, discontinuously, to Taiwan. Phellodendron differs rather markedly from Tetradium in having a syncarpous functional gynoecium that develops into a drupaceous fruit. Its rudimentary carpels are distinct, however, and otherwise appear to be identical with those produced in Tetradium. In other features, as well, these two genera are so alike that it would seem impossible to distinguish one from the other in sterile or staminate herbarium material.

While it may seem unlikely that a genus with syncarpous, drupaceous fruit would be a close relative of one with apocarpous or subapocarpous, follicular fruit — and indeed, on the basis of this fruit difference Engler (1896, 1931) placed Phellodendron and Tetradium (as a section of Euodia) in separate subfamilies of the Rutaceae, the Toddaloideae and Rutoideae, respectively — I think there is little doubt that Phellodendron and Tetradium are, in fact, closely related. Such a relationship is not unusual in the non-aurantioid Rutaceae. Acroanchia J. R. & G, Forst., for example, which has syncarpous, drupaceous fruit, appears to be closely related to Melicope, most species of which have apocarpous or subapocarpous, follicular fruits (Hartley, 1974), and Zanthoxylum L. (including Fagara L.), which has apocarpous or subapocarpous, follicular fruit, appears to be the closest relative of Toddalia Juss., which has syncarpous, drupaceous fruit (Hartley, unpubl.). A particularly close evolutionary proximity of the apocarpous and syncarpous conditions appears to be evidenced in Phellodendron where the presence of separate rudimentary carpels in a genus with a syncarpous functional gynoecium would seem to indicate immediate apocarpous ancestry. I think it is likely that this ancestor was a species of Tetradium.

Tetradium also appears to be closely related to Zanthoxylum, which consists of about 200 species and is pantropical and ranges north into temperate latitudes of eastern Asia and North America. Zanthoxylum differs from Tetradium mainly in having alternate leaves. The two genera are consistently similar in having apocarpous or subapocarpous, follicular fruits with smooth, shiny seeds that remain attached in the dehisced follicle. In most other relevant characters Zanthoxylum is variable, but many of its species, including several from southeast Asia (see Huang, 1957, and Hartley, 1966) are similar to Tetradium in having pinnately compound leaves, terminal inflorescences, unisexual, 4- or 5-merous flowers, and divergent, finger-like, rudimentary carpels, among other characters.

Zanthoxylum, Tetradium, and Phellodendron appear to be related to one another in a linear sequence. The following outline shows the apparent interrelationships of the three genera as indicated by various morphologic features.
Leaves alternate; functional gynoecium apocarpous or subapocarpous (or sometimes reduced to a single carpel); fruits follicular. \textit{Zanthoxylum}

Leaves opposite; functional gynoecium apocarpous or subapocarpous; fruits follicular. \textit{Tetradium}

Leaves opposite; functional gynoecium syncarpous; fruits drupaceous. \textit{Phellodendron}

\textit{Todalia}, which is mentioned above as probably being a close relative of \textit{Zanthoxylum}, does not seem to be part of this sequence.

This revision is based on herbarium specimens. The contributing herbaria, with abbreviations from Holmgren and Keunen’s Index Herbariorum, Part 1, ed. 6 [Reg. Veg. 92 (1974)], are as follows: Arnold Arboretum of Harvard University, Cambridge (A); State Herbarium of South Australia, Adelaide (AD); Auckland Institute and Museum, Auckland (AK); Botanisches Museum, Berlin-Dahlem (B); Bernice P. Bishop Museum, Honolulu (BISH); British Museum (Natural History), London (BM); Herbarium Bogoriense, Bogor (BO); Queensland Herbarium, Brisbane (BRI); Botanical Survey of India, Calcutta (CAL); C.S.I.R.O. Herbarium Australiense, Canberra (CANB); Botany Division, D.S.I.R., Canberra (CHR); Forest Research Institute and Colleges, Dehra Dun (DD); Royal Botanic Garden, Edinburgh (E); Conservatoire et Jardin Botaniques, Geneva (G): Gray Herbarium of Harvard University, Cambridge (GH); Royal Botanic Gardens, Kew (K); Rijksherbarium, Leiden (L); Komarov Botanical Institute, U.S.S.R. Academy of Sciences, Leningrad (LE); National Herbarium of Victoria, Melbourne (MEL); University Herbarium, University of Michigan, Ann Arbor (MICH); National Herbarium of New South Wales, Sydney (NSW); New York Botanical Garden, New York (NY); Museum National d’Histoire Naturelle, Paris (P); Institute of Botany, Academia Sinica, Peking (PE); Department of Botany, Academy of Natural Sciences, Philadelphia (PH); Botanic Gardens, Singapore (SING); Department of Botany, University of Tokyo (TI); Botanical Museum and Herbarium, Utrecht (U); Herbarium of the University of California, Berkeley (UC); National Museum of Natural History (Department of Botany), Smithsonian Institution, Washington D. C. (US); Naturhistorisches Museum, Wien (W).

\textit{Tetradium} Lour., Fl. Cochinch. (1790) 91, non Dulac, 1867. Type species: \textit{Tetradium trichotomum} Lour.


\textit{Megabotrya} Hance ex Walpers, Ann. Bot. Syst. 2 (1852) 258. Type species: \textit{Megabotrya meliaefolia} Hance ex Walpers.


Evodia section Oxyactis (Benn.) Rehd. & Wils. in Sargent, Pl. Wils. 2 (1914) 133, nomen illegit., based on the same type as Evodia section Evodioceras Dode.


Small to large trees or occasionally shrubs; dioecious or rarely occasional plants monoecious; evergreen or deciduous; indumentum of simple trichomes. Buds naked, pubescent, the lateral buds axillary. Leaves opposite, imparipinnate or rarely occasional leaves paripinnate; lateral leaflets mostly petiolulate; terminal leaflet on an extension of the rachis; leaflet blades usually oil dotted, venation pinnate, margin often crenulate with an oil dot at the sinus of each crenulation. Inflorescences corymbose or subcorymbose or occasionally grading to paniculate, spreading or rarely rather compacted, several- to many-flowered, terminal or terminal and from the axils of the uppermost pair of leaves. Flowers unisexual or rarely occasional flowers bisexual, 5- or 4-merous, glbose, broadly ellipsoid, or obvoid in bud; sepals 5 or 4, ovate to triangular, basally connate, valvate, persistent in fruit; petals 5 or 4, elliptic to ovate-elliptic, usually hooked adaxially at the apex, distinct, erect, narrowly imbricate in bud, deciduous in fruit; stamens the same number as petals, distinct, opposite the sepals; functional stamens elongating to about 1.5 times the length of the petals, filaments usually more or less villous from about the middle to the base, adaxially, otherwise glabrous, linear-subulate, curved inward basally, otherwise straight and more or less erect, anthers ovoid, obtuse, dorsifixed; rudimentary stamens (produced in carpellate flowers) much shorter than the petals or sometimes obsolete, ligulate, persistent in fruit; disc intrastaminal, in stamine flowers conical to cylindrical or occasionally barrel-shaped, in carpellate flowers pulvinate to barrel-shaped, persistent in fruit as a short stipe; gynoecium 5- or 4-carpellate, together with the subtending disc about as long as the petals; functional carpels free to the base or connate toward the base, otherwise contiguous and forming a 5- or 4-lobed, 5- or 4-loculate, subglobose to obvoid ovary, placentation axile, ovules 2 or 1 per locule, style apical, straight, composed of 5 or 4 more or less contiguous stylar elements; stigma 1, peltate and usually shallowly 5- or 4-lobed; rudimentary carpels (produced in stamine flowers) finger-like, free to the base or connate toward the base, divergent and sometimes contorted. Fruits of 1-5 or 1-4 1- or 2-seeded follicles, carpels not developed into follicles, persistent; follicles free to the base or connate toward the base, dehiscing adaxially, apically, and partially down the abaxial surface, epicarp dry at maturity, subwoody, the outer surface more or less glandular-punctate, endocarp cartilaginous abaxially grading to pergamentaceous adaxially, persistent in the dehisced follicle. Seed(s) shiny, smooth, black to dark reddish brown, persistent in the dehisced follicle; endosperm copious, fleshy; embryo straight, cotyledons broadly elliptic, plano-convex, hypocotyl terminal.

Trichomes are uniformly simple and unicellular in Tetradium and in all species the new growth of vegetative and floral shoots is clothed with fine, short indumentum. As these shoots mature, this juvenile vestiture may be partially or entirely lost or may be retained and is often further developed. As a result, mature leaves, branchlets of the present year’s growth, and axes and branches of inflorescences vary from glabrous to densely pubescent. For the most part this variability is taxonomically insignificant.

A rather unusual surface feature occurs in Tetradium austrosinense and T. sumatrannum, and to a lesser extent in a few specimens of T. fraxinifolium. The lower surface
of the leaflets of these plants is glaucous and minutely papillate. The papillae appear to be globules of wax.

The terminal inflorescence in *Tetradium* originates from the middle bud of the three found between the uppermost pair of leaves of the shoot. The two lateral buds of the three may form upper axillary inflorescences or they may remain dormant during the flowering period and later form vegetative shoots.

Inflorescences range from corymbose to subcorymbose to paniculate and from spreading to rather compacted. This variability is not taxonomically significant.

*Tetradium* is remarkably variable (for a rutaceous genus) in ovule number and in several characteristics of the seeds and their mode of attachment in the dehisced follicle. This variability, summarized in the following outline, provides a basis for a natural classification of the species.

A. Carpels 2-ovulate.

B. Seeds 2 per follicle (follicles appearing to be 1-seeded in *T. sambucinum*).

C. Both seeds functional; outer testa spongy, bounded externally by a shiny, crustaceous pellicle; inner testa bony.

D. Seeds hemispheric, the two coherent and appearing to represent a single, globose or subglobose seed, attached in the dehisced follicle to an adaxial strip of pergamentaceous endocarp tissue.

1. *T. sambucinum*.

D. Seeds subtrigonous, separate, attached in the dehisced follicle to a funicular aril.

2. *T. fraxinifolium*.

C. One seed sterile (of almost normal size — containing what appears to be endosperm but lacking an embryo); seeds ovoid to ellipsoid, coherent, attached in the dehisced follicle to an adaxial strip of pergamentaceous endocarp tissue; testa bony in the fertile seed, thin and brittle in the sterile seed, bounded externally by a shiny pellicle, without spongy tissue.

3. *T. daniellii*.

4. *T. calcicolum*.

B. Seed 1 per follicle (paired with an aborted seed). Subglobose to ovoid to broadly ellipsoid, attached in the dehisced follicle to an adaxial strip of pergamentaceous endocarp tissue; outer testa spongy, bounded externally by a shiny, crustaceous pellicle; inner testa bony.

5. *T. glabristifolium*.


7. *T. ruticarpum*.

A. Carpels 1-ovulate.
E. Seed ellipsoid to subreniform, attached in the dehisced follicle to an adaxial strip of pergamentaceous endocarp tissue; outer testa spongy, bounded externally by a shiny, crustaceous pellicle; inner testa bony.

8. *T. austrosinense.*


Regarding the relative evolutionary levels of these characters, it is probable that the one-ovulate condition is more highly derived than the two-ovulate and that in the two-ovulate species the one-seeded condition is more highly derived than the two-seeded. The levels of the other characters are more difficult to judge, but it seems likely, mainly because of dissimilarity to *Zanthoxylum,* the supposed ancestor of *Tetradium,* that the arillate condition in *T. fraxinifolium* and the absence of spongy outer testa in *T. daniellii* and *T. calcicolum* represent derived states from the non-arillate condition and presence of spongy outer testa.

Regarding the interrelationships of the species, *Tetradium daniellii* and *T. calcicolum* are very closely related and stand well apart from the other species of the genus. The same is true of *T. austrosinense* and *T. sumatranum.* *Tetradium glabrifolium,* *T. trichotomum,* and *T. ruticarpum* are less closely interrelated, but clearly comprise a natural, fairly isolated group. The remaining two species, *T. sambucinum* and *T. fraxinifolium,* are not at all closely related and are markedly distinct (especially the latter) from the other species of the genus.

As is noted in the generic synonymy, three sections of *Euodia* have been based on species of *Tetradium,* namely, section *Tetradium,* based on *Euodia trichotoma* (= *Tetradium trichotomum*); section *Evodioceras,* based on *Euodia daniellii* (= *Tetradium daniellii*); and section *Subtrigonospermum,* based on *Euodia subtrigonosperma* (= *Tetradium fraxinifolium*). In view of the interrelationships of the species, these sectional names could be used to designate natural species groupings: section *Tetradium* for *T. glabrifolium,* *T. trichotomum,* and *T. ruticarpum*; section *Evodioceras* for *T. daniellii* and *T. calcicolum*; and section *Subtrigonospermum* for *T. fraxinifolium.* I prefer not to use them, however, because of the small size of the genus and also because doing so would necessitate describing two additional sections, one for *T. sambucinum* and one for *T. austrosinense* and *T. sumatranum.*

Economically, *Tetradium* is of rather minor importance as an ornamental tree (notably *T. daniellii,* which is hardy at cold temperate latitudes) while the fruit of one species, *T. ruticarpum,* is reported (as *Boymia ruticarpa* and *Euodia officinalis*) to have medicinal properties (Siebold and Zuccarini, 1837; Rehder and Wilson, 1914).

Chemically, *Tetradium* is reported to yield a variety of secondary metabolites, and from this standpoint the genus may have as yet unrealized economic value. These reports are as follows:

1. The isoquinoline alkaloid berberine is reported from *Tetradium glabrifolium* (as *Euodia glauca* and *E. mellifolia*) by Price (1963) and Hegnauer (1973).
2. Several quinazoline alkaloids are reported from *Tetradium ruticarpum* (as *Euodia ruticarpa*) by Price (1963), Hegnauer (1973), and Waterman (1975).

3. An amide is reported from *Tetradium danielli* (as *Euodia hupehensis*) by Waterman (1975).

4. The flavanoids diosmin and hesperidin are reported from *Tetradium daniellii* (as *Euodia daniellii*, *E. hupehensis*, and *E. velutina*) and *T. ruticarpum* (as *Euodia officinalis* and *E. ruticarpum*) by Hegnauer (1973).

5. Three limonoids are reported from *Tetradium ruticarpum* (as *Euodia ruticarpa*) by Hegnauer (1973).

6. Two triterpenes are reported from *Tetradium fraxinifolium* (as *Euodia fraxinifolia*) by Hegnauer (1973).

The reports of the isoquinoline alkaloid berberine from *Tetradium glabrifolium* were based on earlier studies and are considered to be doubtful by Hegnauer (1973) and Waterman (1975); both of these authors point out that isoquinoline alkaloids, which are of wide occurrence in families of the Ranales *sensu lat.*, are probably restricted, in the Rutaceae, to *Zanthoxylum* (including *Fagara*), *Phellodendron*, and *Toddalia*. The close mutual relationship between *Zanthoxylum*, *Tetradium*, and *Phellodendron*, proposed in the present study, suggests that species of *Tetradium* may well synthesize these compounds. It would thus be of interest to re-examine material of *T. glabrifolium*.

**KEY TO FLOWERING MATERIAL**

1. Perianth, androecium, and gynoecium predominantly 5-parted (4-parted in occasional flowers). .................................................. 2.

2. Leaflets minutely papillate below; ovules 1 per carpel. ................................................. 3.

3. Leaflets below sparsely to densely pubescent with spreading or ascending hairs, main veins 9-12 pairs; petals 2.5-3 mm long. ... 8. *T. austrosinense*.

3. Leaflets below puberulent with minute, appressed hairs, main veins 13-16 pairs; petals 3.2-3.5 mm long. .............................. 9. *T. sumatranum*.

2. Leaflets not papillate; ovules 2 per carpel. ................................................................. 4.


4. Petals green to yellow to white, drying brown or whitish, glabrous or nearly so abaxially. ................................. 5.

5. Lower surface of leaflets usually conspicuously (10x) oil-dotted, usually pubescent over the entire surface; ovary and rudimentary carpels usually glabrous. .................... 7. *T. ruticarpum*.

5. Lower surface of leaflets usually inconspicuously oil-dotted, usually entirely glabrous or with pubescence restricted to the
midrib toward the base (rarely pubescent over the entire surface);
avery pubescent between the carpels and often on the exposed
surface; rudimentary carpels usually pubescent, at least toward the
base. ................................................................. 6.

6. Leaflets below usually obviously glaucous (dried material),
ultimate veinlets clearly visible \((10\times)\), densely reticulate;
sepals about 0.5 mm long; ovules collateral or subcollateral;
rudimentary carpels usually pubescent toward the base and
glabrous toward the apex (rarely entirely glabrous). ...................

................................................................. 5. \textit{T. glabri folium}.

6. Leaflets below seldom obviously glaucous, ultimate veinlets
usually inconspicuous; sepals 0.5-1.5 mm long; ovules super-
posed; rudimentary carpels uniformly villous. ... 3. \textit{T. daniellii}.

1. Perianth, androecium, and gynoecium predominantly 4-parted (5-parted in occa-
sional flowers). ......................................................... 7.

7. Petals 2.5-3 mm long; disc sparsely to rather densely pube-
scnt; main veins of leaflets departing from the midrib at
an angle of 45-50 degrees. ............................... 1. \textit{T. sambucinum}.

7. Petals 3-6.5 mm long; disc glabrous; main veins of leaflets
departing from the midrib at an angle of 65-80 degrees.

................................................................. 8.

8. Leaflets with large oil dots at the margin and smaller
dots scattered elsewhere on the blade, margin crenu-
late or rarely entire, main veins 13-22 pairs. .................. 2. \textit{T. fraxinifolium}.

8. Leaflets with oil dots all of approximately the same
size, margin entire, main veins 11-14 pairs. .................. 6. \textit{T. trichotomum}.

**KEY TO FRUITING MATERIAL**

1. Follicles 2-seeded (appearing to be 1-seeded in \textit{T. sambucinum}). ...................... 2.

2. Seeds 4-4.5 mm long, separate, firmly attached in the dehisced follicle to a
rather thick, fleshy aril. ........................................... 2. \textit{T. fraxinifolium}.

2. Seeds 1.5-4 mm long, coherent, loosely attached in the dehisced follicle to an
adaxial strip of pergamentaceous endocarp tissue. ............... 3.

3. Fruits 4-carpellate,\(^1\) all four carpels usually developing into follicles;
follcles 3-4 mm long and about as wide; seeds collateral, hemispheric, the
two together appearing to represent a single globose or subglobose seed. ................................. 1. \textit{T. sambucinum}.

\(^1\) In all species of \textit{Tetradium} the carpel number can be determined in fruiting material since carpels
that do not develop into follicles are persistent.
3. Fruits predominantly 5-carpellate (occasional fruits 4-carpellate), 2-5 of the carpels developing into follicles; follicles 5-11 mm long, definitely longer than wide; seeds superposed, ovoid to ellipsoid. .......................... 4.

4. Follicles beaked, sparsely to rather densely pubescent with spreading hairs, 5-11 mm long. .......................... 3. *T. daniellii*.


1. Follicles 1-seeded. ................................................................. 5.

5. Follicles about 3.5 mm long, developed from 1-ovulate carpels and thus not containing an aborted seed; leaflets minutely papillate below. .......................... 8. *T. austrosinense*.

5. Follicles 3.5-7 mm long, developed from 2-ovulate carpels and thus containing an aborted seed (usually flattened against the upper adaxial surface of the developed seed); leaflets not papillate. .......................... 6.


6. Fruits predominantly 5-carpellate (occasional fruits 4-carpellate), each composed of 1-5 follicles. .......................... 7.

7. Follicles densely appressed-pubescent laterally, glabrous abaxially; endocarp sparsely to rather densely pubescent; leaflets usually glabrous or nearly so, ultimate veinlets clearly visible (10x) on the lower surface, densely reticulate .......................... 5. *T. glabrifolium*.

7. Follicles glabrous or occasionally with sparse hairs laterally and/or abaxially; endocarp glabrous; leaflets sparsely to densely pubescent below, ultimate veinlets usually inconspicuous .......................... 7. *T. ruticarpum*.


*Philagonia procera* Bl. ex Nees, Flora 8 (1825) 125, *nomen illegit.*, based on *Philagonia sambucina* Bl.

2. *Tetradium sumatranum*, for which fruits are not known, is closely related to *T. austrosinense* (both species have 1-ovulate carpels and minutely papillate leaflets). Vegetative differences between the two are given in the key to flowering material.
**Evodía sambucina** (Bl.) Hook. f. ex Koorders & Valeton, Meded. Lands Plantentuin 17 (1896) 216.


*Evodía sambucifolia* Dode, *ibid.*, sphalm., = *Philagonia sambucina* Bl.

Medium to large tree to 34 m high; branchlets puberulent to finely pubescent when young, becoming glabrous or nearly so. Leaves 17-36 cm long; rachis puberulent, especially adaxially; leaflets (3-)4-5(-6) pairs; petiolules of lateral leaflets obsolete to 10 mm long, terminal leaflet on an extension of the rachis 10-20 mm long; blades of leaflets chartaceous to subcoriaceous, inconspicuously oil-dotted, below drying pale green to brown, usually with appressed puberulence or short spreading hairs on the midrib and main veins, otherwise glabrous or nearly so; above usually with appressed puberulence or short spreading hairs on the midrib, otherwise glabrous or nearly so; elliptic-oblong or less often elliptic, ovate, lanceolate, or oblanceolate, 6-18 cm long, 2.5 cm wide, base in lateral leaflets acute to obtuse, usually rather oblique, in terminal leaflet cuneate, main veins 13-16 pairs, departing from the midrib at an angle of 45-50 degrees, ultimate veins usually rather conspicuous (10x), rather loosely reticulate, margin crenulate, at least toward the apex, inconspicuous oil dots associated with the crenulations, apex acuminate, the acumens 10-20 mm long. Inflorescences 13-25 cm long, rachis puberulent, branches puberulent to finely pubescent, pedicels puberulent to finely pubescent, obsolete to 1.5 mm long. Flowers 4-merous; sepal puberulent to glabrous, usually ciliolate, 0.5-0.8 mm long; petals yellowish green, drying brown, abaxially glabrous or rarely sparsely puberulent, adaxially sparsely to rather densely villous, 2.5-3 mm long; disc sparsely to rather densely pubescent; ovary appressed pubescent, carpels free to the base abaxially, connate toward the base adaxially, ovules 2 per carpel, collateral; rudimentary carpels more or less villous toward the base, otherwise glabrous, free to the base. Fruits 4-carpellate, all four carpels usually developing into follicles; follicles puberulent, trigonous, not beaked, 3-4 mm high and about as wide, free to the base abaxially, connate toward the base adaxially, endocarp sparsely hairy. Seeds black, 2 per follicle, collateral, hemispheric, coherent and appearing to represent a single globose or subglobose seed, 1.5-2 mm long, attached in the dehisced follicle to an adaxial strip of pergamentaceous endocarp tissue; outer testa spongy (bounded externally by a crustaceous, shiny pellicle); inner testa bony.

Distribution. W. Malaysia, Sumatra, Java, and Sumbawa; recorded from primary and secondary, usually poorly-drained, rain forests, 30-1400 m.


Lesser Sunda Islands. Sumbawa: Mt Batulante, *Kostermans* 18864 (A, BO); without definite locality, *Kostermans* 18716a (L).

*Blume*’s original description of *Philagonia sambucina* was based on staminate and carpellate material. The lectotype is chosen from the latter.

2. **Tetradium fraxinifolium** (Hook.) Hartley, *comb. nov.*


*Evodia impellucida* var. *macrococca* Huang, *ibid.* 117. t. 30. Type: *Tsai* 56591, China, Yunnan Province, Shang-pa-hsien (not seen).

*Evodia robusta* Huang, *ibid.* 119, non Hook. f., 1875. Type: *Tsai* 56776, China, Yunnan Province, Lu-si-hsien (not seen).

Small to medium tree to 12 m high; branchlets glabrous, glabrate, or occasionally finely pubescent. Leaves 23–67 cm long; rachis glabrous, glabrate, or occasionally finely pubescent; leaflets 2–7 pairs; petiolules of lateral leaflets obsolete to 10 mm long, terminal leaflet on an extension of the rachis 12–35 mm long; blades of leaflets chartaceous to subcoriaceous, usually conspicuously oil-dotted, below drying whitish, green, or brown, often glaucous and sometimes minutely (10x) subpapillate, glabrous to sparsely or rarely densely pubescent, above glabrous to puberulent, lanceolate or occasionally ovate, elliptic-oblong, or elliptic, 9–25 cm long, 3.5–8.5 cm wide, base in lateral leaflets acute to rounded, often oblique, in terminal leaflet cuneate, main veins 13–22 pairs, departing from the midrib at an angle of 65–80 degrees ultimate veinlets usually inconspicuous, margin crenulate or rarely entire, marginal oil dots larger than those scattered elsewhere on the blade, apex acuminate, the acumen 7–25 mm long. Inflorescences 7–24 cm long, rachis, branches, and pedicels puberulent to pubescent, pedicels 1–6 mm long. Flowers predominantly 4-merous (occasional flowers 5-merous); sepals finely pubescent to glabrous, ciliolate, 0.5–1.5 mm long; petals pale yellow to green,
drying brown, abaxially glabrous, adaxially villous to glabrous, 3.5—6.5 mm long; disc glabrous; ovary appressed-pubescent to glabrous, the carpels connate toward the base abaxially, free to the base adaxially, ovules 2 per carpel, subcollateral; rudimentary carpels sparsely to rather densely appressed-pubescent toward the base, otherwise glabrous, connate toward the base. Fruits predominantly 4-carpellate (occasional fruits 5-carpellate), 1—4 of the carpels developing into follicles; follicles sparsely pubescent to glabrous, compressed-subglobose, not beaked, 5.5—10 mm long, connate toward the base abaxially, free to the base adaxially, endocarp sparsely pubescent or glabrous. Seeds reddish-brown to brownish—black, 2 per follicle, subcollateral, separate, subtrigonous, equal or slightly unequal in size, 4—5 mm long, firmly attached in the dehisced follicle to a rather thick, fleshy, funicular aril; outer testa spongy (bounded externally by a shiny, crustaceous pellicle); inner testa bony.

Distribution. Nepal east to northern Vietnam and southwestern China; recorded from well-drained forests and thickets, 750—3000 m.

Nepal. Annapura Himal, Lati Khola, Stainton, Sykes, & Williams 6679 (BM); north of Pokhara, Stainton, Sykes, & Williams 5064 (A, BM); Ganesh Himal, Stainton 3685 (BM); Likhu Khola, Stainton 4546 (BM); Tamur Valley, southeast of Terhathum, Williams & Stainton 8465 (BM); Mewa Khola, Stainton 6838 (BM); Pha Khola, Williams 1019 (BM); Yampodin-Ghatte, Kanai, Murata, & Togashi 6301109 (BM); without definite locality, Wallich Cat. No. 8521 (BM, GH, L, P, W), Wallich, 1820 (BM), Wallich, 1821 (K, lectotype of Philagonia fraxinifolia Hook.).

Sikkim. Suriel, Wilson, 8 September 1921 (A); without definite locality, Clarke 26635B (L), Hooker (BRI, GH, L, MEL, NY, US, W), King 4868 (CAL), Herb. Kuntze 6930 (NY), Thomson, 3 May 1857 (L, US), Treutner 139 MEL).

Bhutan. Shali, Cooper 4473 (BM).

India. West Bengal: Darjeeling, Clarke 27327 (BM), 35229C (BM); Darjeeling District, Takdah, Chakrabatti 132D (DD), Lace 2205 (CAL). Assam: Garo Hills, Panigrahi 22427 (L); Shillong, Clarke 44335 (US); Khasi Hills, Chand 5377 (L), 6160 (MICH), 8294 (L, MICH), Clarke 7312 (BM), 45921B (US), Hooker & Thomson (BRI, GH, L, MEL, NY, U, W), Kanijal 2634 (DD), Koelz 23190 (MICH), 28383 (MICH), 29441 (MICH), 30358 (MICH), 33721 (MICH); Khasi and Jaintia Hills, Kanijal 4553 (CAL, DD); Khasi Hills and Bhramaputra Plains, Herb Kurz (BM); Subansiri Frontier Division, Palin to Amji, SASTRY 40950 (L); Naga Hills, Koelz 25374 (MICH), 26051 (L, MICH), 26118 (MICH), Pirm's Collector 953 (A, W); Lushai Hills, Koelz 27485 (MICH); without definite locality, Biswas 4060 (A), King's Collector (L).

Burma. Valley of the Nam Tamai, Kingdom-Ward 13088 (BM); North Triangle, Kingdom-Ward 21150 (A); hills around Htawgaw, Forrest 25070 (E); Hkamhkam-Htawgaw Road, Kermode 17346 (DD); Kachin Hills, Mokim, March 1898 (A); without definite locality, Rodger 139 (CAL).

Thailand. Northern: Doi Angka, Pa Ngein, Garrett 644 (L), Kerr 644 (L).


China. Yunnan Province: Prope fines Tibeto-Birmanicas in convalle fluvii Djoudjian in pluviiisilva frondosa subtropicalia faucium Naiwanglong, Handel-Mazzetti 9393

(W, holotype of *Euodia impellucida* Hand.-Mazz.; A, isotype); Shweli-Salween Divide, Forrest 24115 (BM, K); Shweli Valley, Forrest 8687 (E); three days south of Teng-yueh [Teng-chung], Forrest 26470 (E, US); Kiukiang Valley north of Muhconga, Yu 20510 (PE, holotype of *Euodia subtrigonosperma* — only a photograph seen; E, isotype); Kiukiang, Taron, Chiengen, Yu 19451 (E); without definite locality, Forrest 15803 (K), 16079 (K), 17743 (K), 17859 (K), 18592 (K), 25250 (K).


The type sheet of *Philagonia fraxinifolia* consists of two flowering branchlets, one staminate and one carpellate, and one separate carpellate inflorescence. Because the species is dioecious with unisexual flowers, these specimens would have been taken from two or perhaps three different plants. The carpellate flowering branchlet is chosen as the lectotype.

In the plate accompanying the original description of *Philagonia fraxinifolia*, figure 1 depicts a bisexual flower, although in the legend it is referred to as a female flower. The same drawing is on the type sheet. This is obviously an error because the female flowers in this species have ligulate staminodes rather than fully developed stamens as are shown in the drawing.

In the original description of *Philagonia fraxinifolia*, Hooker gives the following synonymy:

*Tetradium?* fraxinifolium Wall. in Herb. Hook. 1821 [Wallich's question mark].


The Wallich name, which also appears (with the question mark) on the label of the type sheet of *Philagonia fraxinifolia*, was never published, and Hooker merely questions the conspecificity of *Rhus fraxinifolium* and *Philagonia fraxinifolia*. In a short discussion following the description he states: “It [Philagonia fraxinifolia] may be the Rhus above quoted of the late Mr. Don, though assuredly the style and stigma do not correspond with that genus.” I have not seen the type of the Don plant (it is apparently not in the British Museum — R. J. Henderson, pers. comm.), but it was described as having hermaphrodite flowers and serrate leaves, neither of which characters agrees with material I have seen of *Tetradium fraxinifolium*.

The type collections of *Euodia impellucida*, *E. poilanei*, and *E. subtrigonosperma*, and a paratype (Forrest 8687) of *E. impellucida var. macroccoa*, the type of which I have not seen, all fall well within the range of variability of the Himalayan and Indian collections that center, morphologically, around the type of *Philagonia fraxinifolia*. None of the authors of the former taxa mention a possible relationship with the latter species, and I suspect they did not compare it with their new taxa.

I have not seen any authentic material of *Euodia robusta* Huang (a later homonym of *E. robusta* Hook. f., described from Malaya), but judging from the description of its seeds (two per locule, subtriangular, reddish-brown, 4–5 mm long), it is certainly allied to *Tetradium fraxinifolium*, and on other characters falls reasonably well within its range of variability.

In the original description of *Euodia impellucida*, Handel-Mazzetti described the leaflets as “... glandulis pellucidis marginalibus tantum.” In the type collection of this
species the leaflets are glaucous and minutely subpapillate below with conspicuous marginal oil dots. Smaller oil dots are, in fact, present elsewhere on the blade but are mostly obscured by the waxy bloom.

3. **Tetradium daniellii** (Benn.) Hartley, *comb. nov.*

*Type: Daniell, 1861, China, Liaoning Province, Talien-whan.*

*Type: Bretschneider 1328, China, Hopeh Province, Shang-fang-shan.*

*Evodia daniellii* (Benn.) Hemsl., J. Linn. Soc. Bot. 23 (1886) 104.

*Ampacus daniellii* (Benn.) Kuntze, Rev. Gen. Pl. 1 (1891) 98.

*Type: Delavay 4526, China, Yunnan Province, Ta long tan près de Ta pin tze.*

*Evodia henryi* Dode, *ibid.* 706.  
*Syntypes: Farges 413, China, Szechwan Province, distr. de Tchen-kéou-tin; Henry 6712, China, Hupeh Province, Ichang; Wilson 3183, China, Hupeh Province, Hupeh occidental (not seen).*

*Evodia hupehensis* Dode, *ibid.* 707.  
*Type Henry 2939, China, Hupeh Province, Ichang.*

*Evodia labordei* Dode, *ibid.* 707.  
*Type: Laborde & Bodinier 2729, China, Kweichow Province, Mt. de Kaopo (not seen).*

*Evodia sutchuenensis* Dode, *ibid.* 705.  
*Type: Farges 1284 p.p. stamineate, China, Szechwan Province, distr. de Tchen-kéou-tin.*

*Syntypes: Wilson 1164, July 1908 (stamineate), China, Szechwan Province, Wa-shan (= *Tetradium daniellii*); Wilson 1164, October 1908 (carpellate), China, Szechwan Province, Wa-shan (= *Tetradium ruticarpum*).*

*Evodia henryi* var. *villicarpa* Rehd. & Wills., *ibid.* 134.  
*Type: Wilson 3571, China, Szechwan Province, west of Romi-chango.*

*Evodia velutina* Rhed. & Wils., *ibid.* 134.  
*Type: Wilson 994, China Szechwan Province, west and near Wen-chuan Hsien.*

*Type: Forrest 11091, China, Yunnan Province, on the Tong Shan in the Yangtze bend.*

*Evodia daniellii* var. *delavayi* (Dode) Huang, Acta Phytotax. Sin. 6 (1957) 128, t. 36, fig A

*Evodia daniellii* var. *henryi* (Dode) Huang, *ibid.* 129; t. 36, fig. C.
Evodia danielli var. hupehensis (Dode) Huang, *ibid.* 131; t. 36, fig. H.

Evodia danielli var. labordei (Dode) Huang, *ibid.* 130; t. 36, fig. B.

Evodia danielli var. villicarpa (Rehd. & Wils.) Huang, *ibid.* 128; t. 36, fig. G.

Shrub or small to rather large tree to about 20 m high; branchlets puberulent to finely pubescent, becoming glabrous or nearly so. Leaves 15–44 cm long; rachis pubescent to glabrous; leaflets 2-4(-5) pairs; petioloïdes of lateral leaflets obsolete to 8 mm long, terminal leaflet on an extension of the rachis 6–35 mm long; blades of leaflets chartaceous to subcoriaceous, sparsely and usually inconspicuously oil-dotted, below drying pale grey-green and occasionally somewhat glaucous, usually glabrous except for rather long hairs along the midrib toward the base (often restricted to the axes of main veins toward the base) grading to entirely glabrous or rather densely pubescent, above glabrous or nearly so, broadly ovate to lanceolate or rarely elliptic or elliptic-oblong, 5–18.5 cm long, 2.5–10.5 cm wide, base in lateral leaflets acute to subtruncated, sub-rounded, or subcordate, usually slightly oblique, in terminal leaflet acute to cuneate or occasionally rounded, main veins 7–14 pairs, departing from the midrib at an angle of 45–75 degrees, ultimate veinlets usually inconspicuous, margin subentire to crenulate, often with rather large oil dots associated with the crenulations, apex acuminate, the acumen 3–20 mm long. Inflorescences 3.5–19 cm long, rachis, branches, and pedicels puberulent to pubescent, pedicels obsolete to 5 mm long. Flowers predominantly 5-merous (occasional flowers 4-merous); sepals pubescent to glabrate, ciliolate, 0.5–1.5 mm long; petals white or whitish, drying whiterish or pale brown, abaxially glabrous, adaxially sparsely or occasionally densely pubescent or villous, (2.5–)3–5 mm long; disc glabrous; ovary pubescent between the carpels, otherwise rather densely hairy to glabrous, the carpels free to the base, ovules 2 per carpel, superposed; rudimentary carpels densely or occasionally rather sparsely hirsute, free to about the base. Fruits predominantly 5-carpellate (occasional fruits 4-carpellate), 2–5 of the carpels developing into follicles; follicles sparsely or rather densely pubescent with spreading hairs, narrowly pyriform, tapering apically-adaxially into a narrow beak 0.7–4.5 mm long, including the beak 5–11 mm long, free to the base, endocarp glabrous. Seeds black, 2 per follicle, superposed, ovoid to ellipsoid, coherent, the upper seed fertile, 2.5–4 mm long, the lower seed sterile (containing what appears to be endosperm but no embryo), usually 1.5–3.5 mm long, the pair of seeds attached in the dehisced follicle to an adaxial strip of pergamentaceous endocarp tissue; testa in fertile seed bony, without spongy outer testa, in sterile seed thin, brittle, also without spongy outer testa.

Additional illustrations. Huang, Acta Phytotax. Sin. 6 (1957) t. 35 & t. 37, figs. D, E, & F (as Euodia danielli); *ibid.* t. 34 (as Euodia sutchuenensis); *ibid.* t. 33 (as Euodia vestita).

Distribution. Southwestern China (extreme south-eastern Tibet and Yunnan Province) northeast to Korea; recorded from woods, margins, and open slopes; sea level to 3200 m.

China. Southeastern Tibet: Mekong-Salween Divide, *Forrest* 14299 (E, K). Yunnan Province: Mekong-Salween Divide, *Forrest* 14772 (E, K), *Rock* 10270 (A, US); between Yung-ning and Yung-geh [Yung-sheng], *Schneider* 1663 (A, E); Chien-ch’üan-Mekong Divide, *Forrest* 22294 (A, K); Tong-shan, in the Yangtse bend, *Forrest* 11091 (E, holotype of Euodia vestita W. W. Smith; A, BM, K, isotypes); Ta-long-t’an près de Ta-pin-tze [Ta-p'ing-tzu], Delavay 4526 (P, holotype of Euodia delavayi Dode; K, isotype; A,


South Korea. Seoul, Jack, 24 September 1905 (A); Chemulpo [Inch’on], Carles 107 (BM, K); Province Keiki, Kejiyo, Wilson 10555 (BM, US), Province Keiki, Hakusen and on Kanghwa Island, Wilson 10612 (A, BM, US); Mt. Chii, Koidzumi, 1933 (MICH); Shinsyu [Shinsu-do], Keisyando, Uno 2598 (A, NY, PH).

Cultivated. South Korea: Seoul, Chung 1169 (MICH), Faurie 468 (A). New Zealand: Botanic Garden Christchurch, Sykes CHR 124917 (CHR), CHR 124998A (CHR), CHR 124998B (CHR). United States of America: California, Davis, McCaskill & Reagan 684 (AK); Massachusetts, Jamaica Plain, Arnold Arboretum, Hornby 4276 (MICH), 6898 (MICH), Merrill, August 1925 (NSW), Palmer, 4 August 1942 (AD, MICH, UC), Sorensen 6672 (AK); Maryland, Glendale, Plant Introduction Station, Meyer, 13 October 1967.
As interpreted here, Tetradium daniellii is quite variable, especially in petiolule length (obsolete to 8 mm), vestiture of leaflet lower surface (glabrous to rather densely pubescent), leaflet shape and size (broadly ovate to lanceolate or rarely elliptic or ellipticooblong, 5–18.5 cm long, 2.5–10.5 cm wide), vestiture of the follicle (sparingly to rather densely pubescent), length of the follicle beak (0.7–4.5 mm), and overall length of the follicle (6–11 mm).

The type material of most of the names here placed in synonymy differs somewhat from the type collection of Zanthoxylum daniellii, which has rather short- to medium-length petiolules, ovate, medium-sized leaflets with vestiture restricted to the midrib below, and sparsely pubescent, rather large follicles with medium-length beaks of Euodia delavayi has subsessile leaflets that are pubescent along the midrib and main veins below; that of E. henryi has nearly glabrous leaflets and unusually long-beaked follicles; that of E. hupehensis has leaflets tending to be lanceolate; that of E. sutchuenensis has unusually large, ovate to broadly elliptic leaflets; that of E. henryi var. villicarpa has rather densely pubescent, long-beaked follicles; that of E. velutina has leaflets that are rather densely pubescent below and small, short-beaked follicles; that of E. vestita has leaflets that are rather densely pubescent below and rather large, long-beaked follicles. Euodia labordei, the type of which I have not seen, is described as having subsessile to short-petiolulate leaflets that are sparsely pubescent on the nerves below and rather small, villous follicles.

This may appear to be an overly conservative interpretation of this species, but in the study of the large number of herbarium specimens of obviously closely inter-related plants here assigned to it, I have not found sufficient morphologic discontinuity in any of the variable characters, or sufficiently distinct combinations of various character states to warrant recognition of more than a single taxon.

Zanthoxylum bretschneideri, the type of which closely matches that of Zanthoxylum daniellii, was placed in the synonymy of Euodia daniellii by Rehder & Wilson (1914) and Huang (1957).

One of the two syntypes of Euodia baberii (Wilson 1164, July 1908) closely matches the type of Zanthoxylum daniellii. The other, as is noted in the synonymy, is Tetradium rutacearum.

4. **Tetradium calcicolum** (Chun ex Huang) Hartley, *comb. nov.*

*Evodia calcicola* Chun ex Huang, Acta Phytotax. Sin. 6 (1957) 120. t. 32. Type: Ching 6306, China, Kwangsi Province, south of Nee Bai, Kweichow border.

Large shrub or small tree to 6 m high; branchlets puberulent, becoming glabrous or nearly so. Leaves 9–19 cm long; rachis puberulent to glabrate; leaflets 2 pairs; petiolules of lateral leaflets 1–2.5 mm long, terminal leaflet on an extension of the rachis 5–15 mm long; blades of leaflets subcoriaceous, sparsely and inconspicuously oil-dotted, below.
drying pale grey-green, somewhat glaucous, pubescent along the midrib toward the base, otherwise glabrous, above entirely glabrous or puberulent on the midrib toward the base, ovate to elliptic, 5—9.5 cm long, 2.3—4.5 cm wide, base in lateral leaflets obtuse to rounded, usually slightly oblique, in terminal leaflet obtuse to rounded, main veins 10—14 pairs, departing from the midrib at an angle of 60—85 degrees, ultimate veinlets usually inconspicuous, margin entire, apex acuminate, the acumen 5—15 mm long. Inflorescences 5.5—13 cm long, rachis and branches finely pubescent, pedicels finely appressed-pubescent, 1—3.5 mm long. Flowers 5-merous; sepals puberulent, ciliolate, 0.7—1 mm long; petals purple, drying dull purplish-red, abaxially sparsely to rather densely appressed pubescent, adaxially villous, 3.5—4 mm long; disc glabrous, ovary sparsely to densely appressed pubescent, the carpels free to the base, ovules 2 per carpel, superposed. Fruits 5-carpellate, all of the carpels developing into follicles; follicles glabrate abaxially, densely appressed pubescent laterally, pyriform, not beaked, about 5 mm long, free to the base, endocarp glabrous. Seeds black, 2 per follicle, superposed, ellipsoid, coherent, the upper seed fertile, about 3 mm long, the lower seed sterile (containing what appears to be endosperm but no embryo), about 2 mm long, the pair of seeds attached in the dehisced follicle to an axile strip of pergamentaceous endocarp tissue; testa in fertile seed bony, without spongy outer testa, in sterile seed thin, brittle, also without spongy outer testa. Staminate flowers not seen.

Distribution. Southwestern China, Kwangsi Province and (according to Huang, loc. cit.) Yunnan Province; recorded from woods and thickets, 690—800 m.

China. Kwangsi Province: south of Nee Bai, border of Kweichow, *Ching* 6306 (A, NY, UC, isotypes of *Euodia calcicola* Chun ex Huang); Pin-lam, Ko 55618 (A).

5. *Tetradium glabri folium* (Champ. ex Benth.) Hartley, *comb. nov.*


**Evodia yunnanensis** Huang, Acta Phytotax. Sin. 6 (1957) 104, t. 26 Type: Wang 80688, China, Yunnan Province, Cheun-yueh-hsien (only photograph seen).


Large shrub or small to medium tree to 20 m high; branchlets finely pubescent to glabrate when young, becoming glabrous or nearly so. Leaves 14—38 cm long; rachis finely pubescent to glabrous; leaflets (1—)2—9 pairs; petiololes of lateral leaflets 3—15 mm long, terminal leaflet on an extension of the rachis 10—35 mm long; blades of leaflets chartaceous to subcoriaceous, sparsely and inconspicuously oil-dotted or without evident dots, below drying whitish or pale green or less often brownish-green, usually obviously glaucous, glabrous or with appressed to spreading hairs on the midrib, especially toward the base and, to a lesser extent, on the main veins; above glabrous or with appressed to spreading hairs on the midrib, especially toward the base, broadly ovate to lanceolate or less often elliptic to elliptic-oblong, often strong unequal-sided, 4—15 cm long, 1.7—6 cm wide, base in lateral leaflets acute to subrounded or subtruncate, usually oblique, in terminal leaflet acute to cuneate, main veins 8—18 pairs, departing from the midrib at an angle of 60—80 degrees, ultimate veinlets conspicuous (10x), densely reticulate, margin entire or more or less crenulate, rarely with conspicuous oil dots associated with the crenulations, apex acuminate, the acumen 5—30 mm long. Inflorescences 9—19 cm long; rachis, branches, and pedicels finely pubescent to glabrous, pedicels 0.3—4 mm long. Flowers predominantly 5—merous (occasional flowers 4-merous); sepals finely pubescent to glabrous, ciliolate, about 0.5 mm long; petals green to yellow to white, drying whitish to brown, abaxially glabrous or occasionally with sparse, appressed hairs, adaxially villous to nearly glabrous, 2.7—4 mm long; disc glabrous; ovary rather densely pubescent between the carpels, otherwise glabrous or finely pubescent toward the apex, carpels free to the base or connate toward the base abaxially, ovules 2 per carpel, collateral or sub-collateral; rudimentary carpels sparsely to densely pubescent toward the base or occasionally entirely glabrous, connate basally. Fruits predominantly 5-carpellate (occasional fruits 4-carpellate), 4—5 (or occasionally 1—3) of the carpels developing into follicles; follicles sparsely to densely appressed-pubescent laterally, otherwise glabrous, trigonous, not beaked, 3.5—5 mm high and about as wide, free to the base or connate toward the base abaxially, endocarp sparsely to rather densely pubescent. Seed black, 1 per follicle, paired with an aborted seed, subglobose to broadly ellipsoid to ovoid, 2.5—4 mm long, attached in the dehisced follicle to an adaxial strip of perigamentaceous endocarp tissue; outer testa spongy (bounded externally by a shiny, crustaceous pellicle); inner testa bony.

Additional illustrations. Huang, Acta Phytotax. Sin. 6 (1957) t. 25, figs. A, B, & C (as Euodia glauca, E. meliifolia, and E. fargesii); Li, Woody Fl. Taiwan (1963) 370, t. 133 (as Euodia meliifolia); Chang in Li et al., Fl. Taiwan 3 (1977) 516, t. 708 (as Euodia meliifolia).

Distribution. Sikkim and northeastern India east through Indochina and southern China to Taiwan and southern Japan, and south to W. Malaysia, Sumatra, and the Philippines; recorded from well-drained forests, thickets, and open places; sea level to 1200 m.

Sikkim. Without definite locality, Kurz (BO); Thomson (BO).

India. West Bengal: Darjeeling Division, Division Forest Officer 1384 (DD); Tista Valley, Haines BB873 (A, DD). Assam: Goalpara, Long Sung Block, Kanjital 5081 (US);
Hartley: *Tetradium* (Rutaceae)

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(A, MEL), 1720 (A, K, US); Canton [Kwang-chou] & vicinity, Levine CCC 1143 (A, GH, US), CCC 1775 (A, GH), leg. Ah To CCC 1854 (A, GH, US), Sampson leg. Asui, 25 August 1885 (K); Hwei-yang District [Hui-yang Hsien], Lin Fa Shan, Tsang 25921 (A); Poon Yue District, Levine CCC 3244 (A, GH); without definite locality, McClure Lingnan Univ. 19709 (A, NY). Hainan Island: Ching Mai [Ch'eng-mai] District, Lei 9 (B, K, L, NY, UC, US, W), 832 (A, B, BO, K, L, NY, US, W); Noda [Tan-hsien] & vicinity, Chun Univ Nanking 5687 (UC), Univ Nanking 5766 (UC), Tsang Lingnan Univ. 15585 (A, K, NY, UC, US); Dung Ka to Wen Fa Shi, Chun & Tso 43761 (A, L, NY, US, W), 43795 (BISH, L, NY, W); Dung Ka to Mo San, Chun & Tso 43564 (NY); Ch'ang-kiang [Ch'ang-chiang] District, Ngo Ko Shan, Lau 1930 (A, NY); Five Finger Mountain [Wu-chih Shan], Chun Univ Nanking 7056 (UC), Fenzel 222 (W); Kan-en [Kan-ch'eng] District, Chim Fung Mountain, Lau 5346 (A); Manning [Wan-ning], How 73189 (BO); Lo-tung, Lau 27468 (A); Hainan, Liang 63392 (NY), 64634 (NY), 65135 (A, NY), Wang 33111 (NY), 34072 (NY, UC, US), 35680 (NY, US), 36445 (NY); Po Teng [Pao-t'ing] & vicinity, Chu 29 (UC), How 72749 (BISH, BM); Yaichow [Yai-ch'eng], How 71094 (A, B, NY, US), How & Chun 70139 (B, NY, US), Liang 62250 (A, NY), 62345 (NY), 63026 (NY, US); Fan Yah, Chun & Tso 44010 (A, BISH, L, NY, W); Taam-chau District, Tsang Lingnan Univ. 16247 (A, K, NY, UC); Loi area, Hung Mo Shan, McClure Lingnan Univ. 18274 (A, B, K, NY, UC, US), Tsang & Fung Lingnan Univ. 18274 (B, MICH); Tai Tsing, McClure CCC 7751 (A, B, K, NY); without definite locality, Chun Univ Nanking 5899 (UC), Univ Nanking 7121 (UC), Fenzel 24 (W), Henry 8706 (K). Hong Kong: Kowloon, Liou 720 (A, NY); Chung Chi College, Hu 5567 (US), 5596 (US); Tai-o, Chun 3099 (A, NY); Tai P'o, McClure CCC 13300 (A); Saigon, Chun 6864 (A, BO, UC); Lantau Island, Tsang Lingnan Univ. 16637 (A, NY, UC, US, W); Mt. Victoria, Tang 257 (A); Wan-tsai Gap Road, Sampson, 5 November 1886 (K); Bowen Road, Lau 159 (A); Happy Valley, Lamont, October 1874 (L), Sargent, 5 November 1903 (A); Little Hong Kong Woods, Lamont 116 (L); without definite locality, Champion 382 (K, holotype of Boymia glabrisfoliata Champ. ex Benth.), Chun 5225 (UC), 6562 (UC), 7477 (NY), 40010 (K, NY), Herb. Forbes 68 p. p. (PH), Ford, 17 August 1893 (A), Gibbs Herb. Hongkong 7456 (NSW), Hance (K, holotype of Megabotrya melifolia Hance ex Walpers), Herb. Hance 311 (BM, W). Fukien Province: Chuanchow [Ch'uan-chou], Chung 1050 (UC). Without definite locality: Parkes, 1841 (K).

Taiwan. Taipei, Kangu, Keng, 26 October 1950 (A, L, US); Taihoku, Sinten, Ito, 24 September 1923 (BM); Nan-t'ou, Lake Candidius [Jih-yueh T'au], Wilson 9971 (A); Nan-t'ou, Mt. Bigen, Kawakami & Mori 3196 (A); Heng-ch'un, Chang 2418 (NY); Bankinsing, Henry 831 (A, K, NY), 1562 (A, NY); in montibus Okaseki, Faurie 34 (A, BM); South Cape, Henry 932 (A), 974 (BM), 1296 (A, K, US).

Ryukyu Islands. Amami O Shima, Hosoyamada, 29 July 1927 (A); Okinawa, Hatusima 18236 (US), 18241 (US), Kurata & Nakaike 2302 (U), Sonohara 8 (US), 67 (L); Ishigaki, Smith 120 (US); Yonaguni, Walker & Tawada 6837 (US).


Sumatra. Central, Tandjoeng Ampaloe, Koorders 104108 (BO).


Cultivated. India, Dehra Dun, New Forest, Raizada, July 1939 (DD), September 1939 (DD).

The type collections of Boymia glabrifolia and Megabotrya meliifolia, both from Hong Kong, are clearly conspecific and the two names have long been considered to be synonymous. Assuming that their respective dates of publication as given in the present synonymy are correct, the former name has priority. Apparently only Seemann (Bot. Voy. Herald (1857) 370), who placed the latter name in synonymy under the former, considered this to be the case. Bentham (loc. cit.), in publishing the new combination Euodia meliifolia, listed Boymia glabrifolia in its synonymy and has been followed by subsequent authors.

The leaves of Tetradium glabrifolium, as the species is interpreted here, are quite variable in length (14–38 cm) and in number of leaflets [(1–)2–9 pairs]. The larger leaves of the syntypes of Euodia glauca, from Japan, and the type of Euodia ailantifolia, from Vietnam, are about twice as long (up to 38 cm) and have about twice as many leaflets (up to 9 pairs) as those of the type collection of Boymia glabrifolia. In other characters, these collections do not differ significantly, and among other collections of Tetradium glabrifolium, especially from Kwangtung Province and Taiwan, a complete range of intermediate leaf sizes and leaflet numbers may be found.

The type collection of Eurycoma dubia, from the Philippines, is in young flower bud, but is almost certainly conspecific with the type of Boymia glabrifolia. Merrill, Philipp. J. Sci. 14 (1919) 409, placed the Philippine species in the synonymy of Euodia meliifolia.

The type of Euodia balansae, from Vietnam, is similar to that of Euodia ailantifolia, differing mainly in having leaves with fewer leaflets (4–5 pairs). Dode, sometime after his publication of the former species, recognized the two as being conspecific. An undated annotation slip on the holotype sheet of E. ailantifolia reads: "Evodia balansae mihi Dode Specimen a me visum post speciem descriptam."

The syntypes of Euodia fargesii, from the Chinese provinces of Szechwan and Hupeh, have leaflets that are pubescent along the lower midrib toward the base. As Tetradium glabrifolium is interpreted here, this is a common feature in collections from the northern part of its range. Most collections from the southern part of the range, including the type of Boymia glabrifolia, have glabrous leaflets, but occasional collections from southernmost China, Indochina, Taiwan, and the Philippines have similarly pubescent leaflets.

The collection number of one of the syntypes of Euodia fargesii, Wilson 1930, represents four collections made from different localities on different dates. They are as follows: May 1907, Szechwan (W); 7 June 1907, Western Hupeh (A, E); 1 July 1907, Hupeh, Pa-tung (K); and August 1907, Hupeh, Chang-yang (NY). Dode, in the original description of E. fargesii, cited only the collection from Western Hupeh.
I have seen only a photograph of the type of *Euodia yunnanensis*, but all nine of the *Wang* collections cited above from Yunnan Province, Che-li Hsien, are paratypes. These collections differ from most of the other material I have placed in *Tetradium glabrifolium* mainly in having leaflets with the lower surface pubescent on the midrib and main veins. This is only a minor variation which also occurs, sporadically, in collections from Assam, Thailand, Vietnam, and Kwangsi Province. The paratypes of *E. yunnanensis* also differ from most of the other material of this species in having leaflets that are not noticeably glaucous on the lower surface. Glaucousness appears to be variable in most parts of the range of the species.

The type of *Phellodendron burkii*, from W. Malaysia, is clearly conspecific with that of *Boymia glabrifolia*. In an unpublished note distributed with reprints of the original description of the Malayan species, van Steenis points out that since its publication it has been found to be conspecific with *Euodia melitifolia*.

The leaflets of *Tetradium glabrifolium* are distinctive in the genus in having densely reticulate ultimate veinlets that are clearly visible on the lower surface with about 10x magnification. This is a difficult feature to describe quantitatively, but once recognized provides a reliable “spot” character for the identification of the species.


*Brucea trichotoma* (Lour.) Spreng., Syst. 1 (1825) 441.

*Ampacus trichotoma* (Lour.) Kuntze, Rev. Gen. Pl. 1 (1891) 98.

*Euodia viridans* Drake, J. Bot. (Morot) 6 (1892) 273. Syntypes: *Balansa* 3669, Vietnam, Tonkin, Mont Bavi; *Balansa* 4038, Tonkin, village de Tchion-tao à la base du Mont Bavi; *Balansa* 4043, Tonkin, Tu-phap.

*Euodia trichotoma* (Lour.) Pierre, Fl. For. Cochinch. 3 (1893) t. 287, fig. a.


Shrub or small tree to 8 m high; branchlets finely pubescent to glabrate. Leaves 12–37 cm long; rachis finely pubescent to glabrate; leaflets (1–)2–5(–6) pairs; petiolules of lateral leaflets obsolete to 5.5(–10) mm long, terminal leaflet on an extension of the rachis 10–20(–30) mm long; blades of leaflets chartaceous to subcoriaceous, oil-dotted, below usually drying green or brownish-green, glabrous or with fine pubescence mainly on the midrib and main veins, above glabrous or with fine pubescence on the midrib,
elliptic, elliptic-oblong, lanceolate, or occasionally ovate, 3–16 cm long, 1.3–5 cm wide, base in lateral leaflets cuneate to subrounded, often oblique, in terminal leaflet cuneate, main veins 11–14 pairs, departing from the midrib at an angle of 65–85 degrees, ultimate veinlets inconspicuous, margin entire, apex acuminate, the acumen 5–15 mm long. Inflorescences 5–30 cm long, rachis finely pubescent to glabrate, branches and pedicels finely pubescent, pedicels 0.5–2.5 mm long. Flowers predominantly 4-merous (occasional flowers 5-merous); sepals finely pubescent to glabrate, ciliolate, 0.5–1 mm long; petals green to yellow to white, drying brown to whitish, abaxially glabrous, adaxially sparsely subvillous to glabrous, 3–4 mm long; disc glabrous; ovary glabrous or with a few short hairs basally between the carpels, carpels connate toward the base abaxially, free to the base adaxially, ovules 2 per carpel, collateral; rudimentary carpels sparsely hairy or glabrous, connate toward the base. Fruits predominantly 4-carpellate (occasional fruits 5-carpellate), 1–4 of the carpels developing into follicles; follicles entirely glabrous or with sparse pubescence laterally toward the base, subglobose to obovoid, 4–7 mm long, connate toward the base abaxially, free to the base adaxially, endocarp glabrous. Seed balck, 1 per follicle, paired with an aborted seed, subglobose to broadly ovoid, 3.7–6 mm long, attached in the dehisced follicle to an adaxial strip of pergamnentaceous endocarp tissue; outer testa spongy (bounded externally by a shiny, crustaceous pellicle); inner testa bony.

Additional illustration. Huang, Acta Phytotax. Sin. 6 (1957) t. 23 (as Euodia trichotoma).

Distribution. Thailand, Laos, and Vietnam north and east to the Chinese provinces of Shensi, Hupeh, and Kwangtung; recorded from well-drained forests and thickets; 300–1900 m.


Vietnam. Tonkin: Laichau, Poilane 29658 (L); Chapa, Petelot 2483 (A, 3124 (A, UC), 5692 (A, US); Mont Bavi, Balansa 3669 (G–DC, holosyntype of Euodia viridans Drake); village de Tchion-tao à la base du Mont Bavi, Balansa 4038 (G–DC, holosyntype of Euodia viridans Drake); K, LE, holosyntypes); Tu-phap, Balansa 4043 (G–DC, holosyntype of Euodia viridans Drake); route de Hanoi à Hoa Binh, Petelot 2599 (A); Dam-ha, Sai Wong Mo Shan, Tsang 30357 (A, E, L); Cho Ganh, Petelot 1165 (UC); Hacoi, Taai Wong Mo Shan, Tsang 27026 (A, E), 29300 (A, E), 29454 (A, BO, E, L); Annam: In Montibus Cochinchnae, Loueireo (BM, holotype of Tetradium trichotonum Lour.).

China. Yunnan Province: Fo-hai [Meng-hai], Wang 73987 (A), 74237 (A), 74893 (A), 77145 (A), 77294 (A); between Muang-hun and Muang-hai, Rock 2391 (A, UC, US); Che-li [Ching-hung] Hsien, Wang 75835 (A), 75942 (A), 77980 (A), 79663 (A); Szemaof [Fu-hsing-cheng], Henry 12137 (K, holosyntype of Euodia colorata Dunn; A, US, holosyntypes), 12137A (K, holosyntype of Euodia colorata Dunn; A, NY, holosyntypes), 12137B (K, holosyntype of Euodia colorata Dunn; A, US, holosyntypes), 12137C (K, holosyntype of Euodia colorata Dunn; NY, holosyntypes), 12237 (A, K, NY), 12237A (A, K), 12237B (NY); I-wu, Henry 13577 (K); zw. Yangwu & Schangyentang n. von Yuenkiang, Wassmann 120 (W); Meng-tsze [Meng-tzu], Henry 10951 (A, K, NY, US); Ping-pien Hsien, Tsai 61062 (BO), 62045 (BO); Nan-chiao, Wang 75111 (A), 75116 (A); Szechwan Province: Tiencuan [Tien-chiian], Kuan & Wang 3333 (K); Hung-ya Hsien, Wilson 3573 (A, GH, US, W); Kiating Fu [Lo-shan], Wilson 3572 (A, US), 4568 (A); An Hsien & vicinity, Wang 22187 (A); without definite locality, Chu 3997 (W), Fang 3376 (E, NY).

Euodia viridans, E. colorata, and E. hainanensis, here considered (on the basis of type and syntype collections) to be conspecific with Tetradium trichotomum, have previously been placed in synonymy under Euodia trichotoma – see Rehder and Wilson (1914), Merrill, Comm. Lour. Fl. Cochinch. (1935) 219, and Huang (1957).

I have not seen the type collection of Euodia lenticellata, from Szechwan Province, but four of the collections cited above, Wilson 3572, Wang 22187, and Chu 3997, from Szechwan Province, and Ko 2033, from Shensi Province, are paratypes. As Tetradium trichotomum is interpreted here, these specimens merely represent a northern variant with reduced leaves (down to 12 cm long with leaflets as small as 3 cm long and 1.3 cm wide) and flowers (petals about 3 mm long); among other collections of the species there is a complete series of intermediates with the larger-leaved, larger-flowered plants, such as represented by the type of T. trichotomum, that tend to occur in the southern part of the range.

Huang (1957), in distinguishing between Euodia lenticellata and E. trichotoma in a key, notes that they differ, respectively, in lenticel prominence (convex vs. not convex) and vestiture of the lower surface of the leaflets (covered with long, soft hairs or glabrous or nearly so). In the study of the above-mentioned paratypes of E. lenticellata and collections from the northern part of the range that match them closely (Wilson 791 and 2578, from Hupeh Province, Fang 3376, from Szechwan Province, and Henry 13577 and Wang 75116, from Yunnan Province), I have found that the lenticels are variable in prominence and that the lower surface of the leaflets varies from pubescent with spreading hairs on the midrib and main veins to nearly glabrous with short, appressed hairs on the midrib only. Similar variability in these characters also can be found among collections of more typical Tetradium trichotomum from the southern part of the range.

7. Tetradium ruticarpum (A. Juss.) Hartley, comb. nov.


Evodia officinalis Dode, *ibid.* Syntypes: Farges 305, China, Szechwan Province, Sutchuen oriental, district de Tchen-Kéou-tin (not seen); Henry 6199, China, Hupeh Province, Ichang; *Henry* 1802 (not see) and 6136, China, Hupeh Province, Patung District; *Henry* 6549, China, Hupeh Province (not seen); *Wilson* 1309, China, Western Hupeh Province, Chien-shih Hsien.


Evodia rugosa Rehd. & Wils., *ibid.* 132. Type: *Henry* 10245, China, Yunnan Province, Mengtze.


Evodia compacta Hand.-Mazz., *Symb.* Sin. 7 (1933) 627. Type: *Handel-Mazzetti* 12320, China, Hunan Province, monte Yün-shan bei Wu-kang.

Evodia compacta var. meionocarpa Hand.-Mazz., *ibid.* Type: *Chien* 1029, China, Anhwei Province, Hwang-shan.


Evodia rutaecarpa forma meionocarpa (Hand.-Mazz.) Huang, *ibid.* 112.

Evodia rutaecarpa var. officinalis (Dode) Huang, *ibid.* 114; *t.* 27, fig. *A*.

Shrub or small tree to 9 m high; branchlets puberulent to finely pubescent when young, usually becoming glabrous or nearly so. Leaves 15–40 cm long; rachis finely pubescent or occasionally nearly glabrous; leaflets (1–)2–6(–7) pairs; petiolules of lateral leaflets obsolete to 9 mm long, terminal leaflet on an extension of the rachis 10–30 mm long; blades of leaflets chartaceous, usually conspicuously oil-dotted, below drying brown to greenish brown or rarely pale green and slightly glaucous, rather sparsely to densely pubescent, above puberulent to densely pubescent on the midrib, otherwise rather sparsely pubescent to glabrous, elliptic to ovate or less often lanceolate, oblanceolate, or obovate, often rather unequal-sided, 4.5–17 cm long, 2–8 cm wide, base in lateral leaflets acute to obtuse or less often rounded, subtruncate, or cuneate, oblique or not, in terminal leaflet cuneate or rarely attenuate, main veins 9–17 pairs, departing from the midrib at an angle of 60–85 degrees, ultimate veinlets rather conspicuous (10x) or not, rather loosely reticulate, margin entire or rather irregularly crenulate, inconspicuous oil dots associated with the crenulations, apex acuminate, the acumen 7–20 mm long. Inflorescences 2.5–18 cm long, rachis and branches sparsely to densely pubescent, pedicels sparsely to densely pubescent, puberulent, or nearly glabrous, obsolete to 3.5 mm long. Flowers predominantly 5-merous (occasional flowers 4-merous); sepals sparsely to densely pubescent, puberulent, or nearly glabrous, ciliolate, 0.5–1.2 mm long; petals green to yellow to white, drying brown or whitish, abaxially glabrous or with sparse, short hairs, adaxially villous to nearly glabrous, 3–5 mm long; disc glabrous; ovary glabrous or sparsely hairy, the carpels connate toward the base abaxially, free to the base adaxially, ovules 2 per carpel, collateral or subcollateral; rudimentary carpels glabrous or
rarely sparsely hairy, connate toward the base. Fruits predominantly 5-carpellate (occasional fruits 4-carpellate), 1–5 of the carpels developing into follicles; follicles glabrous or occasionally sparsely hairy, subglobose, not beaked, 3.5–6 mm long, connate toward the base abaxially, free to the base adaxially, endocarp glabrous. Seed black, 1 per follicle, paired with an aborted seed, ovoid or occasionally ellipsoid or subglobose, 3.5–5.5 mm long, attached in the dehisced follicle to an adaxial strip of pergamentaceous endocarp tissue; outer testa spongy (bounded externally by a crustaceous, shiny pellicle); inner testa bony.

Additional illustrations. Siebold and Zuccarini, Fl. Jap. 1 (1837 or 1838) 50, t. 21 (as *Boymia rutilcarpa*); Huang, Acta Phytotax. Sin. 6 (1957) t. 27, figs. B, C, & D, & t. 28 (as *Euodia rutilcarpa*).

Distribution. Nepal east to east-central China (Kiangsu and Chekiang Provinces) and Taiwan; recorded from well-drained forests, thickets, and open places; 120–3000 m.

Nepal. Samela, *Polumin, Sykes, & Williams* 483 (BM); Gurjakhani, *Stainton, Sykes, & Williams* 3549 (BM); Lumsum, *Stainton, Sykes, & Williams* 2930 (A, BM).


Bhutan. Punakha, *Cooper* 3048 (E).


Ch'ing-Hsiung have Tsiang Hartley: Mazzetti Euodia zetti Anonymous Steward Province: 6136 28 (NY). (GH, Nan-ch'ang, Kuling (A. Wung-yuen W), Nantou, 6059 (MICH, W).) To Taiwan. Cultivated. China. Hunan Province: Ping-kiang [P'ing-chiang], Hsiung 5315 (K). Kwangsi Province: Chiang 4908 (A); Mo-kan Shan, Cheo & Wilson Univ. Nanking 12807 (GH, UC); Mo-kan-shan, Read 1204 (BM); Tien-mu-shan [Hsi-t'ien-mu-shan], Ching 5102 (A), Law 1347 (K), 1389 (K); Ch'ang-hua-hsien, Keng 631 (A, UC); Ning-po Mts., Faber 95 (A, K), 1717 (K); Tsing-tien-hsien [Ch'ing-t'ien-hsien], Keng 47 (A), 96 (A); region of King Yuan [Ch'ing-yuan], Ching 2493 (A, UC, US, W); without definite locality, Liou 380 (NY). Kweichow Province: Tsunyi [Tsun-i] Hsiien, Liang-feng-yah, Steward, Chiao, & Cheo 115 (L, NY, US, W); Tung'tze [T'ung-tzu], Tsiang 4919 (NY); environs du Kouyang [Kuei-yang], Bodinier 1689 bis (P), Tsiang 8655 (NY); Kweiting [Kuei-t'ing], Tsiang 5447 (NY); Tu-yun, Tsiang 5870 (NY); inter Nganschan et Nganping, Handel-Mazzetti 10440 (A, W); inter Duyun et Gudong, Handel-Mazzetti 10690 (A, W). Hunan Province: monte Yüan-shan bei Wu-kang, Handel-Mazzetti 12320 (W, holotype of Euodia compacta Hand.-Mazz.; A, isotype); ad flumen Tsi-di-jiang supra Hsin-hwa, Handel-Mazzetti 12564 (A, W); Ch'ang-ning Hsien, Yang-shan, Fan & Li 180 (BM, BO, L, W). Kiangsi Province: Kiukiang, Bullock 10 (US), Shearer, 1873 (K); Ti-ping-shan, Hsiung 5315 (A); Kuling Lu-shan, Chiao Univ. Nankang 18585 (NY), Univ. Nanking 18618 (NY, US), Chung 4382 (W); Lu Shan, Chung & Sun 614 (A, NY), Ip Univ. Nanking 1083 (UC); Nan-ch'ang, Chung 607 (A), 693 (A); Kan River about 60 li south of Nan-ch'ang, Chung 28 (A), 31 (A); Kao-an, Hua-ling-shan, Tsiang 10406 (NY), 10419 (NY); Kiennan [Ch'uan-nan] District, Tung Lei Village, Lau 4128 (A, BM); without definite locality, Anonymous CCC 51919 (A). Kwangsi Province: Ling-yun Hsien, Loh Hoh Tsuen, Steward & Cheo 463 (A, BM, NY, W); San-chiang Hsien, Ling-wang Shan, Steward & Cheo 1016 (A, BM, NY, W); Tou-ngok Shan, near T'ung-chung Village, Tsang 23111 (A, W). Kwungtung Province: Lok-chong [Lo-ch'ang], Tso 20688 (NY), 20886 (NY); Yu-yuen [Ju-yüan], Ko 52936 (A); Ying Tak [Ying-te], Tai Tsan, Tsang & Wong Lingnan Univ. 14845 (A, UC), CCC 14188 (A, UC); Sin-fung [Hsin-feng] District, Taam 694 (A); Wung-yuen District, Lau 2462 (A); Lung-t'au Shan, Anonymous CCC 12776 (UC, US, W), To & Tsang 12776 (A, BM); Lok-fan Anonymous Lingnan Univ. 9933 (NY, US, W). Fukien Province: Fan Ka Cha, Dunn 112 (A). 

Taiwan. Taipingshan [T'ai-p'ing], Chang 4882 (NY); Kagi Province, Arisan [A Lan Shan], Wilson 10880 (A); Nantou Hsien, Horisha, Sasaki 42 (UC), Wilson 9955 (A); Nantou, Kawakami & Mori 3397 (A); Jitsugetsu Tan [Jih-yuen T'an], Tanaka 468 (A, BM, NY, US); Taiheisan (Mt. Taihei), between Taiheisan Club and Minamoto, Bartlett 6059 (MICH, US); Rinkiko, InABA, August 1911 (TI, holotype of Euodia hirsutifolia Hayata); without definite locality, Suzuki-Tokio 12776 (A). 


I have not seen the type of collectin of Boymia ruticarpa and it is apparently not among the specimens of the Jussieu herbarium photographed on IDC microfiches (L. Pedley, pers. comm.). Nevertheless, on the basis of Jussieu's original description and accompanying illustration, I am reasonably certain of its identity.
I have included a rather wide range of specimens in this species among which I have not been able to find any constant or correlating characters enabling me to recognise more than a single taxon. Some of the morphologic variation I have accepted includes: leaves 15—40 cm long; leaflets (1—)2—6(—7) pairs, 4.5—17 cm long, 2—8 cm wide, sparsely to densely pubescent on the lower surface; inflorescences 2.5—18 cm long, compact to spreading; petals 3—5 mm long; fruits 3.5—6 mm long; and seeds 3.5—5.5 mm long.

Of the names placed in synonymy, the type material of Euodia officinalis has rather large, spreading inflorescences and small flowers; that of E. rugosa has rather small, sparsely pubescent leaves (the leaflets are more or less wrinkled, but I do not think this is taxonomically significant in this case) and small, compact infructescences; that of E. hirsutifolia has rather long leaves with small leaflets and small fruits; and that of E. compacta and E. compacta var. meionocarpa have small, compact infructescences.

I have not seen either of the syntype collections of Euodia bodinieri, Bodinier 1689 and Ford 343, but it seems likely that one of the specimens cited above, Bodinier 1689 bis (P), which is labelled as Euodia bodinieri, was considered by Dode to represent that species. It has rather small, sparsely pubescent leaves and small flowers.

Euodia hirsutifolia was placed in the synonymy of Euodia ruticarpa by Li, Woody Fl. Taiwan (1963) 371 and Chang in Li et al., Fl. Taiwan 3 (1977) 517.

8. **Tetradium austrosinense** (Hand.-Mazz.) Hartley, *comb. nov.*


Small to medium tree 7—20 m high; branchlets pubescent when young, becoming glabrous or nearly so. Leaves 20—35 cm long; rachis sparsely to densely pubescent; leaflets 3—5 pairs; petiolules of lateral leaflets 2—4 mm long, terminal leaflet on an extension of the rachis 15—30 mm long; blades of leaflets chartaceous, sparsely and inconspicuously oil-dotted or without evident oil dots, below glaucous, minutely (10x) papillate, sparsely to densely pubescent with spreading or ascending hairs, above sparsely puberulent to nearly glabrous, broadly elliptic or occasionally elliptic-oblong, ovate, ovate-lanceolate, or, in some terminal leaflets, obovate to subob lanceolate, 5.5—14.5(—17) cm long, 2.5—7(—8.5) cm wide, base in lateral leaflets obtuse to nearly rounded, often oblique, in terminal leaflet cuneate, main veins 9—12 pairs, departing from the midrib at an angle of 55—70 degrees, ultimate veinlets usually rather conspicuous (10x), rather loosely reticulate, margin entire, apex acuminate, the acumen 4—8 mm long. Inflorescences 11—18 cm long, rachis and branches rather sparsely to densely pubescent, pedicels sparsely pubescent, 1.5—2 mm long. Flowers predominantly 5-merous (occasional flowers 4-merous); sepals sparsely pubescent, about 0.5 mm long; petals green or greenish—yellow, drying brown, abaxially sparsely puberulent to glabrous, adaxially sparsely to densely villous, 2.5—3 mm long; disc glabrous; ovary glabrous, the carpels connate toward the base, ovule 1 per carpel; rudimentary carpels villous toward the base, otherwise glabrous, connate toward the base. Fruits predominantly 5-carpellate (occasional fruits 4-carpellate), 1—5 of the carpels developing into follicles; follicles glabrous or rarely with a few scattered hairs, trigonous or subtrigono us, not beaked, 3.5 mm long and about as wide, connate toward the base, endocarp glabrous. Seed black, 1 per follicle, ellipsoid to subreniform, 2.3—2.5 mm long, attached in the dehisced follicle to an adaxial strip of peggamentaceous endocarp tissue; outer testa spongy (bounded externally by a crustaceous, shiny pellicle); inner testa bony.
Hartley: *Tetradium* (Rutaceae)

Distribution. Northern Vietnam and adjacent southwestern China; recorded from forests (apparently well-drained); 360–1500 m.


9. **Tetradium sumatranum** Hartley, sp. nov.

Arbor mediocris vel magna usque 42 m alta; ramulis puberulis; foliis (19-)26–48 (–55) cm longis; rhachidi puberula; foliolis in paribus (3-)4–6 (–7); petiolulis foliolarum lateraliusm obsoletis vel usque 3 mm longis, rhachidi ad apicem extensa 8–20 mm longa folium terminale ferente; laminis chartaceis vel subcoriaceis, sparse et inconspicue pellucido-punctatis vel sine punctatione distincta, subitus glaucis, minute papillatis, minute adpresse puberulis, supra praeter costa puberulis glabris, elliptica, elliptico-oblongis vel interdum late lanceolatis, 6.5–13.5 cm longis, 3.5–5.5 cm latis, basi obtusis vel rotundatis et plerumque inaequilateralis in foliis lateralius, actus vel cuneatis in foliolo terminali, venis primariis utrinsecus costa 13–16, sub angulo 55°–70° abeuntibus, venulis ultimis inconspicuis, margine integris, apice acuminatis, acumine 7–10 mm longo; inflorescentiis 10–17.5 cm longis, rhachidi et ramis puberulis vel subtilliter pubescentibus, pedicellis subtilliter pubescentibus, 0.5–2 mm longis; floribus pentameris; sepalis dense adpresse pubescentibus, ca. 0.5 mm longis; petals viridulis, in sicco bruneis, abaxialiter subtilliter adpresse pubescentibus vel fere glabris, adaxialiter villosis, 3.2–4.5 mm longis; disco glabro; ovario aequaliter vel inaequaliter adpresse pubescenti, carpellis basin versus connatis, ovulo in quoque carpelllo solitario; carpellis rudimentaris basin versus villosis, aliter glabris, basin versin versus connatis; fructibus non visis.

Holotypus: *Krukoff 4248* (NY).

Medium to large tree to 42 m high; branchlets puberulent. Leaves (19-)26–48(–55) cm long; rachis puberulent; leaflets (3-)4–6(–7) pairs; petiolules of lateral leaflets obsolete to 3 mm long, terminal leaflet on an extension of the rachis 8–20 mm long; blades of leaflets chartaceous to subcoriaceous, sparsely and inconspicuously oil-dotted or without evident oil dots, below glaucous, minutely (10x) papillate, puberulent with minute, appressed hairs, above glabrous except for puberulent midrib, elliptic, elliptico-oblong, or occasionally broadly lanceolate, 6.5–13.5 cm long, 3.5–5.5 cm wide, base in lateral leaflets obtuse to rounded, usually oblique, in terminal leaflet acute to cuneate, main veins 13–16 pairs, departing from the midrib at an angle of 55–70 degrees, ultimate veinlets inconspicuous, margin entire, apex acuminate, the acumen 7–10 mm long. Inflorescences 10–17.5 cm long, axis and branches puberulent to finely pubescent, pedicels finely pubescent, 0.5–2 mm long. Flowers 5-merous; sepals densely appressed-pubescent, about 0.5 mm long; petals greenish, drying brown, abaxially finely appressed-pubescent or nearly glabrous, adaxially villous, 3.2–4.5 mm long; disc glabrous; ovary even or unevenly appressed pubescent, the carpels connate toward the base, ovule 1 per carpel; rudimentary carpels villous toward the base, otherwise glabrous, connate toward the base. Fruits not seen.

Distribution. Endemic to Sumatra; recorded from well-drained, primary rain forest; 400 m.
Sumatra, East Coast: Pematangsiantar, Lörzing 16614 (L), 16938 (L); Asahan, Masihi Forest Reserve, Krukoff 4248 (NY, holotype; A, BRI, L, NY, SING, US, isotypes); Asahan, Pargambiran, Rahmat Si Boeaa 5783 (L).

INSUFFICIENTLY KNOWN OR OTHERWISE EXCLUDED NAMES


*Evodia meliaeifolia* var. celebica Koorders, Versl. Minahasa (1898) 371; Koorders-Schumacher, Syst. Verzeich. 3 (1914) 59; Koorders, Suppl. Fl. Celebes 3 (1922) 12, t. 22. Syntypes: Koorders 18754B, 18755B, and 18757B, Celebes, Prov. Minahasa. The only fertile material I have seen of this taxon is staminate. While undoubtedly belonging in *Tetradium*, its further identity cannot be determined with certainty without seeing carpellate material. The lower surface of the leaflets is minutely papillate, as in *T. austrosinense* and *T. sumatranum*, and, to a lesser extent, in some specimens of *T. fraxinifolium*. It seems probable that it is most closely related to *T. sumatranum*. Relevant collections in the Index to Exsiccatiae are identified as “aff. 9” (*Tetradium* sp. aff. *sumatranum*).


3. The *Euodia* names included here are only those representing plants that belong in *Tetradium* or could be confused with it (in having pinnately compound leaves). *Euodia*, in the sense of its type species and as interpreted in the present study, has unifoliolate or trifoliolate leaves.
Hartley: Tetradium (Rutaceae)

ACKNOWLEDGEMENTS

I wish to thank the directors and curators of the herbaria listed in the introduction for making specimens in their care available to me. Thanks are also extended to Roy Pullen, C.S.I.R.O. Division of Plant Industry, who translated into English portions of Huang's paper on Chinese Rutaceae, and to Rod Henderson, the Australian Botanical Liaison Officer at Kew in 1979, who assisted in having the type of Tetradium trichotomum loaned to me.

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THE FERN GENUS TECTARIA CAV. IN MALAYA

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SUMMARY

A new key to the species of Tectaria in Malaya is presented, with information supplementary to that in Holttum, Ferns of Malaya (1955; second edition, with Appendix II, 1968). Earlier names for six species described in 1955 are cited, with a fuller synonymy, and six additional species are described, namely T. herpetocaulos Holttum, T. melanocaula (B1.) Copel., T. decurrens (Presl) Copel., T. tricuspics (Bedd.) Copel., T. simonsii (Bedd.) Ching, T. fauriei Tagawa, and T. cherasica Holttum sp. nov. Six of these additional species are still only known in Malaya from single collections.

INTRODUCTION

The present paper is compiled from information gathered during a recent attempt to survey all species of Tectaria described from specimens originating in Asia, Malesia, and the Pacific, based mainly on specimens and literature available at Kew, also on a study of Presl's herbarium at Prague (1967) and on notes made in the herbaria at Singapore and Bogor in 1978.

The material is presented as an addition to that recorded in Holttum, Ferns of Malaya 1955 (issued in January 1955 though the printed date is 1954). Earlier names have been discovered for six of the species described in 1955 and much additional information on synonymy. Descriptions published in works on the floras of neighbouring countries are cited, including fuller references to Beddome who included Malaya in his Handbook to the ferns of India (1883 and Supplement 1892): one species named and described by Beddome in 1892 (T. tricuspis) was overlooked when my book of 1955 was prepared because the type collection is not represented in the Singapore herbarium. A fuller statement on known distribution is provided for all the species dealt with in 1955.

A second edition of my book was published in 1968 (the printed date is 1966) containing, in Appendix II (pp 629-638), further information, especially concerning additional species discovered by Mrs. Betty Molesworth Allen; three of these additional species belong to the genus Tectaria, namely T. decurrens, T. herpetocaulos, and T. melanocaula. These three species, briefly characterized in 1968, are here more fully described, also a further species (T. simonsii) also discovered by Mrs. Allen, another (T. cherasica) recently collected by Mrs. A.G. Piggott in Pahang, the forgotten species named by Beddome, and another species, T. fauriei, which I also overlooked in preparing my book. A new key covering all species now known in Malaya is provided.

Of the additional species, only T. decurrens is represented by several earlier collections made in Malaya (all in Perak). T. herpetocaulos, T. melanocaula, and T. simonsii are still only known in Malaya from specimens collected in the forest near the road to the Cameron Highlands at altitudes between 2000 and 3000 feet. So far as I know T. tricuspis has not been collected again in Malaya since Kunstler found it nearly one hundred years ago, though specimens (given another name) have since been found in western Sarawak. Mrs. Piggott's specimen from limestone on Bukit Cheras in Pahang
appears to be unique. Under *T. amplifolia* is an indication that there is perhaps a distinct allied species on limestone in Pahang and Kelantan still not named. All this shows how much more there is to be known about *Tectaria* in Malaya. More field work by trained observers is needed.

The drawings published in Holttum 1955 show the kind of details which need to be observed when learning to recognize these plants in the field. For most purposes a hand lens is sufficient, though to see indusia clearly a higher magnification is necessary. Indusia shrivel on old sori and young fronds should be looked for which show them more clearly. Scales at the base of stipes may yield distinctive characters, but many herbarium specimens do not show them. Buds at the bases of pinnae or at the bases of some main veins in the terminal lamina only develop on older fronds (in *T. siifolia* apparently only on sterile ones), so it is important to look for these.

There is no clear indication of the occurrence of natural hybrids in Malaya, though such may occur; one is recorded in Ceylon. Experimental hybridization might yield interesting results. Of six species examined cytologically by Prof. Manton from Malayan plants, only one (*T. barberi*) proved to be tetraploid (see Holttum 1955, p.626) but a tetraploid form of *T. devexa* has been found in New Guinea.

**Synonymy.** The synonyms are arranged in paragraphs, in each of which all names are dependent on one type specimen, the type and its location being stated at the end of the paragraph. In most cases I have seen holotypes or isotypes; those which I have not seen are so marked. In the case of Fée, whose specimens were dispersed, I have seen none of those which he himself studied, but in most cases here dealt with he cited collections which are represented by isotypes at Kew, and from his descriptions and his excellent figures there is no doubt as to his meaning. I have examined microfiche photographs of Willdenow's types; these give adequate information for the species here dealt with. Some authors in the 19th century attempted to distinguish species which have peltate indusia from those with reniform indusia; the latter were placed in a genus *Sagenia*. Most species have more or less distinctly reniform indusia and it does not appear that those with truly peltate indusia form a natural group, so that the genus *Sagenia* is now not recognized. Fée and Presl both attempted to distinguish genera on vein patterns; it is possible that some of these names may be useful for subdivisions of the genus, but some are not clearly defined and all are generally now disregarded.

**KEY TO THE MALAYAN SPECIES OF TECTARIA**

1. Veins all free .................................................. 1. *T. ingens.*

1. Veins anastomosing, at least to form costal areoles

2. Veins forming areoles along costae and a variable number of other areoles; free included veinlets in areoles few except in *T. barberi*, none in costal areoles

3. Lamina hairy between veins on upper surface

4. Veins anastomosing in costal and costular areoles only ........................................... 2. *T. devexa*

4. Veins more amply anastomosing ........................................... 3. *T. coadunata*
3. Lamina not hairy between veins on upper surface
   5. Sori in a single row on each side of costae or costules; indusia distinct

6. Fertile fronds much contracted; lamina to 25 cm long ........ 4. T. brachiata

6. Fertile fronds not or little contracted, to 60 cm long ........ 5. T. griffithii

5. Sori scattered, small, with inconspicuous indusia ... 6. T. barbéri

2. Veins forming many areoles, the largest ones with included free veinlets, often branched; free veinlets also present in costal areoles

7. Fronds simple, entire .................. 7. T. singapureana

7. Fronds deeply pinnatifid or pinnate or bipinnate

8. Sori small, very irregularly arranged and shaped, some much elongate .................. 8. T. semipinnata

8. Sori uniform or nearly so, none greatly elongate

9. Fronds pinnatifid to a wing along the rachis; stipe also winged

10. Lower lobes of frond much smaller than middle lobes ........ 9. T. grandidentata

10. Lower lobes of frond not reduced

11. Sori in two rows between main veins, immersed ........ 10. T. decurrens

11. Sori in more than two rows, not immersed

12. Indusia conspicuous, persistent, hairy on upper surface .................. 11. T. tricuspis

12. Indusia small, caducous, not hairy .... 12. T. vasta

9. Fronds of mature plants with at least one pair of free pinnæ

13. Sori in one row on each side of main veins, sometimes with additional ones where pinnæ are deeply lobed

14. Sori large, mostly on free veins in areoles


15. Basal pinnæ of well-grown plants bearing at least one pair of free pinnules
16. Fronds dimorphous; lower surface quite glabrous

16. Fronds little or not dimorphous; lower surface of costae hairy

14. Sori not on free veinlets in areoles, mostly small

17. Fronds dimorphous; indusia inconspicuous; buds present at bases of sterile pinnae

17. Fronds not dimorphous; indusia conspicuous; no buds ...

13. Sori scattered or in several rows between main veins

18. Pinnae and pinnules c. 10 times as long as wide

18. Pinnae and pinnules proportionately much wider

19. Stipe and rachis almost black; no buds at base of veins on apical lamina

20. Pinnae deeply lobed; sori indusiate

20. Pinnae not lobed; sori exindusiate

19. Stipe and rachis not black; or, if black, buds present at bases of veins of apical lamina

21. Middle pinnae broadly rounded at base on basiscopic side

22. Caudex erect; buds present at bases of some veins on apical lamina

22. Caudex long-creeping; no buds on apical lamina

21. Middle pinnae narrowly cuneate on both sides at base

23. Pinnae not decurrent at their bases to form rachis-wings; no buds present at bases of pinnae

23. Pinnae decurrent to form narrow rachis-wings which almost reach the next lower pinnae; buds present at the bases of pinnae


Type: C. B. Clarke 9295, Darjeeling (K).

Aspidium cardieri Christ, Journ. de Bot. 19(1905)62.—Tectaria cadieri (Christ) C. Chr., Ind. Fil. Suppl. III (1934) 177. — Type: Cadiere 85, Annam, valley of river Song Gianh, 19° 17' N. (K, isotype).


In Malaya this species is still only known from two collections made on Gunong Brinchang, Cameron Highlands, at about 1500 m, in the forest. I believe that the types of all the above cited species are conspecific with Clarke's original; they indicate a wide distribution but, except near Darjeeling, few specimens apart from the types have been collected. As it occurs in Java, it may be expected also on mountains in Sumatra.

Dr W.A. Sledge (Kew Bull. 27 (1972) 415), stated that in his opinion this species does not differ significantly from Tectaria paradoxa (Fée) Sledge of Sri Lanka except in its larger size. But the two differ also in the character of the scales at the bases of stipes; in T. ingens these are more than 10 mm long, their marginal cells not thin-walled, but in T. paradoxa the scales are shorter and have a distinct margin of thin-walled cells. Dr Sledge also included T. fuscipes (Wall.) C. Chr. as a synonym of T. paradoxa, in spite of Clarke's comments on its distinctive characters. I agree with Clarke that its very dark scales and narrower fronds are sufficient to establish its distinctness. It is distributed from Sikkim to southern Burma (also in Thailand, Vietnam, and Hainan) and might occur in northern Malaya.


Aspidium giganteum var. minor Hook., Spec. Fil. 4(1862)50.—Sagenia gigantea var. minor Bedd., Ferns S. India (1864) 81, t. 243. — Type: Thwaites C.P. 1358, Ceylon (K; BM).

Aspidium membranaceum Hook., Spec. Fil. 5(1864)105.—Pleocnemia membranacea (Hook.) Bedd., Ferns Br. India Suppl. (1876) 15. — Lectotype (selected here): Cuming s.n. (wrongly labelled 277), Philippines (K).

Christensen regarded Aspidium devexum Kunze 1848 as a valid name, but it was not. The first description of the species was published by Mettenius in 1858 under the name Aspidium intermedium which was illegitimate, being a later homonym; he cited A. devexum as a synonym. In 1864 however he evidently recognized the error and stated that the species described was A. devexum Kunze, which name thus acquired validity. But in 1864 Hooker also redescribed the same species, mainly from a Philippine specimen, under the name A. membranaceum. As it is uncertain which name was earlier, I prefer to retain the epithet devexa, which has been current for many years.


This species is widely distributed from N.E. India to S.W. China and southwards to Burma and Thailand. As noted in Holttum (1955) there are only a few small specimens from the north of Malaya. Those at Kew were growing on limestone, which might account for their small size: Henderson 21383 (Langkawi) and Kiah 35315 (Perlis). Christ identified Philippine specimens with this species (Philip. J. Sci. 2C: 187) but they are distinct and were later named T. christii Copel.


Aspidium immersum Hook., Spec. Fil. 4(1862)58, non B1. 1828.—Type: Wallich s.n., without locality (K).

Phlebigonium impressum Fée, Gen. Fil. (1852)314, t.24A, fig.2.—Type:Griffith 34, India (not seen).

Distribution: N.E. India to S. China and Taiwan; Thailand, Vietnam, northern Malaya, Java.

Fertile fronds are much contracted as compared with sterile ones, and have simpler venation, with one sorus-bearing vein in each areole (see figure in Holttum, 1955). The species is adapted to a climate with a seasonal dry period; its distribution is matched by many angiosperms which are similarly adapted.

As pointed out by Morton, the epithet brachiata has precedence over variolosa, though Backer & Posthumus placed the former as a synonym of the latter. Van Alder- werelt treated them as two species, but his descriptions only differ in the texture of the fronds which is not clearly definable; he had seen no type specimens.


Distribution: Assam, Burma, Thailand, Vietnam, Malaya, Sumatra, Borneo, Philippines.


**Aspidium kunstleri** Bedd., Handb. Suppl. (1892) 44. – Type: Kunstler 405, Gopeng, Perak (K).

**Phegopteris polycarpa** Mett. in Kuhn, Linnaea 36 (1869) 124. – **Aspidium kuhnii** C. Chr., Ind. Fil. (1905) 78, nom. nov. (not *A.polycarpum* Bl.). – **Polypodium polycarpum** (Mett.) Bak., Syn. Fil. ed. 2 (1874) 506. – **Dictyopteris polycarpa** (Mett.) Bedd., Ferns Br. India Suppl. (1876) 20 & Handb. (1883) 300. – Type: Jagor s.n., Malacca (B, seen by C. Chr.)

Distribution: Malaya, Borneo, Sumatra (specimens seen in Herb. BO).

Manton showed that this species is tetraploid (all others examined in Malaya are diploid); see Holttum 1955: 626. It may thus be of hybrid origin, with doubling of chromosomes, but I cannot suggest a likely parentage. Among species which have no branched free veinlets in the areoles, it is peculiar in the number of its simple free veinlets, all excurrent. Hooker and Beddome did not see the indusia.


Distribution: Malaya, Sumatra, Borneo.

Christensen has described a fern from West Kalimantan as *Tectaria pandurifolia*. It differs from *T. singaporeana* in having the lamina of the fronds abruptly narrowed at the base but decurrent as a narrow wing almost to the base of the stipe, also in the presence of short hairs on the upper surface of the midrib which in *T. singaporeana* is quite glabrous; I have not seen specimens.


Campylogramma trollii Goebel, Flora 125 (1931) 282, fig. 1–4. — Type: W. Troll, Sumatra, Pulau Berhala, cult. Munchen (M).

Distribution: Malaya, Sumatra, Borneo, Anamba Islands.

The irregular form and distribution of the sori suggests hybridity, but the only plant examined cytologically was diploid.


Distribution: Sarawak, Malaya, Lingga Archipelago, Sumatra.

This species agrees with T. singaporeana in having fronds decrescent towards their bases, and in completely glabrous fronds. It is very local in occurrence, in low country, usually on rocks but not by streams.


Aspidium pteropus Kunze, Bot. Zeit. 4 (1846) 462; Mett., Farngatt. IV (1858) 120. — Sagenia pteropus (Kunze) Moore, Ind. Fil. (1858) 89; Bedd., Ferns S. India (1863) t.82. — Type: Cuming 148, Luzon (LZ destroyed; isotype K).


Caudex erect. Stipe winged almost to the base, wing at the top 5–10 mm wide each side, narrowing downwards; scales on abaxial side many, to 10 mm long, 1.5–2 mm wide at base, firm, entire. Lamina to 60 cm long consisting of 2–7 pairs of lobes joined by a wing 5–10 mm wide each side of the rachis; lobes entire or sinuous or with oblique lobules at ends of main veins, somewhat narrowed at the base, acuminate; basal lobes sometimes forked near their bases; apex of lamina wider than the lateral lobes and more narrowed towards its base; small veins distinct, forming areoles with free included veinlets; lower surface of midribs and main veins bearing short hairs, upper surface glabrous. Sori mostly in free veins in areoles, in a row on each side of main veins, in depressions in the surface which form convexities on the upper surface; indusia large, glabrous.

Distribution: very wide in mainland Asia, throughout Malesia and in the Pacific eastwards to Tahiti. In Malaya, only collected in Perak: Scortechini without locality; Matthew s.n., 25 Dec. 1911, Batu Kurau; Molesworth Allen 4486, Gopeng, on rocky wet ground near stream, locally abundant.


Tectaria clemensiae Copel., Brittonia 1 (1931) 73. — Type: M.S. Clemens 22078, Sarawak, Lundu, Mt Gadin (UC, K, NY).

Caudex thick, erect or suberect. Frond trilobed with a wing extending halfway down the stipe (in a Sarawak specimen one pair of unlobed pinnae is connected to the trilobed apical lamina by a winged rachis); stipe 35–40 cm long with a wing 2–8 mm wide each side in its upper part; scales at base of stipe 10 x 1.5 mm, firm and dark with distinct pale edges of thin-walled cells. Midlobe of apical lamina to at least 30 x 10 cm (sterile) or 23 x 6.5 cm (fertile), rather evenly elliptic with short acuminate apex and entire margins; lateral lobes 22 x 8 cm (sterile) or 13 x 4.5 cm (fertile), shape as apical lobe but widened on basiscopic side of midrib; main veins of sterile lateral lobes 10 mm apart, of fertile lobes 6 mm, at 45° to midrib, almost straight except near margin; crossveins almost straight, smaller veins between them very slender, forming 2–3 rows of irregular areoles containing branched free veinlets; lower surface of midrib and main veins bearing very short erect hairs, upper surface densely covered with thick hairs, other parts of surfaces glabrous; a bud present at the base of each lateral lobe. Sori in two rows between the crossveins (4–5 irregular rows between the main veins), on veins which surround areoles; indusia rather large, apparently peltate, bearing many hairs c. 0.3 mm long on the upper surface.

In Malaya, this species is still only known from the original collection, which is not represented in the Singapore herbarium, for which reason I overlooked it when writing my book. Apart from the indusia and the buds at the base of the main lobes, this species is distinguished from T. vasta by the elliptic shape of the lateral lobes of the lamina; in T. vasta these lobes are little narrowed at their bases.

Holttum: *Tectaria* in Malaya

141; Beddome, Handb. (1883) 212; v.A.v.R., Handb. (1908) 247. – Type: Blume, Java (L).

*Aspidium alatum* Wall. ex Hook. & Grev., Ic. Fil. (1831) t.184; Hook., Spec. Fil. 4 (1862) 47. – Type: Wallich 378, Sylhet (K).

Distribution: Assam, Burma, Nicobar Islands, Thailand, Vietnam, Malaya, Sumatra, Java, Borneo, Celebes, Moluccas, New Guinea.


Distribution: Throughout Malesia and extending to Samoa. *T. dimorpha* St John (OCC. Pap. Bishop Mus. 21 (1954) 185, fig. 4), described from a specimen from Rotuma Island, is at least very closely allied. *T. crenata* is closely allied to *T. decurrens* and the two appear to hybridize in the Philippines.

14. **Tectaria cherasica** Holttum, sp. nov. forma et statura T. coadunato (J. Sm.) C. Chr. similis, ab ea differt pagina supra inter venas glabra; venulis liberis brevibus multis in areolis costalibus venarum inclusis, venulis liberis furcatis in areolis alis etiam interdum praesentibus; indusiis supra pilis tenuibus brevibus praeditis; paleis ad basin stipitum non cellulis pallidis marginatis. Typus: A.G. Piggott 2027, Bukit Cheras, Panching, Pahang, on limestone ridge, 24 Jan. 1977 (K).

Caudex stout, short-creeping. Stipe 27 cm long, stramineous or slightly flushed with red above the base, copiously minutely hairy at base, glabrous upwards apart from short hairs in the groove, basal scales to c. 7 x 1.5 mm, thin and translucent, light castaneous, marginal cells uniform with the rest. *Lamina* (fertile) thin but firm, 40 cm long, 20 cm wide, consisting of an apical portion and four pairs of upcurved pinnules, the basal ones not greatly longer than those next above them; *apical portion* 15 cm long, ovate-deltoïd in outline, base short-crenate, lobed to 10 mm from its axis, basal lobes to 8 x 2 cm, lobulate less than halfway to their costae, upper lobes progressively shorter and less deeply lobulate; *first pair of pinnules* adnate to rachis, 10 x 3 cm, lobed to 4 mm from costa, lobes falcate, obtuse and entire; *second pair of pinnules* short-stalked, 12 cm long with basal basiscopic lobe 3.2 x 1.2 cm shallowly lobulate, acroscopic lobe a little shorter, other lobes subentire; *third pair of pinnules* 16 cm long with one pair of subequal free pinnules 4.5 cm long; *basal pinnules* to 18 cm long (including stalk 1.5 cm), free basiscopic pinnule 8 cm long, acroscopic one 5.5 cm long, both deeply lobed with crenulate lobes, rest of pinnules like frond apex but somewhat asymmetric; *areoles* along midribs of pinnae rather irregular with frequent short included veinlets, the larger non-costular areoles also often with included veinlets which in a few cases are forked; *lower surface* of pinna midribs and costules of lobes bearing slender pale hairs to 0.3 mm long, short and more sparse hairs on smaller veins; *upper surface* more densely hairy on midribs of pinnae, no hairs present between veins except very few near sinuses. *Sori* mostly on
short free veins in areoles, in one row each side of costules of smaller pinna lobes, more irregular on larger lobes; indusia rather large, rather thin, slightly reniform, with many very slender hairs 0.1 – 0.2 mm long on the upper surface.

In general aspects this is rather intermediate between *T. amplifolia* and *T. coadunata*. It lacks the hairs on the upper surface which are distinctive of the latter and has more free veinlets in areoles, but a much less ample reticulation than the former; scales at the bases of stipes are not narrow and dark as in *T. amplifolia*. As no sterile fronds were found, one cannot be sure whether they would be very different from fertile ones, but the fertile fronds are much less contracted than those of *T. brachiatum* and have more amply anastomosing veins, differing also in the rather copious hairs on the lower surface of midribs and in the character of stipe scales. The sori are rather young; the few ripe sporangia have well-formed spores, so that the plant is probably not a hybrid.


*Drynaria menisciicarpa* J. Sm. in Hook., J. Bot. 3 (1841) 421, nom. nud. – *Dryomenis phymatodes* Fée, Gen. Fil. (1852) 225, t. 18A, fig. 1. – *Dryomenis menisciicarpa* Moore, Ind. Fil. (1857) 47. – *Aspidium menisciicarpum* Mett., Farnagg. IV (1858) 121, non B1. 1828. – Type: Cuming 4, Luzon (Fée's specimen not seen; isotype at K).


Comparsion of type specimens cited above, and other specimens from many localities from Sumatra to the Philippines and New Guinea, convinces me that they all represent one species. In several cases there are two pairs of pinnae, and in the type of *A. teysmannianum* four pairs. The fronds are always strongly dimorphous; all lateral pinnae are broadly rounded on the basiscopic base (sometimes the base is quite cordate); basal pinnae in smaller fronds are simple, but in larger ones have a large basal basiscopic lobe; on old sterile fronds there are always buds (sometimes quite large) at the bases of pinnae; the sori are on connected veins, in two slightly irregular rows between the main veins, sometimes asymmetric or confluent; the indusia are small and thin apparently soon caducous so that many specimens appear to lack indusia.


**Distribution**: Malaya, peninsular Thailand; on limestone only.

Kehding collected plants in N.E. Sumatra and in southern Malaya. Luerssen, when describing *A. keckii*, stated that he did not know whether the locality was in Malaya or Sumatra, and subsequent authors wrote Sumatra only. The limestone habitat and the description indicate clearly that Kehding's specimen and the type of *A. amplifolium* are conspecific.

As noted in my book, Henderson's specimen SFN 22325 from G. Senyum in Pahang (of which a duplicate is at Kew) has many short hairs on the lower surface of the pinna midribs and main veins, whereas these are quite glabrous on most other specimens; the G. Senyum specimens are also very large with pinna lobes strongly lobulate. Mrs A.G. Piggott has recently collected small fertile plants on Bukit Cheras in Pahang which also have many hairs on the lower surface and are more dissected than those of young plants of typical *T. keckii*. Local study is needed to decide whether these hairy plants represent a distinct species.


*Nephrodium nudum* Bak., Journ. Bot. 17 (1879) 41. – Type: Burbidge s.n., Sarawak, Lawas River (K).

I suggest that this species would be an interesting subject for experimental study. No one knows how the gametophytes become established on muddy river banks in the tidal zone; how can they withstand regular flooding? Can they grow in a submerged condition, like those of *Ceratopteris*?

**Tectaria modesta** C. Chr. (Dansk Bot. Ark. 9:3 (1937) 72, t.6, fig. 1) was described from a plant which had narrow simple fertile fronds, much like a single pinna of *T. semibipinnata*, and a slender creeping rhizome (Sarawak Museum Collector 218, Kuching). It is possible that this represents a young stage of the present species which is only known in Malaya and Borneo.


This species, distributed almost throughout Malesia, has been only once collected in Malaya, by Betty Molesworth Allen (no. 3985) in the forest on steeply sloping ground near the road to the Cameron Highlands at 3000 ft altitude.

_Caudex_ short, erect or suberect. **Stipe** 30–60 cm long, black, glossy except near the base which bears many short hairs; basal scales firm, to 12 mm long, to 2 mm wide at the base, marginal cells conform with the rest. **Lamina** to 60 cm long, pale green when living with black rachis and pinna midribs, consisting of a deltoid deeply lobed terminal portion and 1–3 pairs of pinnae; lobes of _apical lamina_ more or less deeply lobulate; _middle pinnae_ short-stalked, commonly to 18 cm long, lobed halfway towards the midrib, lobes obliquely falcate with rounded to acute tips; _basal pinnae_ of large fronds bearing one pair of free (sometimes stalked) pinnules which are lobed like the upper pinnae, the basal basiscopic pinnule or lobe always longer than the acroscopic; _lower surfaces_ of midrib and main veins sparsely and minutely hairy, upper surface densely covered with thicker hairs. _Sori_ small, scattered irregularly, mostly on short free veinlets in areoles; indusia small, shrivelling and mostly persistent, not hairy.

Blume wrote the specific epithet _melanocaulon_, meaning black stem; the latter part of the name is derived from the Greek _kaulos_, which Blume altered to make it conform with a neuter generic name. When transferring the species to _Sagenia_, Moore changed the specific epithet to _melanocaulis_, and in this was followed by Copeland when transferring again to _Tectaria_, but _caulis_ is not correct in Greek. Morton (1971) stated that _melanocaulon_ should be treated as invariable, but Blume had already varied it. Backer and Posthumus wrote _melanocaula_, treating the word as a feminine Latin adjective, and I think this is the best solution of the problem.

19. **Tectaria simonsii** (Bedd.) Ching, Sinensia 2 (1931) 32. – _Aspidium simonsii_ Bedd., Ferns Br. India Suppl. (1876) 15, t. 367. – Type: Simons 301, Nuku & Naga Hills, Assam (K).


**Stipe** nearly black, to 60 cm long, minutely hairy at base, the rest glabrous; basal scales very firm and dark. **Lamina** to 40 cm long, “dark bluish green” when living (Molesworth Allen), consisting of a deeply trilobed apex and 1–3 pairs of pinnae; _middle pinnae_ sessile with subcordate base which is a little dilated, margins subentire; _basal pinnae_ of large fronds stalked, with one pair of free pinnules (basiscopic pinnule longer than acroscopic), the distal part trilobed with subentire lobes; veins anastomosing to form areoles with many included free veinlets, concolorous but distinct on both surfaces; _lower surface_ of midribs of pinnae and main veins bearing scattered minute hairs, longer dense antrorse hairs present on the upper surface. _Sori_ small and uneven in shape, sometimes a little elongate, scattered irregularly, usually not on free veins; no indusia seen.

Distribution: Assam to southern China, Taiwan and Ryukyu Islands, Vietnam, Thailand. The only specimen collected in Malaya is Molesworth Allen 4947 from the forest near the 23rd mile, Cameron Highlands Road, at an altitude of 2000 ft.


Distribution: Malesia, Solomon Islands.


*Caudex* long-creeping, 6–10 mm diameter when dried, bearing stipes about 1.5 cm apart; scales 5 x 1 mm, base cordate, dark glossy with pale fragile edges. *Stipe* 30–80 cm long, lightly flushed with red, glabrescent, scaly near base, scales as those of caudex but to 10 mm long. *Fronds* of young plants trifoliate, those of mature plants consisting of an apical lamina and 4 pairs of pinnae; *apical lamina* to 26 x 11 cm (smaller on larger fronds), entire, base cuneate, apex abruptly short acuminate; *upper pinnae* sessile, to 21 x 6 cm, with asymmetric base rounded on the basiscopic side; *basal pinnae* stalked, to 30 cm long and 10 cm wide, asymmetric with a single basiscopic lobe to 20 x 6 cm (largest fronds may have 2 pairs of pinnae with basal lobes); pinnae glabrous apart from rather sparse short hairs on lower surface of midribs and main veins and dense short hairs on their upper surface; *main veins* pale on lower surface, 8–10 mm apart, at a wide angle and upcurved; smaller veins all slightly prominent, forming irregular rather small areoles with included free veinlets. *Sori* mostly not on free veins, rather small, in a single row on each side of the main veins but with additional sori between the rows irregularly present; indusia thin, shrivelling but persistent; perispore consisting of many narrow short projections.

In Malaya still only known from the original collection and no. 9948 from the same locality, “spreading over humus-covered rocks”. The species also occurs in Thailand, Burma, and Bangladesh (see list of specimens in Holttum 1965). Several specimens are recorded as growing on limestone.


Distribution: Malaya, Sumatra, Sarawak; in lowland forests.

When writing my book of 1955 I overlooked the description of Aspidium oligophyllum in van Alderwerelt's Handbook. Rosenstock's type is presumably at Leiden; I did not find a duplicate at Bogor. His description is good and I cannot doubt that it applies to the Malayan plants which I described as T. polymorpha var. cuneifolia. He described the indusia as peltate, stating that they were like those of T. singaporeana, but I found that the indusia of the latter species are variable and usually not fully peltate. The true T. polymorpha is a quite different species with broad-based pinnae.

Ridley described Leptochilus rumicifolius from young plants which have fronds rather copiously hairy on both surfaces. Mrs Allen sent similar plants, from rocks at Klang Gates, to Kew; these plants later developed almost hairless fertile fronds. Probably the hairiness of young plants which grow on rocks is due to the habitat. Ridley thought his plant was sterile, but it has a few sori on one of its simple fronds.


Caudex stout, erect. Stipe 40–60 cm long, narrowly winged in the upper part; basal scales 10 mm or more long, to 2 mm wide at base, firm, with narrow margin of thin-walled cells. Lamina firm, to 50 cm long, consisting of a trilobed apex which is narrowly decurrent at the base almost to the attachment of the uppermost pair of pinnae, and 2 or 3 pairs of pinnae, all with similarly narrow-decurrent bases; buds present at the base of some pinnae on mature fronds; middle pinnae 20–25 cm long, entire or nearly so, gradually narrowed towards their bases, apex narrowly acuminate, sterile pinnae often wider than fertile, to c. 6 cm wide; basal pinnae of small fronds narrowed towards their bases on both sides, unlobed but the lamina on the basiscopic side of the midrib wider than on the acrosopic side, of larger fronds with a narrowly winged stalk and a rather long basal basiscopic lobe; pinna midribs and main veins reddish on the lower surface when dried and minutely sparsely hairy, the upper surface glabrous; smaller veins concolorous and distinctly prominent on both sides, forming many areoles which enclose branched free veinlets. Sori small, round, in about 4 irregular rows between the main veins, not on free veins; indusia rather small, thin, glabrous, persistent.

Distribution: Assam, northern Shan States and adjacent Yunnan, Taiwan, Ryukyu Islands (Okinawa), N. Thailand, Pahang; in several cases reported as growing on rocky stream banks.

The specimen from Pahang is Holttum 20071, Tahan River, below Kuala Teku, on rocks and earth of river bank. I failed to notice this specimen when writing my book of 1955 and referred to specimens from Thailand erroneously under T. vasta.
This species differs from *T. vasta* in its narrow rachis wing which is decurrent from each pair of pinnae but does not reach down to the next lower pair, in the much narrowed bases of pinnae and their more narrowly acuminate apices, in the presence of buds at the bases of some pinnae on old fronds, and in the indusia which are not fringed.

*T. fauriei* is nearer to *T. oligophylla*, agreeing rather closely in the shape of pinnae and of sori and indusia, differing in the decurrent bases of pinnae and in the presence of buds. *T. oligophylla* also has rather long-stalked basal pinnae on old fronds. *T. oligophylla* is always a fern of forest, not of river banks, in my experience. *T. fauriei* probably occurs on the banks of tributaries of the Kelantan River where natural forest remains; it probably would not persist on exposed river banks from which forest had been felled.

Though I have not seen the type specimen of *T. fauriei*, I have seen a specimen from Thailand identified by Prof. Tagawa, author of the species, and also from his description I feel confident that my identification of the Tahan River plant is correct.
EXPERIMENTAL FINDINGS OF
THE TISSUE CULTURE OF ORCHID HYBRIDS
AT THE SINGAPORE BOTANIC GARDENS

by

Lim-Ho Chee Len

Botanic Gardens,

Singapore

ABSTRACT

A Tissue Culture Laboratory was established at the Singapore Botanic Gardens in the early 1970's. By 1975 several orchid hybrids had been successfully mericloned and in 1978 the Laboratory started a tissue culture service to assist local orchid growers and breeders. To date, the Laboratory has successfully mericloned six species and more than one hundred orchid hybrids. Some effective media compositions have been established and used in research and routine commercial production at the Laboratory. Tissue culture techniques using leaves and lateral buds of flower stalks have also been employed. Various tissue culture techniques and media used for local orchids is presented.

INTRODUCTION

Research work on orchids at the Botanic Gardens, Singapore started in 1928 and early work was mainly on hybridisation. Following the success in tissue culture of orchids by G.M. Morel (1960) in France, it was decided to venture into this new line of research at the Botanic Gardens. A Tissue Culture Laboratory was established in the early 1970's and preliminary experiments were conducted with improvised equipment. In 1973 one laminar flow and two shakers were acquired, however these shakers operated on a pulley system which broke down frequently. In 1975 a Brunswick shaker was purchased. By that time, several hybrids of Dendrobium (Singh, 1976), Aranda, Aranthera, and Burkillara, had been successfully mericloned. After many attempts, Dendrobium attenuatum was also successfully mericloned in 1977.

In late 1978 the Tissue Culture Laboratory started a mericlone service to assist local orchid growers and breeders. The Laboratory undertakes experimental tissue culture propagation of parent plants sent in by the public. When fully differentiated plantlets are obtained the experiment is considered successful and a contract is then agreed upon between the owner of the parent plants and the Laboratory for the purchase and supply of a certain number of plantlets. Plantlets supplied are at least 3 cm in length with strong, healthy roots and in a condition ready for potting. Orchid hybrids which have been mericloned at the Laboratory and supplied commercially on a large scale include Dendrobium Tay Swee Keng, Dendrobium Yong Kok Wah, Dendrobium Jaquelyn Hawaii, Aranda Chong Chee Yuen, Kagawara Teoline Fair, Mokara Sally Lim, and Aranda Ng Chong Hang. Facing keen competition from Thailand and Malaysia on the international market for cut flowers, Singapore orchid growers and breeders have increasingly sought the assistance of the Tissue Culture Laboratory for the mass propagation of their choice hybrids. The Laboratory has, therefore, been able to contribute directly to the rapid growth, both in terms of the total annual export and the level of technical sophistication, of the local orchid industry by making readily available an efficient mass propagation technique based on advanced biological knowledge.
Orchid Tissue Culture Techniques

In the pioneeing work of Morel (1960) shoot apices of *Cymbidium* were excised to produce virus-free protocorms which later developed into plantlets. The techniques used at the Tissue Culture Laboratory are basically variations of Morel’s methods. Young leaves (Fu, 1979), axillary buds, lateral buds of flower stalks (Fu, 1978), and roots are sometimes used instead of apical shoots. Various media have been tested and hormones are occasionally added to the basic salt to induce protocorm formation, to accelerate growth, and to promote protocorm differentiation.

Plant Tissues Used

Using the shoot apex of an orchid plant for tissue culture requires the sacrifice of new growth or even, as in the case of monopodial orchids, the whole plant. Since success cannot be guaranteed and most of the plants selected for tissue culture are valuable (sometimes it is the only specimen of a new hybrid of great commercial potential), the cost and risk involved could be high. It is, therefore, desirable to develop techniques using tissues which can be removed without doing much harm to the parent plants. Experiments have been conducted using young leaves, axillary buds, lateral buds of flower stalks, and roots as explants. Some of these experiments were successful and the methods developed have been adopted in routine production at the Tissue Culture Laboratory (see Tables 1 and 2). The parts taken from parent plants for the various tissue culture techniques are summarised below:

<table>
<thead>
<tr>
<th>Culture technique</th>
<th>Part of plant used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apical and axillary meristems</td>
<td>young side shoot measuring 7–8 cm</td>
</tr>
<tr>
<td>sympodial orchids</td>
<td>top 10 cm of the apical shoot</td>
</tr>
<tr>
<td>monopodial orchids</td>
<td></td>
</tr>
<tr>
<td>Leaf</td>
<td>whole young leaf (3–4 x 1–2 cm)</td>
</tr>
<tr>
<td></td>
<td>from mature plant</td>
</tr>
<tr>
<td>Lateral bud (flower stalk)</td>
<td>whole flower stalk about 20 cm</td>
</tr>
<tr>
<td></td>
<td>in length</td>
</tr>
<tr>
<td>Root</td>
<td>young aerial root about 5 cm in length</td>
</tr>
</tbody>
</table>

Sterilization

Prior to excision, all plant parts must be sterilized. The methods for the various plant parts are as follows:

1. Apical and axillary meristems: The leaves are removed to expose the apical or axillary buds. The remaining shoot is then washed with antiseptic soap and soaked in a chlorox solution (10–12%) for 10–15 minutes.

2. Leaves: Cut leaves are washed with antiseptic soap and soaked in a chlorox solution (10–12%) for 15–20 minutes.

3. Lateral buds of flower stalks: Scale leaves are removed from the flower stalks to expose the lateral buds. The remaining stalk is then washed with antiseptic soap.
and soaked in a chlorox solution (12–15%) for 20 minutes.

4. Roots: Cut aerial roots are washed with antiseptic soap and soaked in a chlorox solution (15%) for half an hour.

**Excision**

In meristem culture, 0.2 mm cubes are excised from sterilized plant parts and care is taken to excise only the meristematic cells and not the surrounding tissues. In root culture, young root tips 1–2 cm long are cut for use as explants. In leaf culture, whole young leaves are used.

**Inoculation**

All excised plants are put into 100 ml conical flasks containing 25 ml of liquid media under sterilized conditions. These are then sealed and placed on shakers.

**Shaking and environmental conditions**

Shaking is essential during the early stages of protocorm formation (Wimber, 1963, 1965; Kunisaki et al., 1972). The basic purposes of shaking are to increase aeration, to reduce plant polarity, to enhance cell multiplication, to dilute excretion of explants, and to help distribute nutrients. From our experience, the mode of shaking is not significant however, too violent shaking has been observed to cause browning-off of protocorms.

In the Tissue Culture Laboratory, explants in shakers are exposed to continuous illumination of about 2000 lux and maintained at a temperature of 21–25°C.

**Media**

The most commonly used media for tissue culture of orchids are the White (1943) medium, the Murashige and Skoog (1962) medium, the Vacin and Went (1949) medium, and the Knudson (1949) C medium. These and many modified forms of these media have been tested at the Tissue Culture Laboratory. The most successful of the modified media are: KCBP medium — Knudson C basic salt supplemented with banana and pineapple juice; and VWM medium — Vacin and Went basic salt supplemented with banana, coconut milk, and tomato juice.

The media used depend on the stage of development of the protocorms. For protocorm initiation, the Vacin and Went medium and the Knudson C medium have been found to be far superior to the others for apical shoot tip and axillary bud cultures. For most species and some hybrids it is necessary to add NAA or IAA to induce protocorm formation. In the case of tissue culture using leaves and lateral buds of flower stalks, the Murashige and Skoog medium supplemented with 2–4–D and 6–amino–benzyladenine has been found to be best for protocorm initiation.

For protocorm multiplication and differentiation, the Vacin and Went medium supplemented with coconut milk and sugar is best for most hybrids, especially for *Dendrobium* hybrids. *Vanda* hybrids, however, have been observed to multiply and differentiate faster in the Vacin and Went medium supplemented with coconut milk only. For most *Aranthera* hybrids, the best medium for multiplication and differentiation is the Murashige and Skoog basal salt.
The VWM medium has been found to be the best for the final stage of most hybrids. For some slow-growing hybrids such as *Aranda Majula* 'Rimau' and *Aranda* Christine No. 5, root formation is much faster in the KCBP medium than in the VWM medium. All *Oncidium* hybrids fail to form roots in the VWM medium, but satisfactory root formation is obtained in the KCBP medium. Since species of *Arachnis* and *Aranthera* hybrids excrete strong phenolic compounds, it is necessary to change media every few days during the first six months of their growth. The composition of the media used in the Tissue Culture Laboratory is listed in Table 3. The appropriate media for some local species or hybrids at different stages of development are given in Tables 1 and 2.

**Data and observations on tissue culture of local orchids**

To date the Tissue Culture Laboratory has successfully mericloned 6 species and more than 110 hybrids of orchids. All the species are grown locally and out of the hybrids, 82 are local. Summaries of the basic data, part of plant used, media, growth rate, and relevant remarks on the tissue culture of these local orchid species and hybrids are given in Tables 1 and 2. These tables also show that many orchids have been successfully mericloned and it is possible that all orchid hybrids can be mericloned provided the right media is used.

Coconut milk appears to be an important supplement to all the media used in every stage of protocorm development. Coconut milk is believed to contain hormones (probably cytokinins) in a balanced composition (Letham, 1974) which are effective in inducing protocorm formation and differentiation. Auxins such as NAA and IAA are occasionally added to media to induce protocorm formation, however, they are found to have an inhibitory effect on the differentiation of protocorms.

A wide range variation in growth rates has been observed. Fast-growing hybrids produce marketable plantlets in about one year's time while slow-growing hybrids may take more than two years. Most *Dendrobium* hybrids have been found to be fast-growing and except for some *Aranda* hybrids, monopodial ground orchids are generally slow-growing. Experience seems to suggest, however, that the slow growth of many hybrids may probably be due to the use of unsuitable media rather than to some basic physiological characteristics of the hybrids. Considerable research effort in the Tissue Culture Laboratory has, therefore, been on the improvement of media in use and the search for effective new media.

**Acknowledgement**

The Tissue Culture Laboratory was developed due to the efforts of many researchers, especially Dr. Fu-Fan May Lay and Dr. Choo Yon Sen.
### Table 1. Local Orchid Species Successfully Mericloned

<table>
<thead>
<tr>
<th>Species</th>
<th>Source of meristem explant</th>
<th>Growth rate</th>
<th>Media for initiation (liquid)</th>
<th>Media for multiplication and differentiation</th>
<th>Media for plantlet formation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arachnis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. hookerana</td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWN + NAA</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td>Arachnis spp. often excrete strong phenolic compounds; need to change medium weekly during the first six months</td>
</tr>
<tr>
<td>Dendrobium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. antennatum</td>
<td>apical</td>
<td>slow</td>
<td>VWS + NAA</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>2. laciniosum</td>
<td>apical</td>
<td>slow</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>3. superbiens</td>
<td>apical</td>
<td>fast</td>
<td>VWS + NAA</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>Oncidium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. lanceanum</td>
<td>apical</td>
<td>slow</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>2. haematochilum</td>
<td>apical</td>
<td>fast</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>KCP</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2. Local Orchid Hybrids Successfully Mericloned

<table>
<thead>
<tr>
<th>Parentage</th>
<th>Source of meristem explant</th>
<th>Growth rate</th>
<th>Media for initiation (liquid)</th>
<th>Media for multiplication &amp; differentiation</th>
<th>Media for plantlet formation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeridachnis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Bogor 'Apple Blossom'</td>
<td>Arachnis hookerana x Aerides odorata</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>2. Alexandra</td>
<td>Aeridachnis Vogel, A. x Arachnis flosaeis 'insignis'</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>3. Elizabeth Howie</td>
<td>Arachnis Ishbel x Aerides lawrenceae</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>Arachnis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Capama 'merah'</td>
<td>Arachnis Maggie Oei x Arachnis brevica</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>Arachnostylis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Chorchedool</td>
<td>Arachnis hookerana x Rhynochostylis gigantea</td>
<td>slow</td>
<td>VWM</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>Aranda</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Belzonica</td>
<td>Arachnis Ishbel</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS, MS</td>
<td>VWM</td>
<td>MS medium best for differentiation</td>
</tr>
<tr>
<td>2. Bertha Braga</td>
<td>Vanda laciniosum x Vanda tricolor x Arachnis Maggie Oei</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>3. Bintang</td>
<td>Arachnis hookerana x Vanda Tattleri</td>
<td>fast</td>
<td>VWN/VC</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>4. Chong Chee Yuen</td>
<td>Aranda Blue x Vanda Rorischildiana</td>
<td>fast</td>
<td>VWN/VC</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>5. Chen Chin Mu</td>
<td>Aranda Bintang Raffles x Vanda Wangie</td>
<td>fast</td>
<td>VWN/VC</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>6. Christine No. 1</td>
<td>Arachnis hookerana x Vanda Hilo Blue</td>
<td>fast</td>
<td>VWN/VC</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>7. Christine No. 5</td>
<td>Arachnis hookerana x Vanda Hilo Blue</td>
<td>fast</td>
<td>VWN/VC</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>8. Christine No. 9</td>
<td>Arachnis hookerana x Vanda Hilo Blue</td>
<td>fast</td>
<td>VWN/VC</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>9. Christine No. 27</td>
<td>Arachnis hookerana x Vanda Hilo Blue</td>
<td>whole leaf</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>10. Christine No. 80</td>
<td>Arachnis hookerana x Vanda Hilo Blue</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>Parentage</td>
<td>Source of meristem explant</td>
<td>Growth rate</td>
<td>Media for initiation (liquid)</td>
<td>Media for multiplication &amp; differentiation</td>
<td>Media for plantlet formation</td>
<td>Remarks</td>
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<tr>
<td>Aranda</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Christine No. 130</td>
<td>Arachnis hookerana x Vanda Hilo Blue</td>
<td>whole leaf</td>
<td>fast</td>
<td>MS+24-D+BA</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>12. Christine No. 999</td>
<td>Arachnis hookerana x Vanda Hilo Blue</td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>13. Elizabeth Douglas Home</td>
<td>Arachnis Maggie Oei x Vanda Radman</td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>14. Eric Mekie</td>
<td>Aranda Lucy Laycock x Vanda luzonica</td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>15. Freckles</td>
<td>Arachnis Ishbel x Vanda dearei</td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>16. Hatifah</td>
<td>Arachnis hookerana x Vanda luzonica</td>
<td>axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>17. Hilda Galistan</td>
<td>Arachnis hookerana x Vanda tricolor suavis</td>
<td>axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>18. Imelda Romualdez Marcos</td>
<td>Arachnis main-gazi x Vanda harvest time</td>
<td>axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>19. Jessie</td>
<td>Arachnis hookerana lateole x Vanda Ellen Noa</td>
<td>axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>20. Lucy Laycock</td>
<td>Arachnis hookerana x Vanda tricolor</td>
<td>axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>21. Majula 'Rimau'</td>
<td>Arachnis Maggie Oei x Vanda insignis</td>
<td>axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, MS, VWS</td>
<td>KCBP/VWM</td>
</tr>
<tr>
<td>22. Ng Chong Hang</td>
<td>Aranda Bintang Raffles x Vanda Rose Davis</td>
<td>axillary &amp; axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>23. Noorah Altagoff</td>
<td>Arachnis hookerana x Vanda Dawn Nishimura</td>
<td>leaf base</td>
<td>fast</td>
<td>MS+24-D+BA</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>24. Peter Ewart</td>
<td>Arachnis hookerana x Vanda Kapoho</td>
<td>axillary</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>25. Queen of Purples</td>
<td>Vanda Kapoho x Arachnis brevissima</td>
<td>axillary &amp; leaf base</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>26. Tourism Singapura</td>
<td>Arachnis Ishbel x Vanda lamellata</td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>27. Wee Huax Lay</td>
<td>Arachnis Ishbel x Vanda Rothchildiana</td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>28. Wendy Scott 'Blue Bird'</td>
<td>Arachnis dearei x Vanda Rothchildiana</td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>29. Wendy Scott 'Green Field'</td>
<td>Arachnis hookerana x Vanda Rothchildiana</td>
<td>leaf base &amp; apical</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS, MS</td>
<td>KCBP/VWM</td>
</tr>
<tr>
<td>30. Yvonne Tan</td>
<td>Aranda Queen of Purples x Vanda Rothchildiana</td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
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<table>
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<th>Parentage</th>
<th>Source of meristem explant</th>
<th>Growth rate</th>
<th>Media for initiation (liquid)</th>
<th>Media for multiplication &amp; differentiation</th>
<th>Media for plantlet formation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Anne Black</td>
<td>Arachnis Maggie Oei x Renanthera cocinea</td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS, MS</td>
<td>VWM</td>
<td>MS medium better than VWS for differentiation</td>
</tr>
<tr>
<td>2. Beatrice Ng 'Yellow'</td>
<td>Renanthera storiei x Arachnis Ishbel</td>
<td>axillary &amp; leaf base</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS, MS</td>
<td>VWM</td>
<td>MS medium better than VWS for differentiation</td>
</tr>
<tr>
<td>3. Dainty</td>
<td>Arachnis hookerana var. lateola x Renanthera monachica</td>
<td>axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS, VWM</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>Parentage</td>
<td>Source of meristem explant</td>
<td>Growth rate</td>
<td>Media for initiation (liquid)</td>
<td>Media for multiplication &amp; differentiation</td>
<td>Media for plantlet formation</td>
<td>Remarks</td>
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<tr>
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<tr>
<td>Aranthera 4. Francina Bruyns</td>
<td>Aranthera Dainty x Renanthera stori</td>
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<td>slow</td>
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<td>VWN, VWS</td>
<td>VWM</td>
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<tr>
<td>Aranthera 5. Gracia Lewis</td>
<td>Mohamed Haniff x Renanthera stori</td>
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<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
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<tr>
<td>Aranthera 6. James Storie</td>
<td>Aranthis hookeana x Renanthera stori</td>
<td>apical &amp; axillary</td>
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<td>VWN, VWS, MS</td>
<td>VWM</td>
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**Ascocenda**

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<th>Media for multiplication &amp; differentiation</th>
<th>Media for plantlet formation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Heah Hock Heng</td>
<td>Vanda Josephine van Brero x Ascocenda Hilo Rose</td>
<td>whole leaf</td>
<td>fast</td>
<td>MS+2-4-D +BA</td>
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<td>VWM</td>
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<tr>
<td>2. Botanic Gardens serial No. 4038</td>
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<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS, MS</td>
<td>VWM</td>
</tr>
<tr>
<td>3. Botanic Gardens serial No. 4766</td>
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<td>VWN, VWS</td>
<td>VWM</td>
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**Burkillara**

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<th>Media for multiplication &amp; differentiation</th>
<th>Media for plantlet formation</th>
<th>Remarks</th>
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<tr>
<td>1. Ong Thye Chiew</td>
<td>Aeridachnis Bogor x Vanda Dawn Nishimura</td>
<td>apical &amp; axillary</td>
<td>slow VWN + NAA</td>
<td>VWN, VWS, MS</td>
<td>VWM</td>
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**Cattleya**

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<th>Media for multiplication &amp; differentiation</th>
<th>Media for plantlet formation</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>1. Meadii</td>
<td>Cattleya bowringiana x Cattleya forbesii</td>
<td>apical</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>KCBP</td>
</tr>
<tr>
<td>2. Botanic Gardens serial code CO3</td>
<td>unregistered hybrid</td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>MS+2-4-D +BA</td>
<td>VWM, VWS</td>
<td>VWM</td>
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**Dendrobium**

<table>
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<tr>
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<th>Growth rate</th>
<th>Media for initiation (liquid)</th>
<th>Media for multiplication &amp; differentiation</th>
<th>Media for plantlet formation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Alice Spalding</td>
<td>Dendrobium tokai x Dendrobium unidatum</td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWS/VWN</td>
<td>VWN, VWS</td>
<td>VVM</td>
</tr>
<tr>
<td>2. Dendrobium Barbara Moore</td>
<td>Dendrobium affine x Dendrobium gouldii 'blue'</td>
<td>slow</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>VWM</td>
<td></td>
</tr>
<tr>
<td>3. Caesar</td>
<td>Dendrobium phalaenopsis x Dendrobium statio</td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>4. Cheong Chee Yon</td>
<td>Cheong Fook Sum x Dendrobium</td>
<td>apical</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>5. Ellen Harris</td>
<td>Dendrobium phalaenopsis x Ursula</td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>6. Fiery Gold</td>
<td>Dendrobium Ismail Trengganu x Dendrobium Guadalcanal</td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>Parentage</td>
<td>Source of meristem explant</td>
<td>Growth rate</td>
<td>Media for initiation (liquid)</td>
<td>Media for multiplication &amp; differentiation</td>
<td>Media for plantlet formation</td>
<td>Remarks</td>
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<tr>
<td>Dendrobium</td>
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<td>7. Ng Eng Cheow</td>
<td><em>Dendrobium</em> Alice Spalding x <em>Dendrobium</em> Jaquelyn Thomas</td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>8. Sunny</td>
<td><em>Dendrobium</em> Beach Girl x <em>Dendrobium schallert</em></td>
<td>axillary</td>
<td>slow</td>
<td>VWS+IAA</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>9. Tay Swee Keng</td>
<td><em>Dendrobium</em> Jaquelyn Concert x <em>Dendrobium</em> Irene Cheong</td>
<td>apical</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>10. Yong Kok Wah</td>
<td><em>Dendrobium</em> Mary Trowse x <em>Dendrobium</em> schallert*</td>
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<td>slow</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>11. Botanic Gardens serial No. 4879</td>
<td>unregistered hybrid</td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>12. Botanic Gardens serial No. 8090</td>
<td>unregistered hybrid</td>
<td>apical</td>
<td>fast</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>13. Botanic Gardens serial No. 8262</td>
<td>unregistered hybrid</td>
<td>axillary</td>
<td>fast</td>
<td>VWS+</td>
<td>VWN, KCS, VWS VWM</td>
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<tr>
<td>14. Botanic Gardens serial No. 8324</td>
<td>unregistered hybrid</td>
<td>apical</td>
<td>fast</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>15. Botanic Gardens serial No. 8961</td>
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<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWS+NA</td>
<td>VWN, KCS, VWS VWM</td>
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<tr>
<td>16. Botanic Gardens serial No. 9215</td>
<td>unregistered hybrid</td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>17. Botanic Gardens serial No. 12917</td>
<td>unregistered hybrid</td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>VWM</td>
</tr>
<tr>
<td>Doritaenopsis</td>
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<tr>
<td>1. Elizabeth Waldheim</td>
<td><em>Doritis pulcherrima</em> x <em>Phalaenopsis</em> Lam Soon</td>
<td>lateral bud of flower stalk</td>
<td>slow</td>
<td>MS+2-4-D</td>
<td>VWN, VWS</td>
<td>Tch</td>
</tr>
<tr>
<td>2. Botanic Gardens serial PDI code 1</td>
<td>unregistered hybrid</td>
<td>lateral bud of flower stalk</td>
<td>slow</td>
<td>MS+24D+BA</td>
<td>VWN, VWS</td>
<td>Tch</td>
</tr>
<tr>
<td>Holttumara</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Cochineal</td>
<td><em>Aranda Hilda</em> Galistan x <em>Renanthera coccinea</em></td>
<td>axillary &amp; auxiliary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, MS</td>
<td>VWM</td>
</tr>
<tr>
<td>Kagawara</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1. Teoline Fair</td>
<td><em>Ascocenda</em> Meda Arnold x <em>Renanthera storiei</em></td>
<td>axillary &amp; auxiliary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, MS</td>
<td>VWM</td>
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<tr>
<td>Mokara</td>
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<tr>
<td>1. Sally Lim</td>
<td><em>Arachnis hookerana</em> x <em>Ascocenda</em> Meda Arnold</td>
<td>axillary</td>
<td>fast</td>
<td>VWN</td>
<td>VWN, VWS, MS</td>
<td>VWM</td>
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<tr>
<td>Oncidium</td>
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<tr>
<td>1. Goldiana</td>
<td><em>Oncidium flexuosum</em> x <em>Oncidium sphaecelatum</em></td>
<td>apical</td>
<td>fast</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>KCBP</td>
</tr>
<tr>
<td>2. Josephine</td>
<td><em>Oncidium haematocchilum</em> x <em>Oncidium lanceanum</em></td>
<td>apical</td>
<td>slow</td>
<td>VWS</td>
<td>VWN, VWS</td>
<td>KCBP</td>
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### TABLE 2. LOCAL ORCHID HYBRIDS SUCCESSFULLY MERICLONED

<table>
<thead>
<tr>
<th>Parentage</th>
<th>Source of meristem explant</th>
<th>Growth rate</th>
<th>Media for initiation (liquid)</th>
<th>Media for multiplication &amp; differentiation</th>
<th>Media for plantlet formation</th>
<th>Remarks</th>
</tr>
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<tbody>
<tr>
<td><strong>Phalaenopsis</strong></td>
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<td></td>
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<tr>
<td>1. Botanic Gardens serial No. 3596</td>
<td>unregistered hybrid</td>
<td>flower stalk</td>
<td>slow</td>
<td>MS+2-4-D +BA</td>
<td>VWN, VWS</td>
<td>Tch</td>
</tr>
<tr>
<td><strong>Renanopsis</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1. Lena Rowold</td>
<td><em>Renanthera storiei</em> x <em>Vandopsis taiwaochileides</em></td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN, MS</td>
<td>VWM</td>
</tr>
<tr>
<td><strong>Vanda</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1. Chia Kay Heng</td>
<td><em>Vanda Josephine</em> van Brero x <em>Vanda</em></td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWN</td>
<td>VWN</td>
<td>VWM</td>
</tr>
<tr>
<td>2. Peepoe ‘Diana’</td>
<td><em>Vanda</em> Cooperi x <em>Vanda teres</em></td>
<td>axillary</td>
<td>slow</td>
<td>VWN</td>
<td>VWN</td>
<td>VWM</td>
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<tr>
<td>3. Norbert Alphonso</td>
<td><em>Vanda Alice Laycock</em> x <em>Vanda Cooperi</em></td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VWM</td>
<td>VWM</td>
<td>VMW</td>
</tr>
<tr>
<td>4. Patricia Low</td>
<td><em>Vanda Josephine</em> van Brero x <em>Vanda Jennie Hashimoto</em></td>
<td>apical &amp; axillary</td>
<td>slow</td>
<td>VMW</td>
<td>VMW</td>
<td>VMW</td>
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<tr>
<td>5. Ruby Prince</td>
<td><em>Vanda Ruby</em> x <em>Vanda Cooperi</em></td>
<td>apical &amp; axillary</td>
<td>fast</td>
<td>VWN</td>
<td>VWN</td>
<td>VWM</td>
</tr>
<tr>
<td>6. Sanada Kuma</td>
<td><em>Vanda B.P. Mok</em> x <em>Vanda Bill Sutton</em></td>
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<td>slow</td>
<td>VWN</td>
<td>VWN, MS</td>
<td>VWM</td>
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<tr>
<td>7. Botanic Gardens serial No. 3102</td>
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<td>VWN</td>
<td>VWN</td>
<td>VWM</td>
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### TABLE 3. NUTRIENT MEDIA COMPOSITIONS FOR TISSUE CULTURE OF LOCAL ORCHIDS

All values in units of milligrammes per litre

<table>
<thead>
<tr>
<th>VWN</th>
<th>VWN</th>
<th>VWS</th>
<th>VWS</th>
<th>VWM</th>
<th>KC</th>
<th>KCS</th>
<th>KCBP</th>
<th>MS</th>
<th>MS+2-4-D+</th>
<th>Tch</th>
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<tr>
<td>(Liquid)</td>
<td>(Solid)</td>
<td>(Liquid)</td>
<td>(Solid)</td>
<td>(Liquid)</td>
<td>(Liquid)</td>
<td>(Solid)</td>
<td>(Solid)</td>
<td>(Solid)</td>
<td>(Liquid)</td>
<td>(Solid)</td>
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<tr>
<td>CaSO₄(PO₄)₂</td>
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<td>200</td>
<td>200</td>
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<td>200</td>
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<td>KH₂PO₄</td>
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<td>250</td>
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<td>250</td>
<td>250</td>
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<td>525</td>
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<td>500</td>
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<td>7.5</td>
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<td>FeSO₄·7H₂O</td>
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<td>27.84</td>
<td>27.84</td>
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<td>37.24</td>
<td>37.24</td>
<td>37.24</td>
<td>37.24</td>
<td>37.24</td>
<td>37.24</td>
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<tr>
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<td>400</td>
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<td>1.0</td>
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<tr>
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<td>0.2</td>
<td>0.2</td>
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<tr>
<td>6-amino-benzyladine</td>
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</table>

**Coconut milk**: 150 ml 150 ml 150 ml 150 ml 75 ml 150 ml 150 ml 150 ml 150 ml

**Active charcoal**: 75 ml

**Tomato juice**: 75 ml

**Banana**: 75000 75000 75000 75000 75000 75000 75000 75000 75000

**Pineapple juice**: 150 150 150 150 150 150 150 150 150


**Agar**: 800-1000 800-1000 800-1000 800-1000 800-1000 800-1000 800-1000 800-1000 800-1000 800-1000

**Distilled water**: 850 ml 850 ml 850 ml 850 ml 850 ml 850 ml 850 ml 850 ml 850 ml 850 ml
ORCHID SPECIES
ORCHID HYBRIDS

Dendrobium Botanic Gardens Serial No. 4879

Dendrobium Cheong Chee Yon

Dendrobium Yong Kok Wah
REFERENCES


A NEW KEY FOR BIOLOGICAL IDENTIFICATION

by

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Trichur, Kerala, India

ABSTRACT

Another biological identification key, the synoptical dial key, has been devised. A description of this key, its operation, and improvements over other keys are discussed.

INTRODUCTION

Biologists are familiar with the various types of identification keys such as dichotomous keys, polyclave punch cards and their various modifications; the commonest tools of systematic biology (Bianchi, 1931; Ceska and Trumppour, 1979; Leenhouts, 1966, 1967; Mayr et al., 1953; Metcalf, 1954; Pankhurst, 1974; Saldanha and Kameswara Rao, 1975; Tomsovic, 1976; Voss, 1952, and others). All these keys are very difficult to handle in the field; also whenever the number of species increases, identification becomes all the more difficult. Aware of these difficulties, the authors have been attempting to develop a key that will serve the purpose of the field biologists. These efforts resulted in the invention of a simple synoptical dial key which is the subject of the present paper.

THE SYNOPTICAL DIAL KEY

The present device is also a modified version of the dichotomous key where all the dichotomies are condensed into a single node. The system has been devised to combination reading between any of the characters in a series of complementary set of characters, as in an n-coordinate device.

The functioning device (Plate I) comprises of a series of concentric discs of increasing diameters made of thick paper. The largest one is pasted to a hardboard disc of equal diameter and all the others are superimposed on it in the order of decreasing diameters. Thus, only a peripheral ring of about one centimeter width of each of the discs and the smallest one completely are exposed. All the discs can be rotated around a central common axis. A narrow sector is marked in each disc and completely darkened for distinction. These sectors are marked $\phi$ (zero, marked as $\phi$ to distinguish from the English letter ‘O’). The discs are numbered I, II, III and so on (to n) in Roman numerals in a centripetal sequence, just on the left of the $\phi$s. Thus, the zeros in the different discs function as a ‘zero-set’.

Different characters of the taxa to be included in the key are studied and categorised into different ‘major characters’, each comprising a set of complementary characters
(Chart I). Each disc is meant for recording the complementary set of characters within a major character. Thus, the number of discs can be increased or reduced according to the number of major characters selected. The exposed peripheral portion of the discs are marked into several divisions as there are complementary characters in each major character plus a few empty divisions. The empty divisions serve to add some more characters if found necessary. All the divisions are indexed by lower case English letters a, b, c, and so on (to z) on the extreme upper right corner of the divisions. The respective complementary set of characters is written in the individual divisions sequentially, in all the different discs, so that each character is indexed by a letter, each letter being distinguished from the same letter of other discs by the disc number. Each division of the discs is also furnished with small outline diagrams of the corresponding characters.

On the back of the disc device is a printed chart (Chart II). The chart includes as many vertical columns as there are discs in the device, corresponding to each major character, arranged in the sequence of the arrangement of discs. The major characters are written on the top of the columns and indexed with corresponding Roman numerals as in the discs. The characters of the different taxa included in the key are coded in terms of alphabetic indices (as given in the discs) and written in the various columns. These codes standing for the various taxa are further arranged in the alphabetic sequence; zero (\(\phi\)) following the last letter in each disc. After the codes starting with a particular letter, space for the inclusion of a few more codes is left blank. The name of the taxa corresponding to the codes are written on the right of the columns. Some distinct characters of the taxa that are not given in the discs are also included in the appended chart, wherever possible, to facilitate confirmation.

The names of the taxa are serially indexed by Arabic numerals. These numerical indices of all the taxa that share a particular character are also repeated in the discs as in Leenhouts’ synoptical key. Such cross indexing is done for all the characters. Whenever a taxon included in the key has some characters peculiar to it only, its numerical index is given in block numerals in the discs. The alphabetic index for that character in the code standing for the taxon is put in squares also.

**PROCEDURE OF IDENTIFICATION**

First zero-set the device and find out any one of the prominent characters of the specimen in question of identity. Locate the character in the discs by determining the major character to which it belongs. If the alphabetic index for that character bears a bold number, the corresponding name can be obtained from the appended chart. If the alphabetic index for the character does not carry a bold number, it is coincided with the zeros (\(\phi\)) of all the other discs. A second prominent character of the specimen is located in another disc; if the alphabetic index for that also does not carry a bold number, coincide it with the alphabetic index of the formerly located character. Go through the number given at the bottom of these characters, and find the ones common to both. This process of location of characters, coinciding, and finding out the common numbers is continued with more characters till all except one are eliminated and the specimen is identified as the taxon bearing the common number in the enumeration chart.

In this key the alphabetic codes given in the enumeration chart are scarcely used. If necessary, the codes can be eliminated from the chart also; but the retention of the codes is advantageous. By coinciding the discs according to the alphabetic code for a given taxon, a skeletal description of the taxon can be obtained. Thus, if ‘Synoptical Dial Keys’ are employed in Floras, descriptions can be minimised further.
A SPECIMEN ILLUSTRATION

An example to illustrate the identification method is given below:

As described above, a ‘dial device’ was prepared (Plate I and Chart II) to identify the seedlings of fifty Asian tree species, mostly using the descriptions in Burger’s (1972) Seedling Flora. The different major characters and their complementary sets within, employed in the key preparation, are given in Chart I. A drawing of the seedling of *Vateria indica* Linn., is given (Plate II). The prominent characters of the seedling are the presence of (1) simple, entire, stipulate leaves with pinnate nerves; (2) basal nodes with whorled phyllotaxy, and (3) the two, thick, anisomorphic cotyledons with similar halves and areolate surfaces.

The procedure of identification begins with zero-setting the device (Plate III Fig. 1). The first character pertains to leaf and is held in the division ‘b’ of disc I. Since this character is shared by a large number of taxa (Plate III Fig. 2 — as there are more than one number in the division) coincide the alphabetic index ‘b’ with zeros of all other discs (Plate III, Fig. 2). The next character pertains to phyllotaxy, and is held in the division ‘b’ of the VIIth disc. Coinside ‘b’ with ‘b’ of the first disc (Plate III, Fig. 3). Since there is more than one cross over number (3 and 5) some more characters are to be taken up for identification. The third character pertains to the cotyledons and is in the division ‘e’ of the IIInd disc. Since ‘e’ bears a bold number ‘3’ the taxon is immediately identified as *Vateria indica* from chart II, the corresponding name for the number. Also by coinciding ‘e’ of the IIInd disc with the formerly selected indices (Plate III, Fig. 4), again we will get a single crossover number 3 and hence the taxon is identified.

ADVANTAGES OF THE PRESENT DEVICE

The present system shares many advantages of both punch cards and Leenhouts’ (1966 and 1967) synoptical key. Preparation of the key is simple with the procedure being the same as for Leenhouts’ synoptical key. Characters or taxa can be added, dropped, combined or split easily without any remake. Incompletely known taxa can be included in the key without any difficulty. To a certain extent, imperfect specimens can also be identified. If the discs are made of thin cellophane or plastic sheets, several such devices can be included in Floras. Since identification gives a skeletal discription of the taxon, use of synoptical dial keys in Floras will help to reduce descriptions further. Unlike Leenhouts’ synoptical key, alignment of the characters is possible here without the interruption of characters in-between. Finally, the most important advantage is that the key, being in one unit, is very convenient to work in the field.

ACKNOWLEDGEMENTS

The authors are thankful to Sri. R. Vasudevan Nair, Government Victoria College, Palghat; Prof. B. K. Nayar, University of Calicut; Dr. P. M. Ganapathy, Director, Kerala Forest Research Institute, for their helpful criticisms and valuable suggestions. We also wish to express our sincere thanks to Sri. P. M. Jacob and Sri. M. Muraleedharan Pillai of the Kerala Engineering Research Institute, for their technical advice.
REFERENCES


The following chart also has relevance to this article: Haflinger, E. and H. Eisenhurt (1975). Circular Key for Identifying the Plant Families With Weeds of Worldwide Importance. Supplement to Weed Tables, Ciba-Geigy; Basle, Switzerland; 1 page chart.
A synoptical dial key prepared for the identification of the seedlings of 50 tree species.
## CHART I

A list of major characters and their complementary sets used in the preparation of the sample Dial-key

### DISC I – FORM OF NRL. LEAVES

<table>
<thead>
<tr>
<th>Character</th>
<th>Complementary Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nrl. Ls. simple, entire, parallel nerved</td>
<td>Nrl. Ls. simple, entire, pinnate nerved</td>
</tr>
<tr>
<td>Nrl. Ls. simple, entire, pinnate nerved</td>
<td>Nrl. Ls. simple, crenate/serrate/dentate</td>
</tr>
<tr>
<td>Nrl. Ls. simple, 2-lobed, palmate nerved</td>
<td>Nrl. Ls. simple, 3-5-lobed, palmate nerved</td>
</tr>
<tr>
<td>Nrl. Ls. simple, 3-5-lobed, palmate nerved</td>
<td>Nrl. Ls. simple, 3-5-lobed, parallel nerved</td>
</tr>
<tr>
<td>Nrl. Ls. palmate comp.</td>
<td>Nrl. Ls. once comp., imparip., entire</td>
</tr>
<tr>
<td>Nrl. Ls. once comp., imparip., entire</td>
<td>Nrl. Ls. once comp., imparip., crenate/dentate/serrate</td>
</tr>
<tr>
<td>Nrl. Ls. once comp., parip., entire</td>
<td>Nrl. Ls. twice comp., imparip., entire</td>
</tr>
<tr>
<td>Nrl. Ls. twice comp., imparip., entire</td>
<td>Nrl. Ls. twice comp., imparip., crenate/dentate/serrate</td>
</tr>
<tr>
<td>Nrl. Ls. twice comp., parip., entire</td>
<td></td>
</tr>
</tbody>
</table>

### DISC II – COTYLEDONS

<table>
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<th>Character</th>
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<td>Cots. absent</td>
<td>Cots. single, terete</td>
</tr>
<tr>
<td>Cots. 4–5, terete</td>
<td>Cots. 7–10, terete</td>
</tr>
<tr>
<td>Cots. 2, thick*, anisomorphic, ½s similar</td>
<td>Cots. 2, thick*, isomorphic, ½s dissimilar</td>
</tr>
<tr>
<td>Cots. 2, thick*, anisomorphic, ½s dissimilar</td>
<td>Cots. 2, thick*, isomorphic, ½s similar</td>
</tr>
<tr>
<td>Cots. 2, thick*, isomorphic, ½s dissimilar</td>
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</tr>
</tbody>
</table>

### DISC III – COTYLEDONARY SHAPE

<table>
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<td>Cots. orbicular</td>
<td>Cots. lalongate, reniform/subreniform</td>
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<tr>
<td>Cots. lalongate, obreniform</td>
<td>Cots. lalongate, obtuse-trapeziform</td>
</tr>
<tr>
<td>Cots. lalongate, obtuse-trapeziform</td>
<td>Cots. lalongate, 3-lobed</td>
</tr>
<tr>
<td>Cots. lalongate, 3-lobed</td>
<td>Cots. lalongate, 5-lobed</td>
</tr>
<tr>
<td>Cots. lalongate, entire, falcate-curved</td>
<td>Cots. lalongate, entire, cordate</td>
</tr>
<tr>
<td>Cots. lalongate, entire, ovate/obovate</td>
<td>Cots. lalongate, entire, obtuse-tetragonal</td>
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### DISC IV – COTYLEDONARY TIPS

<table>
<thead>
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<tbody>
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<td>Cot. tip obtuse</td>
</tr>
<tr>
<td>Cot. tip obtuse</td>
<td>Cot. tip round</td>
</tr>
<tr>
<td>Cot. tip round</td>
<td>Cot. tip emarginate</td>
</tr>
<tr>
<td>Cot. tip emarginate</td>
<td>Cot. tip retuse</td>
</tr>
<tr>
<td>Cot. tip retuse</td>
<td>Cot. tip truncate</td>
</tr>
<tr>
<td>Cot. tip truncate</td>
<td>Cot. tip oblique-truncate</td>
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### DISC V – COTYLEDONARY BASES

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<tbody>
<tr>
<td>Cot. base acute/round-sagitate</td>
<td>Cot. base cordate/round</td>
</tr>
<tr>
<td>Cot. base 1 half hastate</td>
<td>Cot. base 1 half with a denticle</td>
</tr>
<tr>
<td>Cot. base acute</td>
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</table>

### DISC VI – PHYLOLAXY OF NRL. LEAVES

<table>
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<td>Nrl. Ls. whorled</td>
<td>Nrl. Ls. opposite</td>
</tr>
<tr>
<td>Nrl. Ls. opposite</td>
<td>Nrl. Ls. opposite+whorled</td>
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### DISC VII – BASAL LEAVES

<table>
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<th>Complementary Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal Ls. of scales</td>
<td>Basal Ls. foliaceous, whorled</td>
</tr>
</tbody>
</table>

### Thickness more than four millimeters.

Abbreviations: comp. – Compound; Cot. – Cotyledon; Cots. – Cotyledons; imparip. – imparipinnate; Ls. – Leaves; NRL. – /Nrl. – Normal; parip. – paripinnate.
The enumeration chart appended to the sample lias-key (to be printed on the back of the Levice)

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>Name of Plants</th>
<th>Characters not given in the discs</th>
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<tbody>
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<td>i</td>
<td>b</td>
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<td>b</td>
<td>b</td>
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<td>Stem with scale Le.</td>
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<td>b</td>
<td>g</td>
<td>s</td>
<td>a</td>
<td>c</td>
<td>b</td>
<td>b</td>
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</tr>
<tr>
<td>3</td>
<td>b</td>
<td>g</td>
<td>s</td>
<td>a</td>
<td>b</td>
<td>b</td>
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<td>4</td>
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Abbreviations: Cot.: Cotyledons; Le./Le.: Leaves; Irl.: Normal.
Plate II. A sketch of the seedling of *Vateria indica* Linn.
Plate III. Figs. 1–4. Different stages in the procedure of identification of seedlings of *Vateria indica* with the sample synoptical dial key.
CHANGES IN THE FERN FLORA OF GUNONG ULU KALI*

A. G. PIGGOTT


ABSTRACT

Changes in the fern flora of Gunong Ulu Kali, Malaysia, resulting from the development there of a hill resort, are discussed. Fourteen fern species new to the mountain are recorded from near the summit, 5,814 ft (1772 m), and a further thirteen from tall montane forest at about 5,000 ft (1500 m).

INTRODUCTION

The realisation that large areas of the natural vegetation of Gunong Ulu Kali would inevitably be destroyed during development of the Genting Highlands resort was a major reason for recording the fern flora there. A list of species occurring above 5,000 ft (1524 m) was compiled during the four years following the opening of the first hotels (Piggott, 1977). The resort, which provides recreational facilities giving pleasure to thousands of people, continues to expand. The mushroom farm was moved to a larger site on the slopes below Location F and the original site converted into a flower nursery and vegetable garden. Although the buildings remain, the new site has now been abandoned. Colourful gardens now surround the resort buildings. Exotic ornamentals have been introduced, and with them some weeds (Stone et al., 1977). Development of the area has resulted in changes in habitat and, consequently, changes in the composition and distribution of the flora. Pioneer species are common in cleared areas and tangled thickets are covering the exposed edges of the forest. Many of these species were previously present only in small numbers and are now rapidly multiplying. Fourteen species new to G. Ulu Kali have been recorded along the ridge between Locations B and I, and a further thirteen along the 1500 m contour. Specimens have been deposited in the herbaria at Kew (K) and Singapore (SING). Changes in the fern flora of the different habitats occurring on the mountain are discussed in the following paragraphs.

ROADSIDE VERGES AND DRAINS

The road along the ridge had not long been constructed when the fern flora there was first examined. Now the verges and drains have matured and weathered, and in places fallen forest debris and sand have accumulated. Previously only infrequent plants of Christella arida (Don) Holtt., Nephrolepis tuberosa (Bory) Presl, Pteris vittata L. and Sphaerostephanos polycarpus (Bl.) Holtt. were seen. These have now become common. Equisetum debile Roxb., first recorded as a single colony near Location C, is very common on sandy patches and small cleared areas throughout the length of the ridge. This fern ally has recently appeared at Fraser’s Hill and is spreading in similar habitats.

New record for G. Ulu Kali: *Pseudophegopteris rectangulare* (Zoll.) Holtt. at Location E, collections 2627 (K) and 2628 (SING) of 26.10.80.

**GRANITE WALLS**

Walls were necessary at several places along the ridge. The new walls were not a suitable habitat for plant growth and only occasional stunted plants of *P. vittata* and *S. polycarpus* were recorded on them. Now they have weathered a little, and debris has lodged between the granite rocks. More ferns are beginning to grow there. Three species new to the summit, but recorded at lower altitudes on G. Ulu Kali, are:

*Aglaoomorpha heraclea* (Kze) Copel. at Location H, collections 2357 (K) and 2358 (SING) of 29.04.79.

*Drynaria rigidula* (Sw.) Bedd. at Locations B, F and H, collection 2359 (K) of 29.04.79.

*Pyrrosia floccigera* (Bl.) Ching at Location H, collections 2360 (K) and 2361 (SING) of 29.04.79.

**SMALL CLEARINGS AND GENTLE EARTH SLOPES**

The acid peat surface soils and acidic subsoils (Piggott, 1978) were removed from small clearings on the ridge at the time the road was constructed, leaving more neutral, though often shallow, sandy weathered rock. These areas are being covered by carpets of *Crawfurdia trinervis*, with purple berries, and thorny tangles of *Rubus moluccanus*, wild raspberry. Here *Pityrogramma calomelanos* (L.) Link, *Diplazium speciosum* Bl. and *Pteris tripartita* Sw. are frequent. Some plants of *Plagiogyria tuberculata* Copel. have also been found in this rather exposed habitat. *Pteridium aquilinum* (L.) Kuhn var. *wightianum* (Ag.) Tryon grows on the edges of the clearings. *Gleichenia hirta* Bl. var. *amoena* (v.A.v.R.) Holtt. is now quite common on some of the gentle earth slopes. Five species new to G. Ulu Kali were found in this habitat:

*Diplazium esculentum* (Retz.) Sw. at Location H, collections 2354 (K) and 2355 (SING) of 29.04.79.

*Goniophlebium subauriculatum* (Bl.) Presl at Location I, collections 2585 (K) and 2586 (SING) of 27.09.80.

*Hypolepis brooksiae* v.A.v.R. at Location H, collection 2695 (K and SING) of 01.01.81.

*Microlepia speluncae* (L.) Moore var. *hancei* (Prantl) C. Chr. at Location B, collection 2402 (K) of 14.10.79.

*M. strigosa* (Thbg.) Pr. at Location F, collection 2401 (K) of 14.10.79.

Plants matching the unidentified sterile *Microlepia* sp., collections 1175 (K) and 1176 (SING) of 09.11.74, which was under observation but lost during road improvements, have been found in the same vicinity at Location G. A few sori were produced and the species identified as *M. todayensis* Chr., collections 2352 (K) of 29.04.79, 2366 (SING) of 10.05.79 and 2644 (K) of 22.11.80.
LARGE CLEARING AT LOCATION H

Very little plant growth has occurred in this area, mainly due to its frequent use by vehicles and as a camp site. P. a. var. wightianum, Hypolepis beddomei (Kunstler) Nair & Ghosh (former name: H. punctata (Thbg.) Mett.) and some Gleicheniaceae are growing along the outer edges.

ROAD CUTTINGS AND EARTH BANKS

Previously infrequent and often stunted, large plants of Blechnum orientale L. are now not uncommon in this habitat on the ridge. Dicranopteris currantii Copel., D. linearis (Burm.) Underwood var. linearis Holtt. and -D. l. var. montana Holtt. have covered some exposed areas. Dipteris conjugata Reinw. has colonised others, often in association with Sphenomeris chinensis (L.) Maxon var. divaricata (Chr.) Kramer. The deeper vertical road cuttings are not yet much colonised and only a few small plants, some of them fallen epiphytes, have appeared in cracks and erosion gulleys.

MOSSY BANKS ABOVE ROAD CUTTINGS

The mossy peat rootmat of the floor of the dwarf forest has been exposed along the top of earth cuts. Where erosion has occurred it overhangs and is well-drained, supporting colonies of Gleichenia vulcanica Bl., Coryphopteris gymnopoda (Bak.) Holtt. and C. g. var. bintangensis Holtt. The two varieties of C. gymnopoda are present in about equal numbers in this habitat, together with apparently intermediate forms. In shade the plants produce rosettes of fronds, but on exposed rootmats this character is less evident. The fronds appear evenly distributed and assume a drooping habit, although not wilted.

EDGE OF FOREST

Fern growth along the exposed edges of the forest is similar to that occurring in upland areas throughout West Malaysia, and consists mainly of thicket-forming species. Along the ridge these are G. longissima Bl., G. truncata (Willd.) Spr. var. plumaeformis (Presl) Holtt. and Histiopteris incisa (Thbg.) J. Sm. In several places G. vulcanica has also formed delicate miniature thickets. Although trunk growth in Cyatheaceae is slow and few tall tree ferns can yet be seen in this habitat, fronds of Cyathea contaminans (Wall. ex Hook.) Copel. are now penetrating the thickets. At lower altitudes, along the road from Genting Simpah to the hotels, tall tree ferns of this species are common on the edge of the forest. Pyrrosia floccigera was recorded as an epiphyte in an exposed position on the edge of the forest at Location E.

DWARF FOREST

The less accessible areas of the ridge forest are still relatively undisturbed. Where access is fairly easy, the forest has been penetrated by footpaths and camp sites have been cleared. Culverts, constructed when the road was built, have improved the drainage of the highest parts of the forest. The habitat has become drier and many of the small delicate epiphytes are now less abundant. Whereas previously many trees were clothed with Hymenophyllaceae, it is now necessary to hunt for them in the shelter of the remaining wet mossy hollows. Phymatopteris laciniata (Presl)Pic.Ser. (former name: Crypsinus laciniatus (Presl) Holtt.) now appears to be more abundant, often on the higher branches of the trees. Matonia pectinata R. Br. has spread where the dwarf forest has been 'thinned' and become more open. Four small fern epiphytes new to G. Ulu Kali were collected:
Calymmodon gracilis (Fee) Copel. at Location E, collection 2630 (K) of 26.10.80.

Grammitis hirtella (Bl.) Tuyama var. coriacea at Location F, collection 2440 (K) of 21.11.79.

Scleroglossum debile (Kuhn) v.A.v.R. at Locations B and I, collections 2568 (K) of 22.03.80 and 2632 (SING) of 26.10.80.

Trichomanes digitatum Swartz at Location I, collection 2633 (K and SING) of 26.10.80.

ROAD TO WESTERN DAM, LOCATION L

During his visit to Malaysia in 1978, Dr. R. E. Holttum collected specimens of Chingia perrigida (v.A.v.R.) Holtt., growing in fairly open scrub at 5,000 ft (1524 m). Earlier specimens from the same place had been incorrectly named C. pseudoferox Holtt. This is a new record for W. Malaysia.

STEEP SLOPE WITH BOULDERS

The sheltered area southeast of ‘Sri Genting’ had not previously been fully investigated. Here, a little above the 5,000 ft contour, tall forest covers a steep slope. There are piles of large granite boulders, and small, wet, deeply shaded valleys. Many of the tree trunks are mossy. This area is relatively undisturbed except along the line of the cable-car route. A form of P. laciniata, differing in appearance from the same species in other locations on the mountain, was frequent on mossy trees and rocks. The pendent fronds, thin but firm, were glaucous above and very glaucous below. Most fronds were simple or trilobed, and many were fertile. Oleandra pistillaris (Sw.) C. Chr. on mossy boulders exhibited a creeping habit rather than the usual shrubby growth. Filmy ferns were common on mossy trunks and rocks. The following fern species, collected from this location, are new to G. Ulu Kali:

Asplenium affine Sw., collection 2497 (K) of 13.01.80.

Diplazium malaccense Presl, collection 2495 (K) of 13.01.80.

D. subintegrum (Holttt.) Holtt., collections 2424 (K), 2425 (SING), 2427 (K) and 2428 (SING) of 04.11.79.

D. tomentosum (Bl.) Milde, collections 2429 (K) and 2430 (SING) of 04.11.79.

Elaphoglossum callifolium (Bl.) Moore, collection 2500 (K) of 13.01.80.

Hymenophyllum denticulatum Sw., collection 2453 (K) of 02.12.79.

H. polyanthus Swartz, collection 2457 (K) of 02.12.79.

Phymatopteris triloba (Houtt.) Pic. Ser. (former name: Crypsinus trilobus (Houtt.) Copel.), collection 2464 (K) of 02.12.79.

Trichomanes idoneum Morton, collection 2455 (K) of 02.12.79.

T. maximum Bl., collection 2465 (K) of 02.12.79.
T. proliferum Bl., collection 2461 (K) of 02.12.79.

T. saxifragoides Presl, collection 2444 (K) of 02.12.79.

CONCLUSION

The genera Calymmitodon, Grammitis, and Scleroglossum are mostly epiphytes of mossy trees in mountain forest. Some species had already been recorded on G. Ulu Kali. C. gracilis, G. hirtella var. coriacea, and S. debile have been little collected in W. Malaysia but their occurrence in dwarf forest on the ridge could be expected. T. digitatum is not common but has been found on mossy trees at lower altitudes in the mountains and also on mangrove trees in the southern part of the peninsula.

Aglaomorpha heraclea and Pyrospia floccigera are fairly common epiphytes of mountain forest to about 4,000 ft (1,220 m) and have been recorded at that altitude nearby. Drynaria rigidula is widely distributed, but not common, in the northern half of the peninsula. It occurs at Fraser’s Hill, only about 20 miles (32 Km) to the north, and also on the lower southern slopes of G. Ulu Kali. It is not, therefore, unlikely that spores could be carried to these higher altitudes and lodge in positions suitable for successful germination.

Diplazium esculentum is a fern of wet ground in open places in the lowlands. Although the author has recorded this species at Fraser’s Hill and also near the southern end of the Main Range, its occurrence on the ridge was quite unexpected. Microlepia spe lucae var. hancei is again predominantly a lowland fern, but has occasionally been collected in the mountains. Neither M. strigosa nor M. todayensis is common in W. Malaysia, although both occur in a few places in the mountains. Gonioprosbium subauriculatum, Hypolepis brooksiæ, and Pseudophegopteris rectangulare are all species which become common in mountain clearings, such as occur at Cameron Highlands and Fraser’s Hill. Only a single large plant of G. subauriculatum and one small colony of P. rectangulare were recorded, but both were sporing profusely and could be expected to spread.

The twelve species new to G. Ulu Kali collected from tall sheltered forest near ‘Sri Genting’ are not uncommon in W. Malaysia, and have been collected from similar situations elsewhere. But Chingia perrigida is only otherwise known from central and southern Sumatra and Java at 5,000 – 8,500 ft (1500 – 2600 m) (Holttum, 1981).

Many of the fern species found on G. Ulu Kali are common in W. Malaysia, some at a wide range of altitudes, others only in the mountains. Several are confined to high mountains with dwarf forest frequently in cloud. A few species have not been recorded elsewhere in W. Malaysia but probably occur on botanically unexplored mountains, and are known to occur in other countries. The only species which might possibly be endangered is Elaphoglossum robinsonii, known only from G. Ulu Kali and nearby G. Mengkuang; but even this is not in danger of becoming extinct. It is now growing in the Fern House of the Royal Botanic Gardens at Kew, and spores have also been distributed to pteridologists for propagation in other parts of the world.

ACKNOWLEDGEMENT

I must thank Dr. R. E. Holttum for his help in identifying the fern specimens and also for accepting an invitation to visit Genting Highlands. It was a most enjoyable and instructive expedition.
REFERENCES


Plate 1. *Pteridium aquilinum* (L.) Kuhn var. *wightianum* (Ag.) Tyron growing in the crack of a granitic outcrop.

Plate 2. *Christella arida* (Don) Holtt. growing in sand and debris which has accumulated in a roadside drain.

Plate 3. *Equisetum debile* Roxb. on an eroding roadside bank.
Plate 4. *Plagiogyria tuberculata* Copel., *Coryphoteris gymnopoda* (Bak.) Holtt., *Gleichenia vulcanica* Bl., and *Diplazium speciosum* Bl. growing on an exposed earth slope.

Plate 5. *Cyathea contaminans* (Wall. ex Hook.) Copel. penetrating thickets at the edge of the forest, c. 1524 m.

Plate 6. *Gleichenia longissima* Bl., *Matonia pectinata* R. Br., and *Dipteris conjugata* Reinw. (left to right) in a “thinned” dwarf forest.
A NEW SPECIES OF *PANDANUS* (PANDANACEAE) FROM BURMA

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ABSTRACT

*Pandanus burmanicus* sp. nov. is described from the Upper Chindwin District, Burma. It belongs in the Subgenus *Rykia* (DeVr.) Stone, the Section *Rykia*, Subsection *Bidens* (St. John) B. C. Stone. To date it is known only from the type locality.

The species of *Pandanus* in Assam, Burma, and Thailand are still incompletely known. The following new species was collected more than half a century ago and had been determined as *P. furcatus* Roxb., to which it is indeed allied, but it is specifically distinct in its several-celled phalanges, with the carpels arranged in adnate transverse series. The forked styles with adaxial stigmatic surfaces clearly indicate that the species belongs in Subg. *Rykia* (DeVr.) Stone, Sect. *Rykia*. Among the species of this group it appears to find a place near *P. piniformis* Hollt. & St. John, which till now has constituted the sole member of St. John’s Sect. *Bidens*, which I regard as a subsection of Sect. *Rykia*. The character of this subsection is that the phalanges are several-celled. Whether this is an artificial character of convenience remains to be seen.

*Pandanus burmanicus* B. C. Stone sp. nov. (Figures 1, 2).

*Arbor habitu* *P. furcato*. *Folia* ad 248 cm longae, 6.8 cm latae, lineari-ensiformia apicem versus sensim attenuato-acuminata, marginibus antrorse denticulatis, costa dorso distaliter antrorse denticulato; marginibus in basi dentibus 2–3 mm longis, 4–10 mm sese separatis; in medio, dentibus acicularibus 1 mm longis valde antrorsis 7–12 mm sese separatis; in apice dentibus vix 0.5 mm longis, 1.5–3 mm sese separatis; nervis longitudinalibus c. 120 per foliam; nervis transversis inconspicuis; basis vaginantibus cupreobrunneis. Inflorescentia foeminea terminalis, solitaria. Fructus c. 20.5 cm longis, 15 cm diametro (48 cm circumferentio), e phalangibus compositus. Carpidia in phalangis transverse-seriatim adnata; phalangibus 3–4-carpidiatis; cuneatis, compressis, c. 45 mm longis, ad 30 mm latis, c. 10–11 mm crassis; pileo delapso intacto 3–4-stylophoro; stylis antrorse deflectis c. 7 mm longis et 4–5 mm latis, brunneis, nitidis, oblique actuis vel furcatis, stigmata infra stylus posita sursum spectantia. Mesocarpium apicalium fibroso-medullosum; basaliwm fibrosum. *Endocarpium* 3–4-loculatum c. 24 mm longum ferrugineum osseum. Cetera ignota.

Type: BURMA: Upper Chindwin District, Kodan stream near Kyoktha Village, 600–1500 ft. alt., 30 November 1917, C. G. Rogers 1033 (Holotype in Dehra Dun Herbarium). Vernacular name: “sathwa”.

The collector notes that this is “the common screwpine of the forests in the Kodan chaung.”
Fig. 1 — *Pandanus burmanicus* Stone. (From holotype). Leaf apex; short segment from near leaf apex; segment from lower third of leaf. Phalange in side, top, and longisection views. Side view shows distal adaxial face.
Fig. 2 – *Pandanus burmanicus* Stone. (From holotype). At left, the holotype specimen. At right, close up view of three phalanges. Note that the pileus detaches with the styles intact.
ORTHORRHYNCHIUM ELEGANS (Hook. f. et Wils.) Reichdt.
(PHYLLOGONIACEAE), NEW RECORD FOR THE PHILLIPINE MOSS FLORA

by

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ABSTRACT

Orthorrhynchium elegans is reported for the first time from the Philippine archipelago. Some noteworthy morphological features are also reported.

A recent study of many undetermined moss collections made by Prof. J. V. Pancho of the University of the Philippines from 1960–70 and deposited at the University herbarium (CAHP) yielded many new records for the local flora. Among which Orthorrhynchium elegans (Hook. f. et Wils.) Reichdt., previously known only from Australia and New Zealand, is of phytogeographical significance, and is, therefore, reported here separately together with some new morphological information.

The collection (Pancho 3915B, July 23, 1965) came from the vicinity of Mt. Apo on Mindanao Island, the second largest island of the country which is situated north of Borneo. The packet contains abundant sterile plants that show the characteristic coplanate and distichous arrangement of the conduplicate leaves as described by Sainsbury (1955) and Wijk (1957) (Figs. 1 & 2). The leaf apices are blunt (Fig. 3). This feature can be used to distinguish the taxon from the morphologically similar Horikawaiæa phyllogonioidæ (Sull.) Nog. which has abruptly acute and slightly recurved leaf apices. The latter was listed in Bartram (1939) as Orthorrhynchium phyllogonioides (Sull.) E. G. Britton.

Wijk (1957) was the first one to point out the important difference between O. phyllogonioides and O. elegans in terms of their phyllotaxy. He reported, in addition, the identification confusion which existed among the many herbarium collections of the two taxa which he had examined and concluded that O. phyllogonioides be best included in the genus Neckera in the family Neckeraceae. Noguchi (1961), on the other hand, contended that the taxon be placed in Horikawaiæa, a new genus which he had proposed in 1937 for the family Phyllogoniaceae, after fully stressing the salient morphological differences between O. phyllogonioides and species of Neckera.

I have been fortunate to have had the opportunity to study the isotypes of Neckera phyllogonioides Sull. and Orthorrhynchium philippinense C. Muell., and also a Bartlett collection (15935a) named O. phyllogonioides by E. B. Bartram. All collections mentioned here are from the Philippines and are part of Bartram’s Herbarium at the Farlow Herbarium. I fully agree with Bartram (1939) in uniting the taxa in question under the single species epithet, O. phyllogonioides. Nevertheless, this species, as suggested by Noguchi (1961), is best placed in Horikawaiæa. The justification has already been convincingly outlined by Noguchi (1961) and will not be repeated here.

A more recent collection (Alvarez 0-80553) of O. elegans at CAHP, which originated from the same general locality of Mt. Apo, contains some fertile specimens. Three mature capsules with pilose, mitriform calyptra were available for detailed examination. The
peristome teeth, lacking the endostome, are only rarely perforated along the median line. The dorsal (or outer) surface of the exostome clearly shows the diplolepideous nature (Fig. 13). The ventral (or inner) surface develops irregular longitudinal (vertical columns) and horizontal thickenings (trabeclae) (Fig. 12) resulting in the formation of a series of thin-walled areas which may look like perforations under the light microscope. The apices of the teeth are slender and of uniform thickness and are often broken. It will be interesting to reexamine the peristome of *O. elegans* under the scanning electron microscope in order to determine the cell patterns as seen in the light of the recent report of Edwards (1979) on haplolepideous peristomes.

This peculiar pattern of cell wall thickening of the primary peristomial layer (cf. Edwards, 1979) in *O. elegans* is not known from any Philippine Neckeraeous taxa. Instead, a similar condition can be observed in the peristome of a few species of *Oedicularium* Mitt., *Palisadula* Toyama, and other genera of the family Pterobryaceae (cf. Iwatsuki, 1979).

The stem of *O. elegans* has been observed to consist of more or less uniform cells without a differentiated strand (Fig. 6). Pseudoparaphyllia appear late in the development of buds. When present, both filamentous and foliose types are seen. Interestingly, the Philippine plants bear abundant filamentous gemmae on the stem and leaf apices, a feature not mentioned in Sainsbury (1955) for the New Zealand population. These asexual propagules are septate and strongly papillose (Figs. 15 & 16), resembling the rhizoids which are always larger in size.

Dwarf male plants (Fig. 9) are discovered for the first time in *O. elegans*. Plants consisting of profusely branched protonema with a few leaves were found growing inside the folds of the conduplicate leaves of the female plants. Like the perichaetial leaves, perigonal leaves are not conduplicate and their leaf margins are irregularly laciniate to serrulate in the upper half (Figs. 9 & 10).

The spores (Fig. 14) are papillose and are of two sizes: the larger ones ranging between 32.5 µ - 40 µ (with a few becoming elongate and bean-shaped), and the smaller ones less than 20 µ in diameter. Whether or not there is a correlation between the spore sizes (anisospory) and sexual dimorphism (cf. Ramsay, 1979) is not known at present.

The distribution of *O. elegans* was mapped by Noguchi (1961) to be confined to Australia and New Zealand. Its discovery in the Philippines is a significant extension of its range while its presence in New Guinea is highly possible. I have seen several collections of *Orthorrhynchium* from the Christmas Islands, Papua New Guinea, and elsewhere in the Malesian region deposited at the University of Michigan (MICH), Singapore Botanic Gardens (SING), and other herbaria. All of them are *Horikawaea phyllogonioides*.

*O. elegans*, together with *Dawsonia superba* Grev., are two noteworthy Austro-New Guinean elements in the local moss flora.

**ACKNOWLEDGEMENTS**

I am much indebted to the curators of the following herbaria for the loan of specimens: MICH, SING, FH, and MONASH. Also, to Dr. H. Bishler (PC) and Dr. W. B. Schofield for the procurement of rare literature. Lastly, to the University of the Philippines at Los Baños for the financial aid in my research. The illustrations were prepared by Mr. Ver Aguila.
REFERENCES


1. habit sketch,
2. frond or secondary branch (arrow pointing at perichaetial bud),
3. leaf apex,
4. laminal cells,
5. leaf base,
6. cross-section of stem,
7–8. leaves,
9. male plant,
10. perichaetium,
11. exothecial cells,
12. peristome tooth, ventral view,
13. peristome tooth, dorsal view,
14. spores,
15–16. gemmae.
Tan: *Orthorrhynchium elegans*
BOTANICAL NOTE

J. F. MAXWELL

Botanic Gardens, Singapore

How to Cite the Name of Miss Joaquim’s Orchid

The national flower of Singapore, Vanda Miss Joaquim, was officially announced as such by the Minister of Culture on 16 April 1981. This hybrid, the first cultivated orchid hybrid recorded for Singapore, was selected from many other contenders because of its historical significance for Singapore plus the fact that it is easily grown, and well-known. This hybrid also stimulated the development of the presently thriving orchid industry in SE Asia and has been one of the favourites of orchid enthusiasts for decades.

Along with the development of the orchid industry and the development of many new hybrids, there has been an increasing amount of confusion concerning the technical details on how to properly cite these new creations.

Plant Names

In addition to common names, which are often variable and inconsistent, there are two more official and internationally recognized kinds of plant names viz. scientific or botanical names and the names of cultivated plants. It is generally understood that the scientific name of a plant consists of two Latin or Latinized words viz. a generic name and a specific epithet, in addition to the author’s name (or names). For example, the scientific name of the para rubber tree is Hevea brasiliensis (Willd. ex A. Juss.) M.-A. Hevea (derived from the Brazilian name for these trees) is the generic name, brasiliensis (from Brazil), the specific epithet, and M.-A. is an abbreviation of the name of the botanist (author) who placed this species under Hevea (Jean Mueller of Aargau, a 19th century botanist). In addition to this, varieties and other subspecific taxa are also frequently used to delimit variation within a species, for example Paphiopedilum stonei (Hk. f.) Pfitz. var. platytaenium Rchb. f.

The names of cultivated plants are slightly different since many of them have artificial origins or cannot technically be considered as true species or varieties. Miss Joaquim’s orchid can be used here as an example on nomenclatural propriety for cultivated plants. It has been suggested that this orchid is probably a natural hybrid (Yeoh, 1963) first occurring in Miss Agnes Joaquim’s garden in Singapore in the latter years of the 19th century. In her garden two Vanda species, Vanda hookerana Rchb. f. (from Kinta Valley in the northern part of W. Malaysia) and Vanda teres Lindl. (from Burma) were planted and to this day it is not clear which one was the pod (female) parent. Botanically this orchid is known as an interspecific hybrid as there are two different parent species involved. The term grex (plural: grexes) is also used for such hybrids. In order to indicate the parentage of such an interspecific hybrid or grex it is customary to cite both parents’ names, but place the pod plant’s name first and to connect these two names with an “x”, e.g. Arachnis flos-aeris x A. hookerana. Generally there are two ways to name such a hybrid plant. The first is to give a new specific epithet in Latin proceedeed by an “x”, e.g. Tilia x vulgaris, a hybrid of two linden tree species viz. Tilia cordata Mill. and T. platyphylla Scop. The second, by far the more conventional way, is to give a common name, not a Latin one, to hybrid plants, e.g. Arachnis Maggie Oei, Oncidium Goldiana, etc.
H. N. Ridley (1893), then Director of the Singapore Botanic Gardens, reported and described Miss Joaquim's orchid in the Gardeners' Chronicle and named it as *Vanda Miss Joaquim*. To conform with the examples given by Brickell (1980) and Withner (1980) this hybrid should be written as *Vanda* (italicised or underlined when written or typed) Miss Joaquim (normal lettering).

Interspecific hybrids (grexes), such as *Vanda* Miss Joaquim, should technically be written as *Vanda* (Miss Joaquim g.), however the extra details of the parenthesis and "g." (grea) are usually omitted by horticulturists for simplicity. The author's name of these hybrids, in this case Mr. Ridley's, is always omitted.

The names of variant plants derived from a single individual, i.e. clones (cultivars) are written inside a pair of simple quotation marks, e.g. *Cattleya* Bow Bells 'Singapura' or by placing cv. (cultivar) before the name of the cultivar, e.g. *Phalaenopsis* Samba cv. Mamamia. The cultivar name, as with the name of the hybrid, is not underlined or printed in italics.

The following examples, in addition to those noted above, illustrate the proper manner in which various orchids should be written:

1. *Vanda hookerana* Rchb. f. (a species with author citation),
2. *Phalaenopsis amboinensis* J. J. S. 'Simanis' (cultivar of a species, the author citation of the species is often omitted by horticulturists), and
3. *Aranda* How Yee Peng 'Ada' (a cultivar of an intergeneric hybrid under a collective generic name, technically written as *X Aranda*).

**Legitimate Names**

Species and varieties of orchids and other plants must be published with a Latin description in order to be botanically acceptable (legitimate). Hybrids and cultivars are also affected by the rules of botanical nomenclature since each hybrid or cultivar can have only one correct (legitimate) name (Gilmour, Greatwood, and Hunt; 1976 and Brickell et al., 1980). Orchids, however, have received special attention from botanists and horticulturists, thus the rules concerning these plants differ somewhat from those regarding others, e.g. other ornamentals, crop plants, fruit trees, etc. (Gilmour, Greatwood, and Hunt; 1976). Orchid hybrids and cultivars, for botanical and legal purposes, must have either published descriptions or approved registrations so that the names are legitimate.

The naming of hybrids and cultivars is sometimes also a legal process since these names are essentially trademarks and are often commercially valuable. The owners or registrants of these names must, therefore, properly register or publish descriptions of these hybrids or cultivars to attain botanical as well as legal recognition of these plants. The names of orchid hybrids and cultivars are, with a few exceptions, based on publication or registration priority; that is, the first valid publication or registration of a legitimate name has priority over all other names of the same hybrid or cultivar. Hybrid names proposed prior to 1 January 1967 are based on the earliest date of publication or registration, while after this date they are based on registration only. Cultivar names are based on publication priority only, that is, registration does not provide for botanical or legal legitimacy. Unfortunately, due to the enormous numbers of orchid cultivars produced, registration of all cultivars is impossible. Several schemes have been proposed to deal with this problem, however no satisfactory solution has been formulated and agreed on by the World Orchid Commission. It must be noted that
exceptions to these rules of priority can only be considered and resolved by the Royal Horticultural Society, London which is the International Registration Authority for Orchid Hybrids. The details of publication and registration are given by Gilmor, Greatwood, and Hunt (1976) and Brickell et al. (1980).

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I would like to thank Prof. Hsuan Keng of the National University of Singapore for providing me with an initial memorandum on this topic and to Mr. Hugh Tan for his technical assistance.

REFERENCES


BOOK REVIEW

by

J. F. MAXWELL

Botanic Gardens, Singapore


This handy book, intended for rubber tree planters, satisfies the need for an identification manual of grass weeds in rubber estates of West Malaysia. Since many modern herbicides are selective preparations intended to eradicate certain species of grasses, it is imperative that these grasses be correctly identified so that the appropriate chemicals be used for the most effective grass control treatment.

Wycherley and Ahmad Azli include 64 species of grasses which, throughout the years, have been found to be noxious and otherwise detrimental to the growth of rubber trees. Far from just being a picture guide, the authors include brief and succinct accounts on the habit and morphology, and ecology of grasses as well as notes on the detrimental or damaging effects of specific species of grasses in rubber plantations. Rubber planters will find these notes as important and interesting as the detailed line drawings of each species. The status of grasses as cover plants and grasses as intercrops are also discussed with complete literature citations for those who care to investigate these sections more thoroughly.

The key to grasses is, by virtue of the inherent complexities of grass morphology and taxonomy, somewhat technical; however all the botanical terms used are illustrated in the beginning of the book and defined in a glossary at the end. Perhaps in an effort to avoid various complications in the use of the key, most leads in the key have more than the usual two couplets. Fortunately, the key refers to more vegetative and structural details of the inflorescences than to the minute and difficult morphological aspects of the spikelets; however a thorough knowledge of all these features must be realized before the key can be used. Since this book is intended mainly for agriculturists, most of whom have limited botanical training, the inclusion of the common names of these species should have been included.

Aside from being the best manual of its kind for rubber planters, this book will also be useful for other agriculturists in oil palm estates, fruit orchards, livestock ranches, farms, etc. as well as students and naturalists. This book is, therefore, highly recommended for all libraries dealing with natural science, agriculture, and for anyone interested in gaining a basic understanding of some of the more ubiquitous grass species found from southern Thailand to Singapore.
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HORTICULTURAL NOTES ON THE ANGSANA
(PTEROCARPUS INDICUS Willd.)

WONG YEW KWAN*
Parks & Recreation Department, Singapore

ABSTRACT

Pterocarpus indicus, a species of Leguminosae and highly adaptable in a variety of habitats, is extensively planted as a shade and ornamental tree in Singapore. Propagation is commonly by woody cuttings and trees of considerable size can be transplanted successfully. Growth rates under mesic habitat conditions are fast. Transplanted stumps of 3.7 m height and 60 cm girth breast height can achieve a height increment of 1.66 m and a girth increment of 14 cm per annum.

General requirements, pest and disease association, phenology, horticultural use of the species, and transplanting technique for large rooted stumps are described.

INTRODUCTION

Pterocarpus is a large genus of trees of the family Leguminosae with distribution throughout the tropics. The Angsana is indigenous to Peninsular Malaysia. Its natural habitat is said to be on the banks of coastal creeks and rocky shores, but it is not certain whether it occurred in Singapore (Corner, 1952). Pterocarpus indicus is extensively cultivated in the Indo-Pacific region as an ornamental tree and for its shade. It has massive limbs, both ascending and spreading, which produce slender, drooping branches. Crowns of trees of various sizes which have not been subjected to pruning or pollarding for some time assume a rounded appearance. Full-sized trees in Singapore measure 25 to 30 m tall with a crown-spread of almost equal dimension and a girth at breast height of 5 – 5.5 m (Fig. 1). There are, however, larger specimens growing in Penang with girths exceeding 6 m. In Singapore there are some old trees along the highways and adorning institutional grounds, but in the past 14 years a vast number of the species has been planted in a great variety of settings, so much so that many young trees are now dominating many local scenes (Figs. 2–5). Its popularity lies in its ease of propagation, fast growth rate, ease of management and, above all, it lends itself to transplanting as a fairly large tree with a high degree of success. Such transplants have been referred to as “instant” trees because branches develop soon after transplanting and within a matter of a few months fair-sized trees obtained.

PROPAGATION

Angsanas can be propagated from seed, however, in view of the ease of propagation by woody cuttings in Singapore, propagation by seed is seldom, if at all, practised. Cuttings of various sizes can be used. The Parks & Recreation Department has planted cuttings of 3 m length, with a lower-end diameter measuring some 10 cm, directly into planting sites with some degree of success. More commonly smaller cuttings are used for rooting.

* At the time of printing, the author had resigned.
* Angsana or Sena, as this species is also known in Malay, is also naturally found in India, SE. Asia, Philippines, Sumatra, and Java.
in the nursery before field planting. A suitable cutting is one with a 1.5 m length and 4 to 5 cm diameter at the lower end. The cutting is inserted about 20 cm deep in a soil mixture contained in a polybag 30 x 30 cm. The cutting can be in the form of a straight stake or be treated so that the top end has a few branches. Treatment with a fungicide will ensure greater success — which may be as high as 90%. Such a cutting will flush within 2–4 weeks and be well rooted within 3 months. Cuttings of the size described can also be planted unrooted directly into the field, but the maintenance of such plants (e.g. watering and pest control) spread over a large area is of course more problematic and the percentage of success will be lower.

For the production of “instant” trees, many of the rooted cuttings are planted out in road verges and roadside open spaces. In such areas planting is done at a higher density than required by mature trees so that after a period of growth (about 2 to 3 years) the grove is progressively thinned for transplanting to places where the landscape requires an instant effect for visual impact or for shade.

FIELD PLANTING AND TRANSPLANTING

Small Rooted Cuttings

If propagation is through woody cuttings planted in polybags in the nursery, the rooted cuttings can be transplanted into the field when they are about 3 to 6 months old. A cutting of this age will have produced a bunch of short slender branches at the top end measuring about a metre long. Care should be taken not to break these branches while the plants are being handled for transplanting. For cuttings of the size described it is normal to plant them out in machine-dug holes of 1 m³. The planting technique is similar to planting out a sapling grown in polybags. In Singapore it is essential to provide a good loamy top soil for the planting holes because not only is the in situ soil clayey, but in many a planting situation cut and fill operations could have either reduced the planting site to the parent materials or given rise to filled areas consisting of compacted sub-soil or stiff clay.

“Instant” Trees

Angsanas lend themselves to transplanting as large trees fairly easily and the survival rate is usually as high as 90% provided the trees to be transplanted are not too large. In the earlier days of the Garden City Campaign, trees with girths as large as 100 cm (measured 1 m above ground level) were transplanted. It was, however, observed that such large transplants would not grow well. It is now, therefore, the practice to transplant trees with girths of not more than 60 cm.

The transplanting of such trees needs a small crane mounted on a truck, simply because of their weight and size. A tree of 60 cm girth is, in fact, already 7 m tall. The branches are first lopped off so that the resultant stump with the various snags is about 4.5 m high. The stump should have 3 to 4 main snags for proper crown development. All slender twigs and branches below the pollarded ends or the main branches are removed. The cut surfaces of the pollarded branches are painted with a wound dressing so as to prevent dessication and extensive rotting. This is of particular importance for the Angsana because it has the habit of producing new branches almost flush with the cut surface of the snag or just below it. If rotting occurs, proper callousing may not be achieved and a developing branch will snap easily at the point of union during a storm.

After the tree has been prepared as described above, the next step is to excavate around
Fig 1. Full grown Angsanas near Anderson Bridge. The age of these trees is likely to be about 100 years. They are the remnants of a row destroyed by a disease in 1926. Their present height is approximately 27m. with a girth at breast height of 4.57m.

Fig 2. Year old transplants of Angsana at Ang Mo Kio Town Centre. Note the feathery appearance of young, mostly ascending, branches at this stage of growth.
Fig 3. Angsanas lining a part of Orchard Mall. These transplants were 4 years old when the photo was taken. Note the fully developed and rounded crowns with drooping branches.

Fig 4. The Margin of the swimming Lagoon at East Coast Park lined with transplants 5 years old.
On Angsanas (*Pterocarpus indicus*)

Fig. 5. Six-year old Angsana transplants providing shade to the cycle and jogging tracks at East Coast Park.

The tree base to create a proper ball of earth for eventual lifting. A trench of about 60 cm depth is first dug around the tree base at a distance of about 50 cm from the base of the stump. More earth is removed by undermining towards the trunk so that the ball of earth is shaped like an inverted dome with the original soil surface on top. The ball of earth is wrapped with gunny sacks or some other suitable material so as to prevent the earth from breaking up when the tree is lifted. A chain and choke arrangement attached to a winch with power take-off from the lorry is used to sever the ball of earth from the ground before the tree is lifted by the crane onto the lorry for transportation to the planting site (Fig. 6).

Trenching can be done mechanically, although the shaping of the ball of earth and wrapping it have to be done manually.

What is described has been the practice in Singapore up to now and this careful treatment has ensured a high degree of success in transplanting. In the face of labour shortage
we have tried out some of the transplanting machines available today. The preliminary trials showed that such machines do not give an intact ball of earth because the grabbing and uplifting actions tend to loosen the earth too much, especially when the soil is loamy, thus leading to root disturbance and greater transplanting shock, particularly in our hot tropical climate in which evapo-transpiration is high. The Parks & Recreation Department is using more clayey soil for growing future transplants and for species such as the Angsana which has a high regrowth potential, there is a chance that transplanting can be done mechanically.

Theoretically in the transplanting of "instant" trees one should ensure as large a ball of earth as possible so as to preserve a large number of undisturbed roots and rootlets. This will lessen transplanting shock. On the other hand, this will also increase handling costs especially when trenching is done manually. Angsana has been found to be a very rugged species which can withstand rough handling. In recent months transplants of 50 cm girths which were lifted with a ball of earth as small as 30 cm radius and 50 cm depth were found to survive well. Further, it has been found that when the ball of earth is very clayey no wrapping is needed and so long as the ball is not disintegrated the stump can still survive.

The hole earmarked to receive the transplant can be 1.5 m square by a metre deep. Enough top soil should be filled in so that it forms a flat-topped mound about 20 cm or so above the original soil surface. It has been found that in transplanting "instant" trees it is best to avoid putting sludge in the planting hole for this has been found to cause higher mortality. One reason may be that the organic matter encourages greater moisture retention leading to fungal infestation of the injured root system of the transplant.

The ball of earth of the transplant is placed so that the original surface is flush with the flat-topped mound. Allowing for settling, the surface of the original ball of earth will be flush with the surrounding land surface in due course. In places where there is a tendency to water-logging a slightly higher mound can be used. One should avoid deep planting which will result in poor plant growth even if the transplant were to survive. For such large transplants there is no necessity to stake, but in areas such as car parks there is a need to provide tree guards to prevent the transplants from being knocked down by cars.

Sometimes during preparation for transplanting, the bark of the stem or snags might be damaged. Should this happen one should use a wood preservative to paint over the injury to prevent rotting. Unless damage is extensive callous formation will soon grow over the wound.

**Spacing**

If final spacing is considered then the Angsana should be given 25 m between trees. However, a planting scheme along roadsides with such spacing will give rise to a rather sparse appearance and will not have a green impact for a long time. It is normal, therefore, for us to plant trees about 12 m apart so that if need be such trees can later be progressively thinned for use elsewhere.
**GROWTH**

**Crown Development**

For transplants as "instant" trees, sprouting from near the pollarded tips of the snags takes place within 2 weeks, although this can be as late as 1 month from the date of transplanting. It has also been observed that the early sprouts may suddenly die back, especially during drought, only to be followed by the emergence of fresh shoots which will eventually develop into the main branches of the tree.

The young branches tend to cluster around the pollarded tip. A few, however, may develop a little further down. Unlike the Yellow Flame (*Peltophorum pterocarpum* (DC.) Back.) epicormic shoots are uncommon under normal conditions of growth after transplanting. Within 3 months there can be as many as 10 young branches per snag (pollarded

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Fig. 6. Transplanting a large rooted stump. The pollarded stump with its ball of earth is positioned by the crane to go into the planting hole. Since the ball of earth has clayey soil, it has not been wrapped.
branch) which measure about 1.5 m length and assume a feathery appearance. After a year, the lower of these branches spread out while the upper ones become the ascending limbs which increase rapidly in girth and length. Each of these 'primary' branches gives rise to many subsidiary branches, many of which are slender and drooping. After two years a well-formed crown develops. After 4 years, if no subsequent pruning is done, a rounded crown is achieved. Crown density, however, varies from tree to tree, depending on the original number of snags of the transplanted stump and the subsequent shoots which develop therefrom.

Growth of large woody cuttings or rooted cuttings planted out in the field assumes a similar pattern, but because of the smaller initial stature of such plants, growth in size and crown proliferation will understandably be slower.

**Bole Development**

It has been observed that the original stump does not grow in height after transplanting. Height is contributed by the numerous new branches which develop from the snags of the original stump. The bole, however, increases in girth. At the time of transplanting the bole of a stump of the usual girth size (60 cm) is rounded in cross section but as the bole increases in size, it becomes fluted. The fluting is increasingly pronounced with greater girth size, with the ridges developing into short buttresses at ground level.

The girth measurements presented below have been taken over the fluted boles.

**Height & Girth Increments**

Quantitative data are not available on height and girth increments of the Angsana because there was no systematic inventory to study growth. However, some figures of growth based on estimates and measurements of a few trees planted in the past 10 years are given here as an indication.

Three trees along Maxwell Road immediately next to the Maxwell Market planted in 1970 have an average girth of 2.15 m, measured 1.5 m above ground level, and a total height of about 17 m. At the time of planting the average girth was about 60 cm and the stump height was about 3.7 m. This means the trees have put on over 11 years an average height increase of 13.3 m and a girth increment of 1.55 m or an equivalent of 1.2 m height, and 14 cm girth growth per annum. These trees now have a crown spread of 12 to 18 m.

Another group of 6 trees growing along Maxwell Road in front of the Tamil School and planted in 1973 have an average girth of 1.63 m, measured 1.5 m above ground and an average height also of 17 m. The other parameters are the same as for the trees mentioned in the preceding paragraph. Calculating in the same way a girth increment of 12.9 cm and a height increment of 1.66 m per annum.

It will be noted that the trees in front of the Tamil School have faster height growth, but slightly smaller girth increments. This could be due to the fact that the spacing of the 2 groups of trees are different since those by the side of the market are spaced 18 m apart while those in front of the school are spaced 12 m apart. The closer spacing in the latter group has caused crown competition to push the trees skywards, while the girth increment is retarded.
On Angsana (Pterocarpus indicus)

Given the right root environment the Angsana grows well and fast, but is sensitive to root-bound conditions. This is shown by the trees growing along the centre divider of Paya Lebar Road. Angsanas stumps of similar sizes were planted there in 1974. Somehow at the time of planting several layers of the old road surfaces were not broken through. In effect, the trees were standing on a concrete surface 1 m below the present road surface and as a result all the trees stagnated. Although they are now 7 years old their average girth is only 0.9 m (0.6 m at the time of planting) or the girth increment was only 4.3 cm per annum compared with the more rapid growth of 14 cm and 12.9 cm girth per annum of the trees mentioned earlier.

Another example of stunted growth is seen in the concourse of the National Development Building where bed rock is near the soil surface and where lateral root spread is further restricted by the concrete surface. Two Angsanas planted there in 1970 have hardly grown, but nevertheless are still alive.

**GROWTH REQUIREMENTS**

**Habitat**

The habitats of the Angsana along the East Coast of Peninsular Malaysia are said to be riparian along coastal tidal creeks (Corner, 1952). In Singapore it is one of the most adaptable tree species and is able to grow well in a wide range of habitats and soil conditions. It grows on flat sandy areas near the coast as well as in hilly areas with stiff clay. It is also able to withstand a considerable degree of water-logging as evidenced by its fair performance at the East Coast Park which has reclaimed land with extremely compacted soil. The compaction and the flat topography of the Park cause poor percolation and surface run-off. As a result the planting holes into which loamy top soil has been filled became sumps for rain water. Many other species have failed to establish under such conditions, but the Angsana is able to grow. It is, however, expected that growth will not be as good as that achievable by the individuals under more mesic conditions.

The Angsana is a light demander and is, therefore, not suited for underplanting in an existing grove of trees. Left to compete amongst themselves, Angsana trees can be planted close together or in groves to form good screens or other ornamental features.

**Nutrients**

Little is known about the exact nutrient requirements of ornamental trees. Our manurial programme is, therefore, a tentative one until more reliable data can be obtained at a later date. One approach is to study the annual litter fall of trees of different ages to gauge the amount of nutrient loss through this factor. In an urban environment it can be assumed that all litter is swept away and the manurial programme should aim at replacing this amount of loss. Further refinement can be achieved through a more quantitative estimate of the stem and branch growth.

The Department has just begun to establish leaf traps in different places to measure annual litter fall for Angsana. Perhaps after a year or so some information can be obtained. Meanwhile, the practice is to apply $\frac{1}{2}$ kg, 1 kg, 1.5 kg of a compound fertilizer to transplants respectively in the 1st, 2nd and 3rd year of growth. Thereafter, application is based on the visual conditions of the trees and the manurial rates can vary between 3-10 kg per annum depending on the size of the trees.
In parks and gardens the fertilizers are broadcast evenly over the soil surface under the tree crown but in roadside situations with concrete sidewalks, the manure is applied in the grooves between concrete slabs or in the holes in the slabs. In such concrete areas it is usually difficult to apply the full rate for a tree of a particular size because of the limited unsealed area of the tree base. The annual rate is, therefore, given in two or more applications.

PESTS & DISEASES

In urban sidewalks, small urban parks, and open spaces the Angsana is particularly free from pests and diseases. When planted in large parks or in areas bordering natural vegetation, foliar damage by pests, mostly grasshoppers (Valanga) and night flying beetles (Apogonia, Adoretus, and Anomala), is not uncommon. Occasionally the young leaves can also be damaged by leaf miners.

As the trees grow fast and new flushes are produced continually it is seldom the practice to control pest damage. If, however, young trees produced by short cuttings are badly damaged, an organophosphate such as "Dipterex" can be used for a weekly spray. More persistent pests can be tackled with "Basudin".

The Angsanas planted along Mandai Road and those growing in the Zoological Gardens, both localities being surrounded by forests, suffer from a kind of leaf blight—the fungus of which has been identified as a species of Gleosporium. Phenologically the Angsana does shed its leaves occasionally but seldom with the crown completely bare. The trees planted along Mandai Road, however, undergo a cyclical rhythm with the crown completely defoliated by the leaf blight followed by luxuriant new flushes. As the leaves get older, they are afflicted by the same malady and the cycle is repeated. The association of the disease with proximity to the forest is due perhaps to the higher relative humidity associated with such a habitat which favours fungal growth.

Angsana trees in Singapore and Peninsular Malaysia suffered extensive mortality from 1875 to 1925. Trees 10 to 40 years old died progressively and sometimes whole rows were wiped out. It appears the present trees standing near Anderson Bridge along Connaught Drive are remnants of a whole row growing along that road. The disease was never identified. Furtado (1935) noted that the malady could have been spread by a Jassid (leaf hopper) while Corner (1952) stated that the disease was akin to the Dutch Elm Disease of the Temperate Zone.

PHENOLOGY

In the northern part of Peninsular Malaysia where the climate tends to be drier and the dry spells more pronounced, gregarious flowering is said to take place frequently. In Singapore mature trees do not flower often and flowering is normally solitary. One exception to this rule was the general flowering which took place in June/July 1976 when old trees littered the roads with carpets of their fragrant yellow flowers, so much so that special efforts were made to sweep them off daily. Apparently this general flowering was in response to the prolonged and pronounced dry spell which stretched from January to March 1976. For the first time many other flowering trees planted in Singapore also flowered gregariously in response to that stimulus—notably amongst them being Gliricidia sepium (Jacq.) Kunth ex Walp., another Leguminous tree.

When a tree flowers, normally a large part of the crown is covered with the flowers
On Angsanas (*Pterocarpus indicus*)

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and the whole affair is over within 4 days to a week (Fig. 7). According to Corner (1952) the disc-like fruits take 4 months to mature.

In Singapore, young trees or new transplants assume an evergreen habit when grown under mesic conditions and given adequate manuring. The crown puts on new flushes continually throughout the year. Old trees or younger transplants which are grown under exacting conditions such as in rocky areas with shallow soil, tend to be deciduous at the top of the crown and such trees assume a stag-headed appearance. Strangely enough such trees also tend to flower and fruit slightly more often.

**SPECIAL HORTICULTURAL CHARACTERISTICS**

**Adaptability**

As indicated before, Angsana is a tree which lends itself to propagation by large woody cuttings and large transplants. Apart from this, Angsans are highly adaptable. In Singapore they are now planted in a great variety of habitats ranging from well-drained hill slopes to flat, water-logged reclaimed land.

**Aggressive Roots**

Perhaps one reason why the Angsana is able to grow well under a wide range of habitats is its powerful root system. It has been observed in trenching operations by Services Departments that the roots are found to be able to spread under road foundations, well beyond the crown limit of the tree, although the soil is very clayey. Figure 8 shows part of the root system of an Angsana tree which proliferated under a service road. A peculiar feature is the presence of anastomosis in the system.

![Fig. 7. Inflorescences of the Angsana associated with leafy twigs. The petals are golden-yellow in colour.](image-url)
In many instances the roots have been found to grow underneath large concrete monsoon drains and then emerge in the surface of lawns located some distance from the base of the tree. Such rugged root systems mean that it is able to exploit nutrient and moisture resources over a wide area, hence the vigorous growth.

Response to Pruning, Pollarding, or Crown Damage

The Angsana is able to recover from pruning or pollarding very quickly. This has advantages in horticulture, but at the same time poses a problem to the management of roadside trees. In areas where the trees need pruning it is desirable aesthetically that the crown recovers its shape rapidly; on the other hand, this means higher frequency of pruning or pollarding to ensure the branches will not get into the way of traffic (especially buses and containers).

In May 1976, during a severe thunderstorm, the crown of a large tree was severely damaged. After the usual tree surgery to harmonise the branching and to prevent rotting, the tree put on new flushes within a couple of weeks and 7 months later had reformed a well-shaped crown.

The Production of Adventitious Roots in Response to Injury

It has been observed that the Angsana has another very interesting characteristic in that, for mature or old trees extensive injury to any part of the trunk or stem causes the callousing bark to produce adventitious fibrous roots which can be extensive and matted. Likewise, fibrous roots are produced in the arch of a cracked bifurcation. The roots grow in size and number rapidly within the crack, presumably because of the collection of water and nutrients therein, thus causing the two arms of the bifurcation to be forced apart. If this happens to be between the main ascending limbs it is most dangerous for it is only a matter of time before one of them collapses. It is, therefore, better to have such a tree felled or proper bracing must be carried out. If the phenomenon occurs in a less critical part of the tree, then that portion should be pruned off.

GENERAL HORTICULTURAL USE

The Angsana is certainly a graceful tree with considerable ornamental value and because of its large size it also provides good shade. It is a tree for open spaces and wide sidewalks or centre dividers where shade is important and needed quickly. It is also a tree to be chosen where the edaphic conditions are too exacting for establishing other trees, i.e. if space permits the planting of such a tree. It is not recommended for narrow sidewalks or in small home gardens, not only because of its big size, but also because of the aggressive roots. For any particular landscape which needs an "instant" effect, the Angsana can be used judiciously, but because of the ease of transplant and fast growth, the Angsana has been chosen for many localities where it should not have been planted.

Angsana root systems are wind-firm, but the young branches of transplants tend to snap in stormy weather at the point of union with the pollarded branches. Smaller rooted stumps with smaller pollarded snags tend to give better union and hence more wind resistance.
Fig. 8. Vigorous roots of a 25-year old Angsana under a service road. Note the unusual phenomenon of anastomosis of the roots. The tree was grown from a seedling.
ADDENDUM TO *PTEROCARPUS INDICUS*

With reference to the Introduction on page 189, subsequent information received shows that there is an exceptionally large tree with a girth size measuring 7.5 m in the grounds of the Fairy Point chalets at Changi.

REFERENCES

TISSUE CULTURE OF CURCULIGO LATIFOLIA DRY. ex W.T. AIT. (HYPOXIDACEAE)

LIM-HO CHEE LEN
Botanic Gardens, Singapore

ABSTRACT

This paper reports the success in clonal propagation of Curculigo latifolia at the Tissue Culture Laboratory, Singapore Botanic Gardens. Experiments using leaf blades, petioles, apical shoots, and rhizomes were carried out and the best results were obtained from rhizome cultures. The medium used contained the Murashige and Skoog inorganic salts (half strength), sucrose (30 g per litre), thiamine (0.4 mg per litre), coconut milk (150 ml per litre), kinetin (5 mg per litre), and IAA (2.5 mg per litre). Mass propagation of this species is in progress.

INTRODUCTION

Singapore, often called the Garden City, is famous for its parks, gardens and, most of all, the refreshing sight of the green canopy of big trees and luxuriant ornamental plants that grace the city especially along the roadsides. Rapid urban development has created many new environments, such as open spaces, under flyovers, or reclaimed land, where many plants find it difficult to grow and thrive. There has been considerable effort in trying to cultivate more species of native plants that can grow in these various new growth conditions. Curculigo latifolia is one species which has been found suitable for landscaping needs under flyovers which are shaded and sometimes rather dry.

Curculigo latifolia is an elegant native herb which grows under fully shaded forest conditions. It is a stemless herb with long leaves and short, thick rhizomes. The inflorescences, which are produced throughout the year, are compact, head-like, close to the ground, and have numerous flowers with bright yellow tepals (Fig. 1). Although this species offers good prospects for ornamental purposes in Singapore, the problem of obtaining large numbers of this species has yet to be solved. Curculigo latifolia is not abundant in Singapore's forests, thus collection of many living plants would have an undesirable effect on the floristics and ecology of their native habitats. In an effort to find alternative means to supply abundant material of this species for roadside planting, tissue culture techniques were investigated. This paper reports the success in mass propagation of Curculigo latifolia using tissue culture techniques at the Tissue Culture Laboratory, Singapore Botanic Gardens.

METHODS AND MATERIALS

Young shoots of Curculigo latifolia about 8–10 cm in height were used for tissue culture. The plants were thoroughly washed to remove dirt on the leaves and soil on the rhizomes. The outer leaves and roots were then removed, leaving the apical tissue and the rhizomes.

The apical shoots, rhizomes, and leaves were then sterilized by soaking sequentially in:

(1) 10% detergent for 10 minutes,
(2) 75% ethyl alcohol for 30 minutes,
(3) 15% chlorox for 30 minutes, and
(4) three changes of distilled water for five minutes each time.
The following three different plant parts were excised for tissue culture:

(1) Shoot apices — The sterilized apical tissue was further trimmed to a small cube of about 1 cubic mm in size containing the apical meristematic tissue of the shoot.

(2) Leaves — The whole leaf, blade and petiole, was cut into 5mm segments and placed proximal side down on agar medium.

(3) Rhizomes — The outer layer of the rhizomes was removed to reduce risk of contamination. The remaining part was then cut into sections and transferred onto an agar medium.

The agar medium used contained the inorganic salts of Murashige and Skoog (1962) at half strength with the addition of sucrose (30 g per litre), thiamine (0.4 mg per litre), coconut milk (150 ml per litre), and various hormones.

All cultures were incubated at a temperature of 20—28°C and exposed to Grolux light for 8 hours per day.

RESULTS

A total of 11 plants were used in the experiment. The number of cultures prepared using the various plant parts and their state of growth at the end of a 3 month period are listed in Table 1.

Table 1: Results of the tissue culture experiment of Curculigo latifolia

<table>
<thead>
<tr>
<th>Explant</th>
<th>no. of cultures prepared</th>
<th>only callus formed</th>
<th>callus and shoots formed</th>
<th>callus, shoots, &amp; roots formed</th>
<th>callus and roots formed</th>
<th>no. growth</th>
<th>contaminated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf blade</td>
<td>18</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Petiole</td>
<td>20</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Rhizome</td>
<td>20</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Apical shoot</td>
<td>11</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

The most unsuccessful results were from those using leaves. Except for a few cases where callus formed (Fig. 2), the leaf cultures either showed no sign of growth or were contaminated. The difficulty is probably in the sterilization technique. To kill all the fungus spores stuck on the leaves, it was found necessary to use a sterilization duration which was probably too long in that the leaf tissue was also damaged.

The petiole and apical shoot cultures formed callus and shoots quite readily (Fig. 3), but were slow to form roots (root formation was observed 2—3 months after the end of the experiment).
The best results obtained were from rhizome cultures. Satisfactory growth of callus, shoots, and roots were observed in 7 out of the 20 cultures prepared (Fig. 4).

In order to encourage root formation, it was decided that hormones such as kinetin and IAA should be added to the agar medium used for incubation. A simple factorial experiment was conducted with three levels of kinetin (1, 2.5, 5 mg per litre) and five levels of IAA (0, 1, 2.5, 5, 10 mg per litre). Five replicates were prepared. In each test a single rootless shoot was introduced and incubated for three months. The results are listed in Table 2.

Table 2 shows that the best root formation and shoot multiplication were obtained at 5 mg per litre kinetin concentration. At 5 mg per litre kinetin concentration, although root formation improved with increasing concentration of IAA, shoot multiplication reached a clear peak at 2.5 mg per litre IAA concentration. Increasing the IAA concentration further appeared to strongly favour the formation of callus at the expense of shoot multiplication. Media discolouration also appear to become worse with increasing concentrations of kinetin or IAA.

Based on the above results, it was decided to use a medium containing the Murashige and Skoog (1962) basic salt (half strength), sucrose (30 g per litre), thiamine (0.4 mg per litre), coconut milk (150 ml per litre), kinetin (5 mg per litre), and IAA (2.5 mg per litre) for mass propagation work.

MASS PROPAGATION

Starting from the tissue taken from 11 plants, a stock of about 70 flasks of cultures were obtained after about 10 months. A production programme was then planned and put into operation. A culture flask normally contains 2–8 shoots at different stages of development. At 3 month intervals the shoots were taken out and separated into indivi-

Table 2: Results of the factorial experiment on hormone-induced root formation of Curculigo latifolia shoots.

<table>
<thead>
<tr>
<th>IAA (mg/L)</th>
<th>kinetin (mg/L)</th>
<th>medium discolou-ration*</th>
<th>callus formation*</th>
<th>root formation*</th>
<th>shoot multiplication (average no.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>none</td>
<td>+</td>
<td>none</td>
<td>1 (1)</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>none</td>
<td>+</td>
<td>none</td>
<td>1-2 (1.1)</td>
</tr>
<tr>
<td>2.5</td>
<td>1</td>
<td>none</td>
<td>+</td>
<td>none</td>
<td>1-3 (1.8)</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>+</td>
<td>+</td>
<td>none</td>
<td>1-2 (1.1)</td>
</tr>
<tr>
<td>10</td>
<td>2.5</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>2-3 (1.8)</td>
</tr>
<tr>
<td>0</td>
<td>2.5</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>1-2 (1.1)</td>
</tr>
<tr>
<td>1</td>
<td>2.5</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>1-2 (1.1)</td>
</tr>
<tr>
<td>2.5</td>
<td>2.5</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>0 (0)</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>2 (2)</td>
</tr>
<tr>
<td>10</td>
<td>2.5</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>2-5 (2.6)</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>1-2 (1.1)</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>3-5 (3.6)</td>
</tr>
<tr>
<td>2.5</td>
<td>5</td>
<td>++</td>
<td>++</td>
<td>+++</td>
<td>2-8 (5)</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>1-5 (3)</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>1-5 (3)</td>
</tr>
</tbody>
</table>

*+= slight ++ = moderate +++ = high
dual plants. Those taller than 8 cm with strong roots were rinsed in distilled water and potted out. The smaller plants were transferred individually onto agar medium for multiplication.

The plants potted out were protected under a plastic cover for one week to help them adjust to nursery conditions. About 90% of the plants potted out have survived. After another 5-6 months these plantlets are normally ready to be planted in field. Fig. 5 shows some plants in the nursery.

About 90% of the plants produced so far have remained identical to the parent plants. The rest seem to produce more leaves and show some variation in leaf colour.

Based on the observed growth rate, it has been estimated that about 5,000 plants from tissue culture can be produced within the first year of mass propagation, sufficient to meet the current landscaping needs of the Parks and Recreation Department.

ACKNOWLEDGEMENT

The Curculigo latifolia tissue culture project was initiated on the direction of Mr. Wong Yew Kwan, recently Commissioner, Parks and Recreation Department. The author wishes to thank Miss Lee Swee Meng, Miss Lein Lee Jiuian, and Mrs. Teo-Lee Guek Choon for their competent assistance in the experiment.

REFERENCE


Fig 1. Curculigo latifolia, mature plant.
Fig. 2. Callus formed from leaf culture.

Fig. 3. Callus and shoots formed from apical shoot.
Fig 4. Rhizome cultures showing satisfactory growth of callus, shoots, and roots.

Fig 5. Curculigo latifolia produced by tissue culture technique.
CONTRIBUTIONS TO THE FLORA OF THE SOLOMON ISLANDS

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Malaysia

From 14 September to 10 December 1957, I collected plants in the Solomon Islands on an expedition made possible by a National Science Foundation grant (G1834) to Professor H. St. John of the University of Hawaii. Although the main purpose of the expedition was to investigate the genus *Pandanus*, of which 86 numbers were collected in the Solomon Islands, 25 in the New Hebrides, and 39 in the Bismarck Archipelago, there was also opportunity to collect other plants of which 232 numbers were collected in the Solomon Islands, 40 in the New Hebrides, and 14 in the Bismarck Archipelago. The very imperfect state of our botanical knowledge of the flora of these three island groups stimulated a desire to study all the available material, and has led so far to eleven papers (Stone & Lane, 1960; Stone 1961, 1962, 1963, 1965, 1966, 1969, 1970, 1972, 1973; Stone & Whitmore, 1971) dealing respectively with a few ferns, *Sararanga* (Pandanaceae) the genus *Boerlagiodendron* (Araliaceae), new *Pandanus* and *Freycinetia* (Pandanaceae), a new species of *Polyscias* (Araliaceae), an account of *Pandanus* in the Solomon Islands, and a study, with descriptions of two new species, of *Tapeinosperma* (Myrsinaceae). The paper of *Sararanga* was monographic in scope, including the Philippine species. Material on *Pandanus* is accumulating and some is awaiting publication. A complete account of the Solomons *Freycinetia* is now in preparation. The Myrsinaceae are being worked up in collaboration with Dr. T.C. Whitmore, formerly of the Forest Dept., B.S.I.P.

The present account is an attempt to deal with all but the most intractable collections from the 1957 expedition, and is set out, in the traditional Englerian arrangement of families, purely for convenience. The order of genera and species within each family is, however, alphabetical. Each collection is documented with appropriate notes, and where needed, descriptions and illustrations.

The first set of the specimens is deposited in the herbarium of the Bishop Museum, Honolulu (BISH); a second set, not so complete, is at the U.S. National Herbarium, Washington DC. (US); a further set is for the time being kept in the author’s possession; and a very few fourth replicates are in the Arnold Arboretum, Cambridge, Massachusetts (A).

I should like to acknowledge the thanks I owe to several colleagues; the late Mr. James Sinclair (Singapore), Dr. T.C. Whitmore (Kepong, W. Malaysia), Dr. T. Koyama (New York), and Prof. A.C. Smith (Honolulu).

Literature Cited


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Stone (cont.)


**ULMACEAE**

*Celtis* L.

*Celtis kajewskii* Merril & Perry, J. Arn. Arb. 22 (1941), 254.

SANTA YSABEL: Tatamba Lagoon, Horara Islet; alt. 15 m. tree with triplinerved ovate leaf blades, 24 Oct. 1957, Stone 2509 (BISH).

**MORACEAE**

*Ficus* L.


MALAITA: Kwara-ae District, near Tantalau Village, c. 325 m. alt., tree about 13 m. tall, leaves clustered near ends of slender branches; figs globose, 4 mm diam., n.v. "fa 'adil'ila", 23 Sept. 1957, Stone 2347 (BISH).


MALAITA: Kwara-ae District, Tantalau, 325 m, tree 15 m tall, leaf blades with tiny basal auricles, n.v. "aitia"; 23 Sept. 1957, Stone 2340 (BISH).


MALAITA: Fiu River 4 miles N. of Aulei near the coast, 7 m, tree, cauliflorous, leaf blades reddish-hispid; 19 Sept. 1957, Stone 2298 (BISH).

MALAITA: Kwara-ae District Kwalo and vicinity, alt. 650m, tree 10 m tall, in a clearing; figs orange, hairy, maroon-brown when ripe; leaf blades scabrous, asymmetric, harshly scabrid. 24 Sept. 1957, Stone 2394 (BISH). — Tantalau Village, 325 m alt., tree in adjacent forest, n.v. "samota"; 23 Sept. 1957, Stone 2323 (K).

**Streblus Lour.**


MALAITA: Kwara-ae District, Kwalo and vicinity, c. 650 m alt., tree with milky sap, n.v. "tou"; 29 Sept. 1957, Stone 2425 (BISH).


**PROTEACEAE**

*Finschia* Warburg


Both specimens are in complete accord with the description and figure in C.T. White’s monograph of 1949. The species was already known from the Solomon Islands from Kolombangara Is. in the New Georgia Group and is known to occur in New Guinea, the Caroline Islands, and the New Hebrides where it has passed under several specific and generic names (e.g. *Finschia densiflora* C.T. White, *Grevillea elaecarpifolia* Guillaumin and *Helicia micronesica* Kanehira).

**LORANTHACEAE**

*Amyema* V. Tieghem


MALAITA: Kwara-ae District, near Tantalau Village, c. 325 m alt., epiphyte, hemiparasite, leaf blades narrowly deltoid—ovate, flowers in open, few-flowered, axillary umbels; leaves subopposite or alternate; 23 Sept. 1957, Stone 2334 (BISH).

I am not entirely convinced of the correctness of the determination, though it is the closest I have been able to come. The following slight differences may be pointed out: the above collection has somewhat smaller flowers; acuminated rather than rounded leaf apices; glabrous inflorescence axes and calyx, except for the marginal cilia; and slightly longer petioles (to 22 mm, not 12 mm). There being little if any real distinction in the essential floral characters and the inadequate material, this is provisionally considered as a slightly aberrant specimen of Danser’s species. Known from Talaud Is. and N.E. New Guinea.

*Amyema aff. sogerensis* (S. LeM. Moroe) Danser, ibid. 10 (1929) 299; ibid. 11 (1931) 246.

MALAITA: Kwara-ae District; Tantalau-Launguata trail via Kwai’ afa River, c. 325 m alt., hemiparasite on tree (host = *Phyllanthus* sp.) shrubby, leaves mostly strictly opposite, green, corolla red; 22 Sept. 1957, Stone 2308 (BISH, US).
This plant differs from Danser’s *A. sogerensis* in the absence of corolla scales. There are supposed to be six scales “directed upwards inside (the corolla) at 1 mm above the base” which cannot be located in the flowers of the cited specimen. This is perhaps due to the undeveloped state of these flowers, which appear only about half-grown.

*A. sogerensis* is reported from S.E. New Guinea and New Ireland. If, as I suppose, the above specimen proves to be of the same taxon it is a logical range extension. One specimen cited by Danser (Forbes 682) was collected at 510 m alt., the other from New Guinea (Forbes 715, Type BM) at 1500 m. The New Ireland specimen must have been from a low altitude (Port Carteret, Barclay 3517).

**AMARANTHACEAE**

*Deeringia* R. Br.


MALAITA: Kwara-ae District, Kwalo, c. 650 m alt., climber in secondary growth of clearing, leaves simple, alternate; blades elliptic, petals 5, stamens 5; fruit 4-lobed, baccate, magenta-pink, slightly fleshy; seeds 4-7, glossy black, subcordate; 24 Sept. 1957, Stone 2368 (BISH).

A new record for the Solomons flora. Reported so far from Malaysia, New Guinea, and Queensland.

*D. amaranthoides* (Lamk.) Merr. was first reported from Bougainville by Merrill & Perry in *J. Arn. Arb.* 23: (1942) 385.

**WINTERACEAE**

*Belliolum* Tieghem


MALAITA: Kwara-ae District, Kwalo and vicinity, alt. 650 m; tree with simple, oblanceolate, spiralled leaves; blades grey-green beneath; 28 Sept. 1957, Stone 2429 (BISH).

**ANNONACEAE**

*Phaeanthus* Hk. f. & Thoms.


MALAITA: Kwara-ae District, Kwalo and vicinity, alt. 650 m; in forests; small tree with red or yellowish fruits on gynophores from a torus; 28-29 Sept. 1957, Stone 2434 (BISH, US).

A new record. Determined by the late Mr. James Sinclair.

**MYRISTICACEAE**

*Myristica* L.


MALAITA: Kwara-ae District, near Tantalau Village, in forests, c. 325 m alt., tree to 30 m.


All specimens were determined by the late James Sinclair. The New Hebridean specimen has been included here for convenience and phytogeographic interest.

LAURACEAE

Litsea Lam.


MALAITA: Kwara-ae District, Kwalo, 650 m; rain forest tree, leaf blades broadly ovate, n.v. “arasibolu”, 29 Sept. 1957, Stone 2421 (BISH).


MALAITA: Kwara-ae District, Kwai-afa River, between Tantalau and Launguata, 325 m., 22 m tree; flowers white in axillary clusters, stamens 8 or 9, n.v. “sasasu”; 22 Sept. 1957, Stone 2313 (BISH)

SANTA YSABEL: Ridge between Koloteve village and Sesedo village, southern tip of island, 175 m., tree with white flowers, n.v. “giagila” (Bugotlang.); 14 Oct. 1957, Stone 2492 (BISH).

The herbarium annotation by A. Kostermanns (SING) reads “Litsea timoriana Span.”

This is a very common Litsea in the Solomons.

RUTACEAE

Micromelum Bl.

Micromelum minutum Wight & Arnott, Prod. (1834) 448.

MALAITA: Kwara-ae District, Tantalau-Kwalo trail at c. 500 m. alt., rain forest tree to 15 m. high, leaflets paler below; petals 5, creamy-white; stamens, 10; fruits with odor of lime (Citrus auranti-folia); 24 Sept. 1957, Stone 2365 (BISH, US).

Zanthonxylum L.


MALAITA: Kwara-ae District, Kwalo and vicinity, c. 650 m. alt., tree in forests, n.v. “bulungali” (though this name is usually applied to species of Canarium); 23 Sept. 1957, Stone 2420 (BISH).

According to Hartley, material with flowers is a desideratum for this very distinct species. The cited specimens, however, regrettably are all in ripe fruit.
MELIACEAE

Chisocheton Bl.

Chisocheton sp.

MALAITA: Kwara-ae District, near Tantalau Village, 325 m. alt., young tree 7 m. tall; fruits ramuline, subglobose, 3–4-celled, brown-fuzzy, 3 cm diam.; seeds 3 or 4, dark brown with red hilum and white funicle; n.v. “latareko”; 23 Sept. 1957, Stone 2352 (BISH). – Kwalo and vicinity, 650 m. alt., young tree, n.v. “latareko”; 29 Sept. 1957, Stone 2432 (BISH).

Dysoxylum Bl.


MALAITA: Kwara-ae District, Kwalo and vicinity, 650 m. alt., forest tree, fruits ramuline or cauline, brown-fuzzy, subglobose, 5-seeded, leaves large, pinnate, with opposite leaflets; n.v. “airande”, 24 Sept. 1957, Stone 2382 (BISH).

EUPHORBIACEAE

Pimeleodendron Hassk.


MALAITA: Kwara-ae District, near Tantalau, alt. c 325 m, tree 20 m tall, in forest, leaves simple, alternate; blades crenate; petiole basally swollen, curved; fruit elliptic, magenta-brown, red when ripe; seed 1, brown, in elastic, milky-sapped pulp, n.v. “aisumbu”; 23 Sept. 1957, Stone 2349 (BISH, US).

Macaranga Thouars


GUADALCANAL: Tenaru River lowlands, swamp forest, 135-180m alt., along the river bank, trees with 3-lobed leaves; lobes long-apiculate; 15 Sept. 1957, Stone 2282 (BISH).


MALAITA: Kwalo and vicinity, alt. 650m., Kwaro-ae District, rainforest tree, n.v. “Kweto” or “abe-Kweto”; 29 Sept. 1957, Stone 2419 (BISH).

Aporosa Bl.


MALAITA: Kwalo and vicinity, alt. 650 m., Kwara-ae District, 14m tall tree; fruits along the twigs, small, grey, globose, fuzzy; stipules large; 24 Sept. 1957, Stone 2386 (BISH).

ANACARDIACEAE

Rhus L.

MALAITA: Tantalau, forest near village, tree to 17m tall, n.v. “areko” (Kwara-ae); 23 Sept. 1957, Stone 2325 (BISH, US); same locality, tree 12m tall, leaves with 5–7 pairs of pinnae, fruiting, n.v. “akwasi”; same date, Stone 2339 (BISH).

Of the vernacular names “akwasi” is preferred as “areko” is usually given to Garuga floribunda.

**CORYNOCARPACEAE**

*Corynocarpus* J.R. & G. Forst.


MALAITA: Kwara-ae District, Kwalo and vicinity, alt. 600 m, tall tree in an old secondary forest; leaves opposite, blades elliptic; fruit light green, ellipsoid, 7.5 x 4.8 cm., 1-seeded; n.v. “ibo”; 24 Sept. 1957, Stone 2367 (BISH).

**ICACINACEAE**

*Stemonurus* Bl.

*Stemonurus sp.*

MALAITA: Fiu River, 4 mi. N. of Auki, on the W. coast, 45m alt., secondary forest, 8m tree in a swamp area; leaves alternate, up to 15 x 6.5 cm; flowers in axillary, cymose panicles, or on the twigs; 19 Sept. 1957, Stone 2296 (BISH).

**LEEACEAE**

*Leea* Royen ex L.


GUADALCANAL: Tenaru River, lowland swamp forest, alt. 135 m, small tree with bipinnate leaves; flattened, purplish fruits, n.v. “borabora”; 15 Sept. 1957, Stone 2280 (BISH).

**RHAMNACEAE**

*Alphitonia* Reissek


A common tree, frequent in secondary forests.
ELAEOCARPACEAE

Aceratium DC.


MALAITA: Kwara-ae District, near Tantalau village, in forests, 325 m alt.; 20 m tree; leaf blades finely toothed, elliptic, glossy green and slightly pubescent above, flat green and pubescent beneath, base slightly emarginate, tip acuminate-apiculate; flowers axillary; fruit short-cylindric, 3 cm long, 2 cm diameter, greenish at base, ripening to pink and reddish, attached by a long, slender peduncle; n.v. “sura’u’u”; 23 Sept. 1957, Stone 2341 (BISH, US).

TILIACEAE

Trichospermum B1.

Trichospermum psilocladum Merrill & Perry, J. Arn. Arb. 20 (1939) 341. Fig. 1.

SANTA YSABEL: Horara Islet, Tatamba Lagoon, near sea-level, in dry forests, tree 15 m tall, with Calophyllum inophyllum, Dillenia crenata, Parinarium glaberrimum, Casuarina nodiflora, Gnetum gnemon, Evodia sp., etc.; 24 Oct. 1957, Stone 2514 (BISH).

This is very similar in general appearance to T. ikutai Kanehira (1932), which is probably the earliest valid name.


MALAITA: Kwalo and vicinity, alt. 650 m, Kwara-ae District, rain forest; tree 15 m tall, n.v. “sulu”; 29 Sept. 1957, Stone 2430 (BISH). (Vegetative).

Determined by T.C. Whitmore.

DILLENIACEAE

Dillenia L.


SANTA Ysabel: Horara Islet, Tatamba Lagoon 15 m alt., common big tree in dry forests; petals white, connate by their tips, falling as a unit; stipules adnate to the petioles, but deciduous; 31 Oct. 1957, Stone 2520 (BISH).

This specimen is an excellent match for the description of this clear-cut species.

GUTTIFERAE

Calophyllum L.


MALAITA: Kwara-ae District, Kwalo, 650 m alt., in rain forest; large tree; n.v. “koumanu” (compare Hawaiian “kamani”); 29 Sept. 1957, Stone 2431 (BISH, US).
Fig. 1. Trichosperma psilocladum Merr. & Perr. (Tiliaceae). From Stone 2514. a—habit of fertile branch. b—portion of inflorescence with flower buds. c—floral details: longitudinal section of flower, with apical view of compressed ovary; petal, stamen, and (below) bracteole. d—fruit, side view. e—fruit, top view. f—fruit, transvers section. g—fruit, longitudinal section. h—side and top views of seed with hair-tufts. i—detail of leaf margin showing trichome positions. j—two representative stellate trichomes.
LEGUMINOSAE

Desmodium Desv.

Desmodium umbellatum (L.) DC., Prodr. 2 (1825) 325.

MALAITA: Kwara-ae District, Tantalau area, forest, alt. 325 m, tree 12 m. tall, petals white, n.v. "aida-ahi"; 23 Sept. 1957, Stone 2329 (A, BISH, US).

MYRTACEAE

Decaspermum J. R. & G. Forster


MALAITA: Kwara-ae District, vicinity of Tantalau village, alt. 325 m, small tree 10 m. high; small flowers with white petals and pink stamens, n.v. "oridi", 23 Sept. 1957, Stone 2338 (A, BISH, US).

This is an attractive little tree and occurs in abundance in the cited localities.

MELASTOMATACEAE

Melastoma L.


Walker (1948, 79) states that the same vernacular name is also applied to a species of Maesa (Myrsinaceae).

ARALIACEAE

Plerandra A. Gray


MALAITA: Kwara-ae District; Kwalo and vicinity, alt., c. 650 m, tree with palmate leaves, infructescence umbellate, fruits black, n.v. "singoria"; 28-29 Sept. 1957, Stone 2438 (BISH).

There are some points of discrepancy between this specimen and the description provided by Philipson which is very short and somewhat incomplete. The above collection shows the following features: mature flower bud 6 mm long or slightly longer; calyx undulate-discoid, the 5 lobes obscure, spreading; petals 5, nearly 1 mm thick; stamens (in staminate flowers) approximately 160; ovary (in female flowers) almost always 11-celled; fruit (seemingly ripe) only 18 x 17 mm (rather than 28 x 15 mm, Philipson's dimensions); leaflets 5 or 7, their petiolules 4-5 cm long (not 2.5 cm), with evident lateral nerves; pedicels about 5 per umbellule (not 20).
Fig. 2. *Plerandra solomonensis* W.R. Phil. (Araliaceae). From Stone 2438, a– branch and leaf. b– small portion of inflorescence. c– um bellule. d– floral details: longitudinal section of flower; separate stamens. e– flower. f– fruit. g– fruit, enlarged, side and top views.
**Gastonia** Comm. ex Lamk.

*(Peekeliopanax* Harms)*


MALAITA: Kwara-ae District, Kwalo and vicinity, c. 650 m. alt.; large, single-boled tree, about 30-35 m. tall, distally few and short branched, dense leafy crown of very long, 1-pinnate leaves (to 2 m long) with c. 14 pairs of leaflets, rachis swollen at nodes; not flowering; n.v. "simalau"; 28 Sept. 1957, *Stone 2409* (BISH).

This is certainly one of the most splendid plants in this interesting family. The height, massiveness of the leaves, strength of the wood, and the relative rarity of this species are all notable characteristics that impress the botanical traveller in the Solomons. It was described from material collected in the Bismarck Archipelago (New Britain) by Peekel. Only two trees of this species were seen during my entire stay in the Solomons and Bismarcks.

**STYRACACEAE**

**Styrax** L.

**Styrax agresti** (Lour.) G. Don, Gen. Syst. 4 (1837) 5.

MALAITA: Kwara-ae District, Kwalo, 650 m. alt., 20 m. tree, ovary superior, corolla 4-5-lobed, white; stamens 8 or 10, epipetalous; ovules few, pendulous; leaves simple, alternate; stipules none; n.v. "aigasi"; 29 Sept. 1957, *Stone 2407* (A, BISH, US).

**APOCYNACEAE**

**Carruthersia** Seemann


MALAITA: Tantalau-Fiu River area, Kwara-ae District; vine, corolla white, lobes with yellowish or pinkish spot at base (where they overlap); leaves subcordate; sap milky; alt. 260 m; 25 Sept. 1957, *Stone 2399* (BISH, US).

This specimen differs from the original description, which was based solely on the holotype collection, Whitmore *2749*, from Bogotu, Santa Ysabel, in having white corollas with only a spot of pink (or yellow) at the base of each corolla lobe, rather than red corolla tubes and pink lobes. No important differences were observed in other features so it would appear that the species is rather variable in corolla color.

**ASCLEPIADACEAE**

**Anodendron** A. DC.

**Anodendron paniculatum** (Roxb.) A. DC., Prodr. 8 (1844) 444.

MALAITA: Kwalo – Tamba’a, Kwara-ae District, alt. 650m., a vine, climbing trees, with terete, brown stems; opposite leaves, nodes annular; fruit of 2 twinned carpels, terete-conic, 12 cm long, nearly 2 cm diam. at the base; seeds plumose, body of seed oblong-elliptic, flat, thin, 17 x 5 mm., attenuate at the apex to a short column 6 x ½ mm, bearing a white plume 6 cm long of numerous, straight, silky hairs; 28 Sept. 1957, *Stone 2447* (BISH).
LOGANIACEAE

Fagraea Thunb.

Fagraea racemosa Jack in Roxb., Fl. Ind. ed. Carey, 2 (1824) 35.

MALAITA: Kwara-ae District, near Tantalau Village, c. 325 m alt., 7 m. tree with drooping branches, large, dull green leaf blades; white, zygomorphic flowers in terminal racemes, n.v. “ngara”; 23 Sept. 1957, Stone 2328 (BISH).

Geniostoma J.R. & G. Forster


MALAITA: Kwara-ae District, near Tantalau; 12 m tree, fruits 1.4 cm long, n.v. “mahus-husi” (one of several spp. so named); 23 Sept. 1957, Stone 2356 (BISH). - Near Kwalo, c. 650 m. alt., 7 m. tree, or shrubby, leaves opposite, stipulate; blades elliptic, acuminate, paler beneath, rather thin and fragile; petiole 2 cm long; fruits axillary, short-pedicellate, ovoid-ellipsoid, greenish-white, 2-celled; seeds numerous, yellow, in juicy pulp, placenta axile; calyx 5-lobed; 24 Sept. 1957, Stone 2392 (BISH).

SAPOTACEAE

Planchonella Pierre


MALAITA: Kwara-ae District, Kwalo and vicinity, Tamba’a path, rain forest at c. 650 m. altitude, small tree with alternate leaves with close, minute, rusty coloured, scaly indumentum, n.v. “mumu”, 29 Sept. 1957, Stone 2423 (BISH).

Vegetative. The holotype is from Kei Is.

COMPOSITAE

Blumea DC.

Blumea riparia (Bl.) DC., Prod. 5(1836) 444.

MALAITA: Kwara-ae District, Tantalau village, 325 m alt.; scandent shrub in clearings; 23 Sept. 1957, Stone 2332 (BISH).

Determined at the Rijksherbarium, Leiden, in 1970.

FLAGELLARIACEAE

Flagellaria L.


MALAITA: Fiu River, at 200 m. alt., in secondary forests with Macaranga, Hibiscus, and Ficus; large vine with leaf tips as coiled tendrils; inflorescence large, terminal, branched. Perianth white; 25 Sept. 1957, Stone 2395 (BISH).
COMMELINACEAE

Pollia Thunb.

Pollia thyrsiflora Endl. ex Hassk. in Miq., Pl. Jungh. (1852) 150.

GUADALCANAL: Tenaru River, in lowland forest, 135-175 m alt.; 15 Sept. 1957, Stone 2286 (BISH).

New record for the Solomons; not listed in Whitmore (1966).

PALMAE

Heterospathe Scheffer

Heterospathe woodfordiana Becc., Webbia 4:2 (1914) 281.

MALAITA: Kwalo and vicinity, Kwara-ae District, alt. 650 m, small, erect, pinnate-leaved palm; fruits red, n.v. “araramei”, 28 Sept. 1957, Stone 2408 (BISH, 3 sheets).

CYPERACEAE

Scleria Berg.


SANTA YSABEL: Above Tatamba, on ridge between Koloteve and Sesedo, c. 275 m. alt., in forests; 15 Oct. 1957, Stone 2494 (BISH).

Scirpus L.


Fuirena umbellata Rottb., Descr. Icon. Pl. (1773) 70, t. 19, f. 3.

NOMENCLATURE OF JOINVILLEA (JOINVILLEACEAE)

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ABSTRACT

The nomenclatural status of the name for the genus Joinvillea and for its two species is reviewed. It is concluded that the correct (first validly published) generic name is Joinvillea Gaudich. ex Brongn. & Gris, 1861; Gaudichaud's original publication of 1841 contravenes Articles 42 and 44 of the International Code of Botanical Nomenclature. The two species are correctly J. plicata (Hk. f.) Newell & Stone, and J. ascendens Br. & Gr.

Joinvillea, a small genus previously attributed to the Flagellariaceae, has now been shown on good evidence to constitute a small independent family (Tomlinson & Smith, 1970; Lee, Yap & Liew, 1975). A recent taxonomic revision has been published by T. K. Newell (1969). In this work, evidence is given to show that the generic name, coined by C. Gaudichaud, dates as a legitimate botanical name only from a publication by A. Brongniart & Gris (1861). Therefore, the correct names of all species of the genus must date either from this same publication or from later publications, earlier appearances of the name in print being considered illegitimate. Newell regards the genus as being comprised of two species, both of them being further divided into subspecies. For these species, Newell concluded that the correct names are (1) J. ascendens Brongn. & Gris (1861), with four subspecies; and (2) J. plicata (Hk. f.) Newell & Stone (1967), based on Flagellaria plicata Hk. f. (1855), with two subspecies.

Lately this view has been challenged by St. John (1978), who maintains Newell's taxonomic conclusions but, on the basis of a different interpretation of the validity of publication of the generic name, regards J. plicata as a synonym of J. elegans Gaudich. In this note, evidence is reviewed and it is concluded that the nomenclatural discussion of St. John is unconvincing, and that therefore, the nomenclature adopted by Newell & Stone (1967) and by Newell (1969) is correct.

The crux of the nomenclatural problem is the applicability of Article 44 of the ICBN (International Code of Botanical Nomenclature). This article reads as follows: "The name of a species or of an infraspecific taxon published before 1 Jan. 1908 is validly published if it is accompanied only by an illustration with analysis showing essential characters (see Art. 32, Note 2). Note: Single figures of microscopic plants showing the details necessary for identification are considered as illustrations with analysis showing essential characters."

This article refers back to Article 32 (to Note 2, but in fact this is an error, and the reference should be to Note 3), which defines valid publication. Note 3 reads: In certain circumstances an illustration with analysis is accepted as equivalent to a description (see Arts. 42 and 44).

We are thus led also to Article 42, which reads as follows: "The publication of the name of a monotypic new genus based on a new species is validated either by (1) the provision of a combined generic and specific description (description generico-specifica) or diag-
nosis, or (2), for generic names published before 1 Jan. 1908, by the provision of an illustration with analysis showing essential characters (see Art. 32, Note 3)."

Gaudichaud conceived the genus *Joinvillea*. Instead of publishing it as a new name with a diagnosis or description, he merely coined the name of the genus and of two species which he believed the genus to be composed of. The two binomials were published as titles to illustrations (Plates) with “analyses” in his ‘Botanique’ Atlas, embodying results of the world tour of the French exploring expedition of 1836-37 in the corvette ‘La Bonite’ commanded by Capt. Vaillant (Gaudichaud, 1841). Two such Plates were published, Pl. 39 and Pl. 40, the former showing “Joinvillea ascendens” (figs. 1–6, showing short sections of a stem, a sterile shoot, and short cross sections of part of a leaf), the remaining figures (7-26) showing “Joinvillea elegans” (figs. 7–9 show stem, leaf, and inflorescence, figs. 10-26 show analytical details of the flowers and fruit and sections thereof). Details of both species can be found in both Plates.

St. John’s argument in brief is this: *Joinvillea ascendens* is not a validly published name, since no flowers or fruits or other “essential” parts were shown in Gaudichaud’s illustrations. Therefore *Joinvillea* as a genus is monotypic. The illustration of *Joinvillea elegans* shows the “essential” parts, i.e. flowers and fruits; it is therefore validly published, and can be taken as a joint or generico-specific publication of the genus and species. The genus, therefore, dates from 1841, as does the species *J. elegans*, which therefore has priority over the synonymous *Flagellaria plicata* Hk. f. of 1855.

This argument is however unconvincing, indeed specious, for the following reasons. First, it is obvious that Gaudichaud intended the genus to consist of two species; it was not monotypic in his original conception. Secondly, the insistence by St. John that the analyses provided for *J. ascendens* are unacceptable because they do not show flowers or fruits or other essential characters, is misleading. The ICBN does not specify what is meant by “analyses” or by the term “essential characters." Inherently, both can and often do include non-floral and non-fruit characters. If Gaudichaud meant to support his species concept by the use of features of the stem or leaf anatomy, this cannot be rejected on legalistic grounds (whether the anatomical features are significant is another matter). In other words, the analyses provided for *J. ascendens*, of vegetative characters, are just as satisfactory, from the legalistic point of view, in conforming to the stipulations of Art. 42 and Art. 44, as those of floral and fruit details provided for *J. elegans*. With our retroactive Code, we are thus forced to acknowledge that the generic name *Joinvillea*, as it appears in the original publication of 1841 by Gaudichaud, is illegitimate, as it clearly is intended to designate a genus of two species. Article 42 is very clear that only *monotypic* new genera can be validated by the publication of a plate with analyses. *Joinvillea* fails to meet this stipulation in 1841.

Newell & Stone (1967) and Newell (1969) accept the name *Joinvillea plicata* (Hk. f.) Newell & Stone for *J. elegans* Gaudich. nom. illegit. (1841). The genus itself was validly established and attributed to Gaudichaud by Brongniart and Gris (1861); they also established the species *J. ascendens* in the same publication. As shown by Newell, Brongniart and Gris also published a synonymous name for this species (*J. gaudichaudiana*), which previously has been used for Samoan plants. Three other species have been described, all now reduced to the status of subspecies. A short synopsis of the nomenclature follows.

Nomenclature of Joinvillea

(1) **Joinvillea ascendens** Brongn. & Gris, l.c. 1861.
   (1a) subsp. *ascendens* — Hawaiian Islands, endemic.


References


IN MEMORIAM

Dr. Monte Gregg Manuel, bryologist, 1947 - 1981.

Friends, bryologists, and Malesian botanists will be saddened to learn of the death of Monte G. Manuel, who for three years past was staff bryologist and bryological curator in the Department of Botany, University of Malaya, Kuala Lumpur. Monte had just departed from Malaysia after his contract and was taking up a new post at the University of Nairobi, Kenya, but suffered a sudden stroke and died in Nairobi in April 1981.

Monte G. Manuel was born in Missoula, Montana, U.S.A., on 29th May 1947, and received his early education in Lakes High School in Tacoma, Washington. After obtaining an Associate in Arts degree from Lower Columbia College in Longview, Washington, in 1968, he entered Central Washington State College in Ellensburg and majored in botany, with a minor in geology, receiving his B.A. in 1970. He then continued at the University of Southwestern Louisiana in Lafayette, studying under William D. Reese, and gained the M. Sc. degree there. He completed his academic work at the University Park laboratory of Dr. Ronald A. Pursell (The Pennsylvania State University) and received his Ph. D. in 1976. He spent a postdoctoral year at the Farlow Library and Herbarium of Harvard University, Cambridge, Massachusetts, where he worked partly with Dr. Norton G. Miller.

Monte had worked for the U.S. Forest Service in Oregon and had a taste for nature and the outdoors. During his graduate work he taught in the biology laboratories and did duties in the herbaria. His Research Fellowship at Harvard was a very valuable experience and he then took a teaching post at Fort Lewis College in Durango, Colorado, for a year (1977-8) where he was very successful. But the tropical floras enthralled him and he won a post at the University of Malaya, where he worked from May 1978 to March 1981. Here he accomplished much in both teaching and research, publishing several papers, and instituting advanced courses in bryology. A devoted botanist, Monte had high research ideals. Before he left Malaysia, he had prepared a generic moss Flora for the area and luckily this was published, albeit posthumously*. This work will be a permanent memento of his application, ability, and enthusiasm, and will certainly become a standard text in the region at universities.

Monte, a bachelor, had many friends in Malaysia and Singapore, in many fields apart from the academic life. His untimely demise, at the age of 34, has deprived tropical bryology of an exemplary taxonomist, and many of us of a good and gifted friend.

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SOME ASPECTS OF INTERRELATIONSHIPS AMONG THE DRYNARIOID FERNS*

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ABSTRACT

Morphological characters of 15 species belonging to seven genera of drynarioid ferns are presented and their significance relative to their origin, interrelationships, and trend of specialization discussed. Based on morphoanatomical evidence accumulated, two morphological groups of drynarioid ferns are proposed: Drynaria and Aglaomorpha. The attributes considered are: palea, rhizome; vegetative frond including epidermal cells, stomata, hypoderms, mesophyll, venation; fertile frond including sorus, sporangium, and spores; and gametophyte.

Existing knowledge of the formal taxonomy and phylogenetic trends among the drynarioid ferns are compared with this study and the different lines of descent are traced. It is suggested that the drynarioid ferns are probably diphylectic in origin and the trend of evolutionary progression has been towards reduction.

INTRODUCTION

The drynarioid group of ferns is an assemblage of large epiphytes of the Polypodiaceae regarded by most pteridologists as intimately related to each other. As currently understood, they consist of 8 genera (Copeland, 1947) and 37 species (Christensen: 1905–1906, 1917, 1934) throughout their range of distribution. Drynaria includes 20 species (Copeland, 1947; Holttum, 1954; Tindale, 1961) while the other genera are each represented by one or two species in the Indo-Malayan region. Several authors have expressed different opinions on the systematic position of the drynarioid ferns (Christensen, 1938; Ching, 1940; Holttum, 1947, 1954; Copeland, 1947, 1960; Alston 1956; Pichi-Sermolli, 1958, 1959; Mehra, 1961; Nayar, 1970, 1974; Bierhorst, 1971; Wagner, 1973). Recently Crabbe et al. (1975) proposed a different classification in which drynarioid ferns were treated as a subfamily of Polypodiaceae without any further subdivision, while Ching (1978) gave the drynarioid ferns a formal status as a very natural and distinct family-Drynariaceae.

This group is quite different from most other polypodiaceous ferns and is considered as one of the most controversial with regard to their relationships and evolution. The views of Goebel (1928), Copeland (1929, 1947), Christensen (1938), Ching (1940), Holttum (1947, 1954), Nayar (1954, 1955, 1959, 1965), Nayar and Kachroo (1953), Zamora (1975), and Zamora and Vargas (1973 a, b) are varied and are highly susceptible to revision because they are based only on a limited number of species or on selected morphological characters. In view of the controversy regarding the relationship among the drynarioid ferns, the present investigation aims to explain the possible relationship among them and to discuss whether the splitting of the drynarioid ferns into two distinct morphological groups on the basis of morphological attributes is justifiable.

*National Botanical Research Publication No. 121 (N.S.)

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MATERIALS AND METHODS

The present study is based on 15 species of drynarioid ferns (Table 1). Most of the materials used were collected from the fernery of the Natural Science Research Centre, University of the Philippines, Diliman, Quezon City except D. fortunei, D. laurantii, D. propinqua, Pseudodrynaria, and Thayeria, which were studied from herbarium specimens (Table 1).

Since the relationship and classification based on similarities and differences in one organ are unreliable unless supported by the totality of evidence from other parts of the plants, all possible morphological characters have been taken into account in this study. For the convenience of description, all the species are arranged in two morphological groups viz. Drynaria and Aglaomorpha. The Aglaomorpha group includes Drynariopsis, Aglaomorpha, Merinthosorus, Pseudodrynaria, and Thayeria, while the Drynaria group has Drynaria and Photinopteris (Chandra 1979b, 1980).

### TABLE 1. SPECIES STUDIED

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Source of Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drynaria descensa Copel.</td>
<td>U.P., NSRC, Fernery; P.M. Zamora, 73-0408 (PUH)</td>
</tr>
<tr>
<td>D. fortunei J. Sm.</td>
<td>S. Suzuki, PNH 63594; 63605</td>
</tr>
<tr>
<td>D. laurantii (Christ) Hieron</td>
<td>Jean Louis, PNH 29441</td>
</tr>
<tr>
<td>D. propinqua (J. Sm.) Wall.</td>
<td>Cavalerie, PNH 26053; Petelote, PNH 63596; B.K. Nayar, LWG, 74339</td>
</tr>
<tr>
<td>D. quercifolia (L.) J. Sm.</td>
<td>U.P. NSRC, Fernery; S. Chandra, 62(PUH)</td>
</tr>
<tr>
<td>D. rigidula (Sw.) Bedd.</td>
<td>U.P., NSRC Fernery; N.S. Vargas, 72-028 (PUH)</td>
</tr>
<tr>
<td>D. sparsisora (Desv.) Moore</td>
<td>U.P., NSRC, Fernery; S. Chandra, 16 (PUH)</td>
</tr>
<tr>
<td>Photinopteris speciosa (Willd.) Mort.</td>
<td>U.P., NSRC, Fernery; N.S. Vargas, 72-0186, (PUH)</td>
</tr>
<tr>
<td>Drynariopsis heraclea (Kunze) Ching</td>
<td>U.P., NSRC, Fernery, N.S. Vargas, 73-0449 (PUH)</td>
</tr>
<tr>
<td>Pseudodrynaria coronans (Wall.) Ching</td>
<td>S. Chandra, LWG, 94125; Poilana 1382 MICH; Y.W. Taam; 1861 MICH: Thakur Rup Chand; 3988 MICH.</td>
</tr>
<tr>
<td>Aglaomorpha splendens (J. Sm.) Copel.</td>
<td>U.P., NSRC, Fernery; S. Chandra, 48, 105 (PUH).</td>
</tr>
<tr>
<td>A. meyeniana Schott</td>
<td>U.P., NSRC, Fernery; S. Chandra, 109 (PUH).</td>
</tr>
<tr>
<td>A. pilosa (J. Sm.) Copel.</td>
<td>U.P., NSRC, Fernery; S. Chandra, 86 (PUH).</td>
</tr>
<tr>
<td>Merinthosorus drynarioides (Hook.) Copel.</td>
<td>D.F. Grether, PNH 3680; Grether and Wagner, PNH 3973.</td>
</tr>
<tr>
<td>Thayeria cornucopia Copel.</td>
<td>Edano, PNH 8770; Jacobs, PNH 10420.</td>
</tr>
</tbody>
</table>
OBSERVATIONS

Among the Drynaria group there appear to be two independent lines of evolution from the ancestor of the Drynaria group of species where one line gave rise to Drynaria and the other to Photinopteris. Contrary to the observations of Copeland (1947) and Nayar (1965), evolution appears to be in two directions from the Drynaria line (Fig. 2). One line gave rise to D. rigidula and the other to D. quercifolia, independently of one another.

D. rigidula is unique and is quite different from all other species of Drynaria in having: (1) rhizomes with undissected dorsal median vascular strands (as in Photinopteris), (2) stipitate pinnate fronds, (3) small foliar epidermal cells with shallow sinuous walls, (4) small stomata, (5) fewer number of areoles between main veins, (6) prominently impressed sori, (7) stellate paraphyses, and (8) small spores and sporangia. This possibly indicates that D. rigidula represents a line of evolution separate from that of other species of Drynaria but from the same common ancestor. This species, however, shows some similarities with Photinopteris in the following features: (1) undissected dorsal median vascular strand of the rhizome, (2) stipitate pinnate fronds, (3) two-ranked leaf arrangement, (4) small stomata, and (5) smaller sporangia and spores.

All other species of Drynaria have presumably evolved from D. quercifolia in two directions. One line gave rise to D. sparsisora and the other to all other Drynaria species. D. sparsisora exhibits relatively advanced features, viz. (1) thick coriaceous texture of the lamina with cartilaginous margins, (2) vestigial stipe articulation, (3) absence of xylem parenchyma between the tracheids in the meristeles of the rhizome, (4) slightly thickened upper foliar epidermis, (5) laminar hypodermis, (6) small stomata, (7) small upper foliar epidermal cells with shallow undulations, (8) small spores with spinulose exine ornamentation, (9) smaller sporangia (10) slightly reduced fertile fronds with minute sori, and (11) few elongated soral receptacles. This probably indicates that D. sparsisora is comparatively more advanced than D. quercifolia and has possibly evolved from it in a separate line. In contrast to Copeland (whose opinions of 1929 and 1947 are diagrammatically interpreted in fig. 1) this idea confirms the view of Holttum (1954) who considered D. quercifolia to be closer to Drynariopsis than to D. sparsisora. Comparative morphology of the sporophyte suggests that all other Drynarias are presumably evolved from D. quercifolia.

Among all Drynaria studied, D. descensa appears to be a reduced derivative of D. quercifolia which it resembles most (Copeland, 1960). D. descensa exhibits relatively advanced features viz. (1) small stature, (2) small nest leaves, (3) reduced xylem tissue (1-2 layers of tracheids) in the rhizome, (4) absence of xylem parenchyma between the tracheids in the meristeles of the rhizome, (5) paleae with shield-like bases and abruptly narrowed apices, (6) paleal margin with minute dentations, and (7) localized geographical distribution. This supports the contention that D. descensa is a reduced derivative of D. quercifolia and is therefore comparatively more advanced.

Photinopteris is similar to Aglaomorpha in the following features: (1) paleal morphology [A. splendens], (2) reduced fertile fronds, (3) development of coenosori, (4) verrucate areolate spores [A. splendens and A. meyeniana], and (5) small spores [A. pilosa].

Photinopteris is similar to Drynariopsis in the following features: (1) indistinctly clathrate paleae with (2) dentate margins, these (3) with glandular hairs, and (4) presence of foliar hypodermis and hydathodes. Though similar to Aglaomorpha and Drynariopsis in
some respects, *Photinopteris* differs from *Aglaomorpha* and *Drynariopsis* in such features as: (1) two-ranked leaf arrangement, (2) stipitate pinnate fronds (as in *D. rigidula*), (3) undissected dorsal median vascular strand of the rhizome (as in *D. rigidula*), (4) paleae with hairy, dentate margins, (5) club-shaped glandular hairs with waxy cap-like secretions, (6) large epidermal cells with deeply sinuous walls, and (7) low stomatal frequency.

*Photinopteris* is similar to the *Drynaria* group in the following features: (1) paleae with hairy, dentate margins and glandular marginal hairs with waxy cap-like secretions, (2) two alternate rows of fronds on the rhizome, (3) pinnate fronds (as in *D. rigidula*), (4) undissected dorsal median vascular strands of the rhizome (as in *D. rigidula*), (5) large foliar epidermal cells with deeply sinuous walls, and (6) low stomatal frequency. In view of the above, it is here suggested that *Photinopteris* be included in the *Drynaria* group.

*Photinopteris*, however, is comparatively more advanced than *Drynaria* in having: (1) long, wide-creeping rhizomes, (2) small stature with thick coriaceous fronds, (3) dimorphic fronds with reduced fertile laminae, (4) laminae with a hypodermis, hydathodes, and differentiated mesophyll, and (5) small spores with verrucate exine ornamentation. *Photinopteris* has, therefore, evolved separately from the ancestors of *Drynaria* and in a different line of evolution.

This combination of characters possibly indicates that *Photinopteris* is probably evolved independently of *Drynaria* but from the same common ancestor and that its similarities with *Drynaria* (especially with *D. rigidula*) are probably due to paralleled evolution. *D. rigidula* probably branched off from the *Drynaria* line independently of the other *Drynaria* species. In contrast to Copeland (1947) and Nayar (1965), this view appears to support the earlier contention of Holtum (1954) who considered the origin of *Photinopteris* as being more uncertain and pointed out that its origin might have been through *Drynaria*, but in any case not immediately from *Drynariopsis* (Fig. 2).

In view of the two-ranked leaf arrangement characteristic of the *Drynaria* group, undissected dorsal median vascular strand of the rhizomes (as in *D. rigidula*), and stipitate pinnate fronds (as in *D. rigidula*), *Photinopteris* is included in the *Drynaria* group.

*D. rigidula* is quite different from all other species of *Drynaria* in having: (1) rhizomes with undissected dorsal median vascular strands, (2) sclerenchyma strands in the rhizomes, (3) stipitate pinnate fronds, (4) small stomata, (5) stellate foliar hairs, (6) prominently impressed sori, and (7) small sporangia and spores. This possibly indicates that *D. rigidula*, though similar to *D. quercifolia* in spore exine ornamentation, is probably nearer to it and branched off from the *Drynaria* line independently of other *Drynaria* species (Chandra & Zamora, 1979). Thus, *D. rigidula* represents a separate line of evolution from the same common ancestor. This combination of unique features in *D. rigidula* is possibly suggestive of the validity of its separation from *Drynaria* (it constitutes the section *Poronema* J. Sm.).

Among the *Aglaomorpha* group, *Drynariopsis* is considered as the most primitive genus. Thus, from *D. heraclea*, there have possibly evolved three genera of drynarioid ferns naturally similar in many respects, but strikingly different in other aspects. *Pseudodrynaria*, though similar to *Drynaria* in unreduced fertile lamina and spinulose spores, differs from the *Drynaria* group in such features as: (1) one-ranked leaf arrangement, (2) broad humus-collecting leaf bases, (3) invaginated vascular cylinder of the rhizomes, (4) basally attached paleae with non-glandular apices and dentate margins, (5) presence of foliar hydathodes and a hypodermis, (6) elongated irregular coenosori, and (7) gametophytic trichomes. On the other hand, *Pseudodrynaria* is similar to the *Aglaomorpha*
Fig. 1. A schematic representation of the inter-relationship of the drynarioid ferns (E. B. Copeland; 1929, 1947)

Fig. 2. A proposed schematic representation of the probable inter-relationship among the drynarioid ferns.
group in having: (1) uniform fronds with broad humus-collecting bases, (2) one-ranked leaf arrangement, (3) paleae with dentate margins, (4) foliar hydathodes and a hypodermis, (5) similar size of sporangia and spores, and (6) hairy gametophytes. Pseudodrynaria however, shows some advanced features over Drynariopsis viz. (1) tendency to form coenosori, (2) high stomatal frequency, (3) non-glandular apices of the paleae, (4) non-glandular paleal margins, and (5) spinulose spores. Thus, contrary to the observations of Nayar (1965), it is here suggested that probably Pseudodrynaria is more allied to the Aglaomorpha group and is possibly derived from Drynariopsis in a separate line of advancement (Fig. 2).

Another species presumed to have been derived from Drynariopsis is Merinthosorus drynarioides, which is regarded as more specialized than Drynaria because of the differentiation of its fronds into fertile and sterile portions. Based on gametophyte development, Nayar (1965) pointed out that Merinthosorus is not very close to any other drynarioid ferns, but its mature gametophyte is very much like that of Drynaria, Pseudodrynaria, and Microsorium. Merinthosorus however, differs from Drynaria and Microsorium in having: (1) one row of fronds on the rhizome, (2) basally attached paleae, (3) foliar hypodermis and hydathodes, (4) smaller stomata, (5) dimorphic fronds, (6) verrucate spores, and (7) small sporangia. Merinthosorus shows some similarities with Aglaomorpha (A. meyeniana) in having: (1) ribbon-shaped, basally attached paleae with similar dentations and without marginal glandular hairs, and (2) similar fertile fronds, spores, and gametophyte trichomes. These similarities appear to support the contention of Copeland (1947) that Merinthosorus is closely related to Aglaomorpha through A. meyeniana (Fig. 1). The similarity of gametophyte development of Merinthosorus (not found in any other drynarioid ferns) with that of Drynariopsis indicates that it is probably more intimately related to Drynariopsis than to any other drynarioid ferns and is possibly derived directly from Drynariopsis (Chandra, 1979a). Its similarities with Aglaomorpha are probably due to parallel evolution. The study of gametophyte development of Drynariopsis (Chandra 1979a) considerably strengthened the earlier view of Holttum (1954) who considers Merinthosorus to have been derived from Drynariopsis (Fig. 2).

Still another genus thought to have sprung from an ancestor like Drynariopsis is Aglaomorpha. Of the three species of Aglaomorpha, Copeland (1929, 1947) considered A. meyeniana as the source of A. splendens which in turn gave rise to A. pilosa (Fig. 1). A. splendens possesses comparatively primitive features such as: (1) indistinctly clathrate paleae with glandular apices, (2) large foliar epidermal cells with deeply sinuous walls, (3) large stomata, (4) low stomatal frequency, and (5) large sporangia and spores. A. pilosa is, however, comparatively more advanced than A. splendens in having: (1) long, wide-creeping rhizomes where each frond is associated with two branch buds, (2) high stomatal frequency, (3) small stomata, sporangia, and spores, (4) further reduced fertile fronds, and (5) localized distribution. Similarly, A. meyeniana also possesses some comparatively advanced features over A. splendens (i.e. absence of xylem parenchyma between the tracheids of the meristoles in the rhizome, further reduction of the fertile laminae, differentiated palisade, presence of upper and lower hypoderms, verrucate spores, and restricted distribution). This suggests the probability that A. splendens is the source of both A. meyeniana and A. pilosa and that A. meyeniana and A. pilosa evolved independently of each other in a different line of evolution from A splendens (Fig. 2). Thus, the earlier view of Copeland (1929, 1947) that A. meyeniana is the source of A. splendens is refuted.

The genus Thayeria has presumably evolved from A. meyeniana (Figs. 1&2). Above the cornucopia base, the frond and fertile apex of Thayeria are like those of A. meyeniana to which it is most likely related (Copeland, 1929, 1947). Available information strongly
TABLE 2. CHARACTERISTIC FEATURES OF THE TWO GROUPS OF DRYNARIOID FERNS

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Drynaria Group</th>
<th>Aglaomorpha Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Paleae structure</td>
<td>peltate, lanceolate or shield-shaped, marginal glandular hairs with cap-like waxy secretion</td>
<td>peltate or basally attached, lanceolate, shield-shaped, or ribbon-like; Marginal glandular hairs without cap-like waxy secretions</td>
</tr>
<tr>
<td>2. Frond arrangement</td>
<td>fronds in two alternating rows on the dorsal surface of the rhizome</td>
<td>fronds in one row on the dorsal surface of the rhizome</td>
</tr>
<tr>
<td>3. Nest leaves</td>
<td>present except in Photinopteris</td>
<td>absent as a rule</td>
</tr>
<tr>
<td>4. Foliage leaves</td>
<td>stipitate</td>
<td>sessile except in Aglaomorpha pilosa</td>
</tr>
<tr>
<td>5. Foliar hypodermis</td>
<td>absent except in D. sparsisora and Photinopteris</td>
<td>always present</td>
</tr>
<tr>
<td>6. Foliar epidermal cell size</td>
<td>large</td>
<td>smaller</td>
</tr>
<tr>
<td>7. Stomatal size</td>
<td>varies from $29 \mu \times 38 \mu$ to $42 \mu \times 54 \mu$</td>
<td>varies from $27 \mu \times 32 \mu$ to $34 \mu \times 42 \mu$</td>
</tr>
<tr>
<td>8. Stomatal frequency</td>
<td>varies from 38 to 79 per mm</td>
<td>varies from 59 to 140 per mm</td>
</tr>
<tr>
<td>9. Venation Pattern</td>
<td>finely reticulate, free included veinlets found only in a few areoles except in Photinopteris</td>
<td>broadly reticulate, free included veinlets present in all the areoles</td>
</tr>
<tr>
<td>10. Hydathodes</td>
<td>absent on the lamina surface except in Photinopteris</td>
<td>present as a rule</td>
</tr>
<tr>
<td>11. Nectary types</td>
<td>epicostular or hypocostular</td>
<td>always hypocostular</td>
</tr>
<tr>
<td>12. Leaf shape</td>
<td>fertile and sterile alike except in Photinopteris</td>
<td>fertile fronds more contracted than sterile ones except in Drynariopsis and Pseudodrynaria</td>
</tr>
<tr>
<td>13. Sori</td>
<td>usually punctiform throughout the frond except in Photinopteris</td>
<td>coenosoral or acrostichoid, only at the upper portion of frond except in Drynariopsis and Pseudodrynaria</td>
</tr>
<tr>
<td>14. Sporangial size</td>
<td>varies from $200\mu\text{-}400\mu \times 210\mu \text{-}380\mu$</td>
<td>varies from $200\text{-}240 \mu \times 240\text{-}390 \mu$</td>
</tr>
<tr>
<td>15. Spore size</td>
<td>varies from $26\text{-}43 \mu \times 40\text{-}70 \mu$</td>
<td>varies from $26\text{-}36 \mu \times 42\text{-}56 \mu$</td>
</tr>
</tbody>
</table>
indicates that Thayeria is the most advanced among the drynarioid ferns. Thus, dorsiventral creeping, scandent habit, and supressed leaves on the dorsal surface of the rhizome appear to support the above contention and have finally strengthened earlier conclusions (Dickason, 1946; Holttum, 1964; Chandra, 1976) that dorsiventral creeping and a scandent habit is biologically specialized and is more probably a derived one. Other morphological attributes such as: (1) woody rhizomes, (2) paleae with closely spaced, broad, dentate margins, (3) lamina with adaxial and abaxial hypodermises, (4) smallest paleae with non-glandular apices, (5) smallest stomata, (6) highest stomatal frequency, (7) highly specialised humus-forming habit, and (8) reduced fertile portion, also support the above contention.

CONCLUSIONS

During the course of this study I have come across evidence indicating reduction in different parts of several species, i.e. stature, paleae, fronds, epidermal cells, epidermal cell wall undulations, stomata, sporangia, and spores. Thus, it is suggested that one evolutionary trend has been towards reduction. It appears that the Aglaomorpha group represents the advanced group among the drynarioid ferns, in particular A. meyeniana, Merinthosorus, and Thayeria (all of which possess thick adaxial foliar hypodermis and nearly similar fertile laminae) represent the most advanced species among the Aglaomorpha group (Chandra, 1979b).

From the foregoing facts it seems that these morphological attributes are of potential value and may be useful for the assessment of relative specialization and relationships among the drynarioid ferns.

On the basis of the accumulated evidence from comparative studies of the sporophytes and gametophytes, it is concluded that the contrasting combination of distinct characters among the drynarioid ferns supports the establishment of two natural, readily recognizable, and definable morphological groups namely Aglaomorpha and Drynaria (Table 2). It also indicates that the drynarioid ferns are probably diphyletic in origin, i.e. one line representing the Drynaria group and the other line representing the Aglaomorpha group.

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I wish to thank Professor Dr. Prescillano M. Zamora of the Botany Department, University of the Philippines, Diliman, Quezon City, Philippines, for providing constant encouragement and helpful suggestions during the course of this study.

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IN-VITRO POLLEN GERMINATION OF CASSIA FISTULA L.

JENNIFER NG
Botanic Gardens, Singapore

ABSTRACT

The germination of *Cassia fistula* L. pollen, ranging from fresh samples to those stored for various periods, is reported. At the time of writing, the oldest samples studied were stored for 4 weeks. It is intended to extend the observations for longer periods.

INTRODUCTION

Under the research programme at the Botanic Gardens, the author is involved in the crossbreeding of ornamental plants. Among the various projects is an attempt to produce new hybrids of *Cassia*. One of the species used is *Cassia fistula*, the Indian Laburnum, a leguminous tree which has spectacular inflorescences. In connection with this research, it is necessary to study the viability of the pollen, especially when it may have to be stored for varying lengths of time to await the anthesis of flowers of other species.

MATERIALS AND METHOD

1. PREPARATION OF CULTURE MEDIUM

A sucrose-agar medium was made by dissolving agar strips (5 g), sucrose (100 g) and boric acid (0.1 g) in 1 litre of distilled boiling water. The solution was poured into petri dishes which were then packed in aluminium foil, autoclaved, and allowed to set at ambient temperature.

2. COLLECTION AND STORAGE OF POLLEN

*Cassia fistula* has been observed to flower at least once a year, usually after a dry spell. The whole crown is often covered with flowers at the beginning of the flowering season, with sporadic flowering lasting up to 3 months.

Flowers were collected at anthesis, between 8 am and 10 am from 10-12 Nov 1981. On each day, eight flowers were collected from the same tree. Pollen was taken from the three anterior fertile stamens, distinguished by their long and curved filaments (Venkatesh, 1956). This decision was made after a series of viability tests of pollen from each of the ten stamens showed that those taken from the three anterior stamens were viable, whereas the other stamens yielded pollen which proved to be nonviable. Pollen to be tested immediately was sown on agar for germination, the rest were stored in tiny pill capsules. Silica gel was used to keep the vials containing the capsules moisture free. The vials were then stored in a refrigerator at 4°C. Pollen was taken out subsequently for testing: one week, two weeks, and four weeks after storage.

3. ASSESSMENT OF GERMINATION

Germination percentage was used to assess the viability of the pollen. Pollen grains were dusted and smeared evenly on the agar using a fine brush and left to germinate
at room temperature (about 24°C). Although some pollen grains were observed to germinate after half an hour, the assessment was not done until after 24 hours to ensure maximum germination.

The germination percentage was derived in the following manner: For each of the three pollen samples pertaining to a particular storage period, a viability test was done on only one petri dish. Counting was done under a microscope fitted with a grid in the eye-piece. A field was selected in which the pollen grains were not clustered together to facilitate counting. An even distribution in the microscopic field selected for counting generally produces lower variation between samples (Stanley, 1974). When such a field was obtained, the whole field was systematically counted using a tally counter. It was found that each field had between 100-150 pollen grains. A second count was made on only the pollen grains with germinated pollen tubes. The total number of pollen grains observed was then compared to the number with germinated pollen tubes.

RESULTS AND DISCUSSION

Fresh pollen showed the best viability. The average germination was 91.2%. Storing the pollen for one week reduced the average germination by 2.4% (Table 1). The decline was progressive after one week and by the fourth week the average germination was 66.9% (Fig 1).

![Graph showing percentage germination of Cassia fistula pollen stored for various periods.](image)
Pollen germination, *Cassia fistula*

<table>
<thead>
<tr>
<th>Sample</th>
<th>Date of collection</th>
<th>Fresh pollen</th>
<th>Stored pollen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 week</td>
<td>2 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number</td>
<td>% germ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>germinated/Total</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>10 Nov 81</td>
<td>112/118</td>
<td>94.9</td>
</tr>
<tr>
<td>2</td>
<td>11 Nov 81</td>
<td>102/127</td>
<td>80.3</td>
</tr>
<tr>
<td>3</td>
<td>12 Nov 81</td>
<td>130/132</td>
<td>98.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>91.2</td>
<td>88.8</td>
</tr>
</tbody>
</table>

Table 1. *In-vitro* germination percentage of fresh and stored pollen of *Cassia fistula*

It was observed that germination was very rapid. After 3 hours most of the pollen grains had germinated. After 24 hours the pollen tubes had grown to an average length of 0.1 mm (Fig 2). The rapidity and high percentage of fresh pollen germination indicated that the sucrose-agar medium used was suitable for *in-vitro* assays of *Cassia fistula* pollen.

The reasonable germination percentage obtained after four weeks of storage indicated the capacity of the pollen to tolerate the storage conditions provided. The optimum storage factors, like temperature, relative humidity and atmosphere surrounding the pollen, would have to be determined for longer storage periods and better germination potentials.

Fig. 2. *In-vitro* pollen germination of *Cassia fistula* on sucrose-agar (x 109). Note the long pollen tubes.
CONCLUSION

The storage conditions employed in this experiment were adequate in keeping the pollen reasonably viable after 4 weeks of storage.

These findings indicate that even if the other species of Cassia were to be out of phase in flowering by as much as 1 month and possibly longer, stored pollen of Cassia fistula could still be used for crossbreeding work.

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