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Editor
The Gardens' Bulletin
Singapore

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Unravelling *Iguanura* Bl. (Palmae) in Peninsular Malaysia

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Abstract

Based on over four years of field studies, a revision of the palm genus *Iguanura* Bl. in Peninsular Malaysia is presented, listing 16 taxa including seven new species and one new variety.

Preamble: My interest in palms began with the realisation that I knew little about them, whether they were introduced exotics or were local and indigenous or endemic. I decided to learn and investigate firsthand those found within Peninsular Malaysia (initially) and to study them in their natural habitat wherever possible, and also to research on available information in the herbaria with emphasis on the genera *Iguanura, Pinanga* and *Areca*. The rediscovery of historical or forgotten species has been both rewarding and exciting, as was the encounter with those that were evidently new. With other team members of the privately sponsored project called Palm Search Malaysia, we were encouraged at an early stage by the fortuitous discovery in N. Perak of a new species, *Areca tunku*, which I published jointly with John Dransfield who had also found the new taxon in Sumatra and in Peninsular Malaysia (see Principes 36 (2), 1992: 79-83). The result of the field work begun in 1989 has provided the essential basis for the revision of *Iguanura* within Peninsular Malaysia. As the genus also occurs in other parts of S.E. Asia, the revision will undoubtedly be interim, and will need to be followed up by broader regional studies and comparisons. Nevertheless existing documentation and taxonomic accounts of the Malayan flora require correction, unscrambling or unravelling, in the light of fresh data and of new species and varieties.

Chronology

The genus *Iguanura* was first described by Blume in 1838 based on the specimen he named *I. leucocarpa* which had been collected in Sumatra by Korthals and others. The earliest species found in Peninsular Malaysia was from Penang Island, collected by Porter in 1822 which featured in Wallich’s catalogue of 1828, and was published by Martius as *Areca wallichiana* in 1837; it was subsequently reidentified much later in 1883 by J.D. Hooker as *I. wallichiana*. Among other early palms collected in the Malacca area around 1841 was *Slackia geonomaefornis* which Griffith published in 1844; his material had also been seen by Martius who described it as *I. geonomaefornis* Griff. ex Mart. in 1849, placing it under Blume’s new genus.

In 1886, Beccari began his monumental publication on Asiatic Palms (Malesia
III) describing his Bornean discoveries, also adding notes on *I. wallichiana*, using Wallich’s specimens in the Munich Herbarium. He also claimed a new species, *I. malaccensis*, based on Kehding’s collection of 1878 from Klang; which is arguably synonymous with *I. geonomiformis* (as per the revised spelling).

Within the section of Malesia III, dated August 1889, Beccari provided further important accounts based on material supplied by Dr King of Calcutta which had been collected by Kunstler in Perak, and by Father Scortechini, who had died of dysentery in Calcutta in November 1886. The new species published were *I. corniculata* (collected by Kunstler from Selama), *I. bicornis* (by Scortechini from Gunung Ijuk), *I. polymorpha* and its variety *canina* (also by Scortechini, from Perak), as well as numerous taxa from other genera.

In 1892, J.D. Hooker published “Flora of British India”, describing Beccari as the precedent co-author for the section on Palmae, incorporating his manuscript data on new *Iguanura* taxa, including *I. wallichiana* v. *major*, *I. wallichiana* v. *minor*, *I. diffusa* (collected by Scortechini from “Gunong Tjok”) and *I. parvula* (collected by Scortechini from Perak), hinting however that the last might be a “very small form of *I. polymorpha*”.

In 1903, H.N. Ridley cited two new species, *I. ferruginea* and *I. spectabilis*, the latter being the spectacular large entire-leafed form found in the G. Bubu area, which had apparently been preceded by Dr Masters who had exhibited and published it in 1898 as a botanical exotic called *Geonoma Pynaertiana*. However, the syntypes for *I. wallichiana* var. *major* are clearly similar to this, and Masters’ species and *I. spectabilis* are consequently reduced to synonyms of the latter. In “Materials for a Flora of the Malay Peninsula” published in 1907, Ridley listed other historical taxa of *Iguanura*, but included *I. diffusa* and *I. parvula* as synonyms of *I. wallichiana*, and *I. brevipes* under *I. polymorpha*. Perplexed by fresh collections of *I. geonomiformis* and the variations in leaf division and inflorescence rachilla, he added to *I. geonomiformis* var. *typica*, *I. geonomiformis* sub. var. *ramosa* and *I. geonomiformis* var. *malaccensis* (which he had cited in 1903). Within this revision these will be treated as forms of *I. geonomiformis*.

The sequel to “Materials” was Ridley’s “Flora of the Malay Peninsula”, published in 1925, which contained several editorial and textual inconsistencies within the Palmae section, including the description of *Licuala ferruginea* in place of its *Iguanura* namesake (correct in the 1907 publication), as first pointed out by Whitmore (1973 endnote 78).

The syntypes of *I. ferruginea* came from different locations, displaying variations in inflorescence, but Ridley’s citation positively identifies characters that are found in *I. polymorpha* Becc. and its var. *canina* in particular. Furriness on which it was distinguished is in fact quite common within the genus and is not necessarily a reliable differentiation for taxonomic purposes.
Plate 1 *I. wallichiana var. major*: Watercolour by Charles De Alwis titled "Iguanura spectabilis Ridley" (by courtesy of National Parks Board and Singapore Botanic Gardens)
Plate 2 *I. geonomiformis*: Watercolour by Charles De Alwis titled "*Iguanura geonomiformis*" (by courtesy of National Parks Board and Singapore Botanic Gardens)
Ridley had also collected a specimen from Ara Kuda in Province Wellesley, Penang, which he labelled “Pinanga canina Becc.”, probably on account of the fruit shape, although none is on the herbarium sample itself. In 1934, Furtado published this as a new species, I. arakudensis, characterised by the broad apical leaflets. Earlier taxonomic attempts to use variations in leaf shape and form as determinants were then undoubtedly part of a learning curve. As the type location has since been turned into rubber and oil palm plantations, the species was deemed extinct (Whitmore 1973), indeed our own field searches have proved abortive. However, other equivalent low-lying terrain in north Malaysia has yielded enough specimens to indicate that Furtado’s taxon with its three-branched inflorescence is, like I. ferruginea, a form of I. polymorpha.

In 1973 Whitmore published “Palms of Malaya”, intending it to be a popular guide to the flora, then much misunderstood or unknown. It was a remarkable work, produced apparently in between more serious work and forestry duties. It is still the key introduction and reference for many, and provides a clear overview of the Iguanura (and other) taxa. He revives the identity of I. diffusa, I. parvula, I. brevipes and I. arakudensis (which he has suggested might be extinct), and reaffirms I. wallichiana, I. geonomiformis, I. corniculata, I. bicornis and I. polymorpha. In his earlier “Taxonomic Notes” (Principes 1970, Vol. 14: 124) he has contradicted Ridley and held that I. brevipes was distinct from I. polymorpha on the basis of the crownshaft and its interfoliar as against the infrafoliar inflorescence of the latter. Whitmore however realised and suggested more field specimens were needed for fuller determination of the I. polymorpha complex. J.D. Hooker’s type for I. brevipes collected from Bukit Larut from the same vicinity as I. bicornis had no fruit, and its habit, whether solitary or clustering, was not described. Subsequent herbarium specimens described as I. brevipes (by Furtado, Whitmore and others) are in my view not at all certain, and are more likely to be I. polymorpha or I. bicornis.

Whitmore himself and his colleagues collected strenuously and made substantial deposits of palm specimens at the Kepong herbarium; his field coverage and notes have significantly extended postwar botanical investigations. He rediscovered I. diffusa in Taman Negara; although it has not been seen in the original type location in Perak, the Pahang form appears to fit the description by Beccari, per J.D. Hooker.

In 1976, Ruth Kiew (née Evans) published the first major revision of the genus, covering the entire known range, including Thailand, Sumatra, Malaya and Borneo (Gardens Bulletin Vol. 28: 191-230). As an extension of her doctoral interest in the genus, the revision itself “was based on one year’s field work in Malaya and one month’s field work in Sarawak, in addition to the study of herbarium specimens”. She lists for the region a total of 16 species including four new Bornean ones that she has determined, with further taxa at the rank of subspecies and variety. Later, she added two further new species described from
Sarawak (Kew Bulletin 1978 Vol. 34: 143, 144) with supplementary notes on Malayan taxa also found in Thailand. For Peninsular Malaysia, she reduces the spectrum to four species: *I. bicornis*, *I. corniculata*, *I. polymorpha* and *I. wallichiana*, with two subspecies for the last: ssp. *wallichiana* and ssp. *malaccensis*, each with two or three varieties respectively, totalling eight taxa at various ranks, including two new varieties.

Kiew’s revision separates the Malayan taxa on the basis of leaf abscission or marcescence, and of leaflet shape; her “trapezoidal” section lists the first three species mentioned above. She errs however by including *I. arakudensis* within *I. bicornis*, whereas it should be regarded as a form of *I. polymorpha*, under which she includes the var. *canina*, *I. brevipes*, *I. ferruginea* and also, erroneously, *I. parvula*. In summary, she places all forms with parallel-sided leaflets, or with entire leaves, within the *I. wallichiana* complex, creating two subspecies, with synonymy as follows:-

1.1 *I. wallichiana* (Wall. ex. Mart.) J.D. Hooker ssp. *wallichiana* var.*wallichiana*  
    (synon.: *Areca wallichiana* Wall. ex. Mart., *I. diffusa* Becc., *I. wallichiana* var. *minor* Becc. in. J.D. Hooker)

1.2 *I. wallichiana* ssp. *wallichiana* var. *major* (Becc. in J.D. Hooker ) Kiew  
    (synon.: *I. wallichiana* var. *major* Becc. in J.D. Hooker, *Geonoma pynaertiana* Masters, *I. spectabilis* Ridley)

2.1 *I. wallichiana* ssp. *malaccensis* (Becc.) Kiew var. *malaccensis*  

2.2 *I. wallichiana* ssp. *malaccensis* var. *humilis* Kiew

2.3 *I. wallichiana* ssp. *malaccensis* var. *elatior* Kiew.

Kiew attempted to localise her *I. wallichiana* taxa into an elegant distribution pattern within the map of the Peninsula, which cannot but be outdated by evidence from more collections and further field samplings. For example her ssp. *malaccensis* can be found more northerly well into Perak and Kelantan.

The basis for Kiew’s preference for Beccari’s *malaccensis* as against the Griffith-Martius *geonomiformis* was that she believed Beccari was first to correctly identify the characteristic spicate inflorescence, whereas Griffith and Martius included “branched” inflorescence - which rendered their earlier accounts synonymous with Martius’ own *Areca wallichiana*. However, the illustrations of *I. geonomiformis* within Martius and Griffith (q.v.) are quite indicative and show bi-
furcating and tri-furcating inflorescences, which are usual variations of the spicate form commonly seen. These forms are quite unlike the divaricate, paniculate branching of *I. wallichiana* and its allies.

In addition to herbarium reference and historical research, the field observations and new collections within the Palm Search programme lead to a rather different scenario from Kiew’s overview of the *I. wallichiana* complex. Working quite independently, but greatly benefitting from her published work and friendly communications, I propose to revise and update her listing as follows:

1.1 *I. wallichiana* (Wall. ex. Mart.) J.D. Hooker var. *wallichiana*  

1.2 *I. wallichiana* var. *major* Becc. in J.D. Hooker  
(synon.: *Geonoma pynaertiana* Masters. *I. spectabilis* Ridley, *I. wallichiana* ssp. *wallichiana* var. *major* (Becc. in J.D. Hooker) Kiew);

1.3 *I. wallichiana* var. *rosea* C.K. Lim var. *nov*.

1.4 *I. diffusa* Becc. ex. J.D. Hooker

1.5 *I. asli* C.K. Lim sp. *nov*.

1.6 *I. kelantanensis* C.K. Lim sp. *nov*.

1.7 *I. piahensis* C.K. Lim sp. *nov*.

2.1 *I. geonomiformis* (Griff.) Mart.  

2.2 *I. humilis* (Kiew) C.K. Lim stat. *nov*.

(synon.: *I. wallichiana* ssp. *malaccensis* var. *humilis* Kiew)

It might be mentioned at this juncture that the range of variations and forms within the *wallichiana* and *geonomiformis* groups gives scope for further field investigations. Kiew’s var. elatior remains tantalising, but seems to be similar to certain other widely distributed forms of *I. geonomiformis*. There are indeed other robust forms of the taxon to be seen in G. Bintang and in Negeri Sembilan: the latter might well be the epicentre on the basis of size. *I. humilis* deserves its new status, as was indeed suggested by Furtado on Corner’s specimen; and although other forms of *I. geonomiformis* can have precocious inflorescences at the
acaulescent stage, they are usually clustering, whereas the new taxon is solitary with a short stem. Our field observations reveal certain other “grey” areas between the two groups or within each, but this has been seen mainly in particular locations (Pahang, Kelantan and Terengganu). In the more well-known collecting areas the distinctions seem evident enough to justify maintaining the historical (and convenient) separation of *I. wallichiana* from *I. geonomiformis*.

The field strategy has obviously been to check on or to get close to type locations, and to corroborate against type specimens. *I. wallichiana* (var. *wallichiana*) can still be found on Penang Hill, but in diminishing stands. *I. geonomiformis* is probably extinct at Ayer Panas, but is not uncommon within the Malacca area. *I. diffusa* has yet to be found in the G. Ijok (or G. Hijau?) vicinity, but the Taman Negara form (or its look-alike) is quite accessible and distinctive.

Within the *I. wallichiana* complex, Ridley’s *I. spectabilis* would have been a wonderful name, which would have been subsumed into “*I. pyraertiana*”. However, as mentioned above, they are both synonymous with Beccari’s *I. wallichiana* var. *major*, the distinctive taxon with erect inflorescence and large entire leaves, as seen on G. Bubu. Other forms (eg. *I. wallichiana* var. *minor*) can be readily differentiated from this variety in the field, and are included under *I. wallichiana* var. *wallichiana*.

I propose to recognise a new variety, *I. wallichiana* var. *rosea*, firmly on its distinctive fruit colour, which is pink from the start, ripening red, as found in two particular locations in Perak and Kelantan. Fruit colour difference as a positive character is also found in the new species to be named *I. asli*, which is quite widespread within *I. geonomiformis* (Kiew’s var. elatior) territory, from eastern Johor to Pahang and Terengganu, which similarly has immature pink fruit turning candy pink (rather than cerise red), somewhat rivalling adjacent populations of *Licuala ferruginea* in colour and splendour. The inflorescence is interfoliar, with curled rachillae, and short peduncles within the sheaths.

*I. kelantanensis* is likely to be more widespread but has so far been seen only in its type locality within the named state. It is acaulescent, and solitary, with variable branching inflorescence, usually having short peduncles.

Another new species, which has so far been seen only in a particular area and is thereby named *I. piahensis*, has a particular distinguishing characteristic that may intrigue the student of dried leaves (as on herbarium sheets) - its fine texture, papery and silky to the touch. Furthermore, the leaf shapes are distinguishable from others of the *wallichiana/geonomiformis* complex: the entire forms are unusually long and parallel-sided. The lobed forms can also be identified, with some comparative practice. Its inflorescence is branching, usually fine and modest, similar to some collections of “*I. wallichiana* var. *minor*”, which however has standard *wallichiana* type leaves.
The rediscovery of Beccari’s diminutive *I. parvula* was indeed the providential highlight of our field journeys. Apart from Whitmore’s steadfast belief, it had been regarded either as an aberrant or immature aspect of *I. polymorpha* or of *I. wallichiana* (per Ridley). Some strange magnetism led us to stray into its remnant (and threatened) habitat in Kedah, in rather unlikely circumstances, to find among logging debris this highly distinctive clustering palmlet, then “new” to us. A month earlier, I had made a series of photographs of Beccari’s type specimen without attaching importance to its species status, and was therefore able to make a clear identification. Beccari was indeed so right in his descriptions. Although the type location was elsewhere in neighbouring Perak, it does not seem to have been collected there since. However, I subsequently located a fine specimen in the Singapore Herbarium collected also from Kedah by Haniff (SFN 21104) in 1928, which had been filed under *I. polymorpha* despite Furtado’s correct determination.

The other two unmistakable Beccari species are of course *I. bicornis* and *I. corniculata*, which, as might be said, require no introduction - after the full description in Malesia III. The former is relatively common, but has so far not been found other than in Kedah and Perak, and usually on high ground above 500m. Our field observations show a range in size and stature from small clumps not taller than 1m to robust ones reaching over 3m. The largest of the fully ripe bigibbous fruit that we have encountered measure 2cm across, and are luscious and sweet, as all *Iguanura* drupes should be. *I. corniculata* is a different proposition in terms of its survival. Because of the fine type specimens made by King’s collector, Kunstler, from Selama, Perak in 1881, it had remained listed as hopefully extant but probably extinct, and as mentioned by Kiew and others, it had not been seen or collected since, i.e. within the last 100 years or so. I would be inclined to treat as suspect the specimen collected by Henderson from near Raub, which he himself considered to be *I. ferruginea*. Several forays into the Selama localities have been abortive, and the prospect of discovery there seems dismal as logging and plantation expansion is extensive, especially in the altitude range of 100-150m. I finally found the elusive taxon during the most recent stages of field work - not in Perak, but in its adjacent state - providentially indeed to rediscover *I. corniculata* within Penang boundaries, after failing to resurrect *I. arakudensis*!

Beccari’s type specimen of *I. polymorpha* and its var. *canina* were apparently collected on Bukit Larut, which was also the type locality for *I. bicornis* and for J.D. Hooker’s *I. brevipes* - all from altitudes above 1000m. Ridley’s *I. ferruginea* syntypes were from two locations. Later collections by Ridley and others came from various places, Perak to Kedah and Kelantan; several were from low altitude areas, for example, Furtado’s *I. arakudensis*, from Province Wellesley. The cited lectotype for *I. ferruginea* (Fox 10684) had a stout 10-branched inflorescence and is clearly synonymous with *I. polymorpha*. The other syntype seemed different, with 2 rachillae but with the characteristic curved fruit. The taxon is variable in its rachillae, often trident, sometimes with 1 or 2 branches, (suggesting a link with *I.
From our own field collections and other herbarium specimens we have noticed that sterile specimens of *I. bicornis* and *I. polymorpha* have sometimes been confused. Indeed *I. brevipes* might have been based on a *bicornis* specimen. With regard to the inter/intrafoliar distinctions set out by Hooker (and later espoused by Whitmore), Kiew has elucidated on this, pointing out the consequences of variable abscission conditions. Our own observations are on similar lines, as all taxa in the “trapezoidal” group can be seen with inter and/or infrafoliar inflorescence with the obvious conclusion that the peduncle was able to hold laden fruit before or after leaf fall, even if some heavier ones would be more “comfortable” while being interfoliar. Besides, the conditions for abscission would be different for clustering, as from solitary forms of growth.

Returning to the *I. polymorpha* complex, the scenario initially seemed to suggest the existence of 4 taxa: *I. polymorpha* (with ovoid, not curved fruit), *I. polymorpha* var. *canina* (with distinctly curved fruit), and *I. ferruginea/arakudensis* (also with curved fruit) for lower altitude forms (all clustering and not solitary). Although we have not yet seen live populations of *I. polymorpha* or its allies on Bukit Larut, we have observed interesting counterparts on Cameron Highlands, where a range of variation in leaf divisions can be seen. There, within particular colonies, the fruit shapes vary from globose to ovoid and curved, with seeds thicker than for *I. ferruginea* forms. The lowland variant is found all over Perak, Kelantan, Terengganu and Pahang, and is the most commonly encountered form.

Our own relatively recent collections from upper Perak, in the vicinity of Terunok (according to Ridley and Whitmore the local word for *Iguanura*, and perhaps for this particular taxon itself), have broadened our concept of *I. polymorpha*. As against the 2-2.5m clumps that we had seen elsewhere, we were astonished by the robust 3-3.5m stems, with leaves twice as large (as elsewhere) and an amazing variety of inflorescence form, from two to nine branches, the last sub-branching to 16 or more. Some rachillae were over 75cm in length, inclusive of the broad (1.5cm) peduncles, borne infraloliar or interfoliar. On some rachillae we counted over 95 buds; the immature fruit were typically curved and irregular in its process of distention. The altitude was c.300m, with more colonies likely higher up or lower (now under water level because of damming). The evidence seems incontrovertible that we are faced with a single main taxon of *I. polymorpha*. *I. polymorpha* var. *canina*, *I. brevipes*, *I. ferruginea*, and *I. arakudensis* should thus be regarded as synonyms. Beccari’s taxon is indeed polymorphic.

Again within Perak, we have found two new members of the “trapezoidal” complex, the first solitary in habit identified in 1989, which we then decided to name *I. belumensis*, after its location. Later we came across herbarium specimens of the same or a similar taxon, originating from Bujang Melaka and G. Bubu, labelled as *I. polymorpha*. The other new species is exceedingly rare and highly endangered: over many trips we have yet to find more than ten plants in its only known location. It is a 4m tall, solitary, (occasionally with basal branches) giant
Iguanura, with two forms of leaf divisions, twice as large in size as the sympatric *I. bicorns* neighbours. It is to be called *I. perdana*.

The underlying paradigm behind the Palm Search project has been to seek in the field as widely and repeatedly as possible, in parallel with herbarium research work. Our original purpose was to learn about existing, known taxa and their conditions of endangerment. To alight upon a new species is surely an act of providence, especially in unsuspecting circumstances, but it has undoubtedly given fuller impetus to persistent botanical effort.

The ultimate new taxon among Peninsular *Iguanura* was stumbled upon in a chance sidetrip from a main botanical field expedition. In a sense it is not “new”, in that countless locals and foresters would have known it, and as it happens, a juvenile specimen had been collected and emplaced within the Kew Herbarium, awaiting determination, as we subsequently learnt. The new species to be called *I. mirabilis* is caespitose and has strongly plicate entire leaves and curved fruit, and although unlike the “trapezoidal” members, it also falls within the abscessing group. Affinities with the Sarawak taxa, especially *I. elegans* and *I. sanderiana*, are suggested, but the new taxon is clearly on its own within the genus.

With regard to local names for *Iguanura*, Ridley (1903) had recorded that the striking palm he called *I. spectabilis* was known to the (local) Malays as “Teruno” (Tronoh, Terunoh, Terunok), a name now unfamiliar to most. Griffith earlier noted that the *I. geonomiformis* was called “Pinang Rambeh”, to which Ridley added “Pinang Sapadan”, further noting that “Pinang Pachat”, “Pinang Burong Tikus” and “Pinang K’lasak”, were used for *I. wallichiana*. According to Kiew, the latter is called “Terunok” in Kelantan. In north Perak, along the river, there is a place called Terunoh, probably a village now obscure or vanished under water. In that vicinity, robust forms of *I. polymorpha* abound and it might be conjectured that the word, clearly botanical, applied historically to this particular taxon. Burkill (1935) quotes and extends Ridley’s list, and noted that *I. corniculata* was called “Pinang Angin”. In his reference however, “Terunok” was misprinted as “Termoh”. Many local names might have been ad hoc concoctions. Generally there has been a decline in specificity in knowledge of traditional names for plants. Most understorey palms including the *Iguanura* and the ubiquitous *Pinanga malaiana* (known as “Legong”) are loosely now referred to as “Pinang”. The Temiar (Senoi) folk are however still in command of their botanical names, also for the palms (including rattans) within their traditional domain. They call the *Iguanura wallichiana* alliance “Boq”, but do not use this for the *polymorpha* forms not known to them. With more anthropological research, other aboriginal names will be reidentified, as used by the Semai and others.

Many of the *Iguanura* taxa may be considered endemic to the Peninsula, although territorial boundaries are in fact arbitrary from a botanical point of view: South Thailand, for example, is indeed part of the same bio-domain, unlike Sarawak
and Sabah, which are placed in a separate botanical division, although within the same nation. Knowledge of the confines of a taxon depends on the extent of the collections and will be modified by further field surveys; for example, *I. parvula* and the new species *I. behunensis* may well be found in South Thailand, where *I. polymorpha* and *I. wallichiana* abound.

Our unravelling of *Iguanura* in Peninsular Malaysia is intended to provide a useful framework for a fuller regional taxonomy of the whole genus. Further field work will undoubtedly yield fresh data and refinements or shifts in perceptions, but the next priorities lie in widening the territorial scope to include Thailand and Sumatra, our immediate floristic bio-domain, and then Borneo, in particular Sarawak, where other exciting species of *Iguanura* are to be found, surprisingly different from the Peninsular forms. Contrary to earlier suggestions (Kiew et alia), preliminary observations already suggest that none of the Malayan taxa are to be found in Sarawak.

*Iguanura Bl. (Palmae)*


Blume first described the genus in 1838 with *I. leucocarpa* collected from Sumatra as his type species. *Slackia* of Griffith, exemplified by *S. geonomiformis* published in 1844 is thus a synonym of the genus. Full citations have been listed in Kiew (1976), and most recently by Uhl and Dransfield (Genera Palmarum: 421-423, fig. 133. 1987). These include similar taxonomic accounts, and Uhl and Dransfield have classified the genus within the tribe *Iguanurinae* J.D. Hooker in Bentham and J.D. Hooker, under the sub-family of *Arecoïdeae*.

The present revision is confined to taxa found in Malaya, and will contribute fresh data on new species and varieties, with more emphasis on field characters and information, but less on herbarium research requiring laboratory and microscope work, eg. on floral, pollen or DNA examinations, which require fuller samplings and remain largely unstudied, giving scope for further inputs.

Blume’s type species, *I. leucocarpa*, is of the form with trapezoidal leaflets, ie. similar to the polymorpha complex, with cleanly abscissing leaves, but the genus now includes other entire-leafed, marcescent forms. It is not certain whether or not *I. leucocarpa* was solitary in habit, but Kiew’s account confirms that the fruit was olive-shaped, the inflorescence was spicate, seeds “not ribbed or ridged”, the drupes were white in colour (per the epithet, when unripe). So far no Peninsular taxa have these seed features. Presumably from examination of the type specimens at Leiden and Bogor, she noted that the anthers were lobed, a character that she
has recognised and confirmed also for certain Sarawak species (I. sanderiiana, I. ambigua and I. remotiflora), and by implication suggesting that all other species had anthers not lobed. This may need to be rechecked with more samplings. It might be suggested however, that anther lobes may tend to crenulate in drying, and therefore examination of fresh material may be essential.

For purposes of this revision I have examined the Iguanura collections in Calcutta, Florence, Kepong, Kew and Singapore, and also at UPM, Kuching and Sandakan. Unless otherwise indicated, all specimens quoted have been viewed. This has complemented the substantial field data and our own collections, providing the basis for determinations and for recording distribution of the taxa. Many of the herbarium specimens, both historical and recent, need to be verified; indeed, a major updated checklist correlating specimens in Calcutta, Florence, Kew and Singapore needs to be made, which will also be interesting for botanical history. Pending this, and to avoid perpetuating existing discrepancies. I allude mainly to types and syntypes for the revised taxa and their synonyms, and to limited selected specimens, listed under Reference Collections, including those in the Palm Search Malaysia herbarium (designated here as PSM).

Within its natural habitat, Iguanura is arguably the most attractive of understorey palms and is easily recognisable by its leaf shapes and forms, with their distinctive praeemorse margins, and the red or bronze flush seen in new leaves. At bifid seedling stages, all taxa are practically identical. With some experience, however, the eophylls and juvenile leaves of the two main groups - the marcescent wallichiana-geonomiformis complex and the abscissing trapezoidal alliance - can be differentiated, the latter being darker green and more oblong. I. mirabilis is particularly distinct in its discernibly plicate leaves. Historically, botanists have dwelt on leaf divisions, shapes and sizes, petiole lengths etc. as determinants. For most taxa, we must now recognise a wider range of variations. Leaf forms may be entire or divided; the division may conveniently be described as lobed or pinnate. Certain species when mature continue to have undivided bifid leaves, which vary in shape from cuneate to oval and oblong, all with the characteristic apical cleft. They also vary in size from the diminutive 20cm long I. parvula to the 2m or longer gigantic blades of I. wallichiana var. major. Large bifid leaves tend to have short petioles for structural reasons.

Leaf divisions described as lobed, are those split into broad leaflets, with two to five pairs (or more), opposite, alternate or irregular: the leaflets may be spaced closely (with short rachial lengths between) or more distantly. The more common leaf division is the pinnate form with many pairs of narrow parallel-sided leaflets, opposite or alternate, but usually with broader apical leaflets. An extreme form of division can be seen in I. diffusa, where unicostate leaflets (including apical ones) have been found. Both for I. wallichiana and for I. geonomiformis and their allies, the lamina can vary from entire to lobed and pinnate, within the same colony, and sometimes on the same plant.
Leaf sheaths are either fibrous and persistent (i.e. marcescent), or self-peeling and abscissing; this differentiation is important, as was well appreciated by Kiew; and obviously has a bearing on the nodal scars on the stems and the internodal dimension. Apart from the entire-leaved *I. parvula* and *I. mirabilis*, others with abscissing leaves are those that divide (after the juvenile stage) into trapezoidal leaflets, closely or more widely spaced along the rachis, opposite or alternate, sometimes quite irregular in leaflet widths (as in *I. polymorpha*). The leaflets which flare distally are like butterflies in shape, but there are great variations, sometimes not rhomboid but almost triangular. Again, the leaf divisions may be lobed or pinnate, with two to twelve pairs of leaflets. The apical pair are usually broad and multi-costate; the tip angles can vary from acute to right-angled or obtuse.

Herbarium specimens, being desiccated, usually fail to convey the texture and relative thickness of lamina and other parts observed in the forest. Although there are broad variations, especially between juvenile and older leaves, certain taxa have a distinctive sheen and tactile quality on their leaf surfaces, as with *I. parvula* and *I. piahensis*, where the silky texture can be relied upon for field identification. Prominence of nerves and the leaf fold is also characteristic in the case of *I. mirabilis*, which has other obvious features. Colour is also lost on herbarium sheets, though botanists have tried to describe the hue after drying. Tomentosity and glaucosity are often obscured. Indumentum is usually well preserved, but this character is often variable and found in most taxa, on the sheaths and rachis, leaf nerves and inflorescence.

All *Iguanura* are stilt-rooted. Some are caespitose and clustering, others are solitary, but occasionally with basal branches. Stems vary from the arudinaceous to the robust, eg, *I. parvula* (5mm in diameter, 1m in height) and *I. wallichiana var. major* (2cm in diameter, up to 4m or more in height), respectively. Basal branches may produce precocious fruiting at low level, especially when the main stems have been destroyed. Caespitose taxa may also appear to be solitary before basal branching develops (as is often seen in *I. geonomiformis*).

Inflorescences spring from within the leaf sheaths, usually interfoliar, but for abscissing forms, they can also develop in an infrafoliar position. The peduncles can be long and extended (sometimes erect, as with *I. wallichiana var. major*), or short and enclosed within the sheaths. The inflorescence may be spicate or divaricately paniculate, (varying in robustness from stout and “succulent” to fine and “twiggy”), the latter sometimes branching to second or third orders. The spicate forms (*I. geonomiformis* complex) may split or “furcate” into two to seven parallel tails (sometimes sub-branching), but unlike the paniculate forms, the rachillae are not divaricate (as in *I. wallichiana* and its allies). As a convenient gauge of relative inflorescence size, that of the ubiquitous *I. wallichiana* is often 90cm long (including a 65cm peduncle); and of *I. geonomiformis*, 80cm long.
Floral characteristics include the deeply sunken triads within the rachilla, spirally disposed. Kiew (1976) gives a full account of the details, indicating that "the male and female flowers are uniform throughout the genus. except for the lobing of the anther" (ibid. 199). There are of course variations in sizes and colours of flowers, but these have not been examined within this revision, in the absence of adequate samplings, and also because of our field-based emphasis. Anther lobes have not been observed in Peninsular Malaysian taxa, and is a character more pertinent to those in Borneo, as also the ridged or ribbed seed forms found there. We have also not examined systematically the seed endosperm for the variations in homogeneity, whether ruminate or equable; this can be the subject for further study. For present purposes, fruit shape is adequately indicative, and the basal stylar remains on Iguamura fruit is indeed the unmistakable feature of the genus. The fruit develops eccentrically, and may be globose, ovoid, olive-shaped, oblong and bigibbous (I. bicorne), or "canine", curved (I. polymorpha), and hooked (I. corniculata). Fruit sizes vary; those described as large would be near 2cm in diameter, the average being 1.2cm and the small, 8mm.

The pericarp forms like a mould within which the endosperm solidifies relatively later after the drupe assumes its shape. The endocarp then swells to sweet, luscious fullness. It is important to note the fruit colour. Commonly, young fruit is white turning cream or orange, then ripening cerise to crimson red (eventually black). In some taxa the drupes are light green turning yellow to orange and red, as in I. parvula and I. piahiensis. There also appear to be distinct forms that have pink (not white) fruit turning bright candy pink and dark red, consistently seen in particular populations, a determining character which I propose to recognise.

The revised list of 16 taxa has been arranged not alphabetically or chronologically, but by similarity, which I believe to be convenient for ease of comprehension. Its accompanying key is based on simple field characters that facilitate identification, without laboratory equipment. Generally, descriptions, notes on colours, textures etc., are based on live and not on dried specimens. From field surveys of extant Iguamura populations. I have also given weight to location and distinctive characters (eg. habit and fruit colour) which are not seen as intermediary forms in other areas. Accurate collection notes on these would be essential for future herbarium identification, and adequate samplings from populations would be desirable.

In summary, the key adopts the following main features and differentiations: leaves marcescent or abscissing; habit caespitose or solitary; leaves entire or divided (lobed or pinnate), leaflets parallel-sided or trapezoidal; texture of lamina; inflorescence spicate (splitting or "furcating") or paniculate (branching divaricately, sub-branching); fruit shape globose, ovoid, curved, hooked, or oblong and bigibbous: fruit colour (within location confines).
Revised List of *Iguanura* in Peninsular Malaysia

16 taxa, including seven new species and one new variety, and their synonyms

1. *Iguanura wallichiana* (Wall. ex Mart.) J.D. Hooker var. *wallichiana*
   synonyms: Areca wallichiana Wall. ex. Mart.
   *I. wallichiana* var. *minor* Becc. in J.D. Hooker
   *I. wallichiana* (Wall.ex.Mart.)J.D.Hooker ssp. *wallichiana* var. *wallichiana* Kiew

2. *Iguanura wallichiana* var. *major* Becc. in J.D. Hooker
   synonyms: Geonoma pynaertiana Masters
   *I. spectabilis* Ridley
   *I. wallichiana* ssp. *wallichiana* var. *major* (Becc. in J.D. Hooker)
   Kiew synon. nov.

3. *Iguanura wallichiana* var. *rosea* C.K. Lim var. nov.

4. *Iguanura diffusa* Becc. in J.D. Hooker

5. *Iguanura asli* C.K. Lim sp. nov.

6. *Iguanura kelantanensis* C.K. Lim sp. nov.

7. *Iguanura piahensis* C.K. Lim sp. nov.

8. *Iguanura geonomiformis* (Griff.) Mart.
   synonyms: Slackia geonomiformis Griff.
   *I. malaccensis* Becc.
   *I. geonomiformis* var. *malaccensis* (Becc.) Ridley
   *I. geonomiformis* sub. var. *ramosa* Ridley
   *I. wallichiana* ssp. *malaccensis* var. *malaccensis* (Becc) Kiew
   synon. nov.
   *I. wallichiana* ssp. *malaccensis* var. *elatior* Kiew synon. nov.

9. *Iguanura humilis* (Kiew) C.K. Lim stat. nov.
   synonym: *I. wallichiana* ssp. *malaccensis* var. *humilis* Kiew synon. nov.

10. *Iguanura parvula* Becc. in J.D. Hooker

11. *Iguanura bicornis* Becc.

12. *Iguanura corniculata* Becc.

   synonyms: *I. polymorpha* var. *canina* Becc.
   *I. brevipes* J.D. Hooker
   *I. ferruginea* Ridley
   *I. arakudensis* Furtado

14. *Iguanura belumensis* C.K. Lim sp. nov.

15. *Iguanura perdana* C.K. Lim sp. nov.

16. *Iguanura mirabilis* C.K. Lim sp. nov.
Key to identification of Peninsular Malaysia taxa of *Iguanura*

1. **Leaves persistent** (marcescent), leaf sheath fibrous .............................................. 2
1. **Leaves abscissing**, leaf sheath smooth inside .......................................................... 10
2. Inflorescence spicate, or furcating into two to seven ................................................. 3
2. Inflorescence paniculate, with divaricate branches sometimes to second and third order ........................................ 4
3. Caespitose (sometimes solitary), stems to 4m: leaves entire, lobed or pinnate ................ 8. *I. geonomiformis*
3. Solitary, stem to 50cm, often covered with roots; leaves entire or pinnate ...................... 9. *I. humilis*
4. Solitary ...................................................................................................................... 5
4. Caespitose .................................................................................................................. 6
5. Acaulescent; leaves pinnate: inflorescence variable, peduncle often within sheath ............. 6. *I. kelantanensis*
5. Stem to 1m: leaves pinnate; leaflets often unicostate; inflorescence branching to second or third order ................................................ 4. *I. diffusa*
6. Fruit globose, pink (not white) ripening deep pink or red ............................................ 7
6. Fruit globose, white, light green, yellow ripening red ..................................................... 8
7. Peduncle short to 15cm, within sheath, rachillae curled .............................................. 5. *I. asli*
7. Peduncle long to 50cm or more, rachillae divaricate; uncommon .................................. 3. *I. wallichiana* var. *rosea*
8. Fruit small to 8mm diameter, light green (not white), cream, orange ripening to red: inflorescence short, rachillae slender; leaves oblong, entire, or lobed, silky texture .......................................................... 7. *I. piahensis*
8. Fruit medium to large, 1cm diameter or more .............................................................. 9
9. Leaves pinnate or entire to 1.3m; inflorescence to 90cm, axillary, spreading; common ............................................. 1. I. wallichiana var. wallichiana
9. Leaves usually entire, very large to 2m or more; inflorescence to more than 100cm, erect and robust ............................................. 2. I. wallichiana var. major
10. Leaves entire ........................................................................................................ 11
10. Leaves lobed or pinnate, leaflets flaring distally (trapezoidal) ................. 12
11. Leaves small to 30cm, oblong; stems caespitose, arudinaceous, short to 1.2m; peduncle in sheath, fruit globose ..................... 10. I. parvula
11. Leaves large to 85cm, cuneate, often truncated at apex, strongly plicate; stems caespitose, to 2cm diam. to 3m; inflorescence three to nine branched with purple indumentum; fruit curved ....................... 16. I. mirabilis
12. Solitary .................................................................................................................. 13
12. Caespitose ............................................................................................................. 14
13. Fruit ovoid or curved; stem 1.5cm diameter, to 3m; leaves to 60cm; inflorescence interfoliar or infrafoliar, paniculate with twiggy branches ........................................................................ 14. I. belumensis
13. Fruit eccentric with flat top; stem (sometimes with basal branches) 2cm diameter to 4m; leaves to 100cm; inflorescence usually interfoliar, paniculate with succulent branches; very rare .............................................. 15. I. perdana
14. Inflorescence spicate, to 20cm or more; fruit curved, sometimes with a pronounced hook .............................................. 2. I. corniculata
14. Inflorescence branched (rarely spicate, if so less than 10cm); stems to 3m .......................................................................................................... 15
15. Fruit bigibbous, inflorescence with five to seven rachillae; stem to 1cm diameter, chestnut colour; habitat montane .................... 11. I. bicornis
15. Fruit ovoid or curved (not hooked); inflorescence variable, three (rarely two or one) to nine rachillae, sometimes sub-branching; stems arundinaceous or robust, not chestnut colour; habitat sea level to montane, distribution widespread ................................................................. 13. I. polymorpha
Plate 3  *I. wallichiana* var. *wallichiana*: Leaves in lobed and pinnate forms.

Plate 4  *I. wallichiana* var. *wallichiana*: Characteristic inflorescence, paniculate, to 90cm.


This earliest of *Iguanura* taxa collected in Malaya, by Porter in 1822, came from Penang, and from examination of remnant populations on Penang Hill at c. 600m, a good idea of the characteristics of the topotype can be obtained. It grows on hill slopes, along or within rocky streams, and is caespitose (not solitary), clustering in a rather untidy way, with stems up to 2m, and persisting pinnate leaves. The inflorescences extend out from among the leaves, with long peduncles, branching with several divaricate rachillae (usually robust, but sometimes finer). The species is to be differentiated from *I. geonomiformis* mainly by the inflorescence configuration. Although in the latter it is often spicate, forms that fork into many parallel rachillae are also common. The fruit are characteristic of the genus, globular with basal stylar remains, and ripening in colour stages from ivory white or light green to cream, then cerise or crimson, eventually black. Eophyll and juvenile leaves are easily identified as of all within the genus, always entire, cuneate or oval, and new leaves which may be entire or lobed are often flushed, reddish or bronze.

From viewing the syntypes of var. *minor* (*King’s Collector* 454, 7941, 7999), I concur with Kiew that they are within the range of forms of *I. wallichiana* var. *wallichiana*. As described in J.D. Hooker, with stems up to 30 inches. and leaves simple or pinnatisect, and finer inflorescence and fruit, they represent the smaller variants, with entire or divided leaf forms, which Beccari called “flabelliformis” or “pinnatisect”.

The main taxon is variable in stature, with forms that are taller, up to 4m in height, often with dominant stems and basal branches, and thrives at altitudes from lowland to mountain slopes at 1000m. Variations in leaf divisions and leaflet widths can also be observed; entire or lobed forms are not uncommon, but the pinnate with many leaflets are also ubiquitous. The northern populations could be considered typical of the species. Those in Perlis thriving in riverine swamps near limestone outcrops, point to a larger common domain that would include south Thailand.

*Distribution*: Kedah, Penang, Perak, Perlis.

*Type*: Penang, 1822, *Porter 8600*, (holotype K)
**Reference Collections:**


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The variety was first recognised by Beccari as being more robust and having larger entire leaves. The synonyms cited by J.D. Hooker, basing on Beccari’s manuscript, were collected between 1880 and 1888, from the Gopeng area: (King’s *Collector* Nos. 431, 8227). The collection notes indicated that the fronds were “4-6ft long, sometimes longer”. The similarity with *I. spectabilis* is unmistakable, and indeed Ridley himself stated that “Some specimens of King’s Collection, viz. 431 and 8227, described as the var. *major* Becc. in the *Flora of British India* are apparently either large forms of *I. geonomaeformis* (sic.) or *I. spectabilis* Ridley” (Materials: 152, 1907). By taxonomic precedence, both *Geonoma pynaertiana* and *I. spectabilis* are thus synonyms. Kiew’s *I. wallichiana* ssp. *wallichiana* var. *major* also becomes a new synonym within this revision, which dispenses with the subspecies rank by reinstating *I. wallichiana* and *I. geonomiformis*. Her description of the variant is conservative in dimensions, and perhaps Ridley’s notes on *I. spectabilis* provides a more impressive account. Ridley first saw the “superb palm
Plate 5  *I. wallichiana* var. *major*: Leaf large and entire, with erect robust inflorescence.
known to Malays as the Teruno” at Bruas where it had been collected by Curtis, who sent it to Dr Masters. He later saw even more robust specimens on Hermitage Hill, a foothill of G. Bubu from where the early ascents by Swettenham and others were made.

In 1937, Furtado collected specimens from the Gopeng area, which had divided leaves, “5-7ft. long”. The variety is similar to *I. wallichiana* var. *wallichiana*, but has robust stems to 4m, 3cm or more in diameter; the lamina is usually entire (rarely divided), cuneate or oblong, strongly ribbed, to 2m or more in length; characteristically, the inflorescence is ascending erect, thick, paniculate to 8 or more branches; fruit is globose or ovoid, larger (2cm or more) than for *I. wallichiana* var. *wallichiana*, colour in ripening similar; flowers also similar. Common in G. Bubu FR, where according to L.G. Saw, an unusual pinnate form has also been seen.

*Distribution*: Kedah, Perak.

*Type*: Perak: Gopeng, *King’s Collector 431* (holotype K. isotype FI)

*Reference Collections*:-


3. **Iguanura wallichiana** var. *rosea* C.K. *Lim var. nov.*


Caespitose. stem and leaves similar in size and form to *I. wallichiana* var. *wallichiana*, inflorescence also similar, but differs and is distinct in its fruit colour, pink when immature ripening dark pink or red. Two specific colonies, in Perak and Kelantan, were found to display the consistent fruit colour distinction. The drupes are globose or ovoid and similar in size to *I. wallichiana*, and also in the carriage and branching of the inflorescence. Both populations studied over a two-year period are locally abundant, relatively robust, some with stems to 4m in height, with large leaves to 1.5m, pinnate with broad or narrower leaflets. We have so far not encountered intermediaries in colour in other locations, and believe that this character can be used for varietal differentiation.
Plate 6 *I. wallichiana var. rosea*: Type specimen: Perak: Belukar Semang, 1992, C.K.Lim H1126 (KEP)
Plate 7 *I. wallichiana* var. *rosea*: Inflorescence similar to var. *wallichiana* but with distinctly pink fruit.

Plate 8 *I. lasii*: Inflorescence with peduncle within sheath, and curved rachillae, and fruit characteristically candy pink.
Plate 9  *I. diffusa*: Type specimen: Perak: G. Tjok, 1884, Scortechini 1189 (FI) (by courtesy of Erbario Centrale, Florence)

Plate 10  *I. diffusa*: Specimen from Taman Negara: stem solitary, leaves pinnate with narrow leaflets; inflorescence interfoliar
The fruit colour distinction has also been displayed by another new species, *I. asi*. Although the variation had been considered as “minor local differences” within *I. wallichiana* and *I. geonomiformis* by Kiew (1976: 221), the forms she mentioned as seen in Taman Negara and elsewhere with pink immature fruit, might well have been that new species, which has other distinctions in its inflorescence. I believe that further surveys will locate other consistent populations of this taxon.

**Distribution:** Kelantan, Perak. Habitat: hill forest slopes. at. c. 500m.

**Type:** Perak: Belukar Semang, 1992. C.K. Lim H 1126 (holotype KEP)

**Reference Collections:**


J.D. Hooker’s description (Flora of Br. India, 1892) based on Beccari’s manuscript, noted that this was “one of the largest of the genus, leaves about 3-4ft, very numerous leaflets, narrow, one to one-and-a-half inches, inflorescence filiform, branches eight to ten, branching to second or third orders”. He further admitted that the specimen was imperfect and “may be a luxuriant state of *I. polymorpha*”. In fact, the type included a good inflorescence, but too few leaflets, and had an inscription by Scortechini: “*I. polymorpha var.?*” Also in Florence, is another specimen under this name. (presumably accepted by Beccari), collected by Ridley in 1895 from Ara Kuda, which consists of one juvenile leaf and is rather unindicative. In 1907 Ridley himself mentioned the taxon as a variant of *I. wallichiana* (Materials: 152). Since then, many others have tried to match collections to the name, but no specimens have yet been found in or near the type location which may be G. Hijau (Bukit Larut) rather than G. Ijok near Selama. In Kelantan, Henderson found a short-stemmed form which he thought to be *I. diffusa*, which had a six-branched inflorescence, further divided into second and third order, with peduncles shorter than in the type specimen.

In 1968, John Dransfield collected a specimen from Taman Negara (686 KEP), noting that the leaves were 4ft in length, with leaflets very narrow, some unicostrate, with short stem to 2ft, with “compound” inflorescence. Whitmore subsequently determined this as *Iguanura diffusa*, and indeed our own field collections in the same area have yielded equivalent samples (eg. H 15-42 SING) which have a range of variations in leaflet widths, some totally unicostate, including
(unusually) the apical pair. Furthermore, within the locally common population we saw only solitary plants with stems to 1m, and would put this up as a character in habit, that would further differentiate it from *I. wallichiana*. The inflorescence was interfoliar, some shorter in peduncle than others., finely paniculate, with six to eleven branches, often sub-branching, with fruit similar to *I. wallichiana* in colour and size. The Taman Negara collections appear to fit the original citations, but because of its geographical disjunction from the type location, an element of doubt persists for the field-biased taxonomist, and it remains desirable to find it nearer the type locality.

**Distribution:** Kelantan, Pahang, Perak. **Habitat:** low hill forests, near river, locally common.

**Type:** Perak: “G. Tjok”, 1884, Scortechini 1189 (holotype FI)

**Reference Collections:**


5. **Iguanura asli** C.K. Lim sp. nov.

*Fructibus inmaturis roseis; a I. wallichiana et geonomiformis inflorescentiae interfoliaceae pedunculo brevi vagina folii occulto, rachillis arcuatis differt.* **Typus:** Pahang: Berkelah FR, 1993, *C.K. Lim H 1539* (holotypus SING)

Caespitose, with dominant stems from 1.5-2.5m, leaves marcescent, divided, similar to *I. geonomiformis*, variable in numbers and leaflet widths; inflorescence branching two to nine, rarely sub-branching, often curled interfoliar, with short tomentose peduncle enclosed in the leaf sheath; fruit globose, 4-8mm, immature pink ripening brilliant candy pink; flowers and seed not examined.

This is indeed a widespread species found from Terengganu to Johor where it might have been taken to be a form of *I. wallichiana* although it is usually within *I. geonomiformis* territory. Indeed the habit and leaf variations are visually more similar to the latter. We later recalled that we had found and photographed examples in other locations, mainly within Johor, which we had assumed to be *I. wallichiana*. There have indeed been earlier collections, and within the Singapore Herbarium, Holttum’s specimen (9476) is an example. Kiew’s observations on fruit colour variations in her ssp. *malaccensis*, (Kiew 1976: 221) is obviously of this new species. In the Rompin area, the brilliant candy pink fruit often rivals adjacent *Licuala ferruginea* not only in colour, but sometimes in size and robustness of the rachillae and fruit. The inflorescence, although variable, is apparently distinct

Plate 12 *I. kelantanensis*: Type specimen: Pahang: Gua Musang, 1992, L.G.Saw FR137607 (KEP)

Plate 13 *I. kelantanensis*: Stemless and solitary, with interfoliar inflorescence.
from the other taxa, usually curled among the leaf petioles, with the peduncles mainly enclosed within the leaf sheath.

The inspiration for the name arose out of encountering the aboriginal groups living near to the first fruiting populations that we saw; it was also determined within the Year of the Indigenous (Orang Asli) Peoples.

**Distribution:** Johor, Pahang, Terengganu; not rare, in low hill forests, riverine swamp.

**Type:** Pahang: Berkelah FR. 1993, C.K. Lim, H 1539 (holotype SING)

**Reference Collections:-**


6. **Iguanura kelantanensis** C.K. Lim **sp. nov.**

*I. wallichianae affinis sed habitu solitario acaulescenti differt.* Typus: Kelantan: Gua Musang, 1992, L.G. Saw FR 37607 (holotypus KEP)

Differing from caespitose *I. wallichiana* by being solitary, acaulescent (sometimes with short stems to 10cm), leaves marcescent, pinnate to 20 pairs of leaflets. often bicostate. Inflorescence branching among petioles. peduncles short or longer (varying by 20cm or more). rachillae six to nine, curled or not; often branching to second order, fruit as for *I. wallichiana*, white ripening red.

To the east of the Main Range, in Pahang and Kelantan, there appear to be considerable variation in the forms within the *I. wallichiana/geonomiformis* complex, especially in the branching of the inflorescence. While surveying this area, we first encountered this stemless, solitary *Iguanura*, which had also been collected by L.G. Saw of FRIM, whose specimen we have chosen as Type. Subsequent collections display wide variability in leaflet width and divisions, and also in size and form of rachillae. I would like to credit Saw with the perception of acaulescence as a distinguishing character, until then not observed in the genus, and quite unlike the short-stemmed forms of *I. geonomiformis*. So far the taxon has only been found in one area, and thus it will be named after the state of Kelantan. In an adjacent forest, Henderson had collected a specimen (20301) identified as *I. diffusa* (q.v.), which has similar inflorescence, and there may be a relationship between the two taxa.
Distribution: Kelantan; habitat: hill forests c. 300m

Type: Kelantan: Gua Musang. 1992. L.G. Saw FRI 37607 (holotype KEP)

Reference Collections:


7. Iguanura piaensis C.K. Lim sp. nov.


Caespitose, clustering. stems to 2m. leaves marcescent, sometimes entire, usually divided into two or more pairs of lobes but closely spaced along rachis. lamina oblong or elliptical. glabrous. texture papery. smooth and silky to the touch; inflorescence fine and sparsely paniculate four to seven branches or more, with fruit slightly smaller (c. 6mm in diameter) than I. wallichiana. usually light green, turning cream to yellow, ripening red.

This is yet another species found so far only in a limited location, where there are contiguous populations of the more gregarious and common I. wallichiana. It is an elegant taxon that can quickly be identified once one “gets one’s eye in”, especially when the oblong entire forms are encountered. Another useful field indicator is the feel of the relatively thin lamina: the nerves are fine and unobtrusive and give rise to the smooth and silky glabrous sheen. Young or juvenile leaves of other taxa can be similar, especially within the I. polymorpha alliance and conversely some old leaves of the new taxon could be coarser. Fruit colours, in the more evidently yellow-cream (not white) stage are reminiscent of I. parvula Becc. (q.v.)

Certain herbarium specimens labelled I. wallichiana var. minor display similar inflorescence, but differ in leaf shape. The specimen collected in 1889 by Wray (3628. K) from an unknown location in Perak, is an example that I consider to be this new taxon. Its name is based on the type location which is one of the home districts of the Temiar tribe.

Distribution: Perak. Habitat: Hill forest 300m alt. Locally not rare.

Plate 14 *I.piahensis*: Type specimen: Perak: Piah FR, 1992, C.K.Lim H1266 (KEP)
Plate 15  *I. piahensis*: Leaves silky textured, sometimes undivided, oblong.

Plate 16  *I. piahensis*: Inflorescence with seven rachillae and fruit to 8mm diameter.
Reference Collections:-


8. *Iguanura geonomiformis* (Griff.) Mart., Hist. Nat. Palm. 3: 229 (1837-1850) and pl. 178 (1894); *Slackia geonomaeformis* Griffith, Calcutta J. Nat. Hist. 5: 469 (1845); Palms of British East India, (1850); Miquel Fl. Ind. Bat. 3: 44 (1855); J.D. Hooker Fl. Brit. Ind., 6: 415 (1892); Ridley, Mat. Fl. Pen. (Monoc) 2: 150 (1907); Fl. Mal. Pen. 5: 13 (1925); Martelli, Nuovo G. bot. Ital. 42: 52 (1935); Whitmore, Palms of Malaya: 63 (1973); Kiew, Principes 16: 3-10 (1972); Gdns Bull. 28: 216 (1976).


The reasons for reinstating *I. geonomiformis* have been explained (which includes the *I. wallichiana* ssp. *malaccensis* propositions of Kiew). Griffith’s description and illustration (Palms of Brit. Ind., 1850: 162, tab. 234) bear out the characteristics as found in Ayer Panas, Malacca, the bifurcating spadix being common. Martius using the same collection contributed to some confusion by his citation: “... spadice saepe simpliciter ramoso”. Incidentally, he also clouded his description of *Areca wallichiana*, by noting: “spadicibus simpliciter valore ramosis”, but described it elsewhere as having 10-15 branching inflorescences. As with *I. wallichiana*, which is still extant in its type location, the populations of *I. geonomiformis* in and around Malacca can still be referred to.

*I. geonomiformis* has very much the habit of *I. wallichiana* - caespitose, clustering often with dominant stems up to 4m, leaves marcescent entire or pinnate, some with narrow leaflets, sometimes divaricate; the long, stout and tomentose inflorescence is often spicate but may fork into parallel tails, sometimes varying in numbers on the same plant. The fruit is similar to its relative, although in colour it is often white rather than green, before maturing red. The individuals in Negri Sembilan are particularly large in stature and fruit size. The taxon has also often been seen in a solitary form, where basal branching had not yet developed.

J.D. Hooker had listed the synonymous *I. malaccensis* Becc. as a “closely allied” species; its type was collected by Kehding in Klang, where the main taxon is common. Likewise most of the collections cited by Ridley for his varieties came from the southern part of the Peninsula, including Singapore. The species is by no
Plate 17  *I. geonomiformis*: Drawing showing furcating inflorescence; (Tab. 178, Martius. Historia Naturalis Palmarum Vol. 3. 1837-1850).
means confined to the south, and has been collected on Larut and Bujang Melaka in Perak and on the eastern side of the Main Range, north to Kelantan, where curious forms present scope for further study.

The vast collection in the Singapore herbarium displays the wide range of inflorescence divisions, from the thick robust spikes, often forking up to two or three, to the “ramose” form, with seven or more tails, sometimes forking again to second order. Ridley and others devised new appellations to cope, including var. malaccensis, sub. var. ramosa, and “var. spectabilis” (unpublished). The lamina of I. geonomiformis varies from entire to lobed and narrowly pinate, as with I. wallichiana. Certain historical specimens of I. wallichiana var. minor, eg. King’s Collector 7996 from Batang Padang, Perak, might well be similar to the form of I. geonomiformis as found on Bujang Melaka.

To describe the larger entire leaf form as found around Belumut, Kiew published her var. elatior, which I include within the main taxon. In the same vicinity, pinnate forms are also found. Similar variations with entire leaves can be seen on Bujang Melaka in Perak, and near Jerantut, Pahang. In other locations, eg. at G. Panti, precocious flowering aculeated individuals have been seen, but these are usually caespitose, and may well be basal branches of a mature plant where the dominant stems have been destroyed. So far we have not encountered variants of I. geonomiformis with pink fruit, such as those of I. asli. There may well be other variants to be described especially from Kelantan, Pahang and elsewhere, which will require more field collections and samplings of populations.

Distribution: Johor, Kelantan, Malacca, Negeri Sembilan, Pahang, Perak, Selangor.

Type: Malacca, Ayer Panas, Griffith 6406, 6407 (holotype K)

Reference Collections:-

Johor, Mawai, 1934, Corner 29001, K, SING; G. Blumut, Holtum 10299 (Type for I. wallichiana ssp. malaccensis var. elatior) SING; F.S.P. Ng 98021, KEP; Gemas. 1966, Palmer 814 SING; Mt. Ophir, 1888. Hullett 751 SING; Ridley 3141 SING; G. Panti, 1892, Ridley s.n. SING; C.K. Lim H 259, H 260, H 914, H1198 PSM Collection; Linggiu, C.K. Lim H 923, H 1023, H 1024, H 1342, H 1345, H 1528 PSM Collection; Ulu Sedili, C.K. Lim H 925; Labis, C.K. Lim H 1520 PSM Collection; Lenggor, C.K. Lim H 931, H 1073, H 1590 PSM Collection; Malacca, Ayer Panas, 1891, Hervey s.n. SING; 1893, Ridley 1583, 1618 SING; Lubok Kedondong, 1892, Ridley s.n. SING; Negri Sembilan, Perhentian Tinggi, 1890, Ridley s.n. (Type for I. geonomiformis sub. var. ramosa) SING; Kuala Klawang, C.K. Lim H 468, H 492, H 1334 PSM Collection; G. Angsi, C.K. Lim H 998 PSM Collection; Bukit Tampin, 1894. Ridley 1891 Fl, SING; G. Angsi, 1904. Ridley 11968 Fl, SING; Pahang, Tahan Woods, 1891, Ridley s.n. SING; Temerloh, 1913, Murdoch 174 SING; Kuala Lipis, 1924, Burkill & Haniff 17188 SING; Kuala
9. **Iguanura humilis** (Kiew) C.K. Lim stat. nov.


I propose to elevate in rank this solitary, short-stemmed relative of *I. geonomiformis* with the upward growing roots, as well described by Kiew who provided a full account of her new variety. The leaves are however, more variable than as identified and illustrated; other specimens from the type location also include those that are pinnate. The inflorescence is spicate, and erect, characteristically, the fruit is globose, white in colour, ripening red. It is interesting that Furtado, who viewed Corner’s specimen, had also noted that it might be a new species. It is common and widespread in Terengganu and is possibly also found in bordering Pahang. It could however be confused with short or stunted forms of *I. geonomiformis* which have been seen to flower in acaulescence, as in G. Panti which are usually caespitose, whereas *I. humilis* is distinctly solitary in habit, and mostly not taller than 75cm. In parts of Taman Negara, and in northwest Pahang, however, solitary forms of *I. geonomiformis* may be seen, but these may well be intermediate variants that may relate with *I. humilis*. Although undivided leaves are usual especially in the Ulu Setiu area, *I. humilis* is also often seen with broad pinnate leaves. The ascending growth of the roots may be correlated with the swampy habitat, and there may well be upland individuals without this feature.

*Distribution:* Kelantan, Pahang, Terengganu.

Type: Terengganu, Ulu Bendong, 1935. *Corner* 30095. (holotype SING, isotype K)
Plate 18  I. humilis: Type specimen: Terengganu: Ulu Bendong, 1935, Corner 30095 (SING)
Plate 19 *I. humilis*: Short-stemmed, with entire (or pinnate) leaves, and spicate inflorescence.
Reference Collections:-


10. **Iguanura parvula** Becc. in J.D. Hooker, Flora of British India 6: 417 (1892); Ridley Mat. Fl. Mal. Pen (Monoc) 2: 152 (1907); Whitmore, Palms of Malaya: 63 (1973); Kiew, Gdns Bull. 28: 212 (1976)

From Beccari’s manuscript, J.D. Hooker’s description is pertinent: “Leaves small, oblong, tip forked, margin undulate; spadix filiform, sparingly branched, peduncle about as long as the petiole more than half embraced by the spathes”. He further noted that the leaves were 8”-10” by 3”, which is typical, although the undulate margin might be the result of drying and is not as evident in the live plants. He also added that it might be “possibly a very small form of *I. polymorpha*” (as annotated by Scortechini), leading others to this assumption. Ridley, however, erroneously considered it (and also *I. diffusa*) a form of *I. wallichiana* (Materials: 152, 1907)

The taxon is the most diminutive of the genus, caespitose, with arundinaceous, sinuous stems which often sprout aerial branches. The leaves are entire (so far no divided forms have been seen) and could be mistaken for young entire leaves of the other taxa in the *I. polymorpha* complex, but they are held stiffly at right angles to the sheath and distinctive in texture. The inflorescence has been accurately described by Beccari. The peduncles are indeed mainly enclosed, but are frequently exposed by early abscission, and become infrafoliar. The fruit is globose, smaller than *I. wallichiana*, ripening from light green, cream, yellow (not white) to red.

The aptly named species has been ignored or misunderstood partly because there was only one historical specimen (in Florence); the evidence in Kew consisted only of a drawing of the holotype, which is nevertheless a fine sketch.

The type location in Perak is not known, but Furtado recognised the species as distinct in 1933, when he correctly determined a fine specimen in the Singapore Herbarium (*SFN 21104*) collected from the Kedah-Perak border by Haniff in 1928. No other collections appear to have been made until our recent finds in Kedah, now deposited at KEP, K and SING, which are from one specific area on forested hill slopes at 200m unfortunately threatened by re-logging activities. We have also encountered rare individuals of this species at 1000m alt. in a logged remnant forest in the G. Bintang Forest Reserve. These then are its residual known distributions.
Plate 20 I. parvula: Type specimen: Perak: c1886, Scortechini s.n. (FI) (by courtesy of Erbario Centrale Florence)
Distribution: Perak, Kedah.

Type: Perak: c. 1886, Scortechini s.n. (holotype Fl).

Reference Collections:


In 1889, Beccari was stimulated by fresh collections sent to him by Dr King from Calcutta, made by Kunstler and by the late Father Scortechini. The species named I. bicornis was one of the New Asiatic Palms he listed, citing two specimens: the one Scortechini collected at c. 1300m from G. Ijok (more correctly G. Hijau which is adjacent to Bukit Larut), and the other by Kunstler (6375) also from Bukit Larut. His description highlights the unique fruit tipped by "two obtuse unequal bosses" (per J.D. Hooker), which is also described as bigibbous. The fruit shape varies from oblong to broad and square; ripening from light green to yellow and brilliant cherry red.

The palmlet is caespitose, clustering often with numerous basal branches, stems to 2-5m and up to 3-5m (in recently observed robust populations), 6-8mm in diameter, usually chestnut brown in colour. The leaf sheath is green, abscissing, leaves entire when young, pinnate with two to eight pairs of trapezoidal leaflets, flaring distally, varying in the angle of the apical tips, from less than 30 degrees to more than 90 degrees, typical and similar within the polymorpha complex. The leaves appear to abscise more readily than others in the complex, giving rise to the smooth stems, and to the infrafoliar position of the inflorescence, which nevertheless usually forms within the sheath, as characteristic in that genus.

The taxon in fruit is especially distinctive, and appears to thrive and is quite abundant in mountain forests usually above 400m to 1500m alt. (it has not been seen in lowlands), from Bukit Larut northwards to Belum Forest Reserve, Gerik, also common in Kedah: Weng, and in S. Thailand. Kiew incorrectly included within this taxon the lowland I. arakudensis Furtado (which was based on a specimen misidentified by Ridley as Pinanga canina Becc.), whereas it is indubitably a form of I. polymorpha.

Distribution: Kedah. Perak.

Type: Perak: G. Ijuk, 1886, Scortechini 1188, (holotype Fl)
Plate 21  *I. bicornis*: Inflorescence with bigibbous fruit, trapezoidal leaflets

Plate 22  *I. bicornis*: Variations in leaf form

Plate 23  *I. bicornis* (top), *I. polymorpha* (left) and *I. mirabilis* (right): Fruit and seeds.
Reference Collections:


The original specimens from the Selama area are so distinctive that this, the first of the new *Iguanura* Beccari described in 1889, has retained pride of place in all taxonomic accounts although it had not been collected until recently, and had been deemed extinct, especially as its type location (at 100-170m alt.) has largely been cleared for plantations. Fortuitously, our recent field trips have yielded a newly discovered population, not in Perak but in adjacent Penang, at low altitudes.

As inferred by Whitmore (1973) and Kiew (1976), it is very much a member of the *I. polymorpha* alliance. It is caespitose, and is distinguished by its long spicate inflorescences (22cm in the type specimen), and fruit more pronouncedly hooked than the narrowest forms in *I. polymorpha*. The recent collections from Penang, however, have fruit more similar to *I. polymorpha*, where the hook is less pronounced. The plant is smaller, up to 2m in height, with finer trapezoidal leaflets. It should be noted that some forms of *I. polymorpha* may be similarly diminutive, as at Merapoh, where individuals with spicate but shorter inflorescence can occasionally be found, clearly a variation among those predominantly with two or three branches. The flowers of the two taxa are observably different in size, those of *I. corniculata* being half to two-thirds as large, and having sepals tinged red at the tips.

So far, the known distribution seems limited to near the Perak-Penang boundary. The collection by Henderson from Pahang, which he labelled as *I. ferruginea*, may need to be corroborated, especially as *I. polymorpha* forms with one to three rachillae have been seen in that state and also elsewhere. Furtado had determined it to be *I. corniculata* on the basis of leaflet shape, and may have introduced (from Kew?) the hooked fruit and leaflet cuttings now in the sachets on the specimen. Yet another fresh lead might be provided by a recent collection in 1990 by Kiew and Anthonyssamy (*RK 2908, UPM*) from the Nenggiri area in Kelantan; the specimen, classified as *I. polymorpha*, has spicate inflorescence, but
Plate 24 *L. corniculata*: Type specimen: Perak: Selama, Kunstler (King's Collector)3131 (F1)(by courtesy of Erbario Centrale, Florence).
Plate 25  *I. corniculata:* Fruit and seeds

Plate 26  *I. corniculata:* Dwarf clustering palm with long spicate inflorescence; specimen from Penang.
unfortunately, no fruit were collected or described. *I. corniculata* remains one of the rarest endemic species, requiring the fullest conservation measures.

_Distribution:_ Pahang, Perak, Penang.

_Type:_ Perak: Selama, 1882, *Kunstler (King’s Collector)* 3131, Holotype Fl. isotypes CAL, K.

_Reference Collections:-


Like the others with abscissing, pinnate, leaves and trapezoidal leaflets, this caespitose taxon is indeed appropriately named, with a range of forms that has given rise to three other proposed species and one variety, now reduced to synonymy. From extensive field observations, the variations in leaf division, forms and apical tip angles, are typical of the whole complex (including *I. bicornis* etc.)

Beccari’s description of the new species and its variety *canina* (*Scortechini* sn., Fl) were based on specimens collected by Scortechini, but the type locations in Perak are not certain. We would infer that they came from relatively high altitudes (c. 1200+m), probably from Bukit Larut. Our reexamination of Beccari’s concept of the taxon has been based on equivalent populations from Cameron Highlands, some with sinuous stems and leaves irregularly pinnate with broad and narrow leaflets on the same leaf, a feature which initially seemed distinctive, not often seen in herbarium samples. Contiguous and intermixed forms can also be observed with a range of fruit shapes - ovoid, elliptic (but not curved) to the lightly curved “tooth” (canine) form. The fruit ripens from white to pink and red. The rachillae vary in number from three to nine, within both forms and are not as clearly different as suggested by Beccari and others.

The _Iguanura brevipes_ of J.D. Hooker was also collected from above 1200m at Bukit Larut, where *I. bicornis* and *I. polymorpha* are also found. The holotype
Plate 27  *I. polymorpha*: Type specimen: Perak: c1886, Scortechini 318b (FI) (by courtesy of Erbario Centrale, Florence)
Plate 28 *I. polymorpha*: Inflorescence with ripe fruit.
(Kuntzer 2029, K) had no fruit, but had flowers which, as described, are indistinguishable from the others in the complex. The spadix, with three to four branches, were indeed interfoliar, but it is not certain if any remnant infrafoliar ones had fallen off. The leaf sheath forming the crownshaft were certainly of the abscissing type, and although Hooker referred to the slender stem, he did not indicate whether the taxon was solitary or caespitose, but noted that it was 2-5m in height. Amongst abscissing Iguanura taxa, the inflorescences can be within or below the sheaths, sometimes both; leaf fall varies with moisture conditions and persistence of the nodal grip of the peduncle, and the size and weight of the inflorescence would also have a bearing. The mixed conditions can often be seen in the field. Practically all the subsequent herbarium specimens we have seen labelled as I. brevipes could fit within I. polymorpha - and some within I. bicornis (one actually had its typical fruit!).

By the time Ridley published Flora of the Malay Peninsula in 1925, he had overlooked many editorial errors and credited his I. ferruginea to Beccari, also providing it with the description of its Licuala namesake in the same volume! When he first published the new taxon in 1903, he noted that it had the habit of I. polymorpha, and distinguished it on the basis of its “stouter inflorescence on a longer peduncle and covered with red wool, the larger flowers, and curved cylindric fruit”. His syntypes were from “Thaiping Hills common from 2000ft upwards” (Fox 10684, and Ridley s.n.) and from Bujang Melaka (Curtis 3164). In “Materials” (1907) he characterised the inflorescence as being stout and having nine to eleven branches, sometimes branched again, and re-emphasised the furry indumentum. In effect by citing the characteristics of his 1891 specimen, he rendered it synonymous within I. polymorpha. Indumentum on rachillae and leaf parts is, however, not uncommon for all Iguanura taxa.

The other syntypes displayed inflorescences with two or three rachillae, and curved seeds. This is a form that is common and widespread, and is found in many parts of Perak, Kedah, Kelantan, Terengganu and Pahang, mainly at lower altitudes. I. arakudensis Furtado is almost certainly of this form; its type was based on Ridley’s misidentification of “Pinanga canina” (Ridley 7027), which had broad apical leaflets and immature three-branched inflorescence. It would have been tempting to erect a distinct taxon, at least at varietal rank, for I. ferruginea based on the trident inflorescence and the curved seeds which are more slender than in var. canina samples. It is now evident that curved and ovoid fruit can be found within the same taxon, with the “canine” shapes more common. As observed by Beccari and others, the drupes form eccentrically from the basal stylar remains which can be on the concave or the convex side. Inflorescence branching and size are also variable. This was further resolved by the collection of fresh specimens (from north. Perak) from taller, clustering, robust forms with stems up to 3.5m, larger leaves (72cm x 40cm), and gigantic inflorescences, variable from three or four to nine branches, sub-branching sometimes to 16. The longest rachillae measured over 78cm, including a peduncle of 33cm (vide. C.K. Lim H 1671).
Plate 29 *I. polymorpha*: Robust form with two to nine branched inflorescence; specimen from Belum, Upper Perak.

Plate 30 *I. polymorpha*: Leaflets variable, inflorescence with ovoid or curved fruit.
In summary, the concept of the aptly named *I. polymorpha* would include a wide range of variations. Its habitat ranges from sea level to 1500m or more. In habit it is always caespitose, stilt rooted, with fine or stout stems. 1m to 3.5m in height, leaves always abscissing, trapezoidal, variable in divisions, leaflet widths and apical tip angles, with short or long peduncles and inflorescences fine or stout, with or without ferrugineous indumentum. with three (rarely one or two) to nine branches, sometimes branching to second order with up to 18 or more branches, with fruit ovoid to curved, ripening from white to pink and red.

**Distribution:** Kelantan, Pahang, Perak. Terengganu:

Type: Perak, c. 1886, *Scortechini 318b*, (holotype FI)

Reference Collections:-

**Kelantan**, Sg. Bring, 1990, Kiew 2808 UPM; Kota Bharu, Gwynne-Vaughan 560 CAL. K; Sg. Kerteh. Nur 12052 K. SING; Jeli FR, Chelliah FRI 6528 KEP, K; 1911, Anderson 165, 173 SING; 1899, Fox 162, 10684 SING; Burkill & Haniff 12715 SING; Barnard CF 29 SING; Ulu Sat, C.K. Lim H 1164, 1509 PSM Collection; Sg. Mekong C.K. Lim H 1302 KEP; Lojing. C.K. Lim H 1247, H 1264, H 1347, H 1630 PSM Collection; **Pahang**, Sg. Gasoh, Jaanam 28264 SING; Merapoh. C.K. Lim H 1543 PSM, H 1576 PSM Collection; **Penang**, Ara Kuda. Ridley 7027 (Type for *I. arakudensis*) SING; Perak, *Scortechini s.n.* (Type for *I. polymorpha var. canina*), FI: Taiping Hills. 1881, King’s Collector 2029 (Type for *I. brevipes*) K; 1891, Ridley s.n. (Type for *I. ferruginea*) SING; Larut, 1899, Fox 10684 SING; Ridley 3157 FI, SING; Wray 714 FI, Ridley 11405 CAL, SING; Curtis 2078 SING; G. Batu Puteh. Wray 396 SING; Bujang Melaka, Curtis 3164 (Syntype *I. ferruginea*) SING; Ridley 9803 FI, SING; Tapah, Avé 132 K; Tambun. Burkill 6299 SING; Padang Rengas, Burkill & Haniff 1357 SING; Kati, C.K. Lim H 1109, H 1202 PSM Collection; Nenering C.K. Lim H 1411 PSM Collection; Belum FR. C.K. Lim H 1132 PSM Collection; C.K. Lim H 1671 KEP, K; Kroh, Furtado s.n. SING; **Terengganu**, Kg. Tok Dor C.K. Lim H 1156, H 1440 PSM Collection; Dungun, C.K. Lim H 1169 PSM Collection; G. Tebu FR, Sinclair & Kiah 40821 K, SING; C.K. Lim H 1416 PSM Collection; Besut. J. Drans. 6504 K; Sg. Tong FR, Meijer & Yong, KEP 94780 KEP, K.

14. *Iguanura belumensis* C.K. Lim sp. nov.


Solitary, stilt-rooted, stem grey or brown, erect to 4m or more, to 1.5cm diam., leaves abscissing, nine or more in crown, pinnate three to five pairs leaflets, trapezoidal (size and variations similar to *I. polymorpha*). leaf sheath brown, internode 1-1.4cm, inflorescence often numerous, inter or infrafoliar, finely
Plate 31 *I. belumensis*: Solitary, with infrafoliar, multi-branched inflorescence.

Plate 32 *I. belumensis*: Type specimen: Perak: Belum FR. 1992, C.K. Lim H1281 (KEP)
Plate 33  *I. perdana*: Inflorescence interfoliar, with rachillae thick and long.
paniculate with many branches, 10-14, often sub-branching, usually profuse in flower or fruit; fruit ovoid (also known to be curved), white, pink tinged, ripening red; seed not ridged.

Found on hill forest slopes at alt. c. 800m, not seen on lower locations, its solitary habit and more robust erect stem sets it apart, as does the profuse inflorescence (though sometimes sparse in poor soil conditions), flowering from 1m to 4m or more. Not uncommon but endangered by logging along the E.W. Highway, it has so far been encountered only in isolation from other Iguanura taxa, although I. bicorns, I. wallichiana and I. geonomiformis have been seen at similar altitude. In the Belum FR, other sympatric palm species include Pinanga subintegra var., P. simplicifrons, P. perakensis, P. malaiana, Nenga macrocarpa and Johannestejsmannia altifrons. In that area, visited over four years, I. polymorpha has not been found at this altitude, although to the east and west, at lower levels, that taxon abounds, and also to the north (probably extending into Thailand), where robust colonies of the clustering relative are dominant.

On G. Bubu, a specimen collected in 1972 at 1000m (Evans 722, UPM) displayed curved fruit, but in another (FSP Ng FRI 6134) they were ovoid. Like others, the fine specimen with robust stems from Bujang Melaka (Shah 3369) was thought to be I. polymorpha. The epithet belumensis was chosen for the locality in which we found it in 1989, and used (ined.), for purposes of herbarium depositions; the choice becomes especially appropriate in the light of more recent national conservation efforts in the type area.

Distribution: Perak.

Type: Perak: Belum FR, 1992, C.K. Lim H 1281 (holotype KEP)

Reference Collections:-


15. Iguanura perdana C.K. Lim sp. nov.

Affinis I. bicorns sed habitu solitario raro caespitoso; elatior, erecta ad 4.5m, laminis majoribus inflorescentis robustis fructa non bicorns, excruetrico apico plano bene distincta. Typus: Perak: Kroh, 1992, C.K. Lim, H 1125 (holotypus KEP)
Plate 34  *I. perdana*: Type specimen: Perak: Kroh, 1992. C.K.Lim H1125 (KEP)

Plate 35  *I. perdana*: Leaves large to 100cm, pinnate forms with trapezoidal or parallel-sided leaflets.
Usually solitary, rarely with basal branches, stilt-rooted, stem greyish brown, erect, 1.8cm diam., robust, erect, to 4.5m; internodes 4-5cm, leaves abscissing, large 100cm x 50cm, pinnate with two forms of leaflets, few (six pairs) broadly flaring distally or numerous (15-17 pairs) narrowly parallel-sided, petiole 20cm. leaf sheath 29cm, green with brown indumentum; often persisting in inflorescence thereby remaining interfoliar, rachillae stout, succulent, nine to ten branches, to 45cm long with 30cm peduncle; flowers widely spaced, relatively large; fruit (only one seen to date), unripe yellow, pink, like *bicornis* but eccentric, with flat top, not two-lobed.

This tantalising taxon needs to be described and recorded even if somewhat incompletely, in view of its rarity; we have only found less than ten plants in one threatened locality. Although it is within a Forest Reserve, adjacent felling and land schemes may affect its survival. It grows sympatrically, with the common *I. bicornis* and the new *I. wallichiana* var. *rosea*. The very large leaves are a third to twice the size of the adjacent *I. bicornis*, usually trapezoidal, but another pinnate form has been seen with parallel-sided leaflets. The inflorescences are signally different, lingering (perhaps because of size) among the leaf sheaths, which are of the abscissing type, leaving clean scars, but are more fibrous, and appear to persist in support of the stout but gangling rachillae. The unique fruit collected was somewhat like a dirty tooth, irregular but not bigibbous. This sampling is incomplete, but other characteristics set this taxon apart not only from *I. bicornis* and *I. polymorpha* but also from *I. belumensis*.

The population is certainly not sterile, as seedlings and the one tantalisingly solitary fruit collected prove. It is indeed an imposing erect taxon, and the epithet, which means prime (in Malay), alludes at attributes which a leader *primus inter pares*, should have.

*Distribution*: Perak; damp hill slopes, alt. 500m.

Type: Perak: Kroh, 1992, *C.K. Lim H 1125*, (holotype KEP)

*Reference Collections*:


16. *Iguanura mirabilis* C.K. Lim *sp. nov.*

Plate 36 *I. mirabilis*: Type specimen: Terengganu: Ulu Setiu. 1993, C.K.Lim H1448 (KEP)

Plate 37 *I. mirabilis*: Rachillae (three to nine branched) with purple indumentum: fruit curved.
Caespitose, stilt-rooted, with basal branches, dominant stems to 3m, 1-2cm diam., internodes 2-3cm, leaves eight to ten at crown, held stiffly with short petioles 3cm or less, abscissing, entire. Lamina strongly plicate, 85cm x 28cm, with deep (23cm) apical cleft. Often with blunt truncated apical edges sometimes attenuated: leaf sheath 14cm: inflorescence among or below sheath, stout, horizontal or erect, with purple indumentum. 5 or more branches sometimes sub-branching, rachillae to 15cm or more. 4-6mm thick peduncle up to 10cm. 10mm x 5mm, often within sheath; buds prominent pink, with red indumentum, male flowers large 5mm wide when open, with pinkish sepals not examined in detail. Fruit curved (like I. polymorpha, also in size), white, ripening cherry red: seed not ridged.

This is indeed a spectacular new species, quite unlike any others within the genus in Peninsular Malaysia. The plicate leaves are stiff, with deep apical clefts, and often blunt at the top edges (oar-shaped), sometimes with extended tips. The leaves absciss cleanly and are entire. The taxon is clearly distinct from the polymorpha complex, although the curved fruit resemble those of I. polymorpha, and has been placed (together with I. parvula) for convenience with the trapezoidal leaflet members, under the abscissing group.

A small specimen with inflorescence had been collected earlier from the same area but remained unidentified at Kew (J.Dransfield 5145): but no other collections had previously been deposited in KEP or SING. In Sarawak, two species (I. sanderiana and I. elegans) may seem to have affinities, their leaves also being plicate and entire (although lobed forms have recently been found with variable apical clefts); however, these are solitary in habit, and the inflorescence and fruit are quite different, globose, with seeds that are ribbed or ridged, features not observed in Peninsular taxa of Iguanura. The new species has been a wonderful culmination for this stage of our palm studies, and the name I. mirabilis is surely appropriate.

Distribution: Terengganu, where it is limited but not uncommon in particular flood-prone swamp forests, sharing the habitat with I. humilis.

Type: Terengganu: Ulu Setiu. 1993. C.K. Lim H 1448 (holotype KEP)

Reference Collections:-

Plate 38  *I. mirabilis*: Caespitose, leaves entire, strongly plicate.
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Palms in the Farquhar Collection of Natural History Drawings

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Over the period of his stay in Malacca from 1795 to 1818, Major-General William Farquhar accumulated an extensive collection of drawings of flora and fauna which he presented to the Royal Asiatic Society in 1827. It was sold in auction at Sotheby’s in 1994 by the Society, and was subsequently acquired and magnanimously donated in 1996 to the Singapore Heritage Museum where the drawings have been given appropriate pride of place. The works by local artists - said to be Chinese - were not the only items collected or kept by Farquhar; there were others sent by him to Marquis Wellesley, then Governor-General of India from 1798-1805. The Wellesley Collection might indeed have offered interesting comparisons. It consisted of 2660 folios of natural history subjects, including 15 volumes on plants, kept at the India Office Library in London. Other East India Company botanical drawings have been deposited at Kew.

From my initial scan of the material pertaining to flora, viewing the marvellous Raffles items and others within the India Office Library, there appear to be no duplicates or similar drawings. Indeed, there were no records there pertaining to Farquhar as a collector of natural history drawings. There are believed to be other items in private ownership from the same artists and vintage; some of the Farquhar ones have watermarks dated 1796. At the Kew Library, I eventually came across two palm drawings which were exact and undoubtedly contemporaneous copies, within the collection of George Findlayson, who had accompanied Crawfurd to Siam in 1821-1822, and was likely to have had access to the same artists in Malaya. It can thus be conjectured that Farquhar’s items were not necessarily exclusive, and that the Chinese artists had a wider clientele: indeed they would have been practising their trade for quite some time, catering for European interest in exotic natural history and other subjects.

In China, John Reeves had begun to commission local painters since 1812, and he amassed a collection of some 2000 items now at the British Natural History Museum. He had supplied the Horticultural Society of London with drawings by artists whose names have been recorded as “Akut, Akam, Akew and Asung”. The employment of artists from Canton and Macao went back even earlier; J. Cunninghame probably used them for the 800 drawings he sent home between 1698-1703. British interest in botany and the commercial potential of Asian plants had been concomitant with the activities of the East India Company since 1698, in common with the Dutch whose botanists since Rumphius had also been energetic in the region, followed by Blume. Joseph Banks and Daniel Carl
Solander made extensive collections during the Cook voyages.

In India, the work of Roxburgh, Hunter, Wallich, and Jack laid the foundation for others such as Griffith; within the first half of the 19th century they provided the earliest taxonomic coverage of the flora of Penang and Malacca. Indeed Farquhar showed the collection of drawings to Dr. William Jack (who accompanied Raffles to Penang) in 1818, who was rather critical about their botanical adequacy. It is more than likely that Jack would have been familiar with the excellent and meticulous herbarium drawings being amassed by Roxburgh at the Calcutta Botanic Gardens in India, including the superb watercolours commissioned by William Hunter in 1802 to represent the flora of Prince of Wales’s Island, which gave an indication of the high quality expected in botanical illustration. Indian artists were employed in the main for botanical and zoological renderings, but it is thought that the Hunter items were by Chinese, probably in Penang. The botanists and amateurs of the day would have supervised the illustrations, and often supplied the paper stock and the specimens; they were often already acquainted with the scientific names given to plant names by Linnaeus and others.

The Farquhar collection is nevertheless important and significant historically, and includes many items in the region then not yet scientifically recorded; some collected and represented from Mount Ophir are believed to be the original holotypes. There are indeed many illustrations that are artistically charming and botanically informative - although some are naive and not quite accurate. They nevertheless provide interesting challenges for the identification of the species observed and recorded, and also for unravelling their actual location and extance. With regard to flora it might appear that the items were not all from Malacca or from Mount Ophir - or from the Malay Peninsula - as the drawing of the Double Coconut of the Seychelles would infer. This and the other eleven palm items were not included in the two bound volumes then owned by the Royal Asiatic Society which were perused by I.H. Burkill and described by him in his articles in the Gardens’ Bulletin (Vol.XII,1949:404-407; Vol.XIV,1955:530-533). Much of the flora had remained unidentified until then, but some of his determinations are due for correction and updating, and have stimulated this paper - which will be confined mainly to the palm taxa, sixteen within the two volumes, and a total of 28 in the whole collection.

The 472 drawings were catalogued in 1991 within the total collection of the Royal Asiatic Society by the indefatigable Raymond Head, who recorded that the Farquhar items were by then no longer in their original bound volumes. He provided an index for the set, numbered 016.001-016.472, and deciphered their inscriptions as best he could, unfortunately without the help of botanists or zoologists - or someone familiar with Jawi or Romanised Malay. There are therefore consequential misrenderings that need to be corrected; for example: item 016.469 is listed as “Caryota wiens”, which is clearly Caryota mitis. There are indeed scribbles difficult to make out, and Jawi does lend itself to various transliterations, calling for familiarity with the local names of the locality and vintage.
Plate 1 *Pinanga malaiana*: "Wild Betel Nut"; (RAS: 016.048).
In the first volume (016.001-016.054 in Head) inscribed “Medicinal plants, etc., of Malacca” on the flyleaf, apparently in Farquhar’s hand, Burkill noted 55 items, of which only one was a palm (No. 49; 016.048 in Head), which he identified not incorrectly as a Pinanga sp. That drawing carried the inscriptions in English “Wild Betel Nut”, and in Jawi “Pinang Utan”; (there was also an irrelevant superscription “Calamus Ketang” by pen, and a pencil note: “Rotang”, on the sheet). It becomes part of the sleuthing exercise to figure out the dates of the annotations, in English and in Jawi - as to which were original - and their authority; Burkill suggests that Linley had contributed a note probably in London, and it is not unlikely that Jack might also have added notes. Local names in Jawi, and the Rumi transliterations have provided an important basis for botanical identification; they certainly guided Burkill’s taxonomic determinations. None of the palm species included in the two volumes had been named by 1827, but some of the other twelve elsewhere in the Farquhar collection already had established scientific names, some attributed to Linnaeus, and were so inscribed, and these will be mentioned later. It is open to conjecture if Farquhar was himself versed in these names, and would have been responsible for the titles. Although he employed artists who were Chinese, according to Wallich, the Jawi vernacular names for distinctive local flora were obviously by Malay scribes of the vintage and literacy of Munshi Abdullah. Many items in the vast Indian natural history collections also had Jawi superscriptions.

In Burkill’s notes on the first bound volume and with reference to the “Wild Betel Nut”, it is surprising that he did not offer the obvious determination as the ubiquitous Pinanga malaiana (Mart.) Scheff., published in 1838 (see Plate 1), which has been collected both in Penang and Malacca (and elsewhere throughout the Peninsula and in Sumatra), and well represented in the Singapore Herbarium. He had however 54 other non-palm items to deal with.

In the second book (016.055-016.096 in Head), which had originally been bound in a volume measuring 37 x 42 cm, inscribed “Drawings of Plants from Malacca Presented by Col. Farquhar Vol. 2”, there are 42 drawings. Burkill notes that items 17 to 21 were from Mount Ophir. It is not known where the first sixteen items came from; they were all labelled rattans in Jawi, but as Burkill observed, item 16(016.070), “rotan sega” is not a rattan or at all a palm but is Flagellaria indica Linn., and that the term “rotan dini” is sometimes applied to this type of plant. Apart from item 14 the others are indeed rattans likely to have been found in the Malacca area, but not exclusively so. The only inscriptions on the pictures are in Jawi. Drawing from more recent taxonomic information, notably by John Dransfield (“A Manual of the Rattans of the Malay Peninsula”), an update on Burkill’s identifications is presented herewith, with corrections in italics:-

1 (016.055). “Rotan perachit”: Daemonorops angustifolia (Griff.) Mart. (1850); now known as rotan getah.

2 (016.056). “Rotan batu” : Calamus insignis var. insignis Griff. (1844); the local name is still used.
Plate 2 *Calamus speciosissimus*:
"Rotan sega badak": (RAS: 016.058).

Plate 3 *Myrialepis paradoxa*: "Rotan kertang"; (RAS: 016.059).

Plate 4 *Korthalsia rostrata*: "Rotan semut"; (RAS: 016.060).
3 (016.057). "Rotan jerenang" : Daemonorops propinqua Becc.in J.D.Hooker (1893); the local name is also used for three other rattan taxa.


5 (016.059). "Rotan kertang" : Myrialepis paradoxa (Kurz) J. Drans. (synon: M. scortechinii Becc. 1893); the local name is also used for three other rattan taxa.

6 (016.060). "Rotan semut" : Korthalsia rostrata Bl. (synon: K. scaphigera Griff. ex Mart. 1849); the local name applies also to other species of Korthalsia, as noted by Burkill (see Plate 3).

7 (016.061). "Rotan tunggul" : Plectocomiopsis geminiflora (Griff.) Becc. 1893; currently called rotan rilang; rotan tunngal is Calamus laevigatus.

8 (016.062). "Rotan manau" : Plectocomia elongata Mart. ex Bl. (synon: P. griffithii Becc. 1893); usually called rotan mantang; rotan manau is Calamus manan.

9 (016.063). "Rotan kemandong" : Calamus sp., probably C. speciosissimus, see item 4; the local name is not known currently.

10 (016.064). "Rotan dahanan" : Korthalsia rigida Bl. (1843); rotan dahan also applies to other species of Korthalsia, sometimes also called rotan semut.

11 (016.065). "Rotan semambu" : not identifiable from the drawing; probably Calamus scipionum Lour. 1790, to which the local name refers.

12 (016.066). "Rotan sisir" : not identifiable from the drawing; “Calamus griffithianus Mart.” as mentioned by Burkill is not known in current checklists; the local name is also not known, and could have been applied to any finely pinnated taxon e.g. Calamus exilis Griff..

13 (016.067). "Rotan gelam" : not identifiable from the drawing; not Daemonorops verticillaris (Griff.) Mart.

14 (016.068). to be discussed below.

15 (016.069). "Rotan getah" : a Daemonorops sp., probably D. angustifolia, from the local name.

Item 14 is labelled “Rotan pinang-pinang”, but it is obviously not a rattan, and Burkill suggests that its stem would have been used as a walking-stick or ‘rotan' cane. He misidentifies it as Pinanga disticha Bl., which is quite surprising as that taxon is easily recognisable by leaf and inflorescence and is again well represented in herbarium collections. It is in fact not a Pinanga but rather an Iguanura sp. (see Plate 5); the genus was only described in 1838 by Blume based on a Sumatran type specimen. This particular species with pinnate trapezoidal leaflets has quite positively not been found in Malacca, or south of Perak - or on Penang Island, another well-known botanical collection site. Thus unless it proves
Plate 5  *Iguanura* sp.: “Rotan pinang-pinang”; (RAS: 016.068).
to be an utterly extinct or undiscovered species, it suggests that Farquhar’s artist had access to collections from areas beyond the British Settlements. From recent field research a new species of single-stemmed Iguanura from the Belum area (also found in Gunung Bubu, and Bujang Melaka) has similar features.

There are twelve other palm drawings which are not part of the two volumes described by Burkhill; their place in the Farquhar collection can be traced from the Head index number (shown in brackets). They were apparently bound in two albums, each with 77 items, and similarly inscribed “Drawings of Plants from Malacca”, although we are quite certain that not all the plants hail from Malacca. Six of the palm with known botanical names were annotated accordingly: “Coco Nut Tree: Cocos nucifera” (016.441). “Pinang Betle Nut Tree - Beetle Tree: Areca catechu” (016.446), “Buah Lontar - Palmyra : Borassus flabelliformis (Lin.)” - correctly B. flabellifer L., synon: B. flabelliformis J.A.Murray (016.447). “Tookas: Caryota mitis” (016.469). “Nipah: Nipa fruticans” (016.422), and “Corma -Dabe, Elate sylvestris” - which was the Linnaeaus name, now Phoenix sylvestris (L.) Roxb. (probably 016.443, listed uninscribed), the last-mentioned being a species then already introduced to Malacca. The first four items had no Jawi inscriptions - suggesting that their naming required no local assistance, whereas the Caryota had a faintly pencilled Jawi corroborative note, and also the Nipah, which was annotated within the picture as “Pokok Nipah”. Another charming drawing is of “Sago”: Metroxylon sagu Rottl. (016.470), which had no Jawi but indecipherable English annotations. There is another labelled only in Jawi with no Rumi transliteration: a naive but elegant rendering of Arenga pinunata (Wurmb) Merr. (016.452, uninscribed), yet another introduced species, also commonly found in kampons. This is one of the two duplicated in Findlaysonis collection, which is labelled “Arenga saccherifera Bl.”.

Two further drawings are of “Poko Nibong” : Oncosperma tigillarium (Jack) Ridl. (016.433). “Sala - The Sala(?) Fruit”: Salacca sp. (016.454) (see Plate 6). The items mentioned so far were from the album dated c.1805-1818, but there is yet another interesting palm within the other earlier album, the “Palas batoo”: Licuala longipes Griff. (016.346) (see Plate 7), with inconspicuous Jawi notes. This is indeed a taxon common in Malacca and on Mount Ophir, where it was later described by Griffith in 1845.

The final palm to be discussed is from the album containing ten others mentioned above. It is that famous endemic of the Seychelles - the Coco-de-Mer, Lodoicea maldivica (Gmel.) Pers. (016.434) (see Plate 8). The drawing bears a pencilled inscription “Lodoicea Sechellarum”, a name geographically correct, unfortunately rendered invalid by taxonomic precedence. It would have seemed most unlikely that there would have been fully grown specimens in Malacca at that time, and that Farquhar’s artists have drawn it at other locations or even from illustrations, as it would have been a noted exotic from the sea route to India and Malaya. A copy of the. same drawing is also in the Findlayson collection at Kew, and it is therefore not unique as evidence of flora from a particular locality. The mystery dispelled by Burkhill (1935) citing an amazing record by Koenig (see JRAS
Plate 6 *Salacca sp.*:
“Sala - The Sala (?) Fruit”: (RAS: 016.454).

Plate 7 *Licuala longipes*: “Palas batoo”;
(RAS: 016.346).

Plate 8 *Lodoicea maldivica*:
Str. Br. 26, 1894: 104) that a three-year old palm had been seen growing in the
garden of a rich man, Bartolomei de Vents by name, in 1778; this indeed gives us
positive evidence that the Farquhar drawing if made c.1818 of the same palm,
would have been 43 years old, and thus quite fecund - also implying that suitable
floristic mates or progeny were also growing nearby.

Farquhar’s collection is certainly amply fascinating even from viewing a
narrow botanical sector such as palms; the total rich trove of the other natural
history illustrations will undoubtedly yield a wealth of early perceptions in the
depiction of Malesian flora and fauna at the commencement of the 19th century.

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Lumpur.


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Distribution and Abundance of Malayan Trees: Significance of Family Characteristics for Conservation

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Abstract

Taxonomic families of plants that characterize the lowland Malayan rain forest differ from one another nearly ten-fold in quantitative measures of distribution and abundance. A 50-ha sample of 300,000 trees includes 814 species or fully one-fourth of the Malayan tree-flora. The median adult population size for trees and shrubs is a linear function of area. From the Pasoh equations, we can calculate the area needed to capture an adult population of a specific size for a particular fraction of the flora, i.e., for 90% of the Pasoh tree flora to be represented by more than 200 adults per species will require about 3000 ha of forest. These equations indicate how many species will have a specific population size within a forest, but not which species. I test the alternative hypotheses that the large characteristic families of the Malayan forest either do or do not differ more than 10-fold in median species abundance and species representation. The Pasoh data reject the latter hypothesis. The characteristic taxonomic families of the lowland forest, e.g., Dipterocarpaceae, Sapotaceae and Burseraceae vary in representation from 10% of regional species to 60%, the power functions of species-area curves vary nearly 10-fold, and median abundances vary from less than 1 to more than 10 individuals per ha. These findings are confirmed in part from an analysis of the flora of Singapore which, with regard to representation, illustrates patterns identical to those at Pasoh. The consequences for conservation are two-fold: (1) general conservation strategies should not be based on studies of focal families; (2) different taxonomic families of trees and shrubs will require very different strategies of reserve design for their conservation.

Introduction

Do taxonomic families of plants differ from one another in quantitative measures of abundance and distribution? Of course, taxonomic families differ markedly in distribution at the broadest scales of geography: Dipterocarpaceae are found in Asia, bromeliads in the Neotropics, Proteaceae are predominantly in Australia and Africa. But within a geographic province, and within a single habitat such as the Malayan lowland rain forest, do the plant families that characterize that habitat, such as the Dipterocarpaceae, Myristicaceae, Sapotaceae and Lauraceae, differ in quantitative features of distribution and abundance?

Plant collectors and field botanists know in a qualitative fashion that some tropical families tend to show up in characteristic ways. For example, Symington (1943, pp xii) wrote of the Dipterocarpaceae of the Malay Peninsula: “In these lowland Dipterocarp forests about 130 species of dipterocarps, representing all the main groups, occur, but in any one district it is doubtful whether there are more than 60 species, and the representation of groups may be incomplete. In any one reserve there may, exceptionally, be as many as 40 species, but between 10 and 30 is the more usual number.” We could add that those few species of the
Dipterocarpaceae that do occur tend be among the most abundant trees in that forest. Nutmegs are quite different, and most of the 53 Malayan species can be collected without traveling far.

A quantitative comparison of families along these lines could influence our ideas about conservation biology in two ways. First, large differences in local representation and abundance among taxonomic families would indicate that the numerical loss of species with reducing land area would not be a random loss from the flora, but would rather be concentrated in certain families. Second, if large inter-familial differences are found, then efforts either to study biodiversity or to develop conservation policies, should avoid the use of one taxonomic group as a proxy representative of overall biodiversity.

This paper compiles the results of a large-scale inventory of the lowland forest of Malaya (50 ha, 320,000 trees, 814 species) and quantitatively compares those results with the entire known tree flora of Malaya (13 million ha, 3500 species), thereby testing the alternative hypotheses that the large characteristic families of trees either do or do not differ more than 10-fold in median species abundance and species representation. The findings are then qualitatively compared with the findings of floristic inventory from Singapore.

**Methods and study site**

The study was made at Pasoh Forest Reserve, Malaysia, which is located at 2° 59' N latitude and 102° 18' W longitude, or about 140 km south-east of Kuala Lumpur, in the interior portion of the state of Negeri Sembilan amidst a broad expanse of flat lands and gently rolling ridges that abut the westward side of the Main Range (Fig. 1). Prior to 1900, this South-Central portion of the Malay Peninsula comprised nearly 100,000 ha of relatively unbroken forest. The plot is situated in the last remnant of that forest.

The 50-ha plot is situated in the center of the primary forest reserve, and comprises 1250 contiguous quadrates each 20 m on a side. Over the course of three years, a team of roughly 20 people enumerated all the free-standing woody plants that exceeded 1 cm diameter at a height of 1.3 meters. The identifications were documented through collection of about 3000 herbarium specimens that include either flower or fruit, and through another 4000 specimens of sterile material. Specimens are stored at KEP and cited in Manokaran et al. (1990), together with a complete list of species. Further details of the plot survey methods, including the methods of measuring and identifying trees, are also described in Manokaran et al. (1990). The base data set has been published in Manokaran et al. (1993).

The present tabulation of the Malayan tree and shrub flora is based upon a 1990 analysis of the published Tree Flora of Malaya (Whitmore 1973, 1974; Ng
1978, 1989), and further details can be found in Kochummen et al. (1990). In tabulating the flora, we used the same definition of a tree that was used in the 50-ha plot, creating a slight discordance with the flora as originally published: we excluded climbers, epiphytes and stranglers, and scrambling shrubs, and also a few of the smaller plants in the Rubiaceae. On the other hand, we added a few shrubs that were not included in the treatment of the Melastomataceae. For the Dipterocarpaceae, we followed Ashton (1983), and in a few other minor ways our tabulation departed from the Tree Flora of Malaya series (e.g., we include the tiny families Dichapetalaceae and Goodeniaceae which were overlooked in the Flora), and for these reasons, our tabulation differs from those in Whitmore (1973) and Ng (1988).

Those species in the plot that were new records for the Malay Peninsula (about 2% of the plot flora) were also added to the total Malayan flora. Monocotyledons, which represent 1-2% of the plot flora, and less than 1% of the trees, were excluded from the analysis because the regional floristic tally has yet to be completed. A brief discussion of the distribution of individual trees species based on an earlier version of this tabulation was presented in Kochummen et al. (1992).

For the purposes of the present analysis, the 50-ha plot is treated as one very large and robust sample of over 320,000 trees that is representative of the South-Central lowland forest type, and the results are used as ecological descriptions of the constituent families. Tests of statistical significance for differences among families cannot be derived from the plot itself because it is being considered as a single sample. It would be improper to use the fifty contiguous one-ha plots as independent samples because they are spatially contiguous, and because the plot was specifically chosen for its homogeneity.

Percent representation for each family is the number of species represented by at least one tree in the 50-ha plot divided by the number of species in the Tree Flora of Malaya. To find the median abundance for each family, we first tally the number of individuals for each species, then sort the species by family. For each family the median abundance is the abundance of the species closest to the 50th percentile. For a family represented in the 50-ha plot by 11 spp, this would be the 6th most abundant species, with 5 species more abundant and 5 species less abundant. The median is preferable to the mean in that the latter is greatly influenced by the magnitude of the most abundant species.

Species area curves were prepared for selected families using nested cumulative plots of 0.1, 1, 10, 30 and 50 ha and the entire Malayan flora. An estimate was made for the each family at the scale of 100,000 ha in the South-Central Peninsula based on the institutional records of the herbarium in Kepong. This estimate is distinguished from the actual plot data.

To determine the number of adults of each species per unit area, I estimated the diameter at first reproduction based on published reports, advice of local
residents, and personal field experience. These were liberal estimates erring toward smaller diameters. Then I tallied the number of adults for each species within areas of 1, 2, 4, 8, 16, 32 and 50 ha, and then determined for each area sample the 50th, 75th, and 90th percentile ranking, that is, the adult population that 50%, 75% and 90% of the species exceeded. The samples of 1, 2, 4, 8, and 16 ha were independent of one another, while the 32 and 50 ha samples necessarily included the smaller samples. Thus, the samples are, in part, autocorrelated, which precludes a strict determination of significance for the r^2 values.

**Results and Discussion**

1. The sample, covering only 0.0004% of land area of Malaya, includes at least one individual of 814 species or 25% of the Malayan tree flora. This is much higher than anticipated and suggests that the usefulness of small reserves for conservation of trees may have been previously underestimated. Several important caveats are rather obvious: one individual does not constitute a conserved population, and no population is secure if a obligate pollinator has been lost from the system. On the other hand, a single self-fertile canopy tree could live for a hundred years or more in relative isolation, and produce thousands of offspring in a single season.

2. The median adult population size for trees and shrubs is a linear function of area. The relationship is the outcome of three constituent functions: the number of trees per area, which is linear; the number of species per area, which is a power function; and the number of individuals per species, which is close to a negative binomial. That the resulting function is very nearly linear is empirically interesting, and can be useful for calculating the numbers of adult trees in this lowland rain forest. The relationship between median adult number (N) and area (A) in ha follows the equation N = 2.02 + 0.56 * A. The relationship is non-linear over the first hectare, as species rapidly accumulate, but thereafter conforms closely to the equation, with an r^2 value of 0.99 (Fig. 2). The relationship between the 75th percentile population and area is much less steep, and is fitted to the equation N = 0.96 + 0.16* A, and again has an r^2 value of 0.99. The 90th percentile was only three adults per species at the 50 ha sample, i.e., 10% of the species were represented by fewer than three adults in 50 ha. The relationship follows the equation N = −.19 + 0.07 * A, and the r^2 value is 0.98.

If we choose 200 adults as a safe population level, then this level would be achieved for half of the species in the Pasoh tree flora in 357 ha: for 75% of the tree flora in 1250 ha; and for 90% of the tree flora in 2856 ha.

3. These equations indicate how many species might be considered ‘safe’ within a forest, but not which species. Individual taxonomic families differ markedly in representation of species (Table 1). First, restricting ourselves to
families with more than 5 species in Malaya, representation in the 50-ha plot ranged from 66% for the Hypericaceae (consisting solely of the genus *Cratoxylum*) to 0% for six families. Among the larger families, representation ranged from 32 out of 53 spp., about 60% for the Myristicaceae to 5 out of 88 spp. or 5% for the Myrsinaceae. The large and characteristic families of the lowland forest differed in the best-fit power functions from 0.06, for the Anacardiaceae and Burseraceae, to 0.15 for the Dipterocarpaceae and Rubiaceae. These different species-area curves are graphically illustrated in Figure 3.

4. Furthermore, median abundance of species varies ten-fold with taxonomic family. The overall median abundance of individual trees greater than 1 cm dbh is about 2 per hectare. Thus, about 400 species are represented by more than 2 individuals per hectare and 400 by less. Median species abundances varied among the larger characteristic rain forest families by nearly 100-fold (Table 2). Considering first those families with 5 or more species within the plot, the abundances range from a high of 14 individuals per ha for the Ulmaceae, and 11 individuals per ha for the Dipterocarpaceae, to lows of 0.4 and 0.1 per ha for the Symlocaceae and Combretaceae respectively.

5. Characteristic taxonomic families of the lowland forest, Dipterocarpaceae, Rubiaceae, Sapotaceae and Burseraceae will have varying levels of species representation and numbers of individuals at different spatial scales. Tables 1 and 2 can be usefully combined by taking all Malayan families represented by more than five species in the 50-ha plot, and ranking them in thirds by percent representation and by abundance, then cross-tabulating the families into a nine-cell (Table 3). The families in the upper left are those that are relatively well-represented in a single forest and also have a relatively high median abundance in that forest. These families comprise what are widespread and abundant species, e.g., Burseraceae. Those in the lower left, e.g., Rubiaceae, are represented by relatively few of the regionally available species, but the species that do occur in a particular forest are very abundant.

The most obvious question to ask at this point is whether or not these patterns are truly recurrent and characteristic features of the taxonomic families, or are they peculiar to Pasoh Forest Reserve. Are there not lowland forests in Malaya where the patterns are reversed for different families, where the Rubiaceae are represented by 50% of their species and the Myristicads by 15%?

A natural, but misleading, approach to that question would be to statistically compare each of the 50 individual one-hectare samples of roughly 6,000 trees each. Doing this, one finds nearly complete concordance among the fifty samples. However, this does not answer the question, but rather only tells us that the one-ha plots, being spatially proximate, are autocorrelated in compositional features, and represent a relatively homogenous forest, something that we already knew having specifically chosen this particular forest for its homogeneity. What we want
to know is whether or not these patterns are found recurrently in further samples around Malaya and Borneo.

There are no other plots comparable to the Pasoh plot where these hypothesis can be tested. The many line, quadrat, and growth and yield samples made in the Forest Reserves of Malaya over the past hundred years do not reject the hypothesis or contradict the findings, but they too heterogenous in method to be used for quantitative comparisons.

An alternative test is to use verified lists of species compiled for local floras, and while these offer no insight on abundances, they do represent hard evidence of a species occurrence. Singapore is one of the better collected tropical locales, and it’s well-documented list of species describes the original forest cover at a time long before the great changes brought to the island by economic growth (Turner et al. 1990). A compilation of percent representation of the characteristic lowland families represented in on the island (corrected to include only shrubs and trees) would reject the hypothesis that families display haphazard quantitative patterns of occurrence. Ulmaceae is represented by 7/8 of the Malayan flora, Myristicaceae by 34/53 or 64%; at the other end, the Dipterocarps are represented in Singapore by 25/156 species or 16%; the Lauraceae by 45/213 or 18%. No family is represented by more species than might be predicted from Figure 3 for an area of 60,000 ha. For those families of small shrubs that bloom frequently and which, therefore, should be expected to be thoroughly collected, such as the Rubiaceae, the representation is roughly as predicted: 89/296 or 30%, and the Myrsinaceae: 14/88 or 15.9%. This analysis shows that the data from an ecological sample from Pasoh can successfully predict the percent representation of taxonomic families in Singapore, something that was not at all intuitively obvious.

The description of these patterns and the magnitude of the differences among the families leads to two question: First, what is the ecological basis for these patterns, and second, what significance do these patterns hold for conservation policy?

Why should taxonomic families differ from one another in their patterns of distribution and abundance? Why should species of laurels be patchy in geographic distribution and sparse in local density, while species of dipterocarps are patchy in geographic distribution but high in local density, and the kedendongs (Burseraceae) are both widely distributed and relatively high in local density?

One of the more obvious factors regulating geographic distribution is the capacity for wide dispersal. The big trees with low representation, the Dipterocarps and very big Apocynads, seem to be invariably wind-dispersed. By contrast, the highest representations are found in trees such as the Anacards, nutmegs, and kedendongs, which bear large, often arilate seeds in fleshy fruits,
many of which are routinely dispersed by mammals and strong flying birds such as the hornbills. But we can see that dispersal is not a completely adequate explanation, for among the species with low representation, along side the Dipterocarps and Apocynads, are the berry-fruited species of the Rubiaceae and Myrsinaceae. Those latter two families are comprised chiefly of shrubs and smaller trees, in complete contrast with the stature of the towering Dipterocarps. Stature is an interesting factor, in that the highest levels of very local endemism among Malayan plants seem to invariably occur among small herbaceous genera. According to Kiew (1990), 50 percent of the species of Malayan Begonia (Begoniaceae) and 75 percent of 80 species of Malayan Didymocarpus (Gesneriaceae) are known from single localities. There are no genera of large trees that have distribution patterns anything like that. The only genera that might come close are the smaller shrubs in the Rubiaceae and Myrsinaceae. More complete data on reproductive ecology of these trees and a more thorough statistical approach may reveal further patterns and correlations.

The consequences of these patterns for conservation are two-fold. First of all, with regard to the methods of policy formulation, it is clear that the focal-family approach should be avoided. Choosing one taxon as a proxy representative for biodiversity is sometimes done explicitly, but more often it is only tacitly done through the limitations inherent in personal knowledge. Consultants who are engaged to aid the development of conservation plans often have, as a necessity of modern research, an intimate taxonomic and ecological knowledge of one or two families, and they perhaps inevitably draw upon their knowledge in forming opinions. The results from Pasoh show that this practice is very dangerous. In deciding upon the size and number of nature reserves, we would reach very different recommend-ations if we base our study on the Dipterocarpaceae rather than on, e.g., Myristicaceae.

Second, with regard to a national strategy for conservation, reserves of different size and number will have a varying success in securing safe populations of species representative of different families. One large preserve, such as Taman Negara in the center of the Peninsula will include the overwhelming majority of species in the Anacardiaceae, Burseraceae, and Myristicaceae. But it will certainly not include the major portion of Dipterocarps, Rubiaceae or Myrsinaceae. Where the representative species of these latter families occur, they are extremely abundant and a small park would include a large population. For these, a greater number of small parks in more scattered locations about the Peninsula would better serve their preservation. For the Lauraceae and Sapotaceae, trees with very low abundance and low representation, it may not be possible preserve their diversity in the wild through any means short of very large-scale conservation of the landscape. If only 10% of the Malayan Peninsula is retained under mixed forest cover, then for these families, ex situ conservation may be a priority.
Table 1  Representation of families of Malayan trees in 50-ha plot at Pasoh Forest Reserve, arranged in descending order of representation; families with more than five species appear before families with less than five species.

<table>
<thead>
<tr>
<th>Family</th>
<th>Total Malayan spp.</th>
<th>Pasoh Plot spp.</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypericaceae</td>
<td>6</td>
<td>4</td>
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<tr>
<td>Ulmaceae</td>
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<td>Burseraceae</td>
<td>36</td>
<td>22</td>
<td>61.1</td>
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<td>53</td>
<td>32</td>
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<td>9</td>
<td>5</td>
<td>55.6</td>
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<td>Combretaceae</td>
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<td>5</td>
<td>50.0</td>
</tr>
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<td>Polygalaceae</td>
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<td>10</td>
<td></td>
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<td>47.6 Meliaceae</td>
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Table 2 Median population size of species in the Pasoh 50-ha plot, arranged by family. Median population is in individuals larger than 1 cm dbh per ha.

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**ABUNDANCE**

Table 3 The major taxonomic families characteristic of the lowland Malaysian rain forest divided by thirds with regard to their abundance with representation in the 50-ha plot in Pasoh Forest Reserve.

<table>
<thead>
<tr>
<th></th>
<th>HIGH</th>
<th>MEDIUM</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burseraceae</td>
<td>(22 spp.) (61.1%) (6.70 ind.)</td>
<td>(42 spp.) (42.9%) (1.97 ind.)</td>
<td>(20 spp.) (38.5%) (1.14 ind.)</td>
</tr>
<tr>
<td>Polygalaceae</td>
<td>(10 spp.) (47.6%) (3.63 ind.)</td>
<td>(32 spp.) (41.0%) (2.76 ind.)</td>
<td>(5 spp.) (50.0%) (0.10 ind.)</td>
</tr>
<tr>
<td>Ulmaceae</td>
<td>(5 spp.) (62.5%) (13.70 ind.)</td>
<td>(32 spp.) (60.4%) (1.82 ind.)</td>
<td>(5 spp.) (65.6%) (0.90 ind.)</td>
</tr>
<tr>
<td>Ebenaceae</td>
<td>(23 spp.) (35.4%) (7.58 ind.)</td>
<td>(11 spp.) (37.0%) (2.67 ind.)</td>
<td></td>
</tr>
<tr>
<td>Annonaceae</td>
<td>(43 spp.) (32.3%) (3.58 ind.)</td>
<td>(7 spp.) (36.8%) (2.20 ind.)</td>
<td></td>
</tr>
<tr>
<td>Melastomataceae</td>
<td>(16 spp.) (28.6%) (6.66 ind.)</td>
<td>(7 spp.) (36.8%) (2.20 ind.)</td>
<td></td>
</tr>
<tr>
<td>Rubiaceae</td>
<td>(46 spp.) (15.5%) (3.53 ind.)</td>
<td>(7 spp.) (21.2%) (3.06 ind.)</td>
<td>(14 spp.) (19.2%) (1.21 ind.)</td>
</tr>
<tr>
<td>Dipterocarpaceae</td>
<td>(30 spp.) (19.2%) (10.96 ind.)</td>
<td>(6 spp.) (13.9%) (2.74 ind.)</td>
<td>(8 spp.) (17.8%) (0.84 ind.)</td>
</tr>
<tr>
<td>Myristicaceae</td>
<td>(5 spp.) (5.7%) (7.30 ind.)</td>
<td></td>
<td>(5 spp.) (22.7%) (1.82 ind.)</td>
</tr>
<tr>
<td>Tiliaceae</td>
<td>(8 spp.) (17.8%) (6.30 ind.)</td>
<td></td>
<td>(48 spp.) (22.5%) (0.96 ind.)</td>
</tr>
<tr>
<td>Apocynaceae</td>
<td>(6 spp.) (16.7%) (3.46 ind.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1 Map of Pasoh and Malaya depicting the number of trees and shrubs with documented occurrence. (These figures exclude monocotyledons, and differ from the tallies in the Tree Flora of Malaya and the Pasoh data set in a few other minor respects which are described in the methods.)
Figure 2 The 50th (median), 75th and 90th percentile of adult trees per species related to area at Pasoh Forest Reserve, Malaysia.

Figure 3 For six characteristic families of the lowland tropical rain forest, the number of species per area, all trees over 1 cm dbh, starting at Pasoh Forest Reserve Malaysia. Data points for 100,000 ha is estimated from records of plant collectors.
Acknowledgments

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The large-scale forest plot at Pasoh Forest Reserve is an ongoing project of the Malaysian Government, directed by the Forest Research Institute Malaysia through its Director-General, Datuk Dr. Salleh Mohd. Nor, under the leadership of N. Manokaran in cooperation with the Center for Tropical Forest Science, Peter S. Ashton of Harvard University and Stephen P. Hubbell of Princeton University. The identification of trees in the 50-ha plot was supervised by Mr. K.M. Kochummen through the support of a Smithsonian Senior Fellowship. Supplemental funds are very gratefully acknowledged from the following sources: National Science Foundation (USA), Conservation, Food and Health Foundation, Inc. (USA); UNESCO-MAB and the continuing support of the Smithsonian Tropical Research Institute (USA), Barro Colorado Island, Panama.

References


A Fusarium Wilt (Fusarium oxysporum) of Angsana (Pterocarpus indicus) in Singapore.

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Abstract

The Angsana wilt disease affecting Pterocarpus indicus in Singapore and caused by Fusarium oxysporum was first reported in Malacca in 1870. Following several outbreaks in various parts of the Peninsular Malaysia the disease was recorded in Singapore in 1914 and by 1919 many of Singapore’s Angsanas had either been killed by the disease or removed to prevent its further spread. Sporadic occurrences of the disease occurred around Singapore between 1970 and 1982 resulting in a rapid investigation of the disease and the implementation of control measures. Between 1980 and 1992, more than 800 Angsanas were removed as a consequence of the disease.

Although both F. oxysporum and F. solani were consistently isolated from infected trees only F. oxysporum proved to be pathogenic in inoculation experiments.

During a 10 month period, 170 Angsana trees were inspected because they had symptoms similar to the Angsana wilt disease. Of the 170 trees, 86% (147) were infected with F. oxysporum, while the other 14% were the result of lightning strikes. Of the 147 infected trees, 90% had also been struck by lightning and 87% had both lightning and ambrosia beetle infestations. The remaining 15 trees (10%) which were not struck by lightning were at secondary infection sites where an adjacent Angsana had already been removed because it was infected with F. oxysporum.

The hypothesis presented here for the life cycle of the Angsana wilt disease is that lightning damage to an Angsana provides the stress which attracts the ambrosia beetles. If these beetles are contaminated with F. oxysporum spores, then infection is likely to follow. The secondary spread away from this primary infection site, is by F. oxysporum which has entered the soil from the infected tree.

Short term control strategies are discussed which include the rapid removal of all lightning damaged trees and the use of insecticides and fungicides either sprayed or injected to prevent the establishment of new infection sites.

Long term control is anticipated following screening of Angsanas collected from a wide geographical area, and selection for resistance to F. oxysporum.

Key Words: Ambrosia beetles; Angsana; Angsana wilt; Fusarium oxysporum; Fusarium wilt; injection; lightning; Platypus parallelus; Pterocarpus indicus; resistance.

1 INTRODUCTION

The wilt disease of Angsana (Pterocarpus indicus) caused by Fusarium oxysporum was responsible for killing on average about 28 trees a month in Singapore between 1989 and 1995. The first indication of infection is the yellowing of leaves on one branch followed by their death. This is followed by the yellowing of leaves on subsequent branches until the tree is completely killed (Plates 1.1, 1.2), a process which can take either a few weeks or many months. Infection is confirmed by the presence of darkened xylem vessels within the primary xylem and the isolation of F. oxysporum.
An Angsana infected with the Angsana wilt disease. The disease has already killed one of the branches, and a second branch is starting to show the early signs of infection. The leaves turn bright yellow before turning brown and falling. This magnificent tree was the last in a avenue of about 10 trees.

The same tree five weeks later showing the rapid progress of the disease.
The disease was first reported in Malacca, on the South-west coast of Malaysia, where between 1870-1880 the disease practically wiped out a magnificent avenue of trees which adorned the sea shore (Fox, 1910).

Thirty years later the disease started to appear in other areas of Malaysia, where, between 1906-1910, around 100 trees were killed by the disease on the island of Penang and at about the same time some Angsanas in Tapah (Perak) were also killed. Soon after, many trees died in Kuala Kubu, Kuala Lumpur (Selangor) and in Taiping (Perak) (Bancroft, 1912).

The disease first appeared on Pulau Brani, an island in the port of Singapore, during 1914. From there it jumped to Connaught Drive on the waterfront, then a kilometre inland to Dhoby Ghaut. It subsequently appeared in the grounds of the Istana where the disease developed in an avenue of Angsanas near the gate to Orchard Road. The avenue was immediately cut in the hope of restricting the spread of the disease (Burkill, 1918). A localised strain of this disease is still endemic in these grounds today (Crowhurst et. al., 1995).

The disease continued inland during early 1919 and by May some trees at the end of an avenue at Tanglin Barracks, 5 kilometres inland showed sign of Angsana wilt. Although the disease spread to many other parts of Singapore, the epidemic was held in check by the rapid removal of any tree showing signs of the disease (Furtado, 1935b).

Sporadic occurrences of the Angsana wilt disease occurred around Singapore between the late 1970s and 1982, however, an outbreak which affected 28 trees in an avenue of Angsanas along Tampines Road, resulted in a rapid investigation into the disease. This investigation culminated in a report written by John Harden (1982) who formulated a number of control measures which were implemented. These included the removal of trees once they were confirmed to be infected, with the trunks and branches being burnt. The areas around infected trees, and around trees suspected of being infected, were drenched with fungicides. Field officers were advised to closely monitor any further spread of the disease and strict horticultural sanitation was introduced.

With the removal of the infected trees and the intensive soil drenching with fungicides, only 8 further infections were encountered during the next year and the spread of the disease again appeared to be under control. The next report of trees being removed because of Angsana wilt was in October 1988, when two Angsanas along Collyer Quay were found to be diseased. Since 1988 this latest epidemic has gathered momentum and over 800 trees have been removed as a consequence of the disease, by the Parks and Recreation Department’s Maintenance Division.

During 1990, the Parks and Recreation Department, because of their concern
regarding this disease, organised a seminar and a field trip to familiarise field officers with this disease. Later in that year a joint application was made by National Parks Board, Primary Production Department and the Parks and Recreation Department to the National Science and Technology Board and to SGS SINGAPORE Pte. Ltd, for funding to study this disease.

2 THE CAUSAL ORGANISM

During the 1982 investigation, the causal organism was tentatively identified by Professor Gloria Lim and Fong Yok King, and confirmed by the Commonwealth Mycological Institute, as *Fusarium oxysporum*. Similar wilt diseases occur on *Pterocarpus angloensis* in Africa (Piearce, 1979), and on *Albizia julibrissin* (Pirone, 1988) in the United States. No successful pathogenicity test was conducted with the fungus at that time.

*Fusarium oxysporum* is a common pathogen of crop plants causing considerable economic losses in peas, beans, tomatoes, cotton and bananas. There are also examples of *F. oxysporum* being pathogenic to palms where it is of commercial importance on both oil and date palms (Turner, 1981; Louvet and Toutain, 1973). It has also been recorded on ornamental palms in Singapore on a number of occasions by staff of the Plant Health Diagnostic Branch of the Primary Production Department in Singapore (PPD Disease Records).

2.1 Isolation

During the preliminary investigation a number of Angsanas showing symptoms of Angsana wilt were sampled and fusaria isolated. The isolates consisted of what were considered typical *Fusarium oxysporum* with short phialides and typical *Fusarium solani* with long branched phialides (Toussoun and Nelson, 1968; Booth, 1977; and Burgess *et al.*, 1988). There was also, however, a wide range of fusaria covering the entire range from short *oxysporum*-like, to long *solani*-like phialides.

During November and December 1991 thirteen sites consisting of 61 trees showing symptoms of Angsana wilt were sampled. The dead areas of the bark were identified by removing the outer bark (*Plates 2.1, 2.2, 2.3*) using a sharp, 3 cm wood chisel and hammer. The inner bark, together with a thin portion of underlying wood was removed and taken as the sample. Between 3 and 5 samples were taken per tree. The first sample was taken at the vertical boundary between healthy and diseased tissue, with subsequent sampling across the dead tissue to the opposite boundary. The samples were placed in a plastic bag which was then labelled.
In the laboratory, the samples were first washed in clean tap water and then for 2 minutes in a 20% sodium hypochlorite solution (1:5 Chlorox® and water), rinsed in sterile distilled water to remove any excess chlorine then transferred to a 15 cm glass petri dish containing sterilised moist filter paper, for incubation. The samples were checked daily for developing fungal growth and spores were transferred to PDA (Potato Dextrose Agar).

From the 61 trees sampled, *Fusarium oxysporum* was isolated from 56, and *Fusarium solani* from 45. From 40 of the 56 (71%) trees from which *F. oxysporum* was isolated, *F. solani* was also isolated, suggesting that this is a disease complex involving both fusaria.

For all samples collected later in the project, the inner bark and a thin layer of the outer wood was removed and discarded. This exposed the primary xylem, which if infected with *F. oxysporum*, would show the characteristic vascular staining (Plates 2.4). Where possible samples were collected from areas invaded by the ambrosia beetles. Such samples of primary xylem usually resulted in pure cultures of *F. oxysporum* (Plate 2.5, 2.6).
Plate 2.2
A small Angsana transplanted into contaminated soil has become infected with the Angsana wilt disease (a). Removing the bark from the buttress and lower trunk has exposed the discoloration of the tissues underneath. The discoloured tissues are invaded by both *F. solani* and *F. oxysporum* (b).

Plate 2.3
Infection starting from the roots and spreading upwards into the trunk is a good indication of secondary spread.
2.2 Identification

Both *Fusarium oxysporum* and *Fusarium solani* were tentatively identified by the project team, using the criteria of phialide characteristics, macro-spore size, colony edge morphology, and culture colour (Table 2.1, Plates 2.7, 2.8), as set out in the keys of Toussoun and Nelson (1968), Booth (1977), and Burgess *et al.* (1988).

Table 2.1 Culture characteristics of *Fusarium oxysporum* and *Fusarium solani*

<table>
<thead>
<tr>
<th>Culture characteristics</th>
<th><em>F. oxysporum</em></th>
<th><em>F. solani</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td>white and fluffy</td>
<td>white range of colours from light brown through yellow to orange.</td>
</tr>
<tr>
<td>Bottom</td>
<td>turn peach to salmon pink</td>
<td>amber to red turning dark brown or black.</td>
</tr>
<tr>
<td>Phialide characteristics</td>
<td>short and simple</td>
<td>long and branch</td>
</tr>
<tr>
<td>Macro-conidia size</td>
<td>20 - 32μ x 3 - 5μ</td>
<td>40 - 75μ x 4.5 - 7μ</td>
</tr>
<tr>
<td>Colony edge morphology</td>
<td>irregular with micro-conidia produced within the agar</td>
<td>smooth uniform hyphae</td>
</tr>
</tbody>
</table>

Plate 2.4
Woody tissue of a diseased Angsana showing the brown streaks of the infected xylem vessels, the presence of ambrosia beetle holes and white powdery frass.
Plate 2.5
Close up view of the same colonised vessel. Bunches of conidia of *F. oxysporum* on short phialides characteristics of this fungus, can be seen on the mycelium.

Plate 2.6
An ambrosia beetle coming out from its hole in surface sterilized diseased wood. The white cottony mycelium of *F. oxysporum* can be seen growing from the frass thrown out by the insect.
Plate 2.7
Slide made from *F. oxysporum* growing on surface-sterilised diseased wood tissue collected in Singapore. (a) Chlamydospores, (b) mycelium with short simple phialides.

Plate 2.8
*F. oxysporum* isolated from diseased Angsana tissue collected in Singapore. Sizes of macro-conidia range from 18-28μ (a), (b) and micro-conidia 4-14μ (c).
For confirmation of their identity, three isolates of each species were sent to the International Mycological Institute, UK, Sydney University’s *Fusarium* Research Laboratory, Australia and the Crown Research Institute, Auckland, New Zealand during the course of the investigation. The three isolates of *F. oxysporum* and *F. solani* represented the range within the population. All three institutes to which the isolates of *F. oxysporum* were sent, confirmed their identity, however, with the *F. solani* isolates, there was no consensus as to their identity. In two instances different names were given to the different isolates. This is not surprising because of the variation between the *F. solani* isolates. Some isolates of *F. solani* were impossible to differentiate from *F. oxysporum* on phialide characteristics when viewed on wood, the difference only became obvious because of colony morphology when the isolates were growing on PDA. A complete range of phialide length along with a wide range of colony colour was found within the population of *F. solani*. It is suggested that when isolates were sent for identification they were seen as individuals from separate populations, rather than the natural variation within a sexually active and therefore a segregating population.

As we are not in a position to judge on the taxonomy of the *F. solani*, and to prevent further confusion in the literature, *F. solani* is retained for this publication.

*Fusarium solani* was consistently isolated from the dead bark outside the *F. oxysporum* infected primary wood tissue. It was also consistently isolated from ambrosia beetles sampled. The status of *F. solani* in this disease complex, therefore warrants further investigation.

### 2.3 Pathogenicity Test

A root inoculation test was conducted to test the pathogenicity of the two fusaria isolated. The two fusaria were consistently isolated from the wood material collected from infected trees.

The method used was that described by Burgess et. al. (1988) in the Laboratory manual for *Fusarium* Research, and by Piearce (1979).

One hundred and fifteen, well rooted hardwood cuttings of Angsana were removed from their pots and the soil thoroughly washed from the roots. The roots were then trimmed to 50% of their original length before the cuttings were placed in a spore suspension and left in the sun for four hours. The spore suspension was made by macerating three plates of one-week old fungal lawns in 500 ml of sterile water.

Sixty cuttings were inoculated with *Fusarium oxysporum*. 45 with *F. solani* and 10 inoculated with macerated PDA as controls. After four hours the cuttings were re-potted using the original soil and watered with the fungal lawn suspension. No watering was done for the next three days, and subsequently every three days.

The first cutting started to wilt after 19 days with the majority of the cuttings wilting between days 21 and 28. The trial was terminated after 35 days.
As can be seen from the results of the inoculation test (Table 2.2, Plate 2.9) the only deaths occurred with those hardwood cuttings inoculated with *F. oxysporum* where 96% of the hardwood cuttings died. The identity of the causal organism was therefore confirmed as *F. oxysporum*.

Table 2.2  Pathogenicity test of the two fusaria isolated from diseased Angsanas

<table>
<thead>
<tr>
<th>Fungus</th>
<th>Angsana</th>
<th>Number inoculated</th>
<th>Number died</th>
<th>Number survived</th>
<th>% death</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>F. oxysporum</em></td>
<td>60</td>
<td>58</td>
<td>2</td>
<td></td>
<td>96</td>
</tr>
<tr>
<td><em>F. solani</em></td>
<td>45</td>
<td>0</td>
<td>45</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

Plate 2.9
Well rooted hardwood cuttings of Angsana inoculated with *Fusarium oxysporum* and *Fusarium solani*. Five weeks after inoculation, all except 3 cuttings inoculated with *F. oxysporum* showed symptoms of Angsana Wilt Disease and died eventually (a). Those cuttings which were inoculated with *F. solani* (b) and those uninoculated plants (control) (c) remained healthy.

3  EPIDEMIOLOGY

3.1 Lightning

Damage to trees caused by lightning has been the subject of periodic publications in Singapore (Thomas, 1900; Fox, 1910; Futardo, 1935a). Osmaston
(1920: page 120) made the statement “From general observations which are not, however, based on definite countings, I believe that under existing conditions (in Asia) about 50% of trees struck (by lightning) survive, and the death of the remaining 50% is, I believe, mainly brought about by insect and perhaps also fungal attack. On more than one occasion I have noticed how Platypus biformis and bark beetles may at once attack a struck tree commencing at first on either side of the rift in the bark and thence gradually extend their operations completely round the stem.” Sharples (1933) suggested, that in the case of rubber trees (Hevea brasiliensis), lightning discharges rendered these trees susceptible to the attack of parasitic insects or fungi.

The relationship between lightning and insect attack has received considerable attention (Miller and Keen, 1969; McMullan and Atkins, 1962; Anderson and Anderson, 1968; Anderson and Hoffard, 1978 and Schmitz and Taylor, 1969). Taylor (1974: page 843) comments that “several genera of forest insects apparently respond to the olfactory attraction of volatile extractives released by a tree newly ruptured by lightning, and the few initially attacking insects may create sexual stimuli that trigger a mass attack on the struck tree and its neighbours.”

Harden (1982) in his report to the Parks and Recreation Department, suggested the possible involvement of the ambrosia beetles in the disease cycle of the Angsana wilt disease. However, such a suggestion posed the enigma that ambrosia beetles only infest weakened trees. For this reason it was generally assumed that the ambrosia beetles infested the Angsanas only after they had been weakened by Angsana wilt.

The puzzle which confronted the project team at the beginning of their investigation was, if F. oxysporum is a soil borne organism, how do new infection sites develop several kilometres away from an old infection site, and are the ambrosia beetles, as suggested by Harden, and which are nearly always associated with the infected trees, part of the disease process.

The Housing Development Board’s tree nursery along University Road, gave us our first indication that lightning might be associated with the epidemiology of the disease. This occurred when a tree growing adjacent to four trees which had been unsuccessfully stem inoculated with F. oxysporum, attracted our attention because of a line of frass which extended from the ground to the tip of a main branch (Plates 3.1, 3.2). On close inspection the tree exhibited all the symptoms of Angsana wilt, and F. oxysporum was isolated from the tree. This situation caused considerable confusion and debate as to why an adjacent tree, and not one of the inoculated trees, should develop the symptoms of the disease. During the following weeks, however, obvious symptoms of what we perceived to be lightning damage began to appear. After three months a 5 - 10 cm strip of bark had peeled off, revealing the wood from just above the ground level to the top of the main branch.
White powdery frass on the Angsana trunk and root flare indicating the presence of the ambrosia beetles actively invading the tree. When this photograph was taken the leaves on the affected branches were drooping and dull green, suggesting that it had only been a few days since the lightning strike. The tree was the third in a row to have been affected.
This was the area which had originally been the site of the ambrosia beetle invasion. The disease subsequently spread to two neighbouring trees.

Of the 21 trees investigated during the following five weeks from which *F. oxysporum* was isolated, 17 of the trees also exhibited symptoms of what we suspected were caused by a lightning strike. These symptoms included, the rapid defoliation of one or several branches of the tree, areas of thin outer bark which had been lifted off in large sheets, and a line of cracked bark down the tree, defining the path of the lightning. The bark along the cracks often appeared to have been burnt or finely fragmented. Fifteen of the 17 lightning trees were also colonised by ambrosia beetles within days of the lightning strikes, with numbers of 500 - 2,000 beetles/m² being common.

### 3.1.1 Water Solubility Of Resin

Because there appeared to be an association between lightning damage and trees infected with Angsana wilt, it was important to determine with certainty, whether or not a tree had been struck by lighting. To this end we started looking at ways to confirm lightning strikes on Angsana.

An observation that the red stains on clothes, caused by the resin from Angsanas, could be washed out by vigorous scrubbing in cold water, but if the clothes were washed and subsequently ironed, then the stains became permanent and impossible to remove, led us to investigate the solubility of the Angsana resin.

It was found that the resin from both the healthy Angsana, and those colonised by *F. oxysporum* and *F. solani*, although not soluble in organic solvents, was soluble in water. Conversely, resin from the bark samples suspected of having lightning damage, were not water soluble.

To determine the temperature at which the resin became insoluble in water, 1.5 g samples of air dried, healthy bark were placed into open glass petri dishes, and heated in an oven. One petri dish sample of bark was removed at every 10°C rise in temperature between 70°C and 220°C. A glass petri dish lid was placed over the petri dish as it was removed from the oven. When these samples were placed in water, it was found that the resin was water soluble for those samples which had been removed at a temperatures of 150°C and below, whereas the resin was no longer water soluble for those samples heated to 160°C and above.

Assuming that the only natural way for the bark to be heated to temperatures above 160°C is the passage of a very high electric current through the bark, i.e. lightning. We had developed a very simple test to determine whether or not an Angsana has been struck by lightning. The test results can be obtained within five minutes, with complete repeatability, and thus a very high degree of accuracy.
3.1.2 Tree Survey: November 1993 - August 1994

Each week, from November 1993 until August 1994, trees showing symptoms of Angsana wilt (Plates 1.1, 1.2) were inspected and detailed records made of lightning symptoms, location, ambrosia beetle infestation, percentage of the canopy and bark affected, size of tree, and the number of nearby Angsana. Bark samples were collected from both the suspected lightning damage and adjacent trees. These were tested in the laboratory for the water solubility of the resin, to determine whether a tree had or had not been struck by lightning.

During the 10 month period, 170 Angsanas were inspected because they had symptoms similar to Angsana wilt. Of the 170, 147 (86%), were infected by F. oxysporum, the remaining 23 (14%) had been struck by lightning but no infection was detected. Of the 147 infected trees, 132 (90%) had been struck by lightning and 128 (87%) had both lightning and ambrosia beetle attack.

All the 15 (10%) trees where lightning damage was not recorded, were secondary infection sites being adjacent to a site where a tree had already been removed because of the Angsana wilt disease. The time taken for the secondary infection to move from an infected tree to the adjacent tree varied from 22 days in the case of two trees in Holland Avenue, to 131 days between two adjacent trees at the Pioneer Rd/International Rd corner. The mean time taken for the secondary infection to move between two trees was 73 days (15 observations).

3.1.3 Symptoms Of Lightning Damage

The first symptoms occur at the time of the lightning strike and these are the physical damages that are associated with the expansion of gases as the liquids in the bark are heated past their boiling points. In the majority of cases, sheets of outer bark, usually in the order of $50 \times 20$ cm, are either lifted off together with the thicker inner bark or they are completely blown off the tree (Plate 3.4). Small areas ($1 \times 5$ cm) of inner bark may also be completely disrupted producing an area of loosely held fibres (Plates 3.5, 3.6).

During the days following the strike it becomes apparent that the tree has sustained a lightning strike as the leaves dry up, turn a dull green then brown before falling (Plate 3.7). If the tree is left standing, the affected branches will flush with new leaves, which may also wilt before reaching full size. In the absence of the F. oxysporum fungus, death or survival of a lightning struck tree depends on many factors including the size of the tree and the extent of the lightning strike.

During this period the bark along the path of the strike will start to dry and crack. It is along the edge of these cracks that the resin appears to have been baked and it is from this area that samples are collected for testing the water solubility of the resin. The drying and cracking of the bark continues over the next few
months until the bark falls to the ground and the area of damage is outlined by the absence of bark (Plate 3.8).

It was common to record more than one tree which had apparently been struck during the same storm. In one instance a group of five neighbouring trees all showed similar symptoms (Plate 3.9). It is also suspected that trees which show symptoms within a few weeks of the first tree dying, might also have been struck at the same time. This delay has been attributed to the shock being transferred through the root system (Futardo, 1935a).

3.1.4 Ambrosia Beetles

Dutch elm disease is the best known example of a disease - insect relationships because of the widespread death of elms in both Europe and the United States. The insect-pathogen relationship is a passive one, with the fungal spores sticking
Plate 3.5
Below the sheets of thin outer bark which have been separated from the inner bark, are the vertical cracks and often small areas of completely disrupted bark producing areas of loosely held fibres.

Plate 3.6
Large sheets of outer bark are separated from the inner bark revealing the vertical cracks and areas of disrupted fibres.
Plate 3.7
An Angsana along Adam Road showing what appeared to be the symptoms of Angsana wilt disease. On close inspection the trunk showed damage due to a probable lightning strike. The leaves turned dull green then brown before falling. This process took about 7 days.

Plate 3.8
The area of exposed wood showing the old ambrosia tunnels, which three months earlier had delimited the area of damage and from which *F. oxysproum* had been isolated.
to the insects before the adults leave the diseased tree, then being physically brushed off in the new feeding tunnels.

Ambrosia larvae on the other hand feed on fungi which are cultivated by the adults, and the spores of these fungi are actively carried from one tree to another in special pouches, mycangia, on the thorax of adults. The ambrosia beetles therefore actively inoculate newly colonised trees with their ambrosia fungi. It is not surprising therefore that when a plant pathogen becomes involved as part of this fungal-insect symbiosis that a fungal-insect-disease situation arises. Current research in New Zealand suggests that an ambrosia beetle (*Platypus* spp.) might also be involved as a vector of Dutch Elm Disease in that country (Scott C. pers. comm.).

In 1973 Zimmermann, found *Fusarium javanicum* to be among a range of fungi colonising the galleries produced by the ambrosia beetle, *Xylebrus*. Appreciating the significance that some of these fungi might be plant pathogens, he tested them in the laboratory and found that *F. javanicum* was indeed a pathogen, which caused a canker on tomato shoots.

The first link between an ambrosia beetle being a vector of a plant disease was when Kessler (1974) suggested that the apparent symbiosis between a *Fusarium* species and ambrosia beetle (*Xylosandrus remanus*) causes black walnut canker,
a link that was confirmed by Weber (1979, 1985). Hara and Beardlsey (1976) studied the biology of the black twig borers, a severe pest of shrubs and trees, causing extensive economic damage to coffee and cacao in tropical Africa, Indonesia and Southern India and to tea in Japan, and found that the eggs were laid on the ambrosia fungus, *F. solani*. The symptoms of the attack were necrosis of leaves and stems, which extended from the entry hole to the terminal shoots of the branch. These are leaf and stem symptoms characteristic of *Fusarium* attack on crop plants such as peas and beans.

In 1978 Anderson and Hoffard demonstrated the link between *Fusarium* canker (*F. solani*), and the ambrosia beetle *Xylosandrus germanus* and *Xylebrus sayi* on tulip poplar trees in Ohio.

There are three reported examples of ambrosia beetles being associated with diseases of pines. Frederick (1976) provided data which suggested the scolytid beetles may be important vectors in the transmission of *Scieroderris lagerbergii* under specific conditions. Wingfield and Marasas (1980) suggested that the fungus-insect relationship of *Ceratocystisips* and *Orthotomicus erosus* is an important part of a disease complex that results in significant losses in pine plantations. In 1983, the same authors demonstrated the pathogenicity of the root pathogens *Verticicladiella procera* and 2 new species and showed that they were carried by scolytid bark beetles.

Other examples of ambrosia beetles being linked as the vectors of plant pathogens are: the mortality of the Red Beech (*Nothofagus fusca*) which is a direct result of the invasion of the sapwood by a fungal pathogen *Sporothrix sp.* introduced by the ambrosia beetle *Platypus sp.* (Faulds, 1977): the sudden death syndrome of cocoa, caused by *Phytophthora palmivora* in Papua New Guinea, which Prior, (1986) linked to the scolytid bark beetles and the ambrosia *Platypus sp.*. In this study Prior found that *F. solani* was also a part of this disease-insect syndrome; and in 1991 Hiji, et. al. suggested that the mass mortality of oak trees in Japan was the result of a range of pathogens introduced by the ambrosia *Platypus quercivorus* and *P. clamus*.

In our current study *F. solani* was consistently isolated from ambrosia beetles sampled. It was also consistently isolated from the dead discoloured bark outside the primary xylem infected with *F. oxysporum*. This bark is characteristically wet, and smells of decay, and is the marker used for locating the *F. oxysporum* infection. This association of ambrosia beetle, *F. solani* and the *F. oxysporum* warrants further investigation.

Of the 132 infected and lightning damaged trees inspected during the last 10 months of the project, 128 (97%) were infested with ambrosia beetle at the time of inspection (Table 3.1).
Table 3.1
Classification of the 170 unhealthy trees inspected during the 10 month period November 1993 - August 1994.

<table>
<thead>
<tr>
<th>Lightning damage</th>
<th>Secondary infection site</th>
<th>Total unhealthy trees</th>
<th>Trees struck by lightning</th>
<th>Trees struck by ambrosia</th>
<th>Lightning and Ambrosia</th>
<th>Lightning and infected</th>
<th>Secondary sites no lightning</th>
<th>Total number infected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>103</td>
<td>103</td>
<td>100</td>
<td>100</td>
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<td>29</td>
</tr>
<tr>
<td>Lightning damage</td>
<td>Primary infection site</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Lightning damage</td>
<td>No infection</td>
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<td>15</td>
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<td>15</td>
</tr>
<tr>
<td>No lightning damage</td>
<td>Secondary infection</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
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<td>150</td>
<td>146</td>
<td>166</td>
<td>143</td>
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<td>170</td>
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<tr>
<td>Percentage</td>
<td></td>
<td>88%</td>
<td>97%</td>
<td>86%</td>
<td>78%</td>
<td>86%</td>
<td>10%</td>
<td>90%</td>
</tr>
</tbody>
</table>

Because of this apparent close relationship between lightning damage, the presence of ambrosia beetles (Plate 3.10), and the subsequent infection by *F. oxysporum*, and the demonstrated link of infection by *F. solani* and ambrosia

**Plate 3.10**
Ambrosia beetles actively invading an Angsana trunk which had recently been struck by lighting.
beetles in the literature, it was important to determine, firstly the identification of the ambrosia beetles and secondly, whether these beetles were capable of carrying F. oxysporum as part of their fungal flora.

Collection of ambrosia beetles were carried out between April 1992 and September 1994 at University Road, Holland Road Fringe car park, Pioneer Road and Sembawang Field Experimental Station. The beetles were trapped using Window Flight Traps (Beaver & Loyttyniemi, 1991; Martin, 1977), funnel traps and also collected individually using forceps.

Whole beetles and severed parts, such as head, thorax and abdomen were analysed for the presence of micro-organisms. The selective media used was a Peptone PCNB agar (PPA) as described by Burgess et. al. (1988). This media was later modified with the addition of 1 g per litre of carbofuran (Furadan® 5G) granules to control the nematodes carried by the beetles, which quickly resulted in bacterial contamination swamping the plates.

3. 2. 1 Identification.

The ambrosia beetle which predominated in all the collections was identified as Platypus parallelus (Fabricus) (= P. linearis Stephens), Family : Platypodidae. (Plate 3.11). This was confirmed by Dr. Mick Cox of the International Institute of Entomology, CAB International, and also by Prof. D. H. Murphy from the National University of Singapore.

The beetle is polyphagous and is found throughout the tropical and subtropical regions of the New World, and in Africa and Malaysia. Dr. Cox (pers. comm.) communicated that the beetle could transmit Fusarium fungus since the platypodid Cylindropalpus auricimans has this ability in West Africa.

The other species of ambrosia beetle, infrequently caught in the collections, was identified as Platypus geminatus by Prof. D. H. Murphy from the National University of Singapore.

3. 2. 2 Isolation of Fusarium oxysporum from ambrosia beetle

F. oxysporum, F. solani, Penicillium sp., Gliocladium sp., and Trichoderma sp., were isolated from larvae taken from the galleries. Saprophytic bacteria were also isolated in some cases.

Similarly, the adult insects (male and female) also yielded F. oxysporum, F. solani, Penicillium sp., and Gliocladium sp., and also Verticillium sp.

In an effort to localise these micro-organisms, parts of the adult insects were plated and analysed for the presence of fungal growth. F. solani was found on the head, thorax and abdomen of the insects, whereas F. oxysporum was only detected
Plate 3.11
The ambrosia beetles (*Platypus parallelus*, family: Platypodidae) trapped from the diseased Angsana. Female (a); Male (b).
on the abdominal parts. *Cladosporium* sp. and *Nigrospora* sp. were also detected in these experiments.

Besides studies on mycangia, other workers were cited by Browne, (1961) who reported that spores could be carried by the beetle on brushes or hairs on the head, under the elytra, and on ventral abdominal hairs. It is also generally agreed that mycelium is utilised as food, but spores usually pass out undigested.

Out of the 200 beetles collected at University Road, only 6% carried *F. oxysporum*, while beetles taken from funnel traps showed 33% had *F. oxysporum* on them. Collections of beetles taken at Holland Road fringe car park, pooled collection of 50 - 100 beetles each, revealed that 30 - 40% of them carried *F. oxysporum*. Of the twenty-six beetles which were either drowned in the resin or captured alive while initiating attack on the bark, 15% were found to carry *F. oxysporum*.

These results demonstrated that where inoculum was high as a result of increased numbers of infected trees, it followed that a larger percentage of the beetles emerging from the area would carry the pathogen. At the university Road there was only one infected tree at the time of trapping, whereas the Holland Road fringe car park area was in the midst of an outbreak. Several trees were diseased or became infected over the trapping period.

### 3.3 Discussion

The link between ambrosia beetles and *Fusarium solani* as an ambrosia fungus is well documented (Kok, 1972; Zimmermann, 1973; and Har and Beardsley, 1976). That *F. solani*, an aggressive plant pathogen, was also linked with the ambrosia beetles as a vector of the disease is therefore to be expected. (Kessler, 1974; Anderson and Hoffard, 1978 and Weber, 1979; 1985)

*Fusarium oxysporum* is very similar to *F. solani* in respect to the production of micro-conidia, so that any *F. oxysporum* which had colonised the ambrosia tunnels, would be picked up by the adult ambrosia beetles leaving the tunnels and transported to, and inoculated into, any new susceptible trees colonised by the beetles.

Murphy (1994 pers. comm.) stated that “the biology of the ambrosia beetles is centred around the transmission of their fungal symbionts, for which they have specialised anatomical devices such as hair tufts or chitinous pockets designed to carry the spores. If a tree became infected with a fungal pathogen such as has happened in the Angsana wilt disease, it would be almost impossible for ambrosia beetles not to pick it up on emergence, and almost inevitable that they would infect any new tree that they successfully infested themselves.”

Throughout the project it was common when isolating *F. oxysporum*, to find the mycelium to be associated with the ambrosia holes in the wood (Plate 3.12).
White cottony mycelium *F. oxysporum* growing out from Ambrosia beetle holes on surface sterilized diseased wood tissue placed in petri dish. The only mycelial growth to be seen on the wood is associated with the ambrosia tunnel.

however, it was only towards the end of the project that we demonstrated that ambrosia beetles do carry the *F. oxysporum*. In one sample 40% of those beetles sampled were carrying *F. oxysporum*.

Of the 170 unhealthy trees inspected, 147 (86%) were infected with *F. oxysporum*, and of these, 132 (90%) were also struck by lightning and 128 (87%) had both lightning and ambrosia beetles. Only 15 (10%) were due to secondary spread and not related to lightning (Table 3.1).

Of the remaining 23 (14%) trees, all were struck by lightning but no *F. oxysporum* was isolated.

These figures demonstrated dramatically the importance of lightning in the epidemiology of the disease, not only in initiating the primary infection sites (97%) but also in the secondary infection sites (86%).

Of the 170 trees examined in the last 10 months of the project, only 4 (3%) of those which had been struck by lightning had no ambrosia beetles associated with the damage at the time of inspection (Table 3.1).

The hypothesis presented here for the life cycle of the Angsana wilt disease is that lightning damage to an Angsana provides the stress which attracts the
ambrosia beetles. If these beetles are contaminated with *F. oxysporum* spores, then infection of the already stressed tree is likely to follow. The secondary spread away from this primary infection site, is by *F. oxysporum* which has entered the soil from the infected tree.

The present epidemic of the Angsana wilt disease is a result of a large build up in the number of infectious ambrosia beetles, and it is this population which should be targeted as the weak link in the disease cycle where, with a combined effort of the various government organisations involved, control of the disease can be achieved.

4. THE CONTROL STRATEGY

Sporadic occurrences of Angsana wilt disease occurred around Singapore between the late 1970s and 1982. This culminated in the visit of Harden (1982) and the following control measures being implemented by Parks and Recreation Department:

- Removal of diseased trees.
- Drenching of the surrounding soil with fungicide.
- Horticultural sanitation.
- Monitoring.

With the removal of the infected trees and the intensive soil drenching with fungicides, no further infections were encountered and the spread of the disease appeared to be under control. In October 1983 the Plant Protection Unit of Parks and Recreation Department was disbanded, and no cases of Angsana wilt were recorded between October 1983 and October 1988. In late 1988 two Angsanas along Collyer Quay were found to be diseased. Between 1988 and 1991 over 800 trees died in Singapore because of the disease.

As the implementation of these stringent control measures failed to eradicate the disease, it became one of the primary objectives of the Angsana wilt project to establish possible reasons for the failure, and to formulate a modified disease control strategy, based on the findings of the epidemiological studies.

The control strategy developed in 1982 was based on the assumption that the disease was solely caused by the soil-borne fungus *F. oxysporum*, and therefore as it was assumed that the disease originated from the soil, there was no urgency to remove infected trees. It was also postulated that drenching the soil with fungicides would eradicate the pathogen from the soil, and also, because the chemicals used were systemic, they would be translocated and therefore have activity against the pathogen within the tree.

The current research, however, has empirically demonstrated that although the disease is of soil-borne origin, the initial spread of the fungus to new sites is by
an insect vector. Controlling the disease once the pathogen has reached the soil in a new site, is therefore to implement control measures at the end of the primary infection cycle. Control. to be successful must be implemented at the beginning of the primary infection cycle.

4.1 Development Of The Control Strategy

The modified control strategy has two objectives. Firstly to prevent the disease from becoming established in new sites, and secondly to slow down the progression of the disease in those areas where secondary infection is already established.

No control strategy will stop an epidemic instantly. Success depends on slowing down the progress of the epidemic, turning the positive multiplication rate of an active epidemic, into a negative multiplication rate which eventually results in the total control of the disease as the pool of inoculum is gradually reduced to one below epidemic thresholds. Sporadic incidences could then be mopped up.

4.2 Overview.

There are two main methods of spread of the Angsana wilt disease. Firstly by the *F. oxysporum* infested ambrosia beetles which invade a damaged tree following a lightning strike, and secondly by the traditionally accepted method of soil-borne hyphae and spores, and by root-to-root contact.

The lightning - ambrosia beetle - *F. oxysporum* complex explained 97% of the primary infection sites inspected during the 1993-94 survey. This complex also played a significant role, being associated with 87% of the secondary infection sites (Table 3.1).

Most of the pockets of secondary infection sites scattered around Singapore are well established, and the pattern of diseased trees within these pockets suggests that the spread of the disease is predominantly localised. The immediate neighbours of an infected tree are highly at risk with a more than an 80% chance of becoming infected. All Angsanas within 100 m of an infected tree are also at risk, although this distance will vary depending on the terrain between the trees and the assistance this provides for the spread of the fungus.

As a result of the trials on injecting infected trees to stop the development of the disease, it was apparent that once a tree was infected, and subsequently when the symptoms of the disease appeared, it was already too late to control the disease within the tree by chemical treatment. This is understandable as *F. oxysporum* is a vascular pathogen attacking and destroying the vessels which move the fungicides around the tree. Once these vessels are destroyed systemic action of the fungicide stops. Although it was demonstrated that chemical treatment will
delay the onset of the disease symptoms for between 4 - 6 months, it will not prevent the inevitable death of the tree. The fungus will again advance as the fungicide within the healthy vessels becomes diluted or is broken down. Secondly once infection is established, ambrosia beetles rapidly help spread the pathogen within the tree.

The time requirements for the removal of the lightning damaged trees is therefore based on the life cycle of the beetles. This time period, from the first invasion of the tree to the emergence of the second generation of infected beetles can be predicted within narrow limits.

As the ambrosia beetles are the weak link in the disease cycle, and a major contributing factor to the current epidemic, it was pertinent to develop the control strategy around the life cycle of the beetles.

4.3 The Control Strategy

The control strategy is aimed at breaking the disease cycle by controlling the ambrosia beetles, and thus preventing *F. oxysporum* from infecting the lightning damaged tree and becoming established in the soil. The strategy is based on the rapid removal of these lightning damaged trees, chemical treatments in the form of sprays to prevent insect invasion of the damaged trees and sprays and injections to protect the surrounding trees from invasion and infection.

- **Monitoring.** The success or failure of the control strategy will depend on the efficiency of the monitoring team in detecting the lightning damaged trees early and co-ordinating the treatment programme.

- **Removal of lightning damaged trees.** It is paramount to the success of the control strategy that: 1) insecticide sprays be applied to the damaged tree within days of the first symptoms of wilting being noted to prevent the colonizaiion by ambrosia beetles, and 2) the tree and as much of the root ball as is possible be removed within three weeks of the lightning strike.

- **Treatment of High Risk trees by injection.** All Angsanas within 100 m of an infected tree are considered to be highly at risk and therefore likely to become infected in the future. All high risk trees should be sprayed to run-off as far up the trunk as is practicable, using a conventional horticultural high volume sprayer with a mixture of fungicide and insecticide and injected with a mixture of fungicide and insecticide within three days of the lightning damaged tree being noted. Addition of a sticker to the chemical spray is recommended.

- **Second injection.** Trees should be re-injected 4 months later.

- **Trenching.** Where possible trenching should be carried out between damaged
and undamaged trees to minimize the likelihood of tree to tree spread via root contact.

- **Hygiene.** As with all infectious diseases, hygiene is of paramount importance. All tools which are used on or around infected trees should be treated with 95% alcohol using a hand-held plastic sprayer. Extreme care must be taken to ensure that ambrosia beetles do not get inside vehicles and transported to new areas. Felled trees should be burned to rid them as a source of beetle dispersal.

- **Replanting with Angsanas.** As long as the lighting damaged tree is removed before infection is established within the damaged tree, then there should be no danger in replanting with a second Angsana. However, once infection is established in the damaged tree, then it must be assumed that the fungus has reached the soil and measures taken accordingly.

- **Trees outside the jurisdiction of Government Departments.** Although the success of this control strategy can proceed independently of the removal of lightning damaged trees within private property, owners should be advised that these trees are not only a physical danger to property, but also a health hazard to surrounding Angsanas, and that it is important that these trees be rapidly removed. It would be frustrating to see the control efforts wasted because of one or two small hot-spots of infection remaining within privately controlled land. Hot-spots which would act as the source of infection for subsequent outbreaks of the disease.

### 4.4 Discussion

Currently 87% of new infections of Angsana wilt disease are ambrosia beetle related and it is this population of infectious beetles which is the initial target of the control strategy. To control this population is to control the epidemic. This can only be done by the rapid removal of all lightning damaged trees, the potential sites of infection. Initially, this will therefore mean the removal of 10% of trees which would not have become infected, however, this is a small price to pay for the ultimate success of the control strategy. As the control strategy takes effect and the population of infectious ambrosia beetles has reduced then the number of trees likely to remain healthy will rise to an ultimate aim of 100%. As the population of infectious ambrosia beetles drops, decisions will have to be made as each new lighting damaged tree is detected, as to whether or not the tree should be removed on the basis of the likelihood of it becoming infected.

Following the implementation of the control strategy, there will be a period of several months before there is a reduction in the number of trees being removed due to Angsana wilt each month. This lag period will correspond to the time that it takes for all those trees which are already infected at the time of treatment, to develop symptoms and be removed. Once this reservoir is removed and the
population of infectious ambrosia beetles is reduced, rapid progress should be made in controlling this insidious disease.

5 SCREENING OF ANGSANA (*Pterocarpus indicus*) FOR RESISTANCE TO *Fusarium oxysporum*

Although the short term aim of the project was to develop a control strategy based on chemical control, the long term aim was to identify lines of *P. indicus* resistant to *F. oxysporum*.

5.1 Collection of planting material

Planting material was collected from four localities in West Malaysia, ten localities in the Philippines, three in Myanmar, five in the Solomon Islands, three in Papua New Guinea, three in Java, eight in the Sulawesi Islands and six localities in the Maluku Islands. In total, 610 trees were sampled for hardwood cuttings and 188 samples of seeds were collected (Fig. 1).

*Pterocarpus indicus* is a natural component of the coastal low-land flora of South East Asia, however, because it is prized as a timber for both building and for furniture, it is very rare to see mature trees in the jungle accessible to the local population. Conversely, because it is so easily propagated and provides excellent shade, Angsanas were commonly found growing in villages as either single trees or as avenues for shade trees, and as rows of trees for fencing. It was also found as isolated shade trees in cleared jungle being used for agriculture.

Planting material was also collected from the Angsanas growing around Singapore on a weekly basis between February and November 1993. During which time 270 samples of cuttings and 58 collections of seed were made.

Where possible 100 seeds per tree were collected (Plate 5.1) as, not only were they physically easier to collect and gave a greater establishment rate, but it also meant that we were selecting within a segregating population where each seedling was genetically unique.

Where seeds were not available, 3 or 4 hardwood cuttings, 20 - 25 cm long and between 2 - 3 cm in diameter were cut. Hardwood cuttings were collected by removing a 2 - 3 cm diameter branch, using either a pruning saw or a tree pruner which was extendible to 5 m. The branch was then cut into 3 - 4, 20 cm lengths. These were placed into a zip-lock® plastic bag for transport. Data were recorded on tree locality and physical characteristics, such as tree form, leaf shape and size etc. Cuttings were soaked in water overnight, then soaked for 30 min in a 1:10 sodium hypochlorite solution (Chlorox®), wrapped in paper towels treated with Benomyl (Benlate® 50WP), and returned to the zip-lock® plastic bags for transport. Every effort was made to ensure that all hardwood cuttings were planted into soil within 14 days from collection.
Fig. 1 Collection of hardwood cuttings and seeds
In instances where neither seeds nor hardwood cuttings were available, then softwood cuttings were taken.

The wings of the seeds of *Pterocarpus indicus* were cut to expose the seeds inside the pods. Seed pods were soaked in water overnight before being sown in washed coarse sand in 450 × 345 × 70 mm plastic trays. Fresh seeds usually germinated within three days. However, this period is extremely variable with some seeds germinated overnight while a few exceptions took over a year to germinate. Vigorous seedlings were pricked out into 75 mm plastic pots containing a general potting mix. Seedlings were allowed to grow until they were between 10 - 15 cm tall before being screened for resistance.

Hardwood cuttings when they arrived from overseas, were thoroughly cleaned and soaked in a dilute fungicide solution for 30 min. before being potted in 75 or 120 mm plastic pots in either sand, soil or a general potting mix. The cuttings were allowed to grow until they were well rooted and growing vigorously before being put through the screening process. The establishment of hardwood cuttings depended on the time from cutting to planting. The establishment rate for the Singapore cuttings was 62% while the establishment of those collected overseas ranged from 13% to 19%.
5.2 Screening for Resistance

A weekly cycle was developed to enable an efficient screening of the large number of established hardwood cuttings and seedlings established in the nursery.

Five different isolates of *F. oxysporum* were grown on PDA (Potato Dextrose Agar) at 28°C for 5 days. Five plugs were removed using a sterilised 5 mm cork borer and ground in a 10 ml glass macerator to form a thick suspension. This suspension was added to 500 ml of PDA at 45 - 50°C just prior to pouring. The petri-dishes were left on a bench in natural light to stimulate the production of micro-conidia. After seven days the fungal lawns were blended together in sterile water. The final concentration used was three plates to 500 ml of sterile water.

Cuttings and seedlings were removed from their pots, labelled, and their roots washed clean and trimmed to about 1.0 - 1.5 cm in length. They were then placed into plastic jars containing the inoculum. They were left in the inoculum for four hours under full sunlight, before being re-potted using the original potting mix. The pots were then watered with the inoculum from the jars. The inoculated cuttings or seedlings were only watered when the soil became dry in order to maintain them under mild stress. Inoculated plants were monitored closely for five weeks, and plant deaths were recorded accordingly.

5.3 Results

Inoculated plants usually started to show signs of wilting (yellowing and dropping of leaves) towards the end of the third week. Scraping the stem to reveal some discoloration and vascular staining would confirm that the material was infected. Some plants died during the third and fourth weeks, however, the majority of plants died during the fifth week, with a few taking more than five weeks to wilt and die.

At the end of five weeks, those plants that had survived were checked, and healthy plants were re-labelled and returned to the nursery area to await subsequent screening.

From November 1992 to Nov. 1995, 35 batches of *P. indicus*, consisting of over 2,600 seedlings and 650 cuttings were subjected to one screening, and from those, 1,214 seedlings and 69 cuttings have since been inoculated the second time, and 652 seedlings and 47 cuttings were inoculated for the third time.

All plants will now be planted into natural soil known to contain *F. oxysporum*, for a final confirmation of resistance.

5.4 Discussion

During the course of the project over 650 hardwood cuttings and 2,600
seedlings which had been collected from 7 countries were tested. Because we are looking for a single gene resistance, which is expressed as an all-or-nothing reaction, resistant plants survive and susceptible plants die.

All the material had been subjected to three screenings. All surviving plants will now be planted into natural soil which is known to contain *F. oxysporum* before we can confidently describe this material as resistant to *F. oxysporum*.

From Table 5.1 it can be seen that there is a wide range in the percentage survival of the hardwood cuttings. This is understandable as the resistance/susceptibility of the hardwood cuttings is that of the parent tree. The low incidence of survival of hardwood cuttings from Singapore (25%) would suggest a low incidence of resistance within the Singapore Angsana population. This could go some way to explain the development of the disease here rather than in other regions.

Table 5.1  Screening of Angsana seedlings and hardwood cuttings for resistance to *Fusarium oxysporum*.

<table>
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<tr>
<th>ORIGIN</th>
<th>FIRST INOCULATION</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>SECOND INOCULATION</th>
<th></th>
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<tbody>
<tr>
<td></td>
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<td>Number survived</td>
<td>Percentage survived</td>
<td>Number inoculated</td>
<td>Number survived</td>
<td>Percentage survived</td>
<td>Number inoculated</td>
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The ratio of resistance to susceptible plants in the seedling population must, however, reflect the genetic composition of the population. That the overall percentage of survival was close to 50% (535) is encouraging, and further genetical studies will be carried out.

That the survival of the seedlings increased from 54% in the first inoculation to 82% in the second and to 95% in the third inoculation is an encouraging indication that resistance has been identified. On the other hand, at no time did the results obtained with the hardwood cuttings parallel the success obtained with seedlings. Not only was the initial establishment of the hardwood cuttings very low (less than 20% for overseas cuttings) but the attrition rate while growing the plants in small plastic bags under the direct tropical sun was very high.

This work will continue and it will take an estimated further two years to have resistant planting material available for multiplication.

ACKNOWLEDGEMENTS

It is with gratitude that we wish to thank the National Science and technology Board and Mr. Jim Baker from SGS Singapore Pte. Ltd., for their foresight and financial support that made this project possible, and Mr. Robert Lee of SGS All-Pest Pte. Ltd. for his support throughout this project.

We would also like to thank Professor Gloria Lim; Dr. D. Brayford of International Mycological Institute, England; Professor L. Burgess of Sydney University; Dr. B. Summerell of Royal Botanical Gardens, Sydney, Australia; Dr B. Hawthorn of Food and Hort Research, CRI of New Zealand; and Dr. H. Nirenberg of Federal Biological Research Centre for Agriculture and Forestry, Germany for their assistance in the identification of the *Fusarium* isolates.

Also to the following, without whom, the collection of the Angsana material from such a wide geographical area would not have been feasible: Mr. U. Aung Than and staff of the Forest Department, National Parks and Wildlife Conservation Division, Myanmar; Dr. Dimingo A. Madulid, Mr. Toy Sageal, and Mr. Efran Romeo of the Botany Division, National Museum, Manila, Philippines; Mr. Myknee Qusa and Mr. Patterson of the Forestry Division, Ministry of National Resources, Honiara, and Mr. Geoff F.C. Dennis of Solomon Islands; Mr. Ian Orrell of the Oil Palm Research Association, and Mr. Jim Bell of Papua New Guinea; and finally Ms. Sandra Upston and Mr. Julian Sanderson of SGS Singapore Pte. Ltd. who made the collection in the Sulawesi and the Maluku Islands possible.

The assistance of Professor Lee Seng Kong and Mr. Ho A.C. of Nanyang Technological University in the development of the aeroponic system is fully acknowledged. In addition the assistance of Professor D. H. Murphy of National University of Singapore is also acknowledged.
REFERENCES


Freshwater Swamp Forest in Singapore, with Particular Reference to That Found Around the Nee Soon Firing Ranges

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Abstract

The freshwater swamp forest found around the firing ranges at Nee Soon is the last remaining area of this forest formation in Singapore. The vascular plant flora of freshwater swamp forest in Singapore is reviewed, with particular reference to the Nee Soon forest. Some preliminary soil, water and foliar analyses indicate that the swamp forest at Nee Soon may have considerably higher amounts of phosphorus available to the vegetation than the dryland forest of Bukit Timah Nature Reserve. Nitrogen and potassium availabilities appear to be similar at the two sites. The Nee Soon swamp forest is an extremely important site for Singapore’s native biota and should receive the highest priority for conservation.

Introduction

One of the least well-known of the forest formations of West Malaysia is freshwater swamp forest. So named to distinguish it from the saltwater mangrove swamps, it is a forest type of wet, often seasonally flooded, lowland areas (Whitmore 1975). The only work of any note specifically concerning freshwater swamp in this region is Corner’s (1978) account of his studies, which were mostly floristic in nature, of these forests in southeast Johore and Singapore. Corlett (1991) has estimated that approximately 5\% of Singapore was covered in freshwater swamp before the major forest clearance of the nineteenth century began. The only remaining area of swamp forest in Singapore today is to be found around the Nee Soon Firing Ranges in the Central Catchment Nature Reserve (Fig. 1). The fauna of the Nee Soon forest and surrounding areas has been outlined by Ng and Lim (1992). Botanically, this area has never been studied closely, and it seems timely to consolidate our current knowledge of the forest into one publication.

The Nee Soon Swamp Forest

Swamp forest occurs in low-lying areas where slow-flowing streams drain shallow valleys. The ground becomes saturated with the water table close to the soil surface and there are often periods of flooding. Such swamps probably occurred historically in the upper reaches of all the rivers in Singapore (Corlett 1991). Corner (1978) made detailed studies of the flora and forest structure of the swamp forest near Mandai Road, which is now submerged beneath Upper Seletar Reservoir, and in Jurong. Industrial and housing development have totally destroyed the Jurong swamps. This leaves the Nee Soon swamp as the last remnant of the forest formation in Singapore. It has probably survived because of the Firing Ranges, which lack
baffling walls or banks, making the surrounding area dangerous to the public and unsuitable for any form of development. The approximate extent of the swamp forest is shown in Figure 1. This has been delineated from data collected by a number of field researchers, particularly D.H. Murphy who has mapped many of the main streams of the area. It is estimated that the swamp forest covers about 87 ha, though much of this has been disturbed quite heavily at various times in the past. There is concern that changes in the drainage regime of the forest may be causing excessive soil erosion along some of the streams and causing the death of the larger trees in certain areas (D.H. Murphy pers. comm.).

Figure 1. Map showing the location of the Nee Soon Freshwater Swamp Forest, Singapore. The stippled area indicates the approximate extent of the swamp forest.

Floristics

Appendix 1 gives a list of vascular plant species recorded from swamp forest in Singapore. It is compiled from the list given by Corner (1978) for his plots at Jurong and Mandai Road, specimens in the herbarium of the Singapore Botanic Gardens (SING) where Nee Soon or Chan Chu Kang are given as collecting localities, recent collections from the Nature Reserves mostly as outlined by Turner et al. (1994) and the results of the forest survey of Wong et al. (1994). Clearly, the flora of the swamp forest is rich, with more than 700 species having been recorded from this vegetation type in Singapore.
Vegetation Structure and Physiognomy

The forest at Nee Soon has an appearance similar to that outlined for freshwater swamp forest in other localities by Corner (1978). The ground is saturated with frequent small streams and pools of water. Many of the trees exhibit the prolific development of large stilt roots and/or abundant pneumatophores of various descriptions, that Corner illustrates profusely in his book. In apparently primary areas, the trees can reach large size, with heights of 40 m or more being recorded (Hill 1977).

During a survey of the forest communities of the Central Catchment Nature Reserve (Wong et al. 1994) three 0.2 ha plots were enumerated in the swamp forest. The location of plots 26, 27 and 28 are given in Figure 1. The floristic composition for trees of greater than 30 cm girth at breast height (1.3 m) in the three plots is given in Table 1. The composition of the three plots was different from the plots surveyed in the primary forest on dryland sites (Turner et al. 1996b). Important species in terms of basal area were *Pometia pinnata*, *Palaquium xanthochymum*, *Mangifera griffithii*, *Gluta wallichii* and *Strombosia ceylanica*. Corner (1978) reported these to be abundant in his Mandai Road plots, indicating a strong similarity in the forest between the two sites, which is not surprising given their propinquity.

Table 1
Composition of the forest community (> 30 cm gbh) in three 0.2 ha plots in the Nee Soon swamp forest. \( n = \) number of individuals of each species, \( ba = \) total basal area (cm²). Species are in descending order of total basal area summed for the three plots. Some individuals could not be identified and are referred to by code numbers.

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<td>Garcinia parvifolia</td>
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<td>2</td>
<td>454</td>
</tr>
<tr>
<td>Kibatalia maingayi</td>
<td>1</td>
<td>575</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knema conferta</td>
<td>1</td>
<td>535</td>
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<td>Mastixia trichotorna</td>
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<td>509</td>
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<td>Cryptocarya ferrea</td>
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<td>97</td>
<td>3</td>
<td>366</td>
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<tr>
<td>MYRISTICACEAE1</td>
<td>1</td>
<td>460</td>
<td></td>
<td></td>
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<tr>
<td>Beilschmiedia kanslteri</td>
<td>1</td>
<td>447</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Castanopsis nepheloides</td>
<td>1</td>
<td>436</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plot</td>
<td>Species</td>
<td>Count</td>
<td>Species</td>
<td>Count</td>
</tr>
<tr>
<td>------</td>
<td>---------</td>
<td>-------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>Z12</td>
<td>Knema laurina</td>
<td>1</td>
<td>215</td>
<td>Macaranga triloba</td>
</tr>
<tr>
<td>U12</td>
<td>Lisea robusta</td>
<td>1</td>
<td>412</td>
<td>Myristica lowiana</td>
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<tr>
<td></td>
<td>Prunus polystachya</td>
<td>1</td>
<td>247</td>
<td>Parishia maingayi</td>
</tr>
<tr>
<td></td>
<td>Dysoxylum densiflorum</td>
<td>1</td>
<td>316</td>
<td>Shorea platycarpa</td>
</tr>
<tr>
<td></td>
<td>Baccarea minor</td>
<td>1</td>
<td>296</td>
<td>Knema hookeriana</td>
</tr>
<tr>
<td></td>
<td>Calophyllum dispar</td>
<td>1</td>
<td>277</td>
<td>Kibara coriacea</td>
</tr>
<tr>
<td></td>
<td>Baccarea parvifolia</td>
<td>1</td>
<td>258</td>
<td>Diospyros lanceifolia</td>
</tr>
<tr>
<td></td>
<td>Phoebe grandis</td>
<td>1</td>
<td>241</td>
<td>Mangifera foetida</td>
</tr>
<tr>
<td>Z11</td>
<td>Aglaia maingayi</td>
<td>1</td>
<td>223</td>
<td>Baccaurea racemosa</td>
</tr>
<tr>
<td></td>
<td>Gnetum gnemon</td>
<td>1</td>
<td>215</td>
<td>Z14</td>
</tr>
<tr>
<td></td>
<td>Garcinia eugeniifolia</td>
<td>1</td>
<td>215</td>
<td>Aglaia odoratissima</td>
</tr>
<tr>
<td></td>
<td>Pierandra coerulescens</td>
<td>1</td>
<td>207</td>
<td>Pimeiodendron griffithii</td>
</tr>
<tr>
<td></td>
<td>Garcinia forbesii</td>
<td>1</td>
<td>199</td>
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</tr>
<tr>
<td></td>
<td>Baccarea macrotrea</td>
<td>1</td>
<td>183</td>
<td>Neoscorechonia kingii</td>
</tr>
<tr>
<td></td>
<td>Aporusa penangensis</td>
<td>1</td>
<td>176</td>
<td>Myristica iners</td>
</tr>
<tr>
<td></td>
<td>Cyathocalyx ramuliflorus</td>
<td>1</td>
<td>168</td>
<td>Shorea ovalis</td>
</tr>
<tr>
<td></td>
<td>Sarcodraka griffithii</td>
<td>1</td>
<td>154</td>
<td>Diospyros pilosantha</td>
</tr>
<tr>
<td></td>
<td>Melanoschyla caesia</td>
<td>1</td>
<td>72</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Knema malayana</td>
<td>1</td>
<td>147</td>
<td>Z15</td>
</tr>
<tr>
<td></td>
<td>Eugenia papillosa</td>
<td>1</td>
<td>134</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Gynotroches axillaris</td>
<td>1</td>
<td>134</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Garcinia nervosa</td>
<td>1</td>
<td>115</td>
<td>Horsfieldia wallichii</td>
</tr>
<tr>
<td>Z13</td>
<td>Lansium domestican</td>
<td>1</td>
<td>103</td>
<td>Pyrenana acuminata</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>103</td>
<td>1</td>
<td>103</td>
</tr>
</tbody>
</table>
The terrestrial herbs have been surveyed also in these three plots (Turner et al. 1996a). Twenty species were recorded (Table 2), with only Aglaonema nebulosum and Labisia pumila being found in all three plots. The Araceae proved to be particularly diverse.

### Table 2
Terrestrial herbaceous species recorded from the three 0.2 ha plots enumerated in Nee Soon swamp forest. + indicates presence.

<table>
<thead>
<tr>
<th>species</th>
<th>plot</th>
<th>plot</th>
<th>plot</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aglaonema nebulosum</em></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><em>Aglaonema nitidum</em></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Alocasia denudata</em></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Amischotolype gracilis</em></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Cryptocoryne griffithii</em></td>
<td>+</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><em>Cyrtosperma merkusi</em></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Homalomena sp. 1</em></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><em>Homalomena sp. 2</em></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Labisia pumila</em></td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><em>Lecanorchis malaccensis</em></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><em>Leptaspis urceolata</em></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Lindsaea doryophora</em></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><em>Mapania cuspidata</em></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Mapania squamata</em></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><em>Opliorrhiza singaporensis</em></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><em>Peliosanthes teta ssp. humilis</em></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Plocoglottis javanica</em></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><em>Schismatoglottis wallichii</em></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Syngramma alismifolia</em></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td><em>Trichomanes obscurran</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total number of species</strong></td>
<td>6</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>
Soil

The soil in freshwater swamp forest is generally rich in organic matter, presumably because the anaerobic nature of the waterlogged conditions reduces the rate of decomposition. However, this process has not proceeded far enough to develop soils of high enough organic matter content to be considered peats (generally >90% loss-on-ignition by mass). Some preliminary analyses for soil samples from Nee Soon (Table 3) showed the soil surface to have high loss-on-ignition, averaging nearly 80% and approaching 90% in places, though the values dropped rapidly below 5 cm depth to generally less than 50% loss-on-ignition. Some pH measurements showed that stream water and soil water lay in the range 4.6-5.5, with soil pH at 5 cm depth to be lower, 4.0-4.5. The concentrations of the major plant nutrients, nitrogen, phosphorus and potassium, were measured in the litter, soil and some foliar samples (shade leaves) gathered at Nee Soon (Table 4 and 5). Surprisingly, the litter generally had lower concentrations of the important elements than the top 5 cm layer of the soil. Possibly this represents the flushing of nutrients down through the soil.

The nutrient concentration data can be compared with values obtained for the coastal hill dipterocarp forest at Bukit Timah (Grubb et al. 1994). The comparison of the soil values between the two sites is difficult given the very different soil bulk densities because of the high organic matter content of the soils at Nee Soon. Bukit Timah has more acidic soil (3.7-4.0 versus 4.0-4.5) and slightly higher litter concentrations of N (12.9-14.5 versus 9.4 mg g⁻¹), lower concentrations of P (0.21-0.23 versus 0.47 mg g⁻¹) and higher concentrations of K (2.0-5.9 versus 0.48 mg g⁻¹). The foliage samples show a similar pattern with higher mean P in the leaves at Nee Soon (1.72 versus 0.68 mg g⁻¹), but lower N (13.2 versus 17.1 mg g⁻¹) and K (8.3 versus 10.5 mg g⁻¹) concentrations. It would appear that Nee Soon probably has more phosphorus available for plant growth than Bukit Timah, but possibly slightly less nitrogen and potassium. Phosphorus appears to be the nutrient limiting the growth of non-mycorrhizal plants on Bukit Timah soil (Burslem et al. 1994), though mycorrhizal plants seem not to be responsive to P fertilization (Burslem et al. 1995). Nee Soon may, therefore, present a potentially more fertile site for plant growth, but of course the water-logged conditions are highly unfavourable to many species. This relatively high nutrient availability may be what prevents peat formation from occurring.
Table 3
Analyses of soil and leaf litter from Nee Soon Swamp Forest, Singapore.

<table>
<thead>
<tr>
<th></th>
<th>loss-on-ignition (%)</th>
<th>total N (mg g⁻¹)</th>
<th>total P (mg g⁻¹)</th>
<th>total K (mg g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>leaf litter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sample 1</td>
<td>-</td>
<td>9.88</td>
<td>0.52</td>
<td>0.52</td>
</tr>
<tr>
<td>sample 2</td>
<td>-</td>
<td>8.50</td>
<td>0.42</td>
<td>0.48</td>
</tr>
<tr>
<td>sample 3</td>
<td>-</td>
<td>9.83</td>
<td>0.49</td>
<td>0.43</td>
</tr>
<tr>
<td>mean</td>
<td></td>
<td>9.40</td>
<td>0.47</td>
<td>0.48</td>
</tr>
<tr>
<td>soil (0-5 cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sample 1</td>
<td>88.7</td>
<td>22.2</td>
<td>0.87</td>
<td>0.51</td>
</tr>
<tr>
<td>sample 2</td>
<td>60.8</td>
<td>12.8</td>
<td>0.70</td>
<td>0.52</td>
</tr>
<tr>
<td>sample 3</td>
<td>89.6</td>
<td>17.5</td>
<td>0.87</td>
<td>0.64</td>
</tr>
<tr>
<td>mean</td>
<td>79.7</td>
<td>17.5</td>
<td>0.81</td>
<td>0.56</td>
</tr>
<tr>
<td>soil (5-10 cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sample 1</td>
<td>54.8</td>
<td>9.53</td>
<td>0.84</td>
<td>0.72</td>
</tr>
<tr>
<td>sample 2</td>
<td>34.8</td>
<td>6.25</td>
<td>0.45</td>
<td>0.69</td>
</tr>
<tr>
<td>sample 3</td>
<td>47.5</td>
<td>7.41</td>
<td>0.54</td>
<td>1.16</td>
</tr>
<tr>
<td>mean</td>
<td>45.7</td>
<td>7.73</td>
<td>0.61</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Table 4
Foliar analyses for shade leaves from trees at Nee Soon Swamp Forest, Singapore.

<table>
<thead>
<tr>
<th>species</th>
<th>total N (mg g⁻¹)</th>
<th>total P (mg g⁻¹)</th>
<th>total K (mg g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archidendron sp.</td>
<td>18.9</td>
<td>1.28</td>
<td>8.9</td>
</tr>
<tr>
<td>Calophyllum sp.</td>
<td>7.7</td>
<td>0.55</td>
<td>5.7</td>
</tr>
<tr>
<td>Desmos dasymaschala</td>
<td>16.2</td>
<td>2.86</td>
<td>11.0</td>
</tr>
<tr>
<td>Diospyros sp.</td>
<td>10.6</td>
<td>1.88</td>
<td>7.5</td>
</tr>
<tr>
<td>Litsea ridleyi</td>
<td>9.7</td>
<td>2.41</td>
<td>12.3</td>
</tr>
<tr>
<td>Nephelium sp.</td>
<td>14.2</td>
<td>1.95</td>
<td>7.1</td>
</tr>
<tr>
<td>Pterandra echinata</td>
<td>12.4</td>
<td>1.22</td>
<td>5.8</td>
</tr>
<tr>
<td>Strombosia ceylanica</td>
<td>14.3</td>
<td>1.16</td>
<td>8.3</td>
</tr>
<tr>
<td>sp. indet.</td>
<td>14.8</td>
<td>2.17</td>
<td>7.9</td>
</tr>
<tr>
<td>mean</td>
<td>13.2</td>
<td>1.72</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Conservation

Nee Soon is now Singapore’s last fragment of freshwater swamp remaining. Many species of plants and animals are now restricted to this area, hence making Nee Soon of great importance in terms of the biodiversity of Singapore. The plant list includes Aeschynanthus wallichii, Bulbophyllum macranthum, Cystorchis variegata, Kopsia singapurensis, Luvungu grassifolia, Neoscortechinia kingii and Xylopia fisca. Ng and Lim (1992) list many animal species restricted, in Singapore, to Nee Soon. Species found at Nee Soon are generally not found at Bukit Timah, and vice versa, so the two are the twin pillars of biodiversity in Singapore and require strict protection.

Acknowledgements

We are grateful to D.H. Murphy, H.T.W. Tan, K.S. Chua and Haji Sidek for sharing their expertise and data concerning Nee Soon swamp forest. Jeanette Ong provided valuable technical assistance in the laboratory, and Jean Yong helped in preparing the figure.

References


APPENDIX 1

SPECIES LIST OF VASCULAR PLANTS FOR FRESHWATER SWAMP FOREST IN SINGAPORE

Species marked with an asterisk are those recorded by Corner (1978) from freshwater swamp forest in Singapore. Where taxonomic revisions have necessitated name changes, or specimens were misidentified, the name used by Corner is given in parentheses. Other species are those collected recently or known from herbarium specimens where Nee Soon swamp forest or Chan Chu Kang are given as the collecting locality. For more information regarding NRS series collections see Turner et al. (1994). Species recorded from the three 0.2 ha plots at Nee Soon (Wong et al. 1994) are marked with a dagger (†). Only forest species are included. The determination of Mangifera species follows Kostermans & Bompard (1993).

LYCOPODOPHYTA

Lycopodiaceae

Huperzia nummulariifolia (Blume) Jermy - Ridley s.n. (Oct 1889)
* Huperzia phlegmaria (L.) Rothm. (Lycopodium phlegmaria) - Ridley 2420 (1884)
* Huperzia squarrosa (G. Forst.) Trevisan (Lycopodium squarrosum)

Selaginellaceae

Selaginella argentea (Wall.) Spr. - NRS1972

FILICINOPHYTA

Adiantaceae

† Syngramma alismifolia (C. Presl) J. Sm. - NRS1610
* Taenitis blechnoides (Willd.) Sw.

Aspleniaceae

Asplenium batuense Alderw. - NRS1185
Asplenium macrophyllum Sw. - Goodenough s.n. (1890)
* Asplenium nidus L.
* Asplenium nitidum Sw. (Asplenium glaucophyllum)

Blechnaceae

Blechnum finlaysonianum Hook. & Grev. - Ridley 6121 (1894)
* Blechnum orientale L.
* Stenochlaena palustris (Burm.) Bedd. - NRS1589

Cyatheaceae

* Cyathea glabra (Blume) Copel. - NRS1526
* Cyathea latebrosa (Wall. ex Hook.) Copel. - NRS1508

Davalliaceae

Davallia angustata Wall. ex Hook. & Grev. - Ridley 3599a (189?)

Dennstaedtiaceae

* Histiopteris incisa (Thunb.) J.Sm.
Lindsaea doryophora Kramer - NRS1519
* Lindsaea parasitica (Roxb. ex Griff.) Hieron. (L. scandens) - NRS0158

Dryopteridaceae
Tectaria barberi (Hook.) Copel. - Maxwell 82-71 (18 Mar 1982)
Tectaria singaporeana (Wall. ex Hook. & Grev.) Copel.

Hymenophyllaceae
Trichomanes christii Copel. - NRS0867
* Trichomanes motleyi (Bosch) Bosch
** Trichomanes obscurum Blume - Ridley 6119 (1894)

Lomariopsidaceae
Teratophyllum aculeatum (Blume) Mett. ex Kuhn - NRS0051
* Teratophyllum ludens (Fée) Holttum - NRS0132

Polypodiaceae
* Drynaria quercifolia (L.) Sm.
  Lecanopteris sinuosa (Wall. ex Hook.) Copel. - Ridley s.n. 1896
* Platycerium coronarium (D. Koenig ex O.F. Müll.) Desv. - NRS1603
* Pyrosia angustata (Sw.) Ching
  Pyrosia longifolia (Burm.) Morton - NRS0131

Schizaeaceae
Lygodium longifolium (Willd.) Sw. - Ridley 4229 (Dec 1892)
Schizaea digitata (L.) Sw. - NRS0171

Thelypteridaceae
Christella parasitica (L.) Lév. - NRS0145
* Mesophlebion chlamydophorum (Rosenst. ex C. Chr.) Holttum (Thelypteris chlamydophora)
  Sphaerostephanos heterocarpus (Blume) Holttum - Ridley 6120 (1894)

Vittariaceae
* Vittaria ensiformis Sw.

Woodsiaceae
Diplazium crenatoserratum (Blume) Moore - Ridley 4399 (1892)

GNETOPHYTA

Gnetaceae
† Gnetum gnemon L.
* Gnetum gnemonoides Brongn. - NRS0781
  Gnetum macrostachyum Hook.f. - NRS0196
* Gnetum microcarpum Blume - Maxwell 82-198 (29 Jul 1982)
CONIFEROPHYTA

Podocarpaceae
* Nageia wallichiana (Presl) Kuntze

ANGIOSPERMOPHYTA

Acanthaceae
Hygrophila ringens (L.) R.Br. ex Steud. - NRS2438
Justicia vasculosa Wall. - NRS1388
Staurogyne setigera Kuntze - NRS0166

Alangiaceae
* Alangium ebenaceum (C.B. Clarke) Harms var. tutela (Ridl.) Kochummen
† Alangium nobile (C.B. Clarke) Harms

Anacardiaceae
† Buchanania sessifolia Blume
*† Campnosperma auriculatum (Blume) Hook.f.
*† Campnosperma squamatum Ridl. - NRS101
*† Gluta wallichii (Hook.f.) Ding Hou (Melanorrhoea wallichii) - Hullett 601 (8 Feb 1887)
† Mangifera foetida Lour.
† Mangifera griffithii Hook.f.
* Mangifera magnifica Kochummen (Mangifera quadrifida)
* Mangifera paludosa Kosterm. (Mangifera aff. parvifolia)
* Melanochyla auriculata Hook.f. - Ridley 3975 (1892)
*† Melanochyla caesia (Blume) Ding Hou (Melanochyla kunstleri)
† Parishia maingayi Hook.f.

Ancistrocladaceae
Ancistrocladus tectorius (Lour.) Merr. - NRS1523

Anisophylleaceae
* Anisophylea disticha (Jack) Baill. - Maxwell 82-101 (7 Apr 1982)

Annonaceae
Artabotrys costatus King - NRS1358
Artabotrys suaveolens (Blume) Blume - Maxwell 82-70 (18 Mar 1982)
*† Cyathocalyx ramuliflorus (Maingay ex Hook.f. & Thomson) Scheff.
* Cyathostemma viridiflorum Griff. - Maxwell 80-211 (28 Nov 1980)
† Desmos dasynaschala (Blume) Saff.
* Desmos dumosus ( Roxb.) Saff. - Maxwell 81-57 (1 Apr 1980)
* Friesodielsia biglandulosa (Blume) Steenis (Oxymitra biglandulosa) - Sinclair SFN40271 (1 May 1954)
* Friesodielsia borneensis (Miq.) Steenis (Oxymitra borneensis)
* Friesodielsia glauca (Hook.f. & Thomson) Steenis (Oxymitra glauca)
Friesodielsia latifolia (Hook.f. & Thomson) Steenis - Goodenough s.n. (189?)
Goniothalamus macrophyllus (Blume) Hook.f. & Thomson - NRS1171
* Goniothalamus ridleyi King - NRS0160
* Mezzettia parviflora Becc. (Mezzettia leptopoda)
* Mitrella keuntii (Blume) Miq. - NRS0119
* Polyalthia angustissima Ridl.
* † Polyalthia glauca (Hassk.) Muell.
* Polyalthia hypolenca Hook.f. & Thomson
* Polyalthia lateriflora (Blume) King
* Polyalthia sclerophylla Hook.f. & Thomson
* Popowia tomentosa Maingay ex Hook.f. & Thomson (Popowia hirta)
* Pyramidanthus prismaticus (Hook.f. & Thomson) Merr.
* Uvaria cordata (Dunal) Alston - NRS0120
* Uvaria leptomurida (king) R.E. Fries
* Xylopia caudata Hook.f.
* † Xylopia fusca Maingay ex Hook.f. & Thomson
* † Xylopia malayana Hook.f. & Thomson - DJM100

Apocynaceae

* Alstonia angustifolia Wall. ex A.DC.
† Alstonia angustiloba Miq.
* Alstonia spatulata Blume
* Anodendron candollei Wight
† Kibatalia maingayi (Hook.f.) Woodson
* Kopsia singapurensis Ridl. - NRS0126
  Leuconotis griffithii Hook.f. - Ridley s.n. (1894)
  Leuconotis maingayi Dyer ex Hook.f. - NRS0169
* Parameria polyneura Hook.f.
  Parsonsia stenocarpa King & Gamble - Maxwell 80-208 (28 Nov 1980)
* Tabernaemontana corymbosa Roxb.
* Urceola torulosa Hook.f.
* Urnularia flavescens (Dyer ex Hook.f.) Stapf
* Willughbeia coriacea Wall. - NRS0048

Aquifoliaceae

* Ilex cymosa Blume - Ridley s.n. (23 Sep 1890)
* Ilex macrophylla Hook.f.

Araceae

† Aglaonema nebulosum N.E.Br. - NRS0161
* † Aglaonema nitidum (Jack) Kunth - NRS0766
  Aglaonema simplex Blume - NRS0868
* † Alocasia denudata Engl. - Ridley s.n. (30 Oct 1889)
* Anadendrum montanum (Blume) Schott - NRS2418
† Cryptocoryne griffithii Schott - NRS1525
† Cyrtosperma melanosorum (Hassk.) Schott - NRS0889
* Homalomena griffithii (Schott) Hook.f. - Ridley s.n. (May 1889)
* Homalomena sagittifolia Jungh. ex Schott - NRS2419
* Pothos latifolius Hook.f.
  Rhaphidophora korthalsii Schott - NRS1591
  Rhaphidophora sylvestris (Blume) Engl. var. montana (Blume) Nicols. - NRS0992
  Schismatoglottis wallichii (Roxb.) Hook.f. - NRS1604
  Scindapsus hederaceus (Zoll. & Moritzi) Miq. - NRS1509
Araliaceae
* Arthrophyllum diversifolium Blume (Arthrophyllum ovalifolium)
* Schefflera cephalotes (C.B. Clarke) Harms

Asclepiadaceae
* Dischidia albiflora Griff. (Dischidia collyris)
* Dischidia complex Griff.
* Dischidia hirsuta (Blume) Decne.
* Dischidia major (Vahl) Merr. (Dischidia rafflesiana)
* Dischidia nummularia R.Br.
* Toxocarpus griffithii Decne. (Toxocarpus glabrescens)

Bignoniaceae
* Deplanchea bancana (Scheff.) Steenis

Bombacaceae
* Coelostegia griffithii Benth.
* Durio singaporensis Ridl.
* Neesia malayana Bakh. - Ridley 3770 (1892)
  Neesia synandra Mast. - NRS0996

Burseraceae
Canarium littorale Blume - Ridley 44 (Nov 1889)
* Canarium odontophyllum Miq. - Corner’s specimen (s.n. 25 Apr 1934) taken from a 12 foot sapling is the only record of this species from the Malay Peninsula.
* Canarium pilosum Benn.
* Dacryodes incravata (Engl.) H.J. Lam
* Dacryodes rostrata (Blume) Lam
* Santiria apiculata Benn.
* Santiria griffithii (Hook.f.) Engl.
* Santiria laevigata Blume
*† Santiria rubiginosa Blume
† Trionnna malaccensis Hook.f.

Caprifoliaceae
Viburnum sambucinum Blume - Ridley 6829

Cecropiaceae
Poikilospermum suaveolens (Blume) Merr. - NRS1020 CCA 18

Celastraceae
*† Bhesa paniculata Arn. - NRS0170
† Bhesa robusta (Roxb.) Ding Hou
* Euonymus javanicus Blume
*† Lophopetalum multinervium Ridl.
† Lophopetalum wightianum Arn.
  Salacia grandiflora Kurz - NRS0128
Chrysobalanaceae

* Auna racemosa Rafin. - Ridley 1898 (7 Dec 1890)
* Liania splendens (Korth.) Prance - Ridley 4732 (15 Feb 1893)
* Parastemon urophyllus (Wall. ex A. DC.) A. DC.
* Parinari costata (Korth.) Blume
* Parinari oblongifolia Hook.f.

Combretaceae

* Combretum sundaicum Miq. - Mat 6783 (1985)
* Quisqualis indica L. - Ridley 8053 (1896)
* Terminalia phellocarpa King

Commelinaceae

† Amischotolype gracilis (Ridl.) I.M. Turner - NRS0179

Compositae

* Vernonia arborea Buch.-Ham. - Goodenough 2739 (1891)

Connaraceae

* Agelaea borneensis (Hook.f.) Merr. - Maxwell 82-107 (28 May 1981)
* Cnestis palala (Lour.) Merr.
  * Connarthus ferrugineus Jack - Maxwell 83-26 (13 Mar 1983)
  * Connarthus grandis Jack - J. Sinclair SFN40321 (3 Jul 1954)
* Connarthus monocarpus L. ssp. malayanus Leenhouts
* Connarthus semidecandrus Jack
  * Roura fulgens Planch. - NRS0860
  * Roura minor (Gaertn.) Leenhouts

Convallariaceae

† Peliosanthes teta Andr. ssp. humilis (Andr.) Jessp. - NRS1169

Convolvulaceae

* Argyreia ridleyi Prain ex Ooststr. - NRS0001 CCA 13
* Erycibe griffithii C.B. Clarke
  * Erycibe tomentosa Blume var. tomentosa - NRS0181

Cornaceae

† Mastixia trichotoma Blume - Maxwell 82-258 (23 Jun 1982)

Cucurbitaceae


Cyperaceae

* Hypolytrum nemorum (Vahl) Spreng. - NRS1176
  † Mapania cuspidata (Miq.) Uittien - NRS1620
* Mapania enodis (Miq.) C.B. Clarke
* Mapania lorea Uittien
  † Mapania squamata (Kurz) C.B. Clarke - NRS1505
* Thoracostachyum bancanum (Miq.) Kurz
Dilleniaceae

* Acrotrema costata Jack - no herbarium material of this species collected in Singapore can be found.
* Dillenia grandifolia Wall. ex Hook.f & Thomson
* Dillenia pulchella (Jack) Gilg
* Tetracera akara (Burm.f.) Merr.
* Tetracera arborescens Jack
  Tetracera indica (Christm. & Panz.) Merr. - NRS0184

Dioscoreaceae

Dioscorea laurifolia Wall. ex Hook.f. - NRS0042
Dioscorea polyclades Hook.f. - Mat s.n. (15 May ?)

Dipterocarpaceae

* Hopea mengerawan Miq. - Goodenough 5094 (8 Apr 1893)
* Shorea gratissima Dyer
* Shorea macroptera Dyer
† Shorea ovalis Blume (S. ?eximia)
* Shorea platycarpa Heim
* Vatica pauciflora Blume (Vatica wallichii) - Hill & Samsuri H3001 (22 Oct 1971)
+ Vatica ridleyana Brandis

Dracaenaceae

Dracaena aurantiaca Wall. - NRS0139
Dracaena elliptica Thunb. - Ridley s.n. (1894)
Dracaena singapurensis Ridley. - Ridley 6235 (1894)
Dracaena umbratica Ridley. - NRS1167

Ebenaceae

* Diospyros coriacea Hiern
* Diospyros lanceifolia Roxb. - Ridley 6695 (1894)
* Diospyros maingayi (Hiern) Bakh.
* Diospyros pilosantha Blanco var. oblonga (Wall. ex G. Don) Ng (Diospyros oblonga) - Hill & Samsuri H3025 (22 Oct 1971)
* Diospyros siamang Bakh.
  Diospyros sumatrana Miq. - Maxwell 82-73 (18 Mar 1982)

Elaeocarpaceae

Elaeocarpus ferrugineus (Jack) Steud. - Goodenough 4948 (24 Feb 1890)
Elaeocarpus floribundus Blume - Sidek 605 (18 Mar 1982)
* Elaeocarpus griffithii (Wight) A. Gray - Ridley 418 (Nov 1889)
* Elaeocarpus mastersii King - Ridley 274 (Nov 1889)
  Elaeocarpus nitidus Jack var. salicifolius (King) Ng - Samsuri Ahmad 1522 (17 Sept 1981)
† Elaeocarpus petiolatus (Jack) Wall.
Elaeocarpus stipularis Blume - Maxwell 82-69 (18 Mar 1982)

Euphorbiaceae

* Agrostistachys longifolia (Wight) Benth. ex Hook.f. (Agrostistachys sessilifolia) - NRS018
* Alchornea villosa Müll.Arg.
* Antidesma coriaceum Tul. - Maxwell 81-60 (1 Apr 1981)
* Antidesma cuspidatum Müll.Arg. - NRS0856
* Antidesma neurocarpum Miq. - NRS0116
* Aporusa confusa Gage - NRS1359
* Aporusa frutescens Blume - NRS0193
† Aporusa penangensis (Ridl.) Airy Shaw
* Aporusa symplocoides (Hook.f.) Gage - NRS0876
* Austrobulbus nitidus Miq.
† Baccaurea hookeri Gage
* Baccaurea kunstleri King ex Gage
† Baccaurea minor Hook.f.
† Baccaurea parviflora (Müll.Arg.) Müll.Arg.
* Blumeodendron tokbrai (Blume) Kurz
* Croton laevisfolius Blume - NRS0872
* Drypetes pendula Ridl.
* Endospermum diadenum (Miq.) Airy Shaw
* Glochidion hypoleucum (Miq.) Boerl. - Maxwell 82-181 (1 Jul 1982)
* Glochidion rubrum Blume
* Glochidion sericeum (Blume) Zoll. & Moritzi - Maxwell 82-53 (26 Feb 1982)
* Hymenocardia sp. [the correct identity of this species has still not been determined]
* Macaranga conifera (Zoll.) Müll.Arg.
* Macaranga gigantea (Rchb. f. & Zoll.) Müll.Arg.
* Macaranga griffithiana Müll.Arg.
* Macaranga hypoleuca (Rchb.f. & Zoll.) Müll.Arg.
* Macaranga punctulata Gage
* Macaranga recurvata Gage
† Macaranga triloba (Reinw.) Müll.Arg. - NRS0037
† Neosercotechia kingii (Hook.f.) Pax & K. Hoffm. - NRS0771
* Pinelodendron griffithianum (Müll.Arg.) Benth.
* Sapium discolour (Champ. ex Bent.) Müll.Arg.

Fagaceae

* Castanopsis inermis (Linfl. ex Wall.) Benth. & Hook.f.
† Castanopsis nephelioides King ex Hook.f.
* Castanopsis wallichii King ex Hook.f. - Ridley 3842 (Jun 1892)
* Lithocarpus elegans (Blume) Hatus. ex Soepadmo
† Lithocarpus sundaeicus (Blume) Rehder

Flacourtiaeaceae

* Casearia capitellata Blume - Ridley s.n. (1892)
* Casearia lobbiania Turcz. - Ridley s.n. (1894)
* Casearia sp. - the specimen cited by Corner (SFN32517) is Campnosperma squamatum, presumably the wrong number was referred to.
* Flacourtia rukam Zoll. & Moritzi - NRS1015
* Osmelia maingayi King
† Osmelia philippina (Turcz.) Benth. - Maxwell 83-18 (17 Feb 1983)

Flagellariaceae
* Flagellaria indica L. - NRS0015

Gesneriaceae
Aeschynanthus albidus (Blume) Steud. (= A. purpurascens Hassk.) - NRS1012
* Aeschynanthus parvifolius R.Br.
* Aeschynanthus wallichii R.Br.

Gonystylaceae
* Gonystylus confusus Airy Shaw
† Gonystylus maingayi Hook.f.

Gramineae
* Leptaspis urceolata (Roxb.) R.Br. - NRS0039
   Lophatherum gracile Brongn. - Goodenough 1701 (8 Feb 1890)

Guttiferae
† Calophyllum dispar P.F. Stevens
* Calophyllum ferrugineum Ridley (Calophyllum retusum)
* Calophyllum rubiginosum M.R. Hend. & Wyatt-Sm. (C. wallichianum)
* Calophyllum tetramerum Miq. (Calophyllum floribundum)
† Calophyllum teysmannii Miq. (Calophyllum inophyloide var. singapurense)
* Calophyllum wallichianum Planch. & Triana var. incrassatum (M.R. Hend. & Wyatt-Sm.) P.F. Stevens (Calophyllum incrassatum)
* Cratoxylum arborescens (Vahl) Blume
* Cratoxylum cochinchinense (Lour.) Blume (Cratoxylum ligustrinum) - NRS0172
* Cratoxylum formosum (Jack) Dyer
† Garcinia eugeniifolia Wall. ex T. Anderson - Ridley s.n. (1893)
*† Garcinia forbesii King - NRS0887
   Garcinia griffithii T. Anderson - DJM101
? Garcinia hombroniana Pierre - Ridley s.n. (1893)
* Garcinia mangostana L. - Ridley s.n. (1892)
† Garcinia nervosa Miq. - J. Sinclair SFN10915 (6 Sep 1966)
* Garcinia nigrolineaata Planch. ex T. Anderson
*† Garcinia parvifolia (Miq.) Miq. - Ridley s.n. (Nov 1909)
* Garcinia scortechinii King (Garcinia gaudichaudii)

Hanguanaceae
* Hanguana malayana (Jack) Merr. - NRS0035

Hypoxidaceae
Curculigo latifolia Dryand. - NRS0025 CCA 13

Icacinaceae
* Cantleya corniculata (Becc.) Howard
   Gomphandra quadrifida (Blume) Sleumer var. ovalifolia (Ridl.) Sleumer - NRS0777
   Iodes cirrhosa Turcz. - NRS0026
Iodes ovalis Blume - NRS0004
* Phytocrene bracteata Wall.
* Phytocrene latifolia Blume
*† Stemonurus scorpioides Becc. - Ridley s.n. (1892)

Irvingiaceae
* Irvingia malayana Oliv.

Ixonanthaceae

Ixonanthes icosandra Jack - Ridley 1937 (1890)
Ixonanthes reticulata Jack - NRS0783

Lauraceae
* Actinodaphne macrophylla (Blume) Nees
† Alseodaphne bancana Miq. - Samsuri 1401 (9 Feb 1977)
*† Beilschmiedia kunstleri Gamble
† Cryptocarya ferrea Blume - NRS1005
* Cryptocarya griffithiana Wight
* Endiandra maingayi Hook.f. (Hexapora ? curitis)
* Linderia lucida (Blume) Boerl. (Lindera malaccensis) - Sinclair SFN40520 (22 Dec 1954)
Litsea elliptica Blume - Samsuri 1446 (9 Feb 1977)
† Litsea erectinervia Kosterm.
* Litsea ferruginea Blume
* Litsea firma Hook.f.
* Litsea gracilipes Hook.f. - Sinclair SFN40274 (1 May 1954)
* Litsea grandis Hook.f. - Ridley 3962 (1892)
Litsea lancifolia (Roxb.) Hook.f. - Maxwell 82-78 (19 Mar 1982)
Litsea ridleyi Gamble - NRS1183
† Litsea robusta Blume
† Phoebe grandis Merr.

Leeaceae
Lea indica (Burm.f.) Merr. - NRS0046

Leguminosae
* Albizia splendens Miq. (Pithecellobium confertum)
Archidendron clypearia (Jack) I.C. Nielsen - NRS0421
*† Archidendron ellipticum (Blume) I.C. Nielsen (Pithecellobium ellipticum) - Maxwell 81-146 (18 Jun 1981)
Archidendron microcarpum (Benth.) I.C. Nielsen - Samsuri Ahmad 1399 (9 Feb 1977)
Bauhinia semibifida Roxb. - NRS0990
* Crudia caudata Prain [we have not been able to trace the specimen referred to by Corner]
* Dalbergia havilandii Prain
Dalbergia pseudosissoo Miq. - J. Sinclair SFN39999 (2 Aug 1953)
Derris amoena Benth. var. maingavana (Baker) Prain - NRS0118 CCA 18
Derris trifoliata Lour. - Goodenough s.n. (30 Oct 1889)
* Dialium patens Baker
Entada spiralis Ridl. - Samsuri Ahmad 1451 (8 Mar 1977)
* Koompassia malaccensis Maingay ex Benth.
* Kunstleria ridleyi Prain
* Milletia eriantha Benth. (Adinobotrys eriantha)
* Ormosia macrodisca Baker
* Parkia speciosa Hassk. - Ridley 419 (Nov 1889)
  Saraca thaipingensis Cantley - NRS0779
* Sindora wallichii Grah. ex Benth.
  Spatholobus ridleyi Prain ex King - Mat 6795 (1894)

Linaceae
* Indorouchera griffithiana (Planch.) Hallier f. - NRS0155

Loganiaceae
* Fagraea auriculata Jack
* Fagraea racemosa Jack ex Wall. - NRS1027

Loranthaceae
  Macrosolen cochinchinensis (Lour.) Tiegh. - Maxwell 82-257 (23 Sept 1982)

Magnoliaceae
* Magnolia candollii (Blume) H. Keng var. singapurensis (Ridl.) Nooteboom (Talauma singapurensis, T. lanuginosa) - Maxwell 81-145 (18 Jun 1981)

Malpighiaceae
  Aspidopteris concava (Wall.) Juss. - Maxwell 82-46 (17 Feb 1982)

Melastomataceae
  Clidemia hirta (L.) D. Don. - NRS0043
  * Dpectria viminalis (Jack) Kuntze (Anplectrum viminalae)
  * Macroloenes echinulata (Naud.) Bakh.f. (Marumia rhodocarpa)
  * Medinilla crassifolia (Reinw. ex Blume) Blume (?Medinilla rubicunda var. hasseltii) - Ridley 273 (Oct 1889)
  † Memecylon edule Roxb.
  * Memecylon floridum Ridley. (Memecylon sp.)
  † Memecylon lilacinum Zoll. & Moritzi
  * Pachycentria constricta (Blume) Blume (Pachycentria tuberculata)
  *† Piernandra coerulescens Jack - NRS0754
  * Piernandra echinata Jack - NRS0192
  Sonerila heterostemon Naud. - NRS0778

Meliaceae
† Aglaia odoratissima Blume - Maxwell 82-282 (4 Nov 1982)
  Aglaia oligophylla Miq. - Ridley 3919 (1892)
*† Aglaia rubiginosa (Hiern) Pannell - Ridley 3790 (1892)
* Aphanamixis polystachya (Wall.) Parker - Maxwell 82-282 (2 Jul 1981)
  Dysoxylum cauliflorum Hiern. - Goodenough 5080 (1893)
  Dysoxylum cyrtobotryum Miq. - Goodenough s.n. (Mar 1890)
  † Dysoxylum densiflorum (Blume) Miq.
  † Dysoxylum exselsum Blume - Goodenough s.n. (15 Mar 1890)
  Dysoxylum flavescens Hiern. - J. Sinclair SFN40262 (23 Apr 1954)
  † Lansium domesticum Correa
*† *Sandoricum beccarianum* Baill. (*Sandoricum emarginatum*)

**Menispermaceae**
- *Fibraurea tinctoria* Lour. - NRS0143
- *Linacia scandens* Lour. - NRS0147
- *Stephania capitata* (Blume) Spreng. - NRS0159
- *Tinospora macrocarpa* Diels - NRS0849

**Monimiaceae**
† *Kibara coriacea* (Blume) Tul.
- *Mathaeas sancta* Blume - NRS1003

**Moraceae**
* Artocarpus elasticus Reinw. ex Blume - Chew CWL34 (5 Mar 1957)
* Artocarpus fulvicortex Jarrett - Ridley 4129 (1892)
*† Artocarpus kemando Miq. - Sinclair SFN40322 (3 Jul 1954)
* Artocarpus nitidus Tréé. ssp. griffithii (King) Jarrett
* Artocarpus scortechinii King
* Ficus albipila (Miq.) King
* Ficus apiocarpa Miq. - NRS2128
* Ficus binnendyki Miq. var. coriacea Corner
* Ficus bracteata Wall. ex Miq.
* Ficus consociata Blume var. murtoni King - E. Tang & Sidek 785 (10 Jul 1995)
* Ficus excavata King
* Ficus fistulosa Reinw. ex Blume var. fistulosa - NRS0010
* Ficus globosa Blume - NRS0183
  - *Ficus heteropleura* Blume - NRS1180
* Ficus microcarpa L.f.
* Ficus microsyce Ridl.
* Ficus obscura Blume var. borneensis (Miq.) Corner
* Ficus pellucido-punctata Griff.
  - *Ficus pisocarpa* Blume - DJM318
* Ficus recurva Blume var. ribesoides King
* Ficus retusa L.
* Ficus ruginervia L.
* Ficus sagittata Vahl -
  - *Ficus scortechinii* King - NRS1174
  - *Ficus sinuata* Thunb. - NRS0186
* Ficus suraida Blume - NRS0014
* Ficus trichocarpa Blume - DJM171
  - *Ficus variegata* Blume - Ridley s.n. (189?)
* Ficus villosa Blume - NRS1618
  - *Ficus virens* Ait. var. glabella (Blume) Corner - Ridley 1602 (30 Oct 1889)
* Ficus xylophylla Wall. ex Miq.
  - *Parartocarpus bracteatus* (King) Becc. - Ridley 4128 (1892)
* Parartocarpus venenosus* (Zoll. & Moritzi) Becc. ssp. forbesii (King) Jarrett
* Streblus elongatus (Miq.) Corner

**Myristicaceae**
* Endocoinia canarioides (King) W.J. de Wilde (*Horsfieldia macrocoma* var. canarioides)
**Myrsinaceae**

* Decaspermum fruticosum J.R. Forst. & G. Forst - DJM174

**Myrtaceae**

* Eugenia chlorantha Duthie - Ridley 3910
* Eugenia kunstleri King
* Eugenia leptostemon (Korth.) Miq. - Mat s.n. (5 May 1895)
* Eugenia microcalyx Duthie
* Eugenia muelleri Miq.
* Eugenia nemestrina M.R. Hend. - Corner SFN37396 (28 Dec 1940)
  Eugenia oblongifolia Duthie - Ridley 360 (Nov 1889)
* Eugenia oleina Wight
* Eugenia pachyphylla Kurz - NRS0138
* Eugenia papillosa Duthie
  Eugenia polyantha Wight - NRS0562
* Eugenia pseudocrenulata M.R. Hend.
  Eugenia pseudosubtilis King - Goodenough 4487 (21 Dec 1889)
  Eugenia pusulata Duthie - Mat 6806 (15 May 1895)
  Eugenia ridleyi King - Mat 6805 (15 May 1895)
* Eugenia rugosa (Korth.) Merr.
* Eugenia tumida Duthie - Maxwell 81-210 (24 Sep 1981)
  Rhodannia cinerea Jack - Goodenough s.n. (10 Feb 1890)
† Tristaniopsis merguensis (Griff.) Peter G. Wilson & J.T. Waterh.

Najadaceae
  Najas indica (Willd.) Cham. - NRS0838

Nepenthaceae
* Nepenthes ampullaria Jack
* Nepenthes gracilis Korth.
* Nepenthes rafflesiana Jack

Nymphaeaceae
* Barclaya motleyi Hook.f. - Sinclair SFN40337 (17 July 1954)

Ochnaceae
* Brackenridgea hookeri (Planch.) A. Gray
  Brackenridgea palustris Bartell. - Ridley 5896 (1894)

Olacaceae
  Erythrophalum scandens Blume - NRS0845
† Ochanostachys amentacea Mast.
*† Strombosia ceylanica Gardn. - NRS1946

Oleaceae
* Chionanthus ramiiflorus Roxb. (Linociera pauciflora)

Orchidaceae
* Agrostophyllum bicuspidatum J.J.Sm.
* Anoectochilus geniculatus Ridl. - Ridley 5896 (1894)
* Appendicula lucida Ridl.
* Bierrmannia laciniata (Carr) Garay (Chamaeaanthus laciniatus)
* Bulbophyllum acuminatum (Ridl.) Ridl.
* Bulbophyllum apodum Hook.f. - Ridley 3933 (1892)
  Bulbophyllum blumei (Lindl.) J.J.Sm. - Mat s.n. (1894)
* Bulbophyllum botryophorum Ridl.
  Bulbophyllum gusdorfii J.J.Sm. - NRS1683
* Bulbophyllum macranthum Lindl. - NRS1320
* Bulbophyllum medusae (Lindl.) Rchb.f. - Goodenough s.n. (1891)
* Bulbophyllum ovalifolium (Blume) Lindl. - Mat s.n. (1894)
* Bulbophyllum pileatum Lindl.
* Bulbophyllum pulchellum Ridl. - Ridley s.n. (19 Dec 1890)
* Bulbophyllum purpurascens Teijsm. & Binnend.
* Bulbophyllum sessile (Koenig) J.J.Sm. - Ridley s.n. (1892)
* Bulbophyllum vaginatum (Lindl.) Rchb.f.
* Calanthe pulchra (Blume) Lindl. - Chew & Whitmore s.n. (5 Mar 1957)
* Ceratostylis subulata Blume (Camerotis adnata)
* Claderia viridiflora Hook.f. - NRS0002
* Coelogyne mayeriana Rchb.f. - Ridley s.n. (1891)
* Corymborkis veratrifolia (Rienw.) Blume - Mat 6756 (1894)
* Cymbidium finlaysonianum Lidl. - Ridley s.n. (1891)
* Cystorchis variegata Blume - Sinclair SFN40277 (8 May 1954)
* Dendrobium aloifolium (Blume) Rchb.f.
* Dendrobium concinnum Miq. (Dendrobium carnosum) - Ridley s.n. (1892)
* Dendrobium crumenatum Sw.
* Dendrobium divisum (Blume) Miq. - Ridley s.n. (1892)
* Dendrobium leonis (Lindl.) Rchb.f. - Ridley s.n. (30 Oct 1889)
* Dendrobium planibulbe Lindl. - Goodenough s.n. (29 Aug 1890)
* Dendrobium prostratum Ridl.
  * Dendrobium pulchellum Roxb. ex Lindl. - Ridley s.n. (May/Jun 1890)
  * Dendrobium setifolium Ridl. - Goodenough s.n. (21 Dec 1889)
  * Dendrobium tegidoglossum Rchb.f. - Ridley s.n. (1894)
* Dendrobium spurium (Blume) J.J.Sm.
* Dendrochilum longifolium Rchb.f.
* Didymoplexis palliens Griff. - Ridley s.n. (1889)
* Eria bractescens Lindl. - Ridley s.n. (1890)
* Eria floribunda Lindl. - Goodenough s.n. (3 Jan 1892)
* Eria neglecta Ridley.
* Eria nutans Lindl.
* Eria pannea Lindl. - Goodenough s.n. (1891)
* Eria pulchella Lindl. - Ridley s.n. (1892)
* Eulophia spectabilis (Dennst.) Suresh (Eulophia squalida) - Ridley s.n. (1892)
* Flickingeria conata (Blume) Hawkes (Dendrobium conatum)
* Flickingeria fimbriata (Blume) Hawkes (Dendrobium plicatile)
* Galeola nudifolia Lour. (Galeola kuhlii) - Ridley 4037 (28 Oct 1892)
* Hyliphila mollis Lindl. - Ridley s.n. (Oct 1889)
† Lecanorchis malaccensis Ridley - NRS1533
* Lipparis gibbosa Finet - Goodenough s.n. (1891)
* Lipparis tricallosa Rchb.f. - Goodenough s.n. (13 Jan 1892)
* Lipparis wrayi Hook.f.
* Malaxis latifolia J.E.Sm. - Ridley 3922 (1892)
* Malaxis micrantha (Hook.f.) Kuntze - Ridley s.n.
* Microsaccus javensis Blume - Ridley s.n. (1894)
* Nephelaphyllum pulchrum Blume - NRS0775
* Nervilia punctata (Blume) Makino
* Oberonia stenophylla Ridley - Corner 393 (Dec 1930)
* Plocoglottis gigantea (Hook.f.) J.J.Sm. - NRS0122
*† Plocoglottis javanica Blume - NRS0999
Podochilus microphyllus Lindl. - Goodenough s.n. (15 Oct 1889)
Pteroceras pallidum (Ridl.) Holtum - NRS1935
* Schoenorchis secundiflora (Ridl.) J.J.Sm.
* Taeniophyllum filiforme J.J.Sm.
* Taeniophyllum obtusum Blume - NRS1318
* Thelasis micrantha (Brongn.) J.J.Sm.
* Thelasis pygmaea (Griff.) Lindl. (Thelasis triptera)
Thrixspermum trichoglottis (Hook.f.) Kuntze - NRS1319
* Trichotosia velutina (Lodd. ex Lindl.) Kraenzl. (Eria velutina)
Vrydagzynea lancifolia Ridl. - Ridley s.n. (Jan 1890)

Oxalidaceae
* Dapania racemosa Korth.
† Sarcotheca griffithii (Planch. ex Hook.f.) Hallier f.

Palmae
Calamus ridleyanus Becc. - Hill & Samsuri 3108 (22 Oct 1971)
* Cyrostachys renda Blume (Cyrostachys lakka)
Daemonorops angustifolia (Griff.) Mart.- NRS0031
Daemonorops didymophylla Becc. - Ridley 3476 (1892)
Daemonorops hystrix (Griff.) Mart. - Ridley s.n.
Daemonorops kunstleri Becc. - Goodenough 1667 (21 Jun 1890)
* Daemonorops leptopus (Griff.) Mart.
Daemonorops longipes (Griff.) Mart. - NRS2424
Daemonorops sabbu Becc. - Sinclair SFN40303 (22 May 1954)
Eleiodoxa conferta (Griff.) Burret (Salacca conferta) - Ridley 3502 (1892)
Iguanura wallichiana (Wall. ex Mart.) Hook.f. - NRS0177
Korthalsia echinometra Becc. - NRS1175
Licuala ferruginea Becc. - NRS1177
Myriallepis paradoxa (Kurz) J. Dransf. - Ridley 3503 (1892)
* Nenga pumila (Mart.) Wendl. - Ridley s.n. (1900)
* Onchosperma horridum (Griff.) Scheff. - Ridley s.n. (1891)
Orania sylvicola (Griff.) H.E. Moore - Ridley 3144 (1891)
Pitanga malaiana (Mart.) Scheff. - NRS0135
Rheopaloblaste singaporensis (Becc.) Hook.f. - Ridley 2134 (1891)

Pandaceae
* Galearia fulva (Tul.) Miq. - NRS0881

Pandanaceae
* Freycinetia angustifolia Blume - Samsuri 1451 (8 Mar 1977)
* Freycinetia confusa Ridl.
* Freycinetia coronerii B.C. Stone
* Freycinetia javanica Blume - NRS1527
* Pandanus atrocarpus Griff.
* Pandanus kamiae B.C. Stone

Passifloraceae
Adenia macrophylla (Blume) Koord. var. singaporeanna (Wall. ex G. Don) W.J. de Wilde -NRS1028 CCA 18
Phormiaceae
* Dianella ensifolia (L.) DC. - NRS0281 CCA 18

Piperaceae
* Piper flavimarginatum C. DC.
* Piper miniataum Blume
  Piper muricatum Blume - NRS1187

Polygalaceae
*† Xanthophyllum affine Korth. - NRS0995
† Xanthophyllum ellipticum Korth.
† Xanthophyllum obscurum Benn.
† Xanthophyllum vitellinum (Blume) Dietr.

Rhamnaceae
  Ventitiago malaccensis (Lour.) Merr. - Maxwell 81-64 (1 Apr 1981)
* Ziziphus elegans Wall.

Rhizophoraceae
*† Carallia brachiata (Lour.) Merr. - Maxwell 81-102 (28 May 1981)
*† Gynotroches axillaris Blume - Sidek & Ali SK620 (9 Dec 1982)
*† Pellacalyx axillaris Korth. - NRS0146

Rosaceae
* Prunus arborea (Blume) Kalkman
* Prunus grisea (C. Muell.) Kalkman
† Prunus polystachya (Hook f.) Kalkman - NRS0191

Rubiaceae
* Aidia corymbosa (Blume) K.M. Wong (Randia auriculata)
  Aidia wallichiana Tirveng. - Ridley 5662 (1892)
* Caelospermum truncatum (Wall.) Baill. ex K. Schum.
  Canthium horridum Blume - NRS0044
  Chasalia chartacea Craib - NRS1025
  Coptosapelta griffithii Hook.f. - Mat 6891 (1895)
† Diplospora malaccensis Hook.f. - NRS0763
  Gardenia griffithii Hook.f. - Hullett 611 (21 Aug 1888)
  Gynochthodes subanceolata Miq. - Samsuri Ahmad 1521 (17 Sep 1981)
  Hedyotis capitellata Wall. ex G. Don - DJM166
  Hedyotis congesta R.Br, ex G. Don - DJM139
* Hydnophytum formicarum Jack
  Ixora coccinea Hook.f. - Mat 6714 (1894)
* Ixora congesta Roxb.
  Ixora lobbii King & Gamble - NRS2410
  Ixora pendula Jack - Ridley 5676
*† Jackiopsis ornata (Wall.) Ridsdale (Jackia ornata)
  Lasianthus appressus Hook.f. or L. attenuatus Jack - NRS0998
  Lasianthus attenuatus Jack - NRS0023
  Lasianthus constrictus Wight - NRS0034
  Lasianthus densifolius Miq. - NRS0756
Lasianthus griffithii Wight - NRS1949
Lasianthus ridleyi King & Gamble - Maxwell 82-100 (7 Apr 1982)

Lecananthus erubescens Jack
Lecanaria membranacea King - NRS0862
Morinda citrifolia L. - NRS0167

Morinda ridleyi (King & Gamble) Ridl. - Maxwell 81-235 (3 Dec 1981)
Morinda rigida Miq.
Morinda umbellata L. - NRS2411
Mussaenda glabra Vahl - NRS0047

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Morinda umbellata L. - NRS2411
Mussaenda glabra Vahl - NRS0047

Mussaendopsis beccariana Baill. - NRS0991
Mussaenda glabra Vahl - NRS0047

Oxyceros scandens (Blume) Tirveng. (Randia clarkei)

Pavetta wallichiana Steud. (Pavetta indica) - NRS0759
Porterandia anisophylla (Jack ex Roxb.) Ridl. - NRS0852
Prismatomeris glabra (Korth.) Valeton - Ridley 6150 (Apr 1894)
Psychotria sp. 9 - Hulott s.n. (1896)

Psychotria maingayi Hook.f.
Psychotria obovata Wall.
Psychotria penangensis Hook.f. - NRS0770
Psychotria sarmentosa Blume - NRS0173

Rothmannia macrophylla (R.Br, ex Hook.f.) Bremek. (Randia macrophylla)

Tarenna adpressa (King) Merr.

Tarenna odorata (Roxb.) B.L. Rob. - NRS0871

Timonius flavescens (Jack) Baker - Maxwell 81-82 (29 Apr 1981)

Timonius wallichianus (Korth.) Valeton - NRS0857

Uncaria acida (Hunter) Roxb. (Uncaria ovalifolia)

Uncaria cordata (Lour.) Merr. - DJM172

Uncaria gambir (Hunter) Roxb. - Maxwell 82-50 (17 Feb 1982)

Uncaria lasana Wall. var. glabrata (Blume) Ridsdale

Uncaria longiflora (Poir.) Merr. var. pteropoda (Miq.) Ridsdale - Ridley s.n.

Urophyllum blumeanum (Wight) Hook.f. - NRS0752

Urophyllum glabrum Wall. - NRS0162

Urophyllum sp. 2 of Wong (Tree Flora of Malaya Vol. 4) - NRS0176

Urophyllum streptopodium Wall. ex Hook.f.

Rutaceae

Glycosmis chlorosperma (Blume) Spreng. - Ridley 3912 (1892)
Luvunga crassifolia Tanaka - NRS0635
Maclurodendron porteri (Hook.f.) T.G. Hartley - Hill & Samsuri H3017 (22 Oct 1971)

Sapindaceae

* Lepisanthes fruticosa (Roxb.) Leenh.
Nepheleium cuspidatum Blume var. eriopetalum (Miq.) Leenh.
Nepheleium lappaceum L. (N. glabrum) - NRS0006
Nepheleium laurinum Blume - Ridley 6211 (Apr 1894)

† Pomelia pinnata Forst. - Sinclair SFN40519 (22 Dec 1954)
Xerospermum noronhianum Blume - Ridley s.n. (1894)
Sapotaceae

*† Gamua motleyana (de Vr.) Pierre ex Dubard
  Madhuca malaccensis (C.B. Clarke) Lam - Mat 6500 (1894)
* Palaquium hexandrum (Griff.) Baill.
  Palaquium gutta (Hook.f.) Baill. - Hill & Samsuri H3038 (22 Oct 1971)
*† Palaquium rostratum (Miq.) Burck
*† Palaquium xanthochymum (de Vr.) Pierre - Ridley 3774 (1892)
* Planchnonella maingayi (C.B. Clarke) van Royen

Smilacaceae

Smilax setosa Miq. - NRS0129
Smilax calophylla Wall. - NRS0997

Sterculiaceae

Byttneria maingayi Mast. - Maxwell 82-59 (26 Feb 1982)
Connersonia bartramia (L.) Merr. - NRS1018
* Heritiera elata Ridl.
  Scaphium linearicarpum (Mast.) Pierre - Himat (?) s.n. (11 Oct 1956)
† Scaphium macropodum (Miq.) Beemee ex Heyne
* Sterculia coccinea Jack - NRS0121
† Sterculia cordata Blume
* Sterculia gilva Miq. (Sterculia bicolor)
*† Sterculia macrophylia Vent. - Samsuri Ahmad 1455 (8 Mar 1977)
*† Sterculia rubiginosa Vent. - Samsuri Ahmad 1395 (9 Feb 1977)

Symplocaceae

* Symplocos barringtoniifolia Brand - Maxwell 82-180 (1 July 1982)
† Symplocos fasciculata Zoll.

Taccaceae

* Tacca integrifolia Ker-Gawl. - Goodenough s.n. (14 Apr 1890)

Theaceae

Adinandra acuminata Korth. - Ridley s.n. (1894)
Adinandra dumosa Jack - NRS0198
† Eurya acuminata DC. - NRS0052
  Gordonia penangensis Ridl. - Ridley 3913 (1892)
† Pyrenaria acuminata Planch. ex Choisy - NRS1016

Thymelaeaceae

*† Aquilaria malaccensis Lam.
  Enkleia malaccensis Griff. - DJM153

Tiliaceae

* Grewia acuminata Juss. (Grewia umbellata) - NRS0185
*† Microcos blattifolia (Corner) Rao (Grewia blattifolia)
*† Pentace triptera Mast.

Ulmaceae

* Gironniera parvifolia Planch.
Verbenaceae
* Clerodendrum deflexum Wall. - NRS1009
  Clerodendrum laevifolium Blume - NRS0758
  Clerodendrum paniculatum L. - NRS0846
* Clerodendrum villosum Blume - NRS0005
  Vitex pinnata L. - NRS0136

Viscaceae
  Viscum articulatum Burm.f. - Ridley 8054 (1896)
  Viscum ovalifolium Wall. ex DC. - Ridley s.n. (1896)

Vitaceae
  Ampelocissus elegans (Kurz) Gagnep. - NRS0011
  Ampelocissus graciilis (Wall.) Planch. - NRS1170
* Cayratia mollissima (Wall.) Gagnep. (Vitis mollissima) - DJM1696
* Cissus hastata (Miq.) Planch. (Vitis hastata) - NRS0187
* Cissus nodosa Blume (Vitis glaberrima) - Ridley 6789 (7 Aug 1895)
  Cissus repens Lam. - NRS0884
  Pterisanthes eriopoda (Miq.) Planch. - Ridley 425 (Nov 1889)
* Pterisanthes polita (Miq.) Laws. - NRS0127

Zingiberaceae
* Amomum hastilabium Ridl.
* Amomum xanthophlebium Baker - Ridley s.n. (1899)
  Globba leucantha Miq. - Betty Allen s.n. (28 May 1949)
* Hornstedtia leonurus (Koenig) Retz. - Ridley s.n. (1892)
* Hornstedtia scyphifera (Koenig) Steud. -
  Plagiostachys lateralis (Ridl.) Ridl. - Ridley s.n. (1892)
  Zingiber griffithii Baker - NRS0787
A Preliminary Survey of Ferns and Fern-Allies of Gunung Kajang Area, Pulau Tioman

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Faculty of Life Sciences,
Universiti Kebangsaan Malaysia,
43600 UKM Bangi, Selangor, Malaysia.

Abstract

A total of 149 specimens of ferns and fern-allies were collected during two trips to Gunung Kajang, Pulau Tioman. They were identified to 24 families, 59 genera, 95 species, 1 subspecies and 11 varieties, excluding 2 species whose identity were uncertain. Asplenium contributes the largest number among genera, with 9 species, followed by Selaginella (6 species) and Seligeria (4 species), and 39 species were identified as new records to Pulau Tioman fern flora.

Introduction

Gunung Kajang (1030 m.) which is situated in the south-eastern part of Pulau Tioman is the highest peak of the island (Figure 1). There is a trail from Kampung Paya, inland of Tanjung Pauh on the south-west coast cutting several small streams to the summit of Gunung Kajang. The trail runs upwards along ridges and valleys in a generally west by south-east direction. The small ridge known as Bukit Permatang runs from east to west and one small cave found on the way to the summit at 950 m. elevation is known as Gua Tahi Angin. Another trail to the summit of Gunung Kajang runs from Kampung Juara at Teluk Juara on the other side of the island has been demolished because of the dangerous slopes on the north and south banks.

The geology of the Gunung Kajang area is dominated by granitoid rocks which give the rocky structure such as exposed granite rock and thin layer of soil. Exposed rock is found near the sea at Kampung Paya and at several places along the trail to the summit of Gunung Kajang.

Two trips of survey have been made to collect and identify the ferns and fern-allies from Kampung Paya to the summit of Gunung Kajang and several meters down from the summit to Teluk Juara. Most of the samples were collected in the form of herbarium specimens except several of them were only observed and noted. Voucher specimens were kept in the Herbarium, Universiti Kebangsaan Malaysia (UKMB).

Survey of Pulau Tioman Ferns

Several collections of plants of Pulau Tioman were made by various collectors. In August 1889, Ridley collected a little on the west coast at the place he called Nypa Bay (Henderson, 1930). In June 1915, Burkill and Robinson collected at
Juara Bay and Tanjung Duata (Burkill, 1927) while Henderson (1930) collected mainly on higher altitude especially on Gunung Kajang and Gunung Rokam between May 10th and May 29th, 1927. It was until 1977 when Lee and members of Universiti Malaya made a list of ferns and fern-allies of Pulau Tioman. A total of 112 species from 23 families and 62 genera have been recorded from Pulau Tioman and Pulau Tulai from their collections and previous records of herbarium specimens. In this preliminary survey, a total of 149 specimens were collected and classified into 24 families, 59 genera and 95 species which include 39 new records for Pulau Tioman (Table 1).

Table 1  List of ferns and fern-allies collected from Gunung Kajang, including previous records

<table>
<thead>
<tr>
<th>FAMILY / Species</th>
<th>Zulkifli et al.</th>
<th>Lee et al.</th>
<th>New Records</th>
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<tbody>
<tr>
<td>LYCOPODIACEAE</td>
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<tr>
<td>Huperzia phlegmaria</td>
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<td>Lycopodiella cernua</td>
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<td>Selaginella polystachya</td>
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<td>ASPLENIACEAE</td>
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<td>FAMILY / Species</td>
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<td>Lee et al.</td>
<td>New Records</td>
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<td>FAMILY / Species</td>
<td>Zulkifli et al.</td>
<td>Lee et al.</td>
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<td>Zulkifli et al.</td>
<td>Lee et al.</td>
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<td><em>Pteris mertensioides</em></td>
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<td><em>Pteris oppositipinna</em></td>
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<td><em>Pteris tripartita</em></td>
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<td><strong>SCHIZAEACEAE</strong></td>
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<td><em>Lygodium circinatum</em></td>
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<td><em>Lygodium flexuosum</em></td>
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<td><em>Lygodium microphyllum</em></td>
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<td><em>Schizaea dichotoma</em></td>
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<td><em>Schizaea digitata</em></td>
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<td><strong>THELYPTERIDACEAE</strong></td>
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<td><em>Amphineuron interruptum</em></td>
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<td><em>Christella arida</em></td>
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<td><em>Christella parasitica</em></td>
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<td><em>Pronephrium repandum</em></td>
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<td><em>Pronephrium rubicundum</em></td>
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<td><em>Sphaerostephanos heterocarpus</em></td>
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<tr>
<td><strong>VITTARIACEAE</strong></td>
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<td><em>Antrophyum califolium</em></td>
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<td><em>Monogramma dareicarpa</em></td>
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<td><em>Vaginularia trichoidea</em></td>
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<td><em>Vittaria angustifolia</em></td>
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<td><em>Vittaria elongata</em></td>
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<td><em>Vittaria scolopendrina</em></td>
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<td><strong>WOODSIACEAE</strong></td>
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<td><em>Diplazium sorzogonense</em></td>
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<td><em>Diplazium tomentosum</em></td>
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<td>Total number of species</td>
<td>95</td>
<td>112</td>
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On the coastal area at Kampung Paya in Tanjung Pauh, *Nephrolepis auriculata, Stenochlaena palustris* and *Pteris ensiformis* dominate the rocks in open places. There are several others like *Asplenium nidus, A. macrophyllum* and *Pyrrosia*
lanceolata which were found on rocks by the beach, whereas Lygodium flexuosum can be easily seen scrambling over the bushes nearby. A single individual of Helminthostachys zeylanica was observed in open ground.

The trail from Kampung Paya runs across several small streams under primary forest of Gunung Kajang foothill. One small stream known as Sungai Ayer Pertama is dominated with a species, Bolbitis sinuata, on rock and terrestrial in flood area of the stream. Along streams, Bolbitis appendiculata ssp. appendiculata grows in similar habitat with the above species. Other rock ferns such as Cephalomanes javanicum grow on expose rock surface in the stream.

Most lowland ferns grow on the forest floor similar to that of the lowland ferns in similar habitat in the mainland. The forest floor is dominated by Selaginella wallichi, Selaginella wildenovii and Colysis pedunculata among others. Another small stream called Ayer Suring shows the same fern flora but no Bolbitis sinuata found. Microsorum heterocarpum grows on rock in shady area. Holttum (1968) recorded that this species has the south limit not further than the Main Range. Riparian ferns such as Pleocnemia conjugata and Pteridrys syrmatia are found along streams but not in large groups, were new records for Pulau Tioman. Holttum (1968), noted that Pleocnemia conjugata was less common in Peninsular Malaysia, probably correlated with its lowland habitat and preference for lightly shaded places which do not occur in normal fully shaded primitive forest.

Another notable place called Ayer Orang Puteh was furnished with naked surface of rocks with a small stream that flows underneath, giving a wet and moist habitat which is a suitable place for rock-loving ferns especially members of Hymenophyllaceae such as Cephalomanes javanicum, Meringium acanthoides, Microgonium bimarginatum and Selenodesmium obscurum. Other lithophytic ferns found were Asplenium affine, A. borneense, A. scolopendrioides, Anthrophyum callifolium, Colysis macrophylla and Loxogramme avenia. Ayer Orang Puteh at the altitude of 650 m also the lowest limit of Cyatheaceae found in Gunung Kajang area; Cyathea eriophora was found on the bank near rocky part of Ayer Orang Puteh.

The area upwards of Air Orang Puteh shows more diversity in fern flora. Out of 95 species of ferns and fern-allies collected from Gunung Kajang area, 49 species (52%) were collected in the very limited area above 700 m. Bukit Permatang (850 m.) was familiar with ferns of Cyatheaceae and Dennstaedtiaceae. Two species of Cyathea i.e. Cyathea hymenodes and Cyathea obscura were new records to Pulau Tioman. Histiopteris incisa grows on rock with a thin layer of humus. Asplenium robustum which grows on high branches of trees in Main Range, especially at Cameron Highlands, was found growing on rock at Bukit Permatang. This species is now rare (Piggot, 1988).

Along the trail reaching the summit, ferns of Gleicheniaceae were found growing in several places. Two species of Dicranopteris and one species each from Diplodipterygium, Gleichenia and Sticherus were found in this area but not found elsewhere at the lower altitude. The summit of Gunung Kajang (1030 m.) is characterised with the present of Cheirolepidium bicuspis which only grows in lower montane
forest. Holttum (1968) noted that specimen from Pulau Tioman has a special form with four-lobed sterile fronds, while our collection showed the form with two-lobed sterile fronds which is the common form of this species. Ferns of family Grammitidaceae which grow on mossy branch of trees and rocks also characterised the summit of Gunung Kajang. Among them were *Prosaptia celebica* and *Prosaptia leysii* which were new records of Pulau Tioman ferns. Another notable fern species at the summit was *Histiopteris incisa* which colonised the landslide area on the north banks of the summit.

**Checklist of Ferns and Fern-Allies of the Gunung Kajang Area**

**FERN-ALLIES**

1. **LYCOPODIACEAE**

1.1 *Huperzia* Bernh.

One species found in Gunung Kajang area.

1.1.1 *Huperzia phlegmaria* (L.) Rothm.

*Lycopodium phlegmaria* L.

Epiphyte. Lower montane forest. Elevation: 1000-1030 m.

**Material:** SUMMIT TRAIL: Elevation 1000 m, Zulkifli & R. Jaman. RJ 2921 (UKMB); SUMMIT: Elevation 1030 m, Zulkifli & R. Jaman, RJ 2936 (UKMB).

1.2 *Lycopodiella* Holub

One species found in Gunung Kajang area, restricted mostly near the summit of the hill.

1.2.1 *Lycopodiella cernua* (L.) Pic. Serm.

*Lycopodium cernuum* Linn.

Terrestrial. Upper hill dipterocarp to lower montane forest. Elevation: 950-1000 m.

**Material:** SUMMIT TRAIL: Elevation ca. 950 m, Zulkifli & R. Jaman. RJ 2888 (UKMB); ca.1000 m elevation, RJ 2939 (UKMB).

2. **SELAGINELLACEAE**

2.1 *Selaginella* Beauv.

A total of 8 species recorded for Pulau Tioman and 6 from the Gunung Kajang area, mostly in shaded area.
Figure 1. Map of Pulau Tioman, showing collection trail (...) to the summit of Gunung Kajang and several previous collecting localities
2.1.1 *Selaginella alutacia* Spring

Lithophyte. Upper hill dipterocarp forest. Elevation: 780-940 m.

**Material:** GUA TAHI ANGIN TRAIL: Elevation ca. 780 m, Zulkifli & R. Jaman, RJ 2899 (UKMB); Elevation ca. 940 m, Zulkifli & R. Jaman, RJ 2966 (UKMB).

2.1.2 *Selaginella delicatula* (Desv.) Alston

Terrestrial. Upper hill dipterocarp forest.

**Material:** BUKIT PERMATANG: Elevation ca. 780 m, Zulkifli & R. Jaman, RJ 2918 (UKMB).

2.1.3 *Selaginella intermedia* (Bl.) Spring var. *intermedia*  
*Selaginella atroviridis* Spring

Terrestrial. Upper hill dipterocarp forest.

**Material:** SUMMIT TRAIL: Elevation ca. 920 m, Zulkifli & R. Jaman, RJ 2924 (UKMB).

2.1.4 *Selaginella selangorensis* Bedd. ex Ridl.

Terrestrial. Upper hill dipterocarp forest to lower montane forest. Elevation 950-1000 m.

**Material:** SUMMIT TRAIL: Elevation ca. 1000 m, Zulkifli & R. Jaman, RJ 2898 (UKMB); Elevation ca. 950 m, Zulkifli & R. Jaman, RJ 2935 (UKMB).

2.1.5 *Selaginella wallichii* (Hook. & Grev.) Spring

Terrestrial. Hill dipterocarp forest. Elevation 350-880 m.

**Material:** SUNGAI AIR PERTAMA TRAIL: Elevation ca. 380 m, Zulkifli & R. Jaman, RJ 2829 (UKMB); Elevation ca. 350 m, Zulkifli & R. Jaman, RJ 2832 (UKMB); BUKIT PERMATANG: Elevation ca. 880 m, Zulkifli & R. Jaman, RJ 2877 (UKMB).

2.1.6 *Selaginella willdenovii* (Desv.) Baker

Terrestrial, forming thicket. Hill dipterocarp forest.

**Material:** SUNGAI AIR PERTAMA TRAIL: Elevation ca. 380 m, Zulkifli & R. Jaman, RJ 2830 (UKMB).

**FERNS**

3. ADIANTACEAE

3.1 *Taenitis* Willd

This genus has never been recorded from Pulau Tioman before. Two species were found in Gunung Kajang area.
3.1.1 *Taenitis blechnoides* (Willd.) Sw.

Terrestrial. Upper hill dipterocarp forest to lower montane forest. Elevation: 940-1030 m.

**Material:** SUMMIT TRAIL: Elevation ca. 940 m, Zulkifli & R. Jaman, RJ 2969 (UKMB); SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2882 (UKMB).

3.1.2 *Taenitis dimorpha* Holttum

Terrestrial in semi-shade. Lower montane forest. Elevation: 1020-1030 m.

**Material:** SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2886 (UKMB); Elevation ca. 1020 m, Zulkifli & R. Jaman, RJ 2960 (UKMB).

4. **ASPLENIACEAE**

4.1 *Asplenium* L.

This genus contributed the largest number of species among the fern families of Gunung Kajang. A total of nine species were identified with two of them, *A. nidus* and *A. robustum* being new records for Pulau Tioman.

4.1.1 *Asplenium affine* Sw.

*Asplenium spathulinum* J. Sm.

On semi-shaded rock. Hill dipterocarp forest.

**Material:** AYER ORANG PUTEH: Elevation ca. 600 m, Zulkifli & R. Jaman, RJ 2861 (UKMB).

4.1.2 *Asplenium borneense* Hook.

On semi-shaded rock. Hill dipterocarp forest.

**Material:** AYER ORANG PUTEH: Elevation ca. 600 m, Zulkifli & R. Jaman, RJ 2856 (UKMB).

4.1.3 *Asplenium macrophyllum* Sw.

On exposed rock. Coastal vegetation.

**Material:** KAMPONG PAYA: Elevation ca. 1 m, Zulkifli & R. Jaman, RJ 2817 (UKMB).

4.1.4 *Asplenium nidus* L.

On exposed rock. Coastal vegetation.

**Material:** KAMPONG PAYA: Elevation ca. 1 m, Zulkifli & R. Jaman, RJ 2818 (UKMB).

4.1.5 *Asplenium normale* D. Don

On shaded rock. Hill dipterocarp forest.

**Material:** SUMMIT TRAIL: Elevation ca. 700 m, Zulkifli & R. Jaman, RJ 2920 (UKMB).
4.1.6 *Asplenium robustum* Bl.

On shaded rock. Upper hill dipterocarp forest.

**Material:** BUKIT PERMATANG: Elevation ca. 850 m. Zulkifli & R. Jaman, RJ 2864 (UKMB).

Note: Piggot (1988), noted that this species was commonly observed as epiphytes on higher branches of trees in Cameron Highlands but is now difficult to find.

4.1.7 *Asplenium scolopendrioides* J. Sm. ex Hook.

On semi-shaded rock. Hill dipterocarp forest. Elevation: 460-600 m.

**Material:** AYER SURING TRAIL: Elevation ca. 460 m. Zulkifli & R. Jaman, RJ 2834 (UKMB); AYER SURING: Elevation ca. 480 m. Zulkifli & R. Jaman, RJ 2839 (UKMB); AYER ORANG PUTEH: Elevation ca. 600 m. Zulkifli & R. Jaman, RJ 2857 (UKMB).

4.1.8 *Asplenium sublaserpitiifolium* Ching

On semi-shaded rock. Hill dipterocarp forest. Elevation: 520 m.

**Material:** AYER ORANG PUTEH TRAIL: Elevation ca. 520 m. Zulkifli & R. Jaman, RJ 2845 (UKMB).

Note: This species probably is the second collection in Malaysia after a single specimen collected by Burkill in June 1915 from Teluk Juara, Pulau Tioman, which was described in Holttum (1968). The occurrence of the species on Pulau Tioman is thus an interesting extension of range as the species described by Ching were collected from the neighbouring parts of Southern China.

4.1.9 *Asplenium unilaterale* Lam.

On semi-shaded rock. Hill dipterocarp forest.

**Material:** AYER SURING: Elevation ca. 480 m. Zulkifli & R. Jaman, RJ 2848 (UKMB); Zulkifli & R. Jaman, RJ 2852 (UKMB).

5. **BLECHNACEAE**

5.1 *Blechnum* L.

A genus of six species in Peninsular Malaysia. This genus was not previously recorded from Pulau Tioman. The shade loving-fern *Blechnum finlaysonianum* was found on forest floor in hill dipterocarp forest.

5.1.1 *Blechnum finlaysonianum* Hook. & Grev.

Terrestrial in shade. Hill dipterocarp forest.

**Material:** SUNGAI AYER PERTAMA TRAIL: Elevation ca. 350 m. Zulkifli & R. Jaman, RJ 2914 (UKMB).
5.2 *Stenochlaena* J. Sm.

A genus with only one species recorded from Malaysia and has not been recorded before from Pulau Tioman.

5.2.1 *Stenochlaena palustris* (Burm. f.) Bedd.

Climber in open situations. Coastal vegetation.

**Material:** KAMPONG PAYA: Elevation ca. 1 m, Zulkifli & R. Jaman, RJ 2821 (UKMB).

6. CHEIROPLEURIACEAE

6.1 *Cheiropleuria* C. Presl

The only species in the genus recorded in Malaysia. It is a species found near the summit of Gunung Kajang.

6.1.1 *Cheiropleuria bicuspis* (Bl.) C. Presl

Terrestrial in shade. Lower montane forest.

**Material:** SUMMIT TRAIL: Elevation ca. 1020 m, Zulkifli & R. Jaman, RJ 2961 (UKMB).

7. CYATHEACEAE

7.1 *Cyathea* Sm.

A total of 7 species recorded for Pulau Tioman, 3 were new records, found in Gunung Kajang area.

7.1.1 *Cyathea eriophora* Holttum

Terrestrial in semi-shade. Hill dipterocarp forest.

**Material:** AYER ORANG PUTEH: Elevation ca. 650 m, Zulkifli & R. Jaman, RJ 2879 (UKMB).

7.1.2 *Cyathea hymenodes* Mett.

*Cyathea latebrosa* (Wall.) Copel. var. *indusiata* Holttum

Terrestrial in light shade. Upper hill dipterocarp forest. Elevation: 850-950 m.

**Material:** BUKIT PERMATANG: Elevation ca. 850 m, Zulkifli & R. Jaman, RJ 2946 (UKMB); Elevation ca. 880 m, Zulkifli & R. Jaman, RJ 2872 (UKMB); SUMMIT TRAIL TO TELUK JUARA: Elevation ca. 950 m, Zulkifli & R. Jaman, RJ 2933 (UKMB).

7.1.3 *Cyathea obscura* (Scort.) Copel.

Terrestrial in open situations. Upper hill dipterocarp forest to lower montane forest. Elevation: 850-1020 m.

**Material:** BUKIT PERMATANG: Elevation ca. 850 m, Zulkifli & R. Jaman, RJ 2927 (UKMB); SUMMIT TRAIL: Elevation ca. 1020 m, Zulkifli & R. Jaman, RJ 2959 (UKMB).
8. DAVALLIACEAE

8.1 Araiostegia Copel.

Only one species recorded from Malaysia. On Pulau Tioman this species was found at Bukit Permatang.

8.1.1 Araiostegia hymenophylloides (Bl.) Copel.

On rock in semi-shade. Upper hill dipterocarp forest.

**Material:** BUKIT PERMATANG: Elevation ca. 800 m, Zulkifli & R. Jaman, RJ 2863 (UKMB).

8.2 Davallia Sm.

One species found from three species recorded from Pulau Tioman.

8.2.1 Davallia divaricata Bl.

On rock in light shade. Upper hill dipterocarp forest.

**Material:** BUKIT PERMATANG: Elevation ca. 850 m, Zulkifli & R. Jaman, RJ 2865 (UKMB).

8.3 Humata Cav.

Two species were found in Gunung Kajang area.

8.3.1 Humata angustata (Wall. ex Hook. & Grev.) J. Sm.

Terrestrial and climber, lithophyte and on old stump in semi-shade. Upper hill dipterocarp forest to lower montane forest. Elevation: 780-1020 m.

**Material:** SUMMIT TRAIL: Elevation ca. 1000 m, Zulkifli & R. Jaman, RJ 2887 (UKMB), Elevation 1000 m, RJ 2890 (UKMB), Elevation ca. 1020 m, Zulkifli & R. Jaman, RJ 2963 (UKMB); BUKIT PERMATANG TRAIL: Elevation ca. 780 m, Zulkifli & R. Jaman, RJ 2919 (UKMB).

8.3.2 Humata repens (L. f.) Diels

Epiphyte in light expose. Upper hill dipterocarp forest to lower montane forest. Elevation: 820-1030 m.

**Material:** BUKIT PERMATANG: Elevation ca. 820 m, Zulkifli & R. Jaman, RJ 2868 (UKMB); SUMMIT TRAIL: Elevation ca. 1000 m, Zulkifli & R. Jaman, RJ 2889 (UKMB); SUMMIT: Elevation ca.1030 m, Zulkifli & R. Jaman, RJ 2929 (UKMB).

9. DENNSTEADTIACEAE

9.1 Microlepis C. Presl

One species found in Gunung Kajang area.
9.1.1 *Microlepia speluncae* (L.) T. Moore var. *villosissima* C. Chr.
Terrestrial in light shade. Hill dipterocarp forest.

**Material**: SUNGAI AYER PERTAMA TRAIL: Elevation ca. 350 m, Zulkifli & R. Jaman, RJ 2833 (UKMB).

9.2 *Histiopteris* (Agardh) J. Sm.

One species found from two different habitats, i.e. terrestrial and rock.

9.2.1 *Histiopteris incisa* (Thunb.) J. Sm.

Terrestrial and lithophyte in open situations. Upper hill dipterocarp forest to lower montane forest. Elevation: 840-1030 m.

**Material**: SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2883 (UKMB); BUKIT PERMATANG: Elevation ca. 840 m, Zulkifli & R. Jaman, RJ 2956 (UKMB).

9.3 *Lindsaea* Dryander

Three species were found in Gunung Kajang area from five species recorded for Pulau Tioman. One sterile specimen cannot be identified.

9.3.1 *Lindsaea doryphora* Kramer

*Lindsaea scandens* Hooker var. *terrestris* Holttum

Terrestrial in light shade. Hill dipterocarp forest to upper hill dipterocarp forest. Elevation: 580-880 m.

**Material**: AYER ORANG PUTEH TRAIL: Elevation ca. 580 m, Zulkifli & R. Jaman, RJ 2847 (UKMB); BUKIT PERMATANG: Elevation ca. 820 m, Zulkifli & R. Jaman, RJ 2875 (UKMB), Elevation ca. 880 m, Zulkifli & R. Jaman, RJ 2878 (UKMB).

9.3.2 *Lindsaea parasitica* (Roxb. ex Griff.) Hieron.

*Lindsaea scandens* Hooker

Climber in shade. Upper hill dipterocarp forest. Elevation: 750-850 m.

**Material**: BUKIT PERMATANG TRAIL: Elevation ca. 750 m, Zulkifli & R. Jaman, RJ 2869 (UKMB); BUKIT PERMATANG: Elevation ca. 850 m, Zulkifli & R. Jaman, RJ 2876 (UKMB).

9.3.3 *Lindsaea repens* (Bory) Thwaites var. *pectinata* (Bl.) Mett. ex Kuhn

Epiphyte in semi-shade. Lower montane forest.

**Material**: SUMMIT TRAIL: Elevation ca. 1000 m, Zulkifli & R. Jaman, RJ 2942 (UKMB).

9.3.4 *Lindsaea* sp.

On rock and scrambling over small bushes in shade. Hill dipterocarp forest. Sterile.

**Material**: AYER ORANG PUTEH TRAIL: Elevation ca. 550 m, Zulkifli & R. Jaman, RJ 2851 (UKMB).
9.4 **Tapeinidium** (C. Presl) C. Chr.

Two species are identified and *T. luzonicum* var. *luzonicum* is a new record for Pulau Tioman.

9.4.1 **Tapeinidium luzonicum** (Hook.) Kramer var. *luzonicum*

Terrestrial in shade. Upper hill dipterocarp forest.


9.4.2 **Tapeinidium pinnatum** (Cav.) C. Chr.

Terrestrial in shade. Upper hill dipterocarp forest.


10. **DIPTERIDACEAE**

10.1 **Dipteris** Reinw.

One species found on summit of Gunung Kajang.

10.1.1 **Dipteris conjugata** Reinw.

Terrestrial in open situations. Lower montane forest.


11. **DRYOPTERIDACEAE**

11.1 **Didymochlaena** Desv.

Only one species occurs in Gunung Kajang area.

11.1.1 **Didymochlaena truncatula** (Sw.) Sw.

Terrestrial in shade. Hill dipterocarp forest.


11.2 **Pleocnemia** C. Presl

One species is identified from Gunung Kajang area and is a new record for Pulau Tioman.

11.2.1 **Pleocnemia conjugata** (Bl.) C. Presl

Terrestrial in semi-shade. Lowland dipterocarp forest to hill dipterocarp forest. Elevation: 210-560 m.
Material: SUNGAI AYER PERTAMA TRAIL: Elevation ca. 210 m, Zulkifli & R. Jaman, RJ 2827 (UKMB);
AYER SURING TRAIL: Elevation ca. 560 m, Zulkifli & R. Jaman, RJ 2906 (UKMB).

Note: Holttum (1968), noted that this species was collected twice in Peninsular Malaysia, once near Melaka and once at Baling, Kedah.

11.3 Polystichum Roth.

This genus has never been recorded previously from Pulau Tioman.

11.3.1 Polystichum prolificans Alderw.

Terrestrial and lithophyte in light shade. Upper hill dipterocarp forest. Elevation: 800-880 m.

Material: BUKIT PERMATANG: Elevation ca. 800 m, Zulkifli & R. Jaman, RJ 2862 (UKMB); SUMMIT TRAIL: Elevation ca. 880 m, Zulkifli & R. Jaman, RJ 2871 (UKMB).

11.4 Pteridrys C. Chr & Ching

One species found in Gunung Kajang area.

11.4.1 Pteridrys syrmatica (Willd.) C. Chr. & Ching

Terrestrial and lithophyte in light shade. Lowland dipterocarp forest. Elevation: 160-300 m.

Material: SUNGAI AYER PERTAMA TRAIL: Elevation ca. 160 m, Zulkifli & R. Jaman, RJ 2833 (UKMB); Elevation ca. 210 m, Zulkifli & R. Jaman, RJ 2826 (UKMB); SUNGAI AYER PERTAMA: Elevation ca. 300 m, Zulkifli & R. Jaman, RJ 2909 (UKMB).

11.5 Tectaria Cav.

One species found out of two species recorded on Pulau Tioman.

11.5.1 Tectaria grandidentata (Cesati) Holttum

Terrestrial in shade. Hill dipterocarp forest.

Material: AYER ORANG PUTEH TRAIL: Elevation ca. 550 m, Zulkifli & R. Jaman, RJ 2846 (UKMB).

12. GLEICHENIACEAE

12.1 Dicranopteris Bernh.

Two species were found in Gunung Kajang. Dicranopteris curranii is a new record for Pulau Tioman.
12.1.1 *Dicranopteris curranii* Copel.
Terrestrial and scrambling in exposed lower montane forest.
**Material**: SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2912 (UKMB).

12.1.2 *Dicranopteris linearis* (Burm. f.) Underw. var. *montana* Holtttum
Terrestrial and scrambling in light-shaded lower montane forest.
**Material**: SUMMIT TRAIL: Elevation ca. 1000 m, Zulkifli & R. Jaman, RJ 2934 (UKMB).

12.1.3 *Dicranopteris linearis* (Burm. f.) Underw. var. *subpectinata* (H. Christ) Holtttum
Terrestrial in expose. Upper hill dipterocarp forest to lower montane forest. Elevation: 950-1000 m.
**Material**: SUMMIT TRAIL: Elevation ca. 950 m, Zulkifli & R. Jaman, RJ 2931 (UKMB); Elevation ca.1000 m, Zulkifli & R. Jaman, RJ 2940 (UKMB).

12.2 *Diplopterygium* (Diels) Nakai

12.2.1 *Diplopterygium longissimum* (Bl.) Nakai
*Gleichenia longissima* Bl.
Scrambling in expose. Lower montane forest.
**Material**: SUMMIT TRAIL: Elevation ca.1000 m, Zulkifli & R. Jaman, RJ 2881 (UKMB).

12.3 *Gleichenia* Sm.
One species was identified from Gunung Kajang.

12.3.1 *Gleichenia microphylla* R. Br. var. *semivestita* (Labill.) v.A.v.R.
Terrestrial in open situationse. Lower montane forest.
**Material**: SUMMIT TRAIL: Elevation ca. 1000 m, Zulkifli & R. Jaman, RJ 2932 (UKMB).

12.4 *Sticherus* Presl

12.4.1 *Sticherus truncatus* (Willd.) Nakai var. *truncatus*
*Gleichenia truncata* (Willd.) Spring var. *truncata*; *Gleichenia laevigata* (Willd.) Hk.
Terrestrial in light-shaded lower montane forest.
**Material**: SUMMIT: Elevation ca.1030 m, Zulkifli & R. Jaman, RJ 2938 (UKMB).
13. GRAMMITIDACEAE

13.1 Ctenopteris Bl. ex Kunze

One species was identified from Gunung Kajang.

13.1.1 Ctenopteris blechnoides (Grev.) W.H. Wagner & Grether
   Ctenopteris moultonii (Copel.) C. Chr. & Tard.

Epiphyte and lithophyte in light shade. Upper hill dipterocarp forest to lower montane forest. Elevation: 820-1030 m.

Material: SUMMIT TRAIL: Elevation ca. 820 m, Zulkifli & R. Jaman, RJ 2867 (UKMB); Elevation ca. 1000 m, Zulkifli & R. Jaman, RJ 2896 (UKMB); SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2930 (UKMB); BUKIT PERMATANG: Elevation ca. 860 m, Trail to Gunung Kajang, Zulkifli & R. Jaman, RJ 2953 (UKMB).

13.2 Grammitis Sw.

A single species of Grammitis was found in Gunung Kajang area.

13.2.1 Grammitis adspersa Bl.

Epiphyte and lithophyte in shade. Hill dipterocarp forest to lower montane forest. Elevation: 580-1030 m.

Material: SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2893 (UKMB); AYER ORANG PUTEH: Elevation ca. 580 m, Zulkifli & R. Jaman, RJ 2943 (UKMB).

13.3 Prosaptia Presl

Two species are found in Gunung Kajang and Prosaptia leysii is a new record for Pulau Tioman.

13.3.1 Prosaptia celebica (Bl.) Tagawa & K. Iwatsuki
   Ctenopteris celebica (Bl.) Copel.

Epiphyte in semi-shade. Lower montane forest.

Material: SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2892 (UKMB).

Note: Holttum (1968), stated that this species has been found twice in mainland Peninsular Malaysia (once on Gunung Tahan (1830 m) and the other at an unrecorded place in Perak.)

13.3.2 Prosaptia leysii (Baker) Ching
   Ctenopteris leysii (Bak.) Holtt.

Epiphyte in semi-shade. Upper hill dipterocarp forest to lower montane forest. Elevation: 860-1000 m.
Note: Holttum (1968), noted that the southern limit of distribution of this species in Peninsular Malaysia is Gunung Ledang (Mount Ophir) at elevations varying from 150 m to 760 m.

13.4 **Scleroglossum** v.A.v.R.

Only one species occurs in Gunung Kajang area.

13.4.1 **Scleroglossum debile** (Kuhn) Alderw.

Epiphyte in shade. Upper hill dipterocarp forest.

**Material**: SUMMIT TRAIL: Elevation ca. 900 m, Zulkifli & R. Jaman, RJ 2894 (UKMB).

14. **HYMENOPHYLLACEAE**

14.1 **Cephalomanes** C. Presl

14.1.1 **Cephalomanes javanicum** (Bl.) Bosch

*Trichomanes javanicum* Blume

On semi-exposed rock. Lowland dipterocarp forest to lower montane forest. Elevation: 200-1030 m.

**Material**: SUNGAI AYER PERTAMA TRAIL: Elevation ca. 200 m, Zulkifli & R. Jaman, RJ 2825 (UKMB); AYER SURING: Elevation ca. 480 m, Zulkifli & R. Jaman, RJ 2840 (UKMB); AYER ORANG PUTEH: Elevation ca. 600 m, Zulkifli & R. Jaman, RJ 2858 (UKMB); SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2937 (UKMB).

14.2 **Meringium** C. Presl

14.2.1 **Meringium acanthoides** (Bosch) Copel.

*Hymenophyllum acanthoides* Bosch

On shaded rock. Hill dipterocarp forest.

**Material**: AYER ORANG PUTEH: Elevation ca. 600 m, Zulkifli & R. Jaman, RJ 2970 (UKMB).

14.3 **Microgonium** C. Presl

14.3.1 **Microgonium bimarginatum** Bosch

*Trichomanes bimarginatum* Bosch

On shaded rock. Hill dipterocarp forest. Elevation: 650 m.

**Material**: AYER ORANG PUTEH: Elevation ca. 650 m, Zulkifli & R. Jaman, RJ 2970 (UKMB).
14.4 *Selenodesmium* (Prantl) Copel.

14.4.1 *Selenodesmium obscurum* (Bl.) Copel.

*Trichomanes obscurum* Bl.

Terrestrial and lithophytic in shade. Hill dipterocarp forest to upper hill dipterocarp forest. Elevation: 600 - 780 m.

**Material:** GUA TAHI ANGIN TRAIL: Elevation ca. 780 m, Zulkifli & R. Jaman, RJ 2900 (UKMB); AYER ORANG PUTIH: Elevation ca. 600 m, Zulkifli & R. Jaman, RJ 2900A (UKMB).

14.5 *Vandenboschia* Copel.

14.5.1 *Vandenboschia birmanica* (Bedd.) Ching

*Trichomanes radicans* Sw. auct.

On shaded rock. Hill dipterocarp forest.

**Material:** AYER SURING: Elevation ca. 489 m, Zulkifli & R. Jaman, RJ 2836 (UKMB).

Note: Holttum (1968), recorded that only one small specimen has been collected at Cameron Highland and postulated that this highland is the southern limit of this species in South-east Asia.

15. LOMARIOPSISIDACEAE

15.1 *Bolbitis* Schott

Three species are found in Gunung Kajang and *B. appendiculata ssp. appendiculata* is a new record for Pulau Tioman.

15.1.1 *Bolbitis appendiculata* (Willd.) K. Iwatsuki ssp. *appendiculata*  
*Egenolfia appendiculata* (Willd.) J. Sm. ssp. *appendiculata*

On shaded rock. Lowland dipterocarp forest.

**Material:** SUNGAI AYER PERTAMA TRAIL: Elevation ca. 200 m, Zulkifli & R. Jaman, RJ 2835 (UKMB).

15.1.2 *Bolbitis heteroclita* (C. Presl) Ching

Terrestrial in shade. Hill dipterocarp forest.

**Material:** AYER SURING: Elevation ca. 480 m, Zulkifli & R. Jaman, RJ 2837 (UKMB).

15.1.3 *Bolbitis sinuata* (C. Presl) Hennipman

*Bolbitis malaccensis* (C. Chr.) Ching

On shaded rock. Lowland dipterocarp forest.

**Material:** KAMPONG PAYA: Elevation ca. 50 m, Zulkifli & R. Jaman, RJ 2910 (UKMB).
15.2 *Elaphoglossum* Schott

A genus of six species recorded from Peninsular Malaysia, but only one species occurs in Gunung Kajang area.

15.2.1 *Elaphoglossum melanostictum* (Bl.) T. Moore

On shaded rock. Hill dipterocarp forest to upper hill dipterocarp forest. Elevation: 580-880 m.

**Material:** BUKIT PERMATANG: Elevation ca. 880 m, Zulkifli & R. Jaman, RJ 2891 (UKMB); AYER ORANG PUTEH TRAIL: Elevation ca. 580 m, Zulkifli & R. Jaman, RJ 2904 (UKMB); SUMMIT TRAIL: Elevation ca. 840 m, Zulkifli & R. Jaman, RJ 2947 (UKMB).

Note: Holttum (1968) noted that this species was found in Penang, but nowhere else in Peninsular Malaysia.

15.3 *Teratophyllum* Mett. ex Kuhn

One species found in Gunung Kajang area.

15.3.1 *Teratophyllum aculeatum* (Bl.) Mett. var. *montanum* Holttum

Climber in light shade. Hill dipterocarp forest to upper hill dipterocarp forest. Elevation: 550-920 m.

**Material:** SUMMIT-TELUK JUARA TRAIL: Elevation ca. 920 m, Zulkifli & R. Jaman, RJ 2965 (UKMB); AYER ORANG PUTEH TRAIL: Elevation ca. 550 m, Zulkifli & R. Jaman, RJ 2851 (UKMB).

16. MARATTIACEAE

16.1 *Angiopteris* Hoffm.

Only one species occurs in Gunung Kajang.

16.1.1 *Angiopteris evecta* (G. Forst.) Hoffm.

Terrestrial. Hill dipterocarp forest.

**Material:** AYER ORANG PUTEH: Elevation ca. 610 m, Zulkifli & R. Jaman, RJ 2917 (UKMB).

17. NEPHROLEPIDACEAE

17.1 *Nephrolepis* Schott

Three species were identified from Gunung Kajang area and *N. hirsutula* is a new record for Pulau Tioman.
17.1.1 *Nephrolepis auriculata* (L.) Trimen  
*Nephrolepis biserrata* (Sw.) Schott

Terrestrial and climbing, and lithophyte in shade and expose. Coastal vegetation to upper hill dipterocarp forest. Elevation: 1-950 m.

**Material:** KAMPONG PAYA: Elevation ca. 1 m, Zulkifli & R. Jaman, RJ 2816 (UKMB); AYER SURING: Elevation ca. 210 m, Zulkifli & R. Jaman, RJ 2843 (UKMB); BUKIT PERMATANG: Elevation ca. 820 m, Zulkifli & R. Jaman, RJ 2922 (UKMB); SUMMIT-TELUK JUARA TRAIL: Elevation ca. 950 m, Zulkifli & R. Jaman, RJ 2968 (UKMB).

17.1.2 *Nephrolepis davalliioides* (Sw.) Kunze  
*Nephrolepis acuminata* (Houtt.) Kuhn

Terrestrial and epiphyte in light shade. Lower montane forest.

**Material:** SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2884 (UKMB).

17.1.3 *Nephrolepis hirsutula* (G. Forst.) C. Presl

Terrestrial in exposed. Lowland dipterocarp forest. Elevation: 70 m.

**Material:** AYER SURING TRAIL: Elevation ca. 70 m, Zulkifli & R. Jaman, RJ 2911 (UKMB).

18. **OLEANDRACEAE**

18.1 *Oleandra* Cav.

Only one species found from two species recorded from Peninsular Malaysia.

18.1.1 *Oleandra pistillaris* (Sw.) Cav.

Terrestrial in light shade. Lower montane forest.

**Material:** Gunung Kajang, near summit. Observed.

19. **OPHIOGLOSSACEAE**

19.1 *Helminthostachys* Kaulf.

Only one individual was observed during the survey.

19.1.1 *Helminthostachys zeylanica* (L.) Hook.

Terrestrial. Alluvial vegetation.

**Material:** KAMPONG PAYA: Elevation ca. 2 m. Observed.

20. **POLYPODIACEAE**

20.1 *Colysis* C. Presl

Two species are found from the Gunung Kajang area.
20.1.1 *Colysis macrophylla* (Bl.) C. Presl

On rock in semi-shade. Hill dipterocarp forest.

**Material:** AYER ORANG PUTEH: Elevation ca. 600 m, Zulkifli & R. Jaman, RJ 2859 (UKMB).

20.1.2 *Colysis pedunculata* (Hook. & Grev.) Ching

On rock in shade. Lowland dipterocarp forest to upper hill dipterocarp forest. Elevation: 180-850 m.

**Material:** SUNGAI AYER PERTAMA TRAIL: Elevation ca. 180 m, Zulkifli & R. Jaman, RJ 2824 (UKMB); AYER SURING: Elevation ca. 480 m, Zulkifli & R. Jaman, RJ 2841 (UKMB); Elevation ca. 480 m, Zulkifli & R. Jaman, RJ 2853 (UKMB); BUKIT PERMATANG: Elevation ca. 850 m, Zulkifli & R. Jaman, RJ 2895 (UKMB).

20.2 *Drynaria* J. Sm.

This genus was never recorded from Pulau Tioman before this survey. One species occurs in Gunung Kajang area.

20.2.1 *Drynaria sparsisora* (Desv.) T. Moore

Epiphyte in semi-shade. Hill dipterocarp forest.

**Material:** SUNGAI AYER PERTAMA: Elevation ca. 460 m, Zulkifli & R. Jaman, RJ 2908 (UKMB).

20.3 *Goniophlebium* (Bl.) C. Presl

Two specimens were collected from Gunung Kajang area. One sterile specimen needs further determination. Four other species occur in Peninsular Malaysia, viz. *G. percussum*, *G. persicifolium*, *G. prainii* and *G. subauriculatum*.

20.3.1 *Goniophlebium korthalsii* (Mett.) Bedd.

Epiphyte in light shade. Upper hill dipterocarp forest.

**Material** SUMMIT TRAIL FROM TELUK JUARA: Elevation ca. 950 m, Zulkifli & R. Jaman, RJ 2967 (UKMB).

Note: Holttum (1968), noted that this species was only once collected in Peninsular Malaysia by H. Kunstler (King’s Collector) in Larut, Perak.

20.3.2 *Goniophlebium* sp.

Terrestrial in semi-shade. Lowland dipterocarp forest. Sterile.

**Material** AYER SURING TRAIL: Elevation ca. 210 m, Zulkifli & R. Jaman, RJ 2843. (UKMB).
20.4 *Loxogramme* C. Presl

Only one species found in Gunung Kajang area from two species recorded for Pulau Tioman.

20.4.1 *Loxogramme avenia* (Bl.) C. Presl

On exposed rock. Hill dipterocarp forest.

**Material:** AYER ORANG PUTEH: Elevation ca. 600 m, Zulkifli & R. Jaman, RJ 2860 (UKMB).

20.5 *Microsorum* Link.

One species was identified from Gunung Kajang area and is a new record for Pulau Tioman.

20.5.1 *Microsorum heterocarpum* (Bl.) Ching

On shaded rock. Hill dipterocarp forest to upper hill dipterocarp forest. Elevation: 480-800 m.

**Material:** AYER SURING: Elevation ca. 480 m, Zulkifli & R. Jaman, RJ 2838 (UKMB); SUMMIT TRAIL: Elevation ca. 800 m, Zulkifli & R. Jaman, RJ 2926 (UKMB).

20.6 *Phymatosorus* Pic. Serm.


*Phymatodes nigrescens* (Bl.) J. Sm.

On shaded rock. Hill dipterocarp forest.

**Material:** AYER ORANG PUTEH: Elevation ca. 580 m, Zulkifli & R. Jaman, RJ 2950 (UKMB).

20.7 *Pyrrosia* Mirbel

Only one species found during the survey.

20.7.1 *Pyrrosia lanceolata* (Linn.) Farwell

*Pyrrosia adnascens* (Sw.) Ching

On exposed rock. Coastal vegetation.

**Material:** KAMPUNG PAYA: Elevation ca. 1 m, Zulkifli & R. Jaman, RJ 2819 (UKMB).

20.8 *Selliguea* Bory

Four species found in Gunung Kajang area.

20.8.1 *Selliguea enervis* (Cav.) Ching

*Cypsinus enervis* (Cav.) Copel.
Epiphyte in light shade. Upper hill dipterocarp forest.

**Material:** SUMMIT TRAIL: Elevation ca. 950 m, Zulkifli & R. Jaman, RJ 2887 (UKMB).

20.8.2 *Selligua heterocarpa* (Bl.) Bl.

On rock in light shade. Upper hill dipterocarp forest.

**Material:** SUMMIT TRAIL: Elevation ca. 750 m, Zulkifli & R. Jaman, RJ 2925 (UKMB).

20.8.3 *Selligua taeniata* (Sw.) Parris

*Crypsinus taeniatus* (Sw.) Copel.

On exposed rock. Upper hill dipterocarp forest.

**Material:** BUKIT PERMATANG: Elevation ca. 820 m, Zulkifli & R. Jaman, RJ 2866 (UKMB).

20.7.4 *Selligua triloba* (Houtt.) M.G. Price

*Crypsinus trilobus* (Houtt.) Copel.

Epiphyte in light-shade. Lower montane forest.

**Material:** SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2903, RJ 2905 (UKMB).

21. PTERIDACEAE

21.1 *Pteris* L.

Six species are recorded from Pulau Tioman. Two species are found in Gunung Kajang area, including *P. oppositipinna* which is a new record for Pulau Tioman.

21.1.1 *Pteris ensiformis* Burm. f.

Terrestrial in open situations. Coastal vegetation.

**Material:** KAMPONG PAYA: Elevation ca. 3 m, Zulkifli & R. Jaman, RJ 2822 (UKMB).

21.1.2 *Pteris oppositipinna* Fée

*Pteris asperula* J. Sm. ex Hieron.

Terrestrial in light-shade. Upper hill dipterocarp forest.

**Material:** BUKIT PERMATANG: Elevation ca. 840 m, Zulkifli & R. Jaman, RJ 2928 (UKMB).

Note: Holttum (1968), noted that this species was only recorded in Selangor, Pulau Pinang and Negeri Sembilan.

22. SCHIZAEACEAE

22.1 *Lygodium* Sw.

Three species are recorded from Pulau Tioman but only one species found during the survey in Gunung Kajang and surrounding area.
22.1.1 *Lygodium flexuosum* (L.) Sw.

Terrestrial and scrambling over bushes. Coastal vegetation.

**Material:** KAMPONG PAYA: Elevation ca. 1 m, Zulkifli & R. Jaman, RJ 2820 (UKMB).

### 22.2 *Schizaea* Smith

Only one species found, mostly near summit of Gunung Kajang.

22.2.1 *Schizaea digitata* (Linn.) Sw.

Terrestrial. Upper hill dipterocarp to lower montane forest. Elevation 950-1020 m.

**Material:** SUMMIT TRAIL: Elevation ca. 1000 m, Zulkifli & R. Jaman, RJ 2897 (UKMB); Elevation ca. 950 m, Zulkifli & R. Jaman, RJ 2941 (UKMB); Elevation ca. 1020 m, Zulkifli & R. Jaman, RJ 2962 (UKMB).

### 23. THELYPTERIDACEAE

23.1 *Pronephrium* C. Presl

Two species are found in Gunung Kajang area and *P. repandum* is a new record for Pulau Tioman.

23.1.1 *Pronephrium repandum* (Fée) Holttum


**Material:** SUNGAI AYER PERTAMA TRAIL: Elevation ca. 380 m, Zulkifli & R. Jaman, RJ 2828 (UKMB); AYER ORANG PUTEH: Elevation ca. 580 m, Zulkifli & R. Jaman, RJ 2850 (UKMB).

23.1.2 *Pronephrium rubicundum* (Alderw.) Holttum

Terrestrial in shade. Hill dipterocarp forest. Elevation: 510-750 m.

**Material:** AYER ORANG PUTEH TRAIL: Elevation ca. 510 m, Zulkifli & R. Jaman, RJ 2844 (UKMB); Elevation ca. 510 m, Zulkifli & R. Jaman, RJ 2849 (UKMB); BUKIT PERMATANG TRAIL: Elevation 750 m, Zulkifli & R. Jaman, RJ 2870 (UKMB).

### 23.2 *Sphaerostephanos* J. Smith

One species found and is a new record for Pulau Tioman.

23.2.1 *Sphaerostephanos heterocarpus* (Bl.) Holttum

*Cyclosorus heterocarpus* (Bl.) Ching

Terrestrial in light shade. Hill dipterocarp forest. Elevation: 360-550 m.

**Material:** AYER SURING TRAIL: Elevation ca. 360 m, Zulkifli & R. Jaman, RJ 2831 (UKMB); Elevation ca. 550 m, Zulkifli & R. Jaman, RJ 2907 (UKMB).
24. VITTARIACEAE

24.1 Antrophyum Kaulf.

Only one species found in Gunung Kajang area.

24.1.1 Antrophyum callifolium Bl.

On shaded rock. Hill dipterocarp forest.

Material: AYER ORANG PUTEH: Elevation ca. 600 m, Zulkifli & R. Jaman, RJ 2855 (UKMB).

24.2 Vaginularia Fée

24.2.1 Vaginularia trichoidea Fée

Monogramma trichoidea J. Sm.

Epiphyte in shade. Lower montane forest.

Material: SUMMIT: Elevation ca. 1030 m, Zulkifli & R. Jaman, RJ 2948 (UKMB).

24.3 Vittaria Sm.

Two species are found in the Gunung Kajang area.

24.3.1 Vittaria angustifolia Bl.

On shaded rock. Upper hill dipterocarp forest. Elevation: 840-850 m.

Material: BUKIT PERMATANG: Elevation ca. 850 m, Zulkifli & R. Jaman, RJ 2902 (UKMB); Elevation ca. 840 m, Zulkifli & R. Jaman, RJ 2951 (UKMB).

24.3.2 Vittaria scolopendrina (Bory) Thw.

On shaded rock. Upper hill dipterocarp forest.

Material: BUKIT PERMATANG: Elevation ca. 900 m, Zulkifli & R. Jaman, RJ 2902 (UKMB).

25. WOODSIACEAE

25.1 Diplazium Sw.

This genus was never recorded previously from Pulau Tioman. Two species are found in Gunung Kajang area.

25.1.1 Diplazium sorzogonense (C. Presl) C. Presl

Athyrium sorzogonense (C. Presl) Milde

Terrestrial in open situations. Upper hill dipterocarp forest.

Material: BUKIT PERMATANG TRAIL: Elevation ca. 780 m, Zulkifli & R. Jaman, RJ 2873 (UKMB).
25.1.2 Diplazium tomentosum Bl.

On shaded rock. Upper hill dipterocarp forest.

Material: GUATAHI ANGIN: Elevation ca. 950 m, Zulkifli & R. Jaman, RJ 2923 (UKMB).

Acknowledgements

We would like to thank the Curators of the Herbarium, Singapore Botanical Garden (SING). especially Mr. Mohd Shah Mohd Noor and Mr. Ali, the Herbarium, Forest Research Institute of Malaysia (KEP) for their cooperation during our visits. We also thank Mr. Sani Miran and Mr. Idris Hj. Sharif for their company during the fieldworks. This work was financially supported by the Department of Botany, Universiti Kebangsaan Malaysia, IRPA 04-07-03-007 and IRPA 08-02-0009.

References


Morphological Variation of *Pangium edule* Reinw. Fruits in Malaysia

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Abstract

Morphological variation of fruits and seeds occurring in *Pangium edule* is described. The fruits of typical form, “kepayang lenga” are oblong with blunt apices, those of “kepayang papan” are subglobular and the apices are sharp while those of “kepayang bubur” are ellipsoidal and the apices are blunt. Seeds differ in their sizes too.

Introduction

*Pangium edule* or commonly known as “kepayang”, is monotypic and belongs to the family Flacourtiaceae. The trees are either found wild or more commonly, cultivated on a small scale throughout Southeast Asia, Melanesia and Micronesia. They reach the height of 25 m and frequently as tall as c. 40 m. As the boles are straight and often reach the extreme diameter of 1 m, they offer good timber source to the locals. The seeds contain high quality oil which has been used for cooking for hundreds of years, moreover the roasted seeds have long been used for the preservation of meat and fishes. Many more uses are documented by Sleumer (1954) and Burkill (1966). In Indonesia and elsewhere the use of the fruits as food is very widespread. In Sarawak the oil is used for cooking and for preserving fish and meat.

Prior to this, the intraspecific variation especially that of the fruits and seeds has not been described. During the trips made by the author to Sarawak to collect samples of the species, observations were made on the occurrence of the variations in this species and herein described.

Materials and Methods

The morphological observations were made on the materials either collected personally by the author in the field or those deposited in various herbaria in the country. Those of the former were deposited in the Herbarium, Forestry faculty, Universiti Pertanian Malaysia (tentatively designated UPMF).

The fruits and seeds collected were observed on the following characters; shape, size, shape and length of the apex. They were then opened to observe the seeds; observation on the seeds were made for the characters of overall shape and size.
Observations

General morphology

Tree branching at about 5 m, buttress small to spreading, up to 1.5 m high. Inner bark cream-yellowish with orange tints. Sapwood yellowish to orangish, slash giving a colourless exudate with a distinct smell of malt. Leaves are ovate and heterophyllous, often on the same branch or tree of any age, up to 75 cm long. Flowers rather fragrant, flowering starts immediately after every new flush of leaves. Fruits 1-(-4) per infructescence of varying sizes (16-24 × 10-16 cm), oblong to ellipsoidal in shape with bluntly to distinctly sharp tips, rather heavy, each weighing up to 2.5 kg, fruiting 1-4 times per year, fruits smaller with massive fruiting, no indication of maturity of fruits from the trees until they fall and rot, fruit stalk up to 60 cm long. Seeds interlocked, embedded in a pungent mesocarp when ripe, almost triangular in shape, 13-40 in number.

Fruit and seeds morphology

Ridley (1922) described the fruits of *Pangium edule* as 17-30 cm long and 9-10 cm across and seeds were recorded as about 5 cm across and triangular in outline. Sleumer (1954) gave a more extensive description of the fruits as being oblong-ovoid, variable in size with blunt tips and containing about 20 irregularly shaped seeds (3-4-6 × 2-3(-4) cm) in size. In this context he had mentioned that the fruits are variable in size, and shape and the seeds are also variable in size. All these descriptions seem to refer to the typical form or "kepayang lenga" (as used in this paper).

Whitmore (1973) on the other hand, described the fruits of *Pangium edule* as pear-shaped with blunt tips and 15-25 by 7-15 cm in size with seeds about 4 cm long. This description seems to refer to "kepayang lenga" too.

While collecting specimens in Sarawak, the author recognised two distinct variants of the *Pangium edule* with respect to fruits and seeds morphology and they are described below:

Typical form of *Pangium edule*

Vernacular names: “kepayang”, “payang”, “buah keluak”, “kepayang lenga”, “kepayang keluwak” or "pangi".

Description: Fruits, oblong to oblong-oval, 18-23 × 10-14 cm, tips almost rounded, blunt, ca. 0.5 cm long; seeds 3.5-4.0(-6.0) cm, seeds per fruit 25-30 (Fig. 1 a-b).

Specimens studied: SARAWAK, Serian, Ilias Paie S.28040 (SAR); Miri, Jack Liam s.n. (SAR); Miri, Anderson S.16428 (SAR); Niah, Anon. KFN 98660 (SAR); Kuching, Faridah-Hanum FHI 398 (UPMF); Samarahan, Faridah-Hanum FHI 401.
The two variants observed are as follows:

**Pangium edule** "kepayang papan".

Description: Fruits subglobular to ellipsoidal. 16-24 x 11-16 cm. tips oblong-triangular, sharp. 1.5-2.0 cm long: seeds 3.5-5.5. cm, seeds per fruit (13-) 20-24 (-29). (Fig. 1 c-d)


**Pangium edule** "bubur".

Description: Fruits ellipsoid to oval. 18-20 x 12-14 cm. tips almost rounded, blunt, ca. 0.5 cm long: seeds 2.5-3.0(-4.0) cm, seeds per fruit 25-30(-40). (Fig. 1 e-f).


Distribution: Throughout Malesia, extending to Melanesia and Micronesia, apparently there is some variation in Borneo too: in Malaysia throughout (Fig. 2).

Burkill (1966) cited the following vernacular names for Peninsular Malaysia, viz. kepayang, payang and buah keluak. The typical Pangium edule or kepayang lenga, kepayang payang is distributed widely in Sabah, Sarawak and Peninsular Malaysia but its variants, Kepayang papan and kepayang bubur so far have only been in found Sarawak. Borneo.

**Discussion**

Except for the differences in the fruit and seed characters, other morphological characters remain very similar. Recent observations and collections made by the
author showed that description by Corner (1940), Sleumer (1954) and Whitmore (1973) all could be referred to “kepayang lenga”, the typical *P. edule*. The other two types observed are atypical of the “kepayang”.

While the fruits of *kepayang papan* are almost globular the seeds are similar to those of *kepayang lenga* in both their shape and size. However, the fruits of *kepayang bubur* are smaller and ellipsoidal and the seeds are relatively smaller too.

![Morphology of fruits and seeds of *Pangium edule*.](image)

Fig. 1. Morphology of fruits and seeds of *Pangium edule*. (a-b, *kepayang lenga*; c-d, *kepayang papan*; e-f, *kepayang bubur*)
Acknowledgements

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References


Ternstroemia magnifica Stapf ex Ridley (Theaceae) and Kibatalia macrophylla (Pierre) Woodson (Apocynaceae), Two Species New to Peninsular Malaysia.

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Abstract

Recent collections of Ternstroemia magnifica Stapf ex Ridley (Theaceae) and Kibatalia macrophylla (Pierre) Woodson (Apocynaceae) were made in Bangi Permanent Forest Reserve, Selangor, and Langkawi Islands, Kedah, respectively, representing new records for the flora of Peninsular Malaysia. Diagnostic descriptions and keys to species are presented with some morphological notes.

Introduction

The pantropical genus Ternstroemia Mutis ex L. f. is represented by shrubs and trees in Peninsular Malaysia. Keng (1978) listed a total of seven species as occurring in the peninsula, viz. T. bancana Miq., T. corneri H. Keng, T. evenia (King) A.C. Smith, T. maclellandiana Ridl., T. montana Ridl., T. penangiana Choisy and T. wallichiana (Griff.) Engler. In the course of our preparation of a checklist of the flowering plants of Bangi Permanent Forest Reserve, Selangor, one theaceaceous specimen belonging to Ternstroemia magnifica was collected. The discovery of this species in Peninsular Malaysia is both surprising and phytogeographically noteworthy. In a similar exercise of collecting plants in the Langkawi Archipelago, Kedah, for the preparation of the Checklist of Langkawi flowering plants, two specimens of an interesting apocynaceous tree species were collected. It was subsequently identified as Kibatalia macrophylla which proved to be a new record for both Peninsular Malaysia and the Malaysian flora. A diagnostic description and a key to the species is herein given.

Ternstroemia magnifica Stapf ex Ridl., Kew Bull. (1938) 175

Tree c. 20 m tall, no buttress. Bole straight, bark profusely lenticellate becoming large cracks; inner bark reddish, sapwood cream: branches terete, greyish, the ultimate ones c. 5 mm in diameter; branching terminalian-type. Leaves spirally arranged, crowded at the shoot, very coriaceous, 16.4-18.7 × 7.0-9.2 cm, oblanceolate to obovate, apex abruptly acuminate, base cuneate, margin entire, lateral nerves c. 12 on each side, very inconspicuous; petioles c. 2 cm long. Flowers not observed. Fruits ellipsoid, brown when dry, smooth, 7.6 × 6.4 cm, calyx-lobes thick, persistent, verrucose, strongly attached to the base, the stalk c. 2.4 cm long. Seeds oblong, rounded at both ends, c. 6 × 2.4 cm attached to the central axis by funiculus, the funiculus flat, filiform.
Specimen examined: Peninsular Malaysia, Selangor, Bangi Permanent Forest Reserve; 22.1.1994, A. Zainudin et al. AZ 4751 (UKMB).

Representative Specimens from Borneo examined: Sarawak, P. Chai S. 19717 (K, SAR), Ilias Paie S. 16973 (K, SAR); Sabah, Aban & Saikeh SAN 71858 (SAN, K), Chew & Corner RSNB 4038 (SAN, K), Jacobs 5702 (L, K, SAR). Mikil 33943 (SAN), Mujin SAN 33772 (K, SAN).

Distribution: Borneo and Malay Peninsula.

Ecology: In Borneo the species is found in the lowland dipterocarp forest of Sabah, Sarawak and Kalimatan. The new record in the Malay Peninsula was collected from a twice logged-over lowland dipterocarp forest of the Bangi Permanent Forest Reserve, Selangor. The occurrence of the species in Peninsular Malaysia is therefore very interesting as it extends its present geographical range of distribution westwards from Borneo island. The close affinity of the Bornean flora to that of the southeast coast of Peninsular Malaysia is quite well accepted and known. However, the new locality for the species at the Bangi Permanent Forest Reserve, Selangor is about 300 km inland from the east coast of Peninsular Malaysia. By extrapolation, it is quite probable that the species is also found in the south of the peninsula, notably in the Endau-Rompin area.

*T. magnifica* is related to *T. evenia* because of the character of inconspicuous leaf venation on the lower leaf surfaces but differs in fruit morphology and also to *T. philippinensis* Merr. but differs from it in the character of the fruits and leaves. In Peninsular Malaysia it is perhaps more closely related to *T. corneri*, from which it can be distinguished as follows:-

Leaves 20-28 cm long; petioles c. 1 cm long; fruits 4.5-5 × 2-2.5 cm, apex briefly forked; calyx smooth, margin free, deflexed; swamp forest...........*T. corneri*

Leaves 16-19 cm long; petioles c. 2 cm long; fruits 7.6 × 6.4 cm, apex not forked; calyx verrucose, margin firmly attached; dry lowland forest...........................................*T. magnifica*

**Morphological notes.** The type specimen (Haviland 1984, K!) was collected in the vicinity of Kuching, Sarawak, and the species is now known to be widely distributed in Borneo. Generally the fruits of the type specimen are not as large as that of the Bangi specimen and the persistent calyx are always more or less deflexed or at least the margin is free from adnation to the mature fruit. Dr. S. C. Chin (SING) confirmed the occurrence of leaf sclereids, a characteristic feature of the Theaceae. However, the character of the seeds bothered Dr. Hsuan Keng (SING) a little. The ovules (and later seeds) are generally attached at the central axis of the ovary in almost all the theaceous plants known to him but in the Bangi specimen the seeds are attached to the funiculus which arise from the top of the central column. This appears to be a discrepancy, axile versus basal placentation in the Theaceae. According to Dr. M. van Balgooy (L. pers. comm.) this is also true for the Kalimantan
specimens which he observed. It appears that this character is common for the species in its range of distribution. When describing the species, Ridley (1938) stated that it is unlike any other species in the genus in its very large staminate flowers and glaucous leaves. The above variations prompted us to suggest that the position of this species within the genus should be assessed. After all the position of Ternstroemia itself within the Theaceae has been assessed many times in its taxonomic history.

**Notes on other Ternstroemia species in Peninsular Malaysia.**

*T. bancana* Miq., Fl. Ind. Bat. suppl. (1861) 477. Quite widespread, more often near the sea.


*T. evenia* (King) A.C. Smith, Sargentia 7 (1947) 78. Endemic to Peninsular Malaysia, recorded from lowland to montane forests in Perak, Kelantan, Pahang and Selangor.


*T. montana* Ridley, J. Str. Br. Roy. As. Soc. 73 (1916) 141. Restricted to the montane forests of Gunung Jerai (Kedah), Gunung Korbu (Perak) and Cameron Highlands (Pahang).


*T. wallichiana* (Griff.) Engler, Pflanzenfam. Nachtr. 1 (1897) 246. Widespread in the lowland forests.


Tree c. 12 m high, probably deciduous. Trunk c. 15 cm in diameter. Leaves 12-14 by 2.3-4.1 cm, elliptic; apex acuminate; base cuneate to obtuse; margin entire. glossy, glabrous above, beneath sparsely pubescent, coriaceous. with 18 secondary veins on each side; tertiary veins inconspicuous; petioles 0.5 cm, glabrous. Infrutescence lax; mericarps 9-12 × 0.5 cm, narrowly ellipsoid; pedicels 1.5 cm long; peduncle 0.2 cm long.

Ecology: A component of beach forests.

Specimens studied: Malaysia, Kedah. Pulau Langkawi, Pulau Beras Basah, A. Latiff, A. Zainudin & Hamid Salleh ALM 3568, 21.11.90 (UKMB); Pulau Singa Besar, A. Zainudin et al. AZ 4394, 19.11.92 (UKMB).

Other specimens examined: Thailand, Winit 1246 (K); Vietnam, Tonkin, Balansa 2103 (K), Poillane 17/2 (K)
Distribution: China (Yunan), Peninsular Burma, Thailand, Indochina and Peninsular Malaysia (Langkawi island).

Rudjiman (1986) recognised 15 species of *Kibatalia* in the world and five of them occur in Malaysia, viz. *K. arborea* (Bl.) G. Don, *K. borneensis* (Stapf) Merr., *K. laurifolia* (Ridl.) Woodson, *K. maingayi* (Hook. f.) Woodson and *K. villosa* Rudjiman. *K. borneensis* is endemic to Sarawak. Earlier, Whitmore (1973) gave an account for Peninsular Malaysia and listed two species only, namely *K. maingayi* and *K. arborea*. Ridley (1923) considered the taxa under *Vallaris*. With the discovery of this new record for Peninsular Malaysia the number of species for the peninsula is now five and for Malaysia six. The occurrence of the species in the Langkawi archipelago represents the current southermost limit for the species as before this the southern limit known is Tennaserim in Burma. Similar pattern of distribution was shown by *K. laurifolia*, another Asiatic species.

**Key to the *Kibatalia* species in Malaysia (adapted from Rudjiman, 1986)**

1. Stamens exserted for 0.5-4 mm ........................................ 2
   Stamens included for 3-30 mm ........................................ 5

2. Leaves 12-34 cm long; costa hairy beneath; petioles 6-15 cm long, sparsely pubescent ........................................ *K. iuacrophylla*
   Leaves 4-19 cm long; costa glabrous; petioles 2-10 cm long, glabrous .......... 3

3. Leaves 4-14 × 0.8-5.5 cm; secondary veins 4-8 on each side; corolla tube 5-10 mm long ........................................ *K. maingayi*
   Leaves 8-19 × 2-7 cm; secondary veins 7-14 on each side; corolla tube 11-14 cm long ........................................ 4

4. Corolla mouth glabrous; inflorescence 1- to 6-flowered; axis with many bracts; petioles 2-6 mm long ........................................ *K. laurifolia*
   Corolla mouth hairy; inflorescence 8- to 25-flowered; axis without bracts; petioles 5-15 mm long ........................................ *K. villosa*

5. Leaves 16-26 × 8-13 cm; leaf apex acuminate; veins 11-18 on each side; corolla tube glabrous; pedicels 4-6 cm long; peduncles 2-6 mm long .......... *K. arborea*
   Leaves 6-20 × 1-6.5 cm; leaf apex caudate; veins 8-11 on each side; corolla tube hairy; pedicels 7-10 mm long; peduncles 12-23 mm long .......... *K. borneensis*

**Notes on other *Kitabalia* species in Malaysia.**


*K. borneensis* (Stapf) Merrill, *Phil. J. Sc.* 17 (1920) 309. A species endemic to Sarawak, in the swamp or heath forests.

recorded this species for Peninsular Malaysia. Known from one collection from Perak.


Common throughout Peninsular Malaysia and in Sarawak known only in Semenggoh Forest Reserve.


Fig. 1. *Ternstroemia magnifica*. A. fruiting branch; note the verrucose calyx which are tightly attached to the base. B. seeds with funiculus attached.
Acknowledgements

We are grateful to Prof. E. Soepadmo, Mr. K. M. Kochummen and Dr. L. G. Saw (all from KEP) for their initial assistance in identifying *Ternstroemia*, Dr. Hsuan Keng (SING) who confirmed the identity of the species, Dr. S. C. Chin (SING) who confirmed the presence of leaf sclereids and Dr. M. van Balgooy (L) for highlighting the character of the ovules, and Dr. A.J.M. Leeuwenberg (WAU) for alerting the correct name of the species, *Kibatalia macrophylla*. Lastly to the Directors or Curators of the following herbaria, K, L, SING, KEP for allowing us to study their materials. This study and publication is supported by IRPA Grant 04-07-03-007 for which the authors are grateful.

Reference


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A New Species of *Barringtonia* (Lecythidaceae) From Peninsular Malaysia

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Abstract

A new species, *Barringtonia, B. terengganuensis* P. Chantaranothai, is described and illustrated from Terengganu, Peninsular Malaysia.

Introduction

The genus *Barringtonia* occurs from eastern Africa to northern Australia and comprises some 56 species. In preparation for publication of the Lecythidaceae for the Flora of Thailand, I also examined material from other regions for comparison. It has revealed the existence of a previously undescribed species of *Barringtonia*.

*Barringtonia terengganuensis* P. Chantaranothai sp. nov.

Differt a *B. pendula* hypanthio minore, petiolis brevioribus, foliis basi cordatis vel rotundatis. *Typus:* Peninsular Malaysia, Terengganu, P.F. Cockburn FRI 8363 (holotypus K).

Small tree up to 6 m tall. Rachis and hypanthium pubescent. Leaves with petioles 4-5 mm long; lamina 26-28.5 × 7-7.5 cm, chartaceous, elliptic, apex acuminate, base slightly cordate or rounded, margin slightly serrate-crenulate; secondary veins 22-23 pairs, 1.4-2 cm apart. Inflorescence a terminal spike, c. 25 cm long, densely flowered, with c. 50 flowers; rachis base 2 mm in diam. tapering to 0.8 mm in diam. near apex; cataphylls 10-12 × 3-5 mm, triangular; bracteoles 0.4-1 × 0.2 mm, triangular, caducous. Flowers in bud pink; hypanthium without pedicel, funnel-shaped, quadrangular, with 4 grooved at the corner, pubescent; sepal 4, orbicular or suborbicular; petal 4, orbicular; ovary 2-locular, ovules 3-6 per locule. Fruits unknown. Fig. 1.

*Peninsular Malaysia.* Terengganu: Ulu Sungai Terengganu near Jaram Galong, primary forest, hillsides, alt. 600 m, 31 May 1968. *P.F. Cockburn* FRI 8363 (Holotype K).

*Barringtonia terengganuensis* is a distinct species which is closest to *B. pendula* (Griff.) Kurz. Both species have grooves at the corners of the hypanthium. It differs from *B. pendula* mainly in its smaller hypanthium, shorter petiole and slightly cordate or rounded leaf base. *P.F. Cockburn* FRI 8363 (K) was originally determined as *B. fusiformis* King. The leaves of *B. terengganuensis* and *B. fusiformis* are similar but the two species differ in the former having a grooved hypanthium and no pedicel.
Fig. 1. *Barringtonia terengganuensis*. A. habit; B. floral bud; C. floral bud in longitudinal section. All from Cockburn FRI 8363. Drawn by M. Tebbs

**Acknowledgements**

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Ontogenetic Basis of Polyad Symmetry in *Samanea saman* (Jacq.) Merr.

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Abstract

*Samanea saman* (Jacq.) Merr. bears more or less radially symmetric polyad. The polyad is formed by eight equal sized, decussate tetrads, thus consisting of 32 pollen grains in total. In the present work, the ontogeny of the polyad is studied and the results show that the symmetry of the polyad is effected by the fact that the premeiotic nuclear divisions in the sporogenous cell precede cell-wall formation.

Introduction

Compound pollen grains, i.e. tetrads and polyads, occur in almost all tribes of Mimosaceae (Leguminosae-Mimosoideae) with high frequency (Guinet 1981). The number of pollen grains per polyad ranges from eight to 64 in various members of the family (Maheshwari 1950). Dnyansagar (1951) has described and illustrated the morphology of the mature polyad of *Samanea saman* (as *Pithecolobium saman* Benth.) He also described the microsporogenesis, but did not study the premeiotic events. Kenrick and Knox (1982) for the first time suggested that the pollen mother cells which give rise to a polyad, descend froin single sporogenous cell in *Acacia*. On the basis of their studies on Australian species of *Acacia*, Knox and Kenrick (1983) concluded that the number of premeiotic mitoses determined the number of pollen grains per polyad. The mature polyad is generally highly symmetric, whatever the grain number may be (Guinet 1983). According to him, this symmetry is related to the ontogenetic sequence which, however, has not been worked out. In the present work, premeiotic events are investigated in *Samanea saman* with a view to determine the ontogenetic sequence that leads to the symmetry of polyad.

Materials and Methods

Young floral heads of *Samanea saman* were fixed in Carnoy’s solution (ethanol-glacial acetic acid in a ratio of 3:1) and stored. at 5°C. The slides were prepared by squashing the anthers in 1% propionic carmine. Photographs were taken from temporary mounts.

Results and Discussion

The study of polyad ontogeny in *Samanea saman* revealed that three rounds of premeiotic mitosis occur in the sporogenous cell, giving rise to eight nuclei. However, these nuclear divisions are not immediately followed by cytokinesis and well-wall formation, thus all these nuclei remain within the same cell. The eight
nuclei are arranged in a circle near the periphery of the cell at almost equal distances from one another (Fig. 1A); then radial walls are laid down and a group of eight pollen mother cells is formed (Fig. 1B). This group of radially arranged pollen mother cells undergoes meiosis and gives rise to the polyad, which consists of eight radially arranged decussate tetrads (Fig. 2A & 2B). Dnyansagar (1951) has described these tetrads as tetrahedral, but according to the terminology of Maheshwari (1950), these tetrads are decussate rather than tetrahedral since each tetrad has two pollen grains arranged in one plane and the other two are in the plane perpendicular to the first.

Knox and Kenrick, (1983) suggested that the sporogenous cell in *Acacia* divides once to form two pollen mother cells in the case of the polyad comprising eight pollen grains, and that there are two rounds of premeiotic mitosis in the case of the polyad comprising 12 or 16 pollen grains. All the polyad comprising 8, 12 or 16 pollen grains were symmetric, containing equal sized tetrads. However, Knox and Kenrick (1983) did not study how the polyad composed of 12 pollen grains was formed. Guinet (1983) discussed that the symmetry of the polyad implies the symmetric arrangement of pollen mother cells which form the polyad. However, it has not been explained how the pollen mother cells achieve this symmetry. Their symmetry seems logical in cases where the pollen mother cells are in even number, such as 2, 4 or 8; but in those where the pollen mother cells are in odd numbers (such as 3 or 7, i.e. in the instances of polyad composed of 12 or 28 pollen grains), it is obvious that one of the daughter cells of the original sporogenous cell remains undivided, and is therefore larger than other cells. This may result in unequal sizes of the pollen grains thus disturbing the symmetry of the polyad (cf. Knox and Kenrik 1983, Fig. 1c). The ontogenetic sequence described here for *Samanea saman* ensures the formation of equal sized pollen mother cells, as the nuclear divisions without cell-wall formation allow the nuclei to be arranged at equal distances from one another, followed by the formation of cell-wall. This mechanism would also allow the formation of equal sized pollen mother cells in those instances where the pollen mother cells are in odd numbers. Further studies in other polyad bearing members of Mimosaceae would reveal if such a mechanism exists in them also.
Fig. 1. Premeiotic developmental stages of the polyad of *Samanea saman* (Jacq.) Merr.:
A. Sprogenous cell with eight nuclei arranged near periphery.
B. Group of eight young pollen mother cells formed by laying down of radial walls in the 8-nucleate sprogenous cell.

Fig. 2. A. Mature of polyad of *Samanea saman* (Jacq.) Merr. (unacetolyed).
B. One of the component tetrads drawn separately to show the decussate arrangement of the pollen grains.
Acknowledgements

I am grateful to Prof. Dr. S.I. Ali for developing my interest in the reproductive biology of Mimosaceae.

References


Revision of the Genus *Zingiber* in Peninsular Malaysia

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Abstract

*Zingiber* (Boehm.) comprises nineteen species in Peninsular Malaysia. Seventeen of these are included in the section *Zingiber* while two belong to the section *Cryptanthium* Horan. A new species, *Z. fraseri*, from Fraser’s Hill in Pahang, and a new variety, *Zingiber officinale var. rubrum*, are described. The latter is widely used in Malay traditional medicine. A new combination *Z. montanum* (Koenig) Theil. *comb. nov.* is proposed based on the rediscovery of some of Koenig’s collections from Phuket. *Z. griffithii var. citrinum* Holtt., and the four varieties of *Z. gracile* Jack recognized by Holttum have been ranked as species. Key to the species and varieties are provided, as well as species descriptions, distribution and specimen citations. The taxa have as far as possible been typified.

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Introduction

The genus *Zingiber* is distributed throughout tropical Asia with the center of diversity in Southeast Asia. It is a large and complicated genus comprising of about 100 species (Burtt 1972, Larsen 1980). Within the last few years several undescribed taxa have been found during field work in China, Thailand and Malaysia, indicating an even greater species diversity.

*Zingiber* is a constituent of the undergrowth in the tropical forests. The plants are perennial and grow mainly in damp places, but they are also frequent in secondary forest and disturbed sites. In Peninsular Malaysia they are most common in lowland and mid-mountain forest, but a few species grow on high mountain ridges (Holttum 1950).

The genus is characterized by the long, curved anther appendage enfolding the style, the three-lobed lip, and the relatively large bracts, each subtending a non-tubular bracteole and a single flower. At the time of flowering the bracts are usually orange or red, and often change to a darker colour as they grow older. The lip is cream or white in some species, and purple mottled with cream in others.
The existing classification of *Zingiber* is based on the eminent works of Schumann (1904) and Valeton (1918), which are still very useful in revising the genus. Ridley described many new Malayan species in his Flora of the Malay Peninsula (1924). Similarly the later revision of the genus by Holttum (1950) deals with the species in the Malay Peninsula. The key presented here largely follows that of Holttum. Two species, *Z. sulphureum* Burkill ex Theilade, *Z. fraserii* sp. nov., and one variety *Z. officinale* var. *rubrum* var. nov. have been added. *Z. griffithii* var. *citrinum* and the four varieties of *Z. gracile* recognized by Holttum (1950) have been ranked as separate species. Apart from that only minor additions have been made. The author is working on a similar revision for *Zingiber* in Thailand and in Sabah, Malaysia.

Materials and Methods

The present revision is based primarily on the study of collections of *Zingiber* from the following herbaria: AAU, C, E, K, KEP, L, P, PSU, SING, and UKM. *Z. gracile*, *Z. elatior*, *Z. auranticum*, *Z. griffithii*, *Z. puberulum*, *Z. montanum* and *Z. officinale* var. officinale and var. *rubrum* were studied in the field as well. All measurements refer to dried material, except those of floral parts. Flowers were boiled in spirit prior to measuring. Most of the type collections have been examined.

Notes on the Key

A major difficulty in working with the genus *Zingiber* is that many of the collections are incomplete. Most of them include an inflorescence, but often no flowers. Even when present at the time of collection, the delicate flowers often deteriorate during the drying procedure. Therefore, vegetative characters and the structure of the inflorescence have been used in the key whenever possible. Hairiness is a variable character and has been added only when it is very conspicuous. Colours of the labellum have been included as supplementary characters. An attempt has been made to offer a simple and workable key for the genus as it is found in Peninsular Malaysia, but it does not necessarily reflect the true relationship within the genus. It should allow identification of species whenever an inflorescence is available regardless of the presence of flowers. In many cases vegetative characters are sufficient for a proper identification though some species of *Zingiber* are difficult to distinguish based on these characters alone.

It should be kept in mind that the large, juicy inflorescences shrink considerably when dried. A key with measurements based on live specimens for identification in the field is desirable, but this will need more field study.

Taxonomic Characters

Measurements of leaves and ligula are taken from the middle of the stem. Dimensions of inflorescences are given at anthesis. The spikes alter shape according
to age, older and fruiting inflorescences are much wider and the bracts are loosely imbricate. Finally the bracts spread irregularly as the fruits dehisce within them giving the spike a shaggy appearance. The measurements of the bracts are given for the lower to middle ones. The lowest bracts are much bigger than the others. The colour of the bracts changes as they grow older, that at anthesis is indicated in the descriptions. The length of the calyx, corolla and labellum includes the ovary. The width of the corolla lobes is measured at the base. For the labellum, the length of the midlobe is from the junction with the sidelobes to the apex, and the length of the sidelobes is from the junction with the midlobe to the apex (Fig. 1). The characters of the ovary, stylodes and stigma are not distinctive and have been omitted in the descriptions.

**Floral Biology and Seed Dispersal**

For each species flowering time is given following the description. whenever data are available. Most species flower mainly between July and September and fruiting occurs from November to January.

![Diagram](image)  
**Fig. 1.** Labellum outline showing the measurements of the length and width of the midlobe ($q, x$) and sidelobes ($y, z$).
The flowers are tubular in their lower part and contain nectar. The yellowish colour of many species of Zingiber is common of flowers with entomogamy (Jones 1983) and is thought to be important in attracting pollinators. The broad labellum provides an excellent landing place for insects. The contrasting deep red-purple markings on the labellum of some species presumably act as nectar guidelines helping insects to find the entrance to the nectar and pollen store.

The flower is constructed so that the long anther at the back of the flower is bent forward in the flower mouth with the long, curved, hornlike anther appendage extending in front of it. The downbent stigma just emerges at the top of the appendage and occupies the entrance of the mouth a little above the lip. The pollen sacs and the stigma are oriented towards the labellum. Bees visiting the flower must force their way in between the anther and lip. Thus the visitor will be covered by pollen, which at anthesis hangs in loose clusters under the anther. When a visitor leaves the flower some of the pollen may be rubbed off against the stigma (Valeton 1918). Whether this results in self-pollination, or whether some kind of self-incompatibility system has developed, is not known.

Few observations have been made on the pollination of Zingiber, and no details on the pollination or breeding system of Zingiber have been published. Flowers of Z. aromaticum open before noon and are regularly visited by swarms of Apis indica and stray individuals of Anthophora zonata (Valeton 1918). Z. zerumbet is regularly visited by small, solitary bees collecting pollen (personal observation).

The fruits are dehiscent loculicidally within the persistent bracts. At the time of fruiting the bracts bend obliquely outwards presenting the black seeds surrounded by the fleshy, white arils. The conspicuous red bracts together with the fruit valves, which are bright red inside, and the fleshy, white or yellow aril are suggested to be an adaptation to bird dispersal. However, so far no observations have been made to confirm this. Further field studies are necessary to elucidate the pollination and seed dispersal in the genus.

Relationships Within the Malayan Species of Zingiber

Of the nineteen species of Zingiber described from Peninsular Malaysia sixteen are thought to be indigenous while the widely cultivated Z. officinale, Z. zerumbet and Z. montanum are regarded as introduced.

Seventeen of the nineteen Peninsular Malaysian species have the inflorescence on a radical, erect peduncle and are included in the section Zingiber. Only two species, Z. wrayi and Z. fraseri, have a radical procumbent or very short peduncle and belong to the section Cryptanthium.

Within the section Zingiber the species may be divided into two groups. One group have bracts which are incurved or curved outwards and the labellum mottled purplish or red-brown and cream. The other group is characterized by closely overlapping bracts with no curvature, and the labellum cream or white without
mottling. Within the first group Z. kunstleri and Z. wrayi have apices of the bracts pointed and curved outwards. The remaining species in the group have rounded bracts with incurved margins. Of these, the smaller species Z. officinale, Z. curtisii and Z. chrysostachys are similar in having light green to yellow bracts, while the larger species Z. spectabile, Z. ottensii and Z. multibracteatum have yellow-orange, red or dull purple bracts. Thus, it seems that the character of the bracts together with the colour of the labellum make up the most important features for classifying the genus as it occurs in Malaysia. The size of the species and the hairiness are more variable characters.

The relationship within the group with closely overlapping bracts and cream labellum is more difficult to outline. The complex of species comprizing Z. griffithii, Z. puberulum and Z. gracile has long caused much confusion. Holttum (1950) reported that there seemed to be no clear line of distinction between Z. griffithii and Z. gracile and possibly hybridization could take place. However, the description of Z. sulphureum cleared up some of the confusion (Cowley & Theilade 1995). Z. sulphureum is a small species with ovate leaves like Z. griffithii but an inflorescence like Z. gracile, and for long it blurred the distinction between the two species. Thus, it seems that it was an undescribed species rather than a hybridization, which caused identification problems.

Holttum (1950) recognized four varieties of Z. gracile: var. gracile, elatior, aurantiacum, and petiolatum although they vary greatly in size and morphology, and he found it likely that all four varieties would later rank as distinct species. In fact, Z. elatior was described as a species by Ridley (1899). Z. gracile is a small plant with a long, thin ligule, while Z. elatior, Z. aurantiacum and Z. petiolatum are much larger plants. Z. elatior and Z. aurantiacum with short ligules. Z. elatior is distinguished by its linear leaves, short petiole and pubescent bracts, and as such it has affinity to Z. montanum. Z. aurantiacum is distinguished by its wider, lanceolate leaves but otherwise it is much like Z. elatior. Z. petiolatum is a much larger species distinguished by the tall, leafy stems, the long petiole, large leaves, the extremely long scape and spike and the tough pink bracts. Z. petiolatum is most similar to Z. puberulum in the large leaves and tough pink bracts. In this treatment all varieties have been ranked as separate species.

Origin and Evolution

The Zingiberaceae is a pantropical family. The largest concentration of genera and species is in Southeast Asia, and judging by the existing distribution of the family the place of origin was within the Indo-Malayan region (Holttum 1950). Through geological time, the landmass of the Malayan Peninsula was unaffected by glaciation, drastic climatic changes or sea flooding, permitting a continuous evolutionary history of about 140 million years (Flenley 1979, Whitmore 1984). Presumably Zingiber; like many genera of the family, evolved in the stable climate in the landmass of the Malayan Peninsula and later spread to its present distribution.
Seventeen of the nineteen species of *Zingiber* found in Peninsular Malaysia belong to section Zingiber. In the neighbouring territories of Thailand and Borneo the genus has proliferated not only within section Zingiber but also within section Cryptanthium. If the ancient rain forest of Peninsular Malaysia is assumed to be the center of origin of the genus, section Zingiber may be regarded as primitive while section Cryptanthium is derived or advanced. Thailand and Borneo would then be secondary centers of diversity.

Most of the species of the Malay Peninsula are large plants with fairly large, lanceolate or oblong leaves and a relatively tall, erect inflorescence with tough bracts. It is suggested that these are primitive characters, which are retained in species like *Z. spectabile*, *Z. multibracteatum*, *Z. puberulum* and *Z. ottensii*. However, for a better understanding of the evolution within the genus a proper cladistic analysis, preferably including chloroplast DNA analysis, would be desirable.

**Key to the genus Zingiber in Peninsular Malaysia**

1a. Inflorescence radical, procumbent, ................................................ sect. Cryptanthium 2
1b. Inflorescence radical, erect, .......................................................... sect. Zingiber 3
2a. Leafy shoots 3-4 m long, scrambling, leaves lanceolate, inflorescence ovate tapering to a pointed apex, bract closely overlapping ...................................................................... 1. *Z. fraseri*
2b. Leafy shoots to 2 m long, leaves elliptic, inflorescence cylindric, bracts deflexed ...................... 2. *Z. wrayii*
3a. Bracts with their apical margins incurved; or with their apices curved outwards and free, not closely imbricating, labellum mottled purplish or red brown and cream ..................................... 4
3b. Inflorescence ovoid to fusiform or cylindric, the bracts closely overlapping their apices not curved, labellum cream or white without mottling .................................................. 10
4a. Apices of bracts narrowed to a blunt point and curved outwards ........................................... 3. *Z. kunstleri*
4b. Apices of bracts rounded and slightly incurved or with incurved margins ......................... 5
5a. Leafy shoots 60-100 cm tall, largest leaves to 20 cm long ....................................................... 6
5b. Leafy shoots 150-300(-350) cm tall, leaves commonly 30 cm long or more ...................... 8
6a. Leaves linear, 15-23 by 1.5-2.5 cm ........................................................................... 4. *Z. officinale*
6b. Leaves lanceolate or ovate, 12-17 by 4-5.5 cm ................................................................... 11
7a. Labellum closely blotched with purple throughout, including the sidelong bracts, bracts about 3-3.5 by 1.5 cm ........................................................................... 5. *Z. curtisii*
7b. Labellum with almost entirely crimson midlobe and white sidelong bracts, bracts about 2.7 by 2.4 cm ........................................................................... 6. *Z. chrysostachys*
8a. Inflorescence 12-30 cm tall, cylindric, bracts with their apices free forming open pouches ................................................................. 7. *Z. spectabile*
8b. Inflorescence usually less than 12 cm long, ovoid to ellipsoid, bracts not forming open pouches .......... 9
9a. Leaf sheaths and ligule sparsely hairy, labellum pale yellow with faint red-brown markings, village plant ................................................................. 8. *Z. ottensii*
9b. Leaf sheaths and ligule velutinus, labellum dark purple spotted with cream, mountain plant ........................................................................... 9. *Z. multibracteatum*
10a. Leaves linear, about 20-30 by 2-3 cm ......................................................................... 11
10b. Leaves lanceolate, 4 cm or more wide, proportionately wider than above ..................... 12
11a. Inflorescence fusiforme or cylindric-ovate, 3-3.5 cm wide, bracts brownish with a green margin, village plant ................................................................. 10. *Z. montanum*
11b. Inflorescence slender fusiform, 2-2.5 cm wide, bracts orange turning red, forest plant. 11. *Z. elatior*

12a. Bracts green when young turning red, slightly convex, ligules 1.5-2.5 cm long, papery, inflorescence 4-5 cm wide ................................................................. 12. *Z. zerumbet*

12b. Bracts pink, yellow or orange sometimes turning red, ligule short or ligule 1.5-1.8 cm and spike less than 2 cm wide ................................................................. 13

13a. Leaves lanceolate-ovate 15-30 by 5-10 cm or 12-14 by 4-4.5 cm ................................................................. 14

13b. Leaves lanceolate, proportionately narrower ................................................................. 16

14a. Leaves 15-20(-25) by 5-8 cm with fine silky hairs below, bracts pink to red .......... 3. *Z. griffithii*

14b. Leaves 24-30 by 8-10 or 12-14 by 4-4.5 cm, bracts yellow sometimes turning red .......... 15

15a. Leaves 24-30 by 8-10 cm, inflorescence cylindrical, 12-15 by 4-5 cm, bracts lemon yellow. 14. *Z. citrusum*

15b. Leaves 12-14 by 4-4.5 cm, inflorescence fusiform, slender, 8-10 by 1.5 cm, bract sulphur yellow .......... 15. *Z. sulphureum*

16a. Leafy shoots 1-2 m tall, leaves to 27 by 4.0 ................................................................. 17

16b. Leafy shoots 2-3 m tall, leaves to 40 by 8 cm ................................................................. 18

17a. Leafy shoots to 1 m tall, leaves to about 18 by 4 cm, ligule 1.5-1.8 cm long .......... 16. *Z. gracile*

17b. Leafy shoots 1.5-2.0 m tall, leaves 20-27 by 3.5 cm, ligule 0.5 cm long .......... 17. *Z. aurantiaum*

18a. Leaf sheaths glabrous, inflorescence fusiform, slender, 30-45 cm long, apices of bracts acute ................................................................. 18. *Z. petiolatum*

18b. Leaf sheaths hairy to velutinous, inflorescence ovoid, to 15 cm long, apices of bracts obtuse ................................................................. 19. *Z. puberulum*


**Rhizome** horizontal, at or near surface of ground, tuberous, aromatic. **Leafy shoots** 0.5 - 3.5 m tall, plane of leaves parallel with the rhizome. **Leaves** distichous, linear or oblong-lanceolate, sessile or with short petioles, ligules short to long, entire or deeply bilobed. **Inflorescence** a spike, usually radical, rarely terminal on the leafy stem; scape erect, procumbent or very short at base of leafy stem; spike compact, fusiform or ovoid to cylindrical. **Bracts** persistent, closely imbricating or with apices free, single flowered, at first green, yellow or reddish turning bright yellow or red. **Bracteoles** one to each flower facing the bract, narrower than the bract, usually persisting and enclosing the fruit. **Calyx** hyaline, tubular-spathaceous, usually shorter than the bracteole, tripartite. **Corolla** tube slender; dorsal lobe broader than lateral lobes, concave; lateral lobes below the lip, usually joined partly together by adjacent sides and to the lip. **Labelulum** 3-lobed, cream to white with or without purple mottling; midlobe oblong-ovate, apex retuse or cleft; lateral staminodes oval or
acute, adnate to the midlobe. Filament short; anther 1-1.5 cm long, narrow; connective prolonged into a slender, curved beak embracing the style. Stigma protruding just below the apex of the appendage, with a circular apical aperture surrounded by stiff hairs. Ovary trilocular with two, slender epigynous glands. Fruit a capsule, oblong with a fleshy wall when fresh, more or less leathery when dry, trilocular with axil placentation, dehiscent loculicidally within the persistant bracts. Seeds numerous, ellipsoid, black or maroon, covered by a saccate, fleshy, white or yellow, lacerate aril.


Distribution: Throughout tropical Asia and to tropical Australia and Japan.

Ecology: Tropical evergreen and monsoon forests, in moist, humus rich soils in shady habitats. Secondary forests, open habitats at the edges of the forests, disturbed places, and bamboo thickets on rocky ground, up to 3000 m.

Uses: The only species extensively used as a flavouring in food is the true ginger Z. officinale. Several species of the genus are known to be used in local medicine throughout Asia. Some species are grown as ornamentals.

1. Zingiber fraseri Theilade sp. nov. (Figs. 2 & 3)

Type: Peninsular Malaysia, Bukit Fraser, trail 4. behind the golf course. Sep. 1993, Theilade 12 (AAU holotype!, K isotype!).

Species Z. griffithii affinis a qua differt surculis longis scadentibus, foliis angustioribus lanceolatis glabris, scapo brevi procumbente, inflorescentia ovoidea in apicem acuto angustata, bracteis et bracteolis longioribus

Leafy shoots slender, to 4 m long with a scrambling habit. leaf sheaths finely hairy. Ligula 2 mm, hairy. Petiole 2 mm, hairy. Leaves lanceolate, 14-20 by 3.5-5.0 cm, glabrous. Inflorescence radical, procumbent. Spike ovate to fusiform, 12 by 3.0 cm, tapering to a pointed apex. Bracts lanceolate, 4.0-5.0 by 1.5 cm, bright red, hairy, apex acuminate. Bracteole 3.5 by 0.7 cm, whitish. Calyx 3.0 cm long. Flowers unknown.

Z. fraseri is related to Z. griffithii but differs in the long, scrambling leafy stems, the narrower, lanceolate, glabrous leaves, the short, procumbent scape, the ovoid inflorescence tapering to a pointed apex and the longer bracts and bracteoles. Vegetatively Z. fraseri is easily recognized by the long, scrambling leafy stems, which is unlike any Zingiber described so far.

Collections other than type: Bukit Fraser, trail 5 behind Rompin’s House, Nov. 1995, Theilade 68 (AAU). In cultivation at Waimea Botanical Gardens, Hawaii.

Ecology: Montane forest at 1300 m altitude. Flowering in August-September, fruiting in October. Probably endemic to Fraser’s Hill.
Fig. 2. *Zingiber fraseri* Theilade sp. nov. a: leaf b: inflorescence.

Fig. 3. *Zingiber fraseri* Theilade sp. nov. Leafy shoot and inflorescence.

*Leafy shoots* to 1.80 m, lower sheaths flushed with purple. *Ligula* bilobed, lobes broadly rounded, to 5 mm long, thin, glabrous to sparsely pilose. *Petiole* 2 mm. *Leaves* lanceolate to evenly elliptic, 30–40 by 7–10 cm, glabrous, apex acute. *Scape* radical, procumbent, 10-30 cm; sheaths 5–8 cm long, slightly hairy at tips. Spike cylindric–ellipsoid, later almost globose, 6–13 by 5–10 cm. *Bracts* oblong to evenly elliptic, 4–5 by 2–3 cm, red, slightly hairy, apex shortly pointed, with slightly inflexed edges. *Bracteole* lanceolate, 3–4 by 1 cm, tinged with pink, sparsely pilose, apex acute *Calyx* 2.8 cm long, sparsely pilose. *Corolla* 6.5 cm long; dorsal lobe 2.0 by 1.2 cm; lateral lobes more narrow, lobes pale yellow. *Labellum* 6.0 cm long, pale yellow mottled with purple; midlobe ovate, 1.2 cm long, apex slightly retuse margin crenate; sidelobes oblong, 0.8 cm long. *Anther appendage* dark purple.

*Type:* Peninsular Malaysia, Upper Perak, Wray 3735 (SING holotype!, K isotype!).


*Distribution:* Peninsular Malaysia and Peninsular Thailand.

*Malaysia:* Johor, Pahang, Perak, Terengganu.

*Ecology:* At streams, to 800 m. Flowering in July to September.

*Note:* Easily recognized by the deflexed bracts and the broad leaves. The inflorescence of *Z. wrayii* has affinity to *Z. kunstleri* but *Z. wrayi* is a smaller plant and the leaves are broader.


*Rhizome* internally purplish–lilac. *Leafy shoots* to 2 m tall, slightly swollen at base with a pale lilac hue, internally purplish–lilac. *Leaf sheath* glabrous. *Ligula* bilobed, lobes broadly rounded, 1–2 mm long, glabrous. *Petiole* 4–5 mm. *Leaves* linear-lanceolate, 45 by 6 cm, glabrous, apex acuminate. *Scape* radical, erect, 30 cm; sheaths 7.5 cm long, slightly hairy at the tips. *Spike* ovate to cylindric, later globose, to about 14 by 9.0 cm. *Bracts* densely imbricate, linear to slightly lanceolate, about 6 by 2–3 cm, pink to red, glabrous, apex narrowed, bluntly pointed, curved outwards or deflexed. *Bracteole* nearly 5 cm long. *Corolla* shorter than bracts, pale white. *Labellum* narrow, lanceolate, shorter than corolla lobes, reddish-brown, apex acute; side-lobes hardly distinct.
Type: Peninsular Malaysia, Taiping Hills, Ridley 11449 (SING lectotype!, K isotype!).

Collections: Corner 30588; Kunstler 2219 (drawing only); Kiah s.n. July 1936; Sinclair & Kiah 38784; Ridley 2401.

Malaysia: Pahang, Perak, Terengganu.

Ecology: In swamps and in hills, 150–950 m, flowering from late July until August, fruiting in November.

Note: Z. kunstleri is easily recognized by the deflexed bracts and the linear leaves.

Affinities: In the deflexed bracts Z. kunstleri is similar to Z. wrayi, but the leaves are narrower and the inflorescence is larger.


Key to varieties:

1a. Rhizomes yellow externally, leafy shoots green basally, labellum dark purple mottled with cream ................................................................. var. officinale
1b. Rhizomes reddish externally, leafy shoots red basally, labellum scarlet red mottled with cream ................................................................. var. rubrum

var. officinale

Rhizome yellow inside. Leafy shoots 0.5-1.0 m, glabrous except for short hairs near base of each leaf-blade. Petiole 2 mm long. Ligula 3-5 mm, slightly bilobed, glabrous. Leaves linear, 15-23 cm by 1.5-1.8 cm, narrowed to a slender tip. Scape radical, erect, slender 15-20(-30cm) tall; sheaths tightly appressed, 4-5 cm long, the upper sometimes enlarged and leaf-like. Spike elliptic or oblong, 4.0-5.0 by 1.5-2.0 cm. Bracts obovate, 2.0-3.0 by 1.5-2.0 cm, light green turning yellow, glabrous with a thin, slightly incurved, margin. Bracteole elliptic, 2.5-3.0 cm long, often longer than the bract. Calyx 1.2 cm long. Corolla 4.5 cm long, lobes yellow: dorsal lobe 1.8 by 0.8 cm; lateral lobes 1.6 by 0.6 mm. Labellum dull purple mottled with cream; midlobe circular, entire, 1.2 cm long; side-lobes rather narrow, 0.6 by 0.4 cm, acute. Anther cream. Appendage dark purple. Capsule red. Pollen globose with cerebroid sculpturing.

Type: Drawing in Roscoe Monand. Pl. Scitam. t. 83 (1828). Lectotype here selected. No specimen at LIIN or in Herb. Cliff (BM) (Burtt 1972).

Distribution: Cultivated in tropical Asia from ancient times and now throughout the tropics. Its country of origin is unknown. It is considered to be indigenous
to Eastern India (Dahlgren et al., 1985). On the other hand it is suggested that the area of origin could be somewhere between the Yangtze and Yellow Rivers, and that due to great changes in natural environments wild ginger disappeared from its original range (Wu, 1985). Z. officinale grows well in Thailand and Malaysia.

Ecology: Occurs as naturalized on wasteground, in deciduous forests and dry rocky bamboo thickets.

Uses: Medicinal plant and spice throughout Southeast Asia. Various races are grown in Malaysia and Thailand where it is a common village plant. The aromatic rhizomes are widely used in cooking or made into marmelade. Occasionally the young rhizomes and parts of the stem are eaten raw. It is also boiled, sun-dried and made into powder, and then used as a condiment to flavour cakes and ginger-beer. Commercially, Jamaica, India, Sri Lanka and China are the most important producer countries.

Medicinally, the rhizome is considered to have diaphoretic, stomachic, carminative and diuretic properties. It is prescribed for heavy colds, coughs and congestion of the chest. It is also used as a remedy for diarrhoea and dysentery. The juice of the rhizome is used to treat migraine and it relieves menstrual cramps. Various lotions, decoctions or poultices may be rubbed on the body after childbirth, applied to swellings, contusions, for rheumatism and further as a bath to lower fever. The crushed rhizome is often smeared on the head for headaches. In China it is used as an antidote to fish and crab poison.

Malay name: “Halia betul” or “real ginger”.

Notes: Z. officinale is recognized by the linear leaves and glabrous ligula; the flowers are characterized by the dull purple labellum which is spotted with yellow.

Affinities: In its narrow leaves Z. officinale resembles Z. montanum Roxb. but the latter has much taller leafy stems and may be distinguished by its hairy ligules and ferruginous, pubescent bracts.

var. rubrum Theilade var. nov. —Halia padi Valeton, Bull. Jard. bot. Buitenz. 27 (1918) 128; —Halia bara or padi and Halia udang Holtttm, Gdns’ Bull. Singapore 13 (1950) 54. (Figs. 4a & 4b)

A varietati officinale differt rhizomatibus minoribus externe rubellis, surculis foliosis ad basin rubris, petiolis rubellis, labello scarlaimo crenicolore maculato.

Rhizome reddish outside, yellow inside, pungent. Leafy shoots 0.5-1.25 m, basally dark red, glabrous except for short hairs near base of each leaf-blade. Petiole 2 mm long, more or less reddish. Ligula 1-5 mm, slightly bilobed, glabrous. Leaves linear, 25-32 by 1.5-1.8 cm, narrowed to a slender tip. Scape radical, erect, slender 20-30 cm tall; sheaths tightly appressed, 4-5 cm long. Spike elliptic or oblong, 4.0-5.0 by 1.5-2.0 cm. Bracts obovate, 2.0-3.0 by 1.5-2.0 cm, green with a thin, slightly involute
Fig. 4a. *Zingiber officinale* var. *rubrum* Theilade var. *nov.* Inflorescence with flower.

Fig. 4b. *Zingiber officinale* var. *rubrum* Theilade var. *nov.* Leafy shoot showing reddish petioles.
margin. Bracteole elliptic, 2.5-3.0 cm long, often longer than the bract. Calyx 1.2 cm long. Corolla 5.0 cm long, yellow. Labellum scarlet red mottled with cream; midlobe circular, 1.5 cm long, apex retuse; side-lobes oblong, 6 by 4 mm. Anther cream. Appendage dark purple. Capsule red. Pollen globose, sculpturing cerebroid.

Type: Malaysia, Sabah, Kota Kinabalu, Central Market, Theilade 66 (SAN holotype! incl. spirit coll. and photos, AAU, SING isotypes). In cultivation at AAU.

Collections other than type: Weber s.n. 1988; Theilade 60 in cultivation at UKM.

Distribution: Cultivated in Southeast Asia for medicinal purposes and as a spice. Frequently sold at markets in Malaysia.

Ecology: Z. officinale var. rubrum grows well in Malaysia, but rarely flowers.

Uses: Var. rubrum is grown on a small scale for medicinal use and as a spice. Various lotions, decoctions or poultices may be rubbed on the body after childbirth. The juice of the rhizome is used to relieve menstrual cramps. See Burkill (1966) for a more extensive account on medicinal uses.

Malay names: The Malays recognize more kinds of the red variety: “halia merah” (merah means red), “halia padi” (small), “haliya bara” (hot coals) and “halia hudang” (prawn). Whether these differ is not certain, but they are all used medicinally like “halia padi”. Ridley (1912) regards “halia bara” as synonymous with “halia padi”.

Notes: Z. officinale var. rubrum differs vegetatively from var. officinale by the smaller, red colored rhizomes which have a stronger, more pungent smell, the red coloring of the basal parts of the leafy stems and petioles and larger leaves. Furthermore, the labellum is larger and scarlet red mottled with cream.

According to Burkill (1966) Rumphius in his Herbarium Amboinense (1747) first described two varieties of Z. officinale as Z. majus—the larger plant known in Malay as “halia” and Z. minus—the smaller plant, or “halia padi”. Of the latter Rumphius distinguished two forms. Valeton (1918) stated that the Javanese “haliya padi” or “sunti” differs from normal Z. officinale in the rhizome and the ovate staminodes with a rounded base. This study has shown that the size of var. rubrum varies greatly with growing conditions. Grown in the villages the plant is usually smaller than var. officinale, but a rhizome brought back to Denmark and cultivated at AAU in rich soil grew 1.25 m tall and has larger leaves. The red coloring of the petioles was most distinct at the time of flowering. It remains to ascertain how many races enter into var. rubrum and whether they genetically differ in size.

5. Zingiber curtisii Holttum. Gdns’ Bull. Singapore 13 (1950) 54-55. (Figs. 5)

Leafy shoot 0.6-1.0 m, slender, the lower sheaths flushed with purple. Ligula 4-5 mm long, thin, hairy towards the base. Leaves ovate, 12-17 by 4-5.5 cm, base broadly cuneate, apex acute, glabrous except for the hairy base of the lower surface
of the midrib. Scape about 10 cm long, sheaths purple. Spike to 14 by 3 cm, cylindrical, apex obtuse. Bracts elliptic, 3-3.5 by 1.5 cm, pale yellow-green, glabrous, apex obtuse and slightly inflexed. Bracteole slightly shorter than bract. Calyx 2.0 cm long. Corolla 5.5 cm long, lobes about 2.0 cm long, white. Labellum same length as corolla lobes, with deep purple markings throughout including the sidelobes. Anther appendage deep purple.

Type: Peninsular Malaysia, Bujong Malacca, August 1898, Curtis s.n. (SING holotype!).

Notes: This species is not distinguishable vegetatively from Z. chrysostachys. However, the inflorescence is longer and more slender, the bracts are longer and narrower, pale yellow green, only slightly inflexed at the tips and forming a closer spike. The lip has deep purple markings throughout including the sidelobes and the anther appendage is deep purple. The type was cultivated in The Botanical Garden, Penang where it flowered in June 1902. Known only from the type collection and a coloured drawing by Hussein done when the species flowered in Penang and now deposited in the Singapore Herbarium.


![Fig. 5. Zingiber curtisii Holttum.](image1)
Drawing by Hussein.

![Fig. 6. Zingiber chrysostachys Ridley.](image2)
Drawing by De Alwis.
Leafy shoots 0.6 m tall. Leaf sheaths the lower sheaths flushed with purple. Ligula 5 mm, glabrous or hairy, bilobed; lobes green with scarious margin. Leaves lanceolate, 12-17 by 4.0-5.5 cm, glabrous except for the hairy base of the midrib below, base broadly cuneate, apex acuminate. Scape radical, erect, 7-10 cm long, often two or more in succession from the same rhizome; sheaths flushed with purple. Spike oblong, to 10 cm long and 4 cm wide, apex rounded. Bracts loosely imbricating, obovate-suborbicular, 2.5-3.0 by 2.3-2.5 cm, bright yellow, sparsely hairy, convex with inflexed upper margin. Bracteoles 2.5 cm long, hairy at base. Calyx 1.5 cm long. Corolla about 4.5 cm long, pale yellowish. Labellum as long as corolla lobes; midlobe obovate, 1.2 cm long, almost entirely crimson with irregular white margins, apex broadly rounded; side-lobes ovate, 0.8 by 0.5 cm, white, spreading to a width of 1.5 cm when flattened. Anther appendage mottled pink to red. Pollen globose with cerebroid sculpturing.

Type: Peninsular Malaysia, Bukit Stau, 1891, Ridley s.n. (SING lectotype!, K isotype!). Lectotype here selected.

Collections: Burkill & Haniff 13830; Curtis 2716; Hervey s.n. 1889, Kiah S.341; Ridley 5199; SFN 35834; Wray 3549, 3110; Zainudin 4471.

Malaysia: Kedah, Perak.

Ecology: Evergreen forest and dry bamboo forest on limestone hills, 200-1400 m.

Uses: In 1924 a bomoh (Malay traditional healer) of Grik in Upper Perak brought leaves of what appeared to be this species to Burkill and Haniff stating that in fever a decoction is administered. He called it “lempui”, a form of “lampoyang” (Burkill 1966).

Affinities: Z. chrysostachys is most closely related to Z. curtisii but the latter has the labellum coloured purple throughout including the side-lobes. No other small species has yellow bracts of this character. In the inflexed bracts and red-marked lip Z. chrysostachys appears to be related to Z. ottensii and Z. spectabile but it is a very much smaller species than either.


Leafy shoots 2.0-3.5 m. basal leafless part to 1 m tall, swollen at base. Leaf sheaths sparsely pilose, margin scarious. Ligula deeply bilobed, the lobes to 1.5 cm long, broad, pale green. Leaves lanceolate, 30-50 by 6-10 cm, glabrous or slightly hairy at the base below. Scape radical, erect, 20-40 cm; sheaths 5 cm long, green to reddish. Spike cylindric, 10-30 by 6-7 cm, apex rounded. Bracts obovate, 4.5 cm
long, at first yellow turning orange, when old entirely red, fleshy, curved outwards with the broadly rounded edge incurved forming open pouches. Bracteole linear, to 4 cm. Calyx to 35 mm long, cream-pinkish. Corolla 70 mm long, yellow; dorsal lobe to 30 by 17 mm; lateral lobes 18 by 6 mm. Labellum 40–60 mm, dark purple with yellow spots: midlobe ovate. 16 by 14 mm. shorter than or of equal length with the lateral corolla lobes. apex cleft; side-lobes broadly rounded, 10 by 10 mm. Anther yellow. Anther appendage purple. Capsule ovoid, 30 by 10 mm. sparsely pilose. Pollen spherical with cerebriform sculpturing.

Type: Peninsular Malaysia. Malacca. Griffith 5762 (K lectotype!).

Collections: Burkhill 1985; Corner 1587; Curtis 1978, 2161; Henderson 21851; Dr. King's Collector s.n., 3205; Maingay 1567; Nur 34215; Ridley, s.n. (1895); Sinclair 7856; Wray 3578.

Distribution: Peninsular Thailand and Peninsular Malaysia


Ecology: In evergreen forests, along trails, roadsides, streams and edges of the forest, on hillsides, disturbed sites, up to 1000 m. Flowering July till September. Fruiting in November.

Uses: Its leaves may be pounded and used for poulticing swellings. Used by Orang Asli against headaches and backaches. Sometimes used by the Malays as a flavouring (Burkill 1966). The tall, colourful inflorescences are sometimes cut and used as ornamentals.

Affinities: Z. spectabile has affinity to Z. ottensii, but it is a much larger species easily recognized by the large, orange inflorescence with incurved bracts forming open pouches. It has the largest inflorescence of any Malayan species.


Rhizome pale grey-purple within having a pungent smell. Leafy shoots to 1.5 m tall. Leaf sheaths broad, slightly hairy near base and apex. Ligula broad, thin, entire. to about 1.2 cm long, hairy towards the base. Petiole 5 mm, finely hairy. Leaves elliptic or widest above the middle. 35(-40) by 6(-8) cm. lower surface slightly hairy towards the base, apex acuminate. Scape radical, erect. 25-40 cm. Spike evenly ellipsoid to cylindrical with a broad apex. 10-12 by 4 cm. Bracts obovate, 4 cm long and almost as wide, convex with incurved tips, dull red to bright red when old. Bracteole linear to lanceolate, 3.2 cm long. Calyx 2.3 cm long, white. Corolla 5.7 cm long, cream to yellow; dorsal lobe 2.2 by 1.1 cm; lateral lobes 2.0 by 0.6 mm. Labellum 5.5 cm long, pale yellow with faint red-brownish markings; midlobe oblong almost round, 2.0 by 1.5 cm, apex rounded and slightly cleft; side-lobes ovate. 1.5 by 0.9 cm. Anther 1.2 cm long, pale yellow. Capsule oblong, red.

Collections: Curtis Apr. 1900; Birch Oct. 1901; Burkill July 1914; Henderson 20200; Holttum 17671; Ridley 7799, s.n. Jun 1893.

Distribution: Thailand, Malaysia, Java and Sumatra.

Malaysia: Penang, Kedah, Selangor, Terengganu.

Uses: *Z. ottensii* is cultivated and used in traditional medicine. The rhizomes are pounded into a poultice used after childbirth.

Malay name: "Lempoyang hitam" or "bonglai hitam" referring to the grey-purple colour of the rhizome.

Affinities: *Z. ottensii* is closely allied to *Z. zerumbet* but differs in the convex bracts with incurved tips and the pale yellow flowers with faint red or brownish markings. Furthermore, *Z. ottensii* can be distinguished by the rhizome, which is dark purple inside in contrast to the yellow rhizome of *Z. zerumbet* and *Z. cassumunar*.


Key to varieties:

1a. Leaves 6.0-9.5 cm wide, spike ovoid to oblong, bracts dull purple ...................................... var. *multibracteatum*

1b. Leaves to 5.0 cm wide, spike cylindrical, bracts light green ...................................................... var. *viride*

**var. multibracteatum**

*Leafy shoots* to 3 m tall. *Leaf sheaths* brownish velutinus. *Petiole* 2-3 mm long, velutinus with brown-yellowish hairs. *Ligula* 3-5 mm long, brownish velutinus. *Leaves* lanceolate or obovate, 35-40 by 6.0-9.5 cm, lower surface sericeus, midrib pubescent or densely so, edge hairy in the young leaves, apex acute. *Scape* radical, erect, 25-85 cm; sheaths pubescent. *Spike* ovoid to oblong, 10-12 by 4.5-7.5 cm, apex obtuse. *Bracts* obovate, convex, 3.5-4.0 by 3.2 cm, dull purple, pubescent, apex broadly rounded, incurved, margin 1.5 mm wide, thin. *Bracteoles* lanceolate, 3.0-3.5 by 1.5 cm. *Calyx* tubular, 3.0 cm long. *Corolla* 8.0 cm long, lobes 3.0 cm long, reddish. *Labellum* purple, spotted cream; midlobe obtuse, 2.5-3.0 cm long, apex retuse; side-lobes oblong, 0.8 cm long. *Capsule* 2.0 cm long. *Seeds* maroon.

Type: Peninsular Malaysia, Pahang, Fraser's Hill, 1300 m. Corner S.F.N. 33174 (SING holotype!, K, L isotypes).

Collections: Burkill & Haniff 12765; Mohd. Shah et al. 1059; Nur S.F.N. 32869; Sinclair 6083, 38693; Theilade 17, 18.

Malaysia: Kelatan, Pahang, Perak.

Ecology: Common in the Cameron Highlands, 1100-1300 m.
Notes: *Z. multibracteatum* is a large plant only found at high altitudes. It is characterized by the velutinus petiole and ligule, the very broad ovoid inflorescence of convex, firm, dull purple bracts with thin edges, and the large flowers with purple cream-spotted lip.

Affinities: Vegetatively *Z. multibracteatum* is similar to *Z. puberulum* Ridl., but in the inflorescence and colour of labellum it is clearly allied to *Z. spectabile* and *Z. ottensii*.

**var. viride** Holtum (1950), l.c.

*Z. multibracteatum var. viride* differs from the typical form in having leaves to 5.0 cm wide, a cylindrical inflorescence and bracts to 5 cm wide, light green.

Type: Peninsular Malaysia, Cameron Highlands, Tanah Rata, Holttum s.n. Aug. 1946 (SING holotype).

Collections: Lewis 166.

Malaysia: Pahang.

Ecology: Upper montane forest in Cameron Highlands, 1800-2000 m.


*Rhizome* pale carrot colour internally, strongly aromatic. *Leafy stem* 1.2-1.8 m, sheaths glabrous or hairy near edges. *Ligula* bilobed, about 2 mm. hairy. *Leaves* linear, 20-35 by 2-4 cm, pubescent beneath, evenly narrowed to the tip. *Scape* erect, 20-25 cm long. *Inflorescence* fusiforme or cylindric-ovate, 10-16 by 3.0-3.5 cm. apex acute. *Bracts* ovate, 3-3.5 cm long, brownish with green, papery edges, pubescent. *Bracteole* 1-1.5 cm. *Calyx* 1.2 cm. *Corolla* 6.0 cm long, pale yellow. *Labellum* 6.0 cm long, pale yellow; midlobe broadly rounded. 2.0 cm, apex bilobed, deeply split when old; side-lobes oblong.

Type: Thailand, Phuket, Koenig s.n. (C holotype!).

Collections: Burkill & Haniff 14066, 16482, 17551; Gianno 416.

Distribution: This species is probably native to India. In Sanskrit it is called "vanaardraka", in Hindi "banada" and in Kannada it is called "kadu shunti". All the names signify that it is a "wild ginger", i.e. a forest ginger in contrast to the cultivated *Z. officinale*. It occurs widely in Southeast Asia as a village plant. According to Holttum (1950) it is not very common in Malaysia.
Fig. 7. *Zingiber montanum* (Koenig) Theilade *comb. nov.* Inflorescence with opened flowers.

Malaysia: Pahang, Perak.

Uses: *Z. montanum* is used in traditional medicine all over tropical Asia. It is primarily a carminative and a stimulant for the stomach used in cases of diarrhoea and colic. In Malay medicine the rhizome is rubbed on the body to reduce fever and to heal a person infiltrated by spirits. Other uses of the plant are very similar to those of *Z. officinale* and it can be regarded as a substitute for this species.

Vernacular names: In Ayurvedic medicine *Z. montanum* is sometimes called “camphor ginger” to distinguish it from *Z. zerumbet* called “stone ginger”. The latter has some bitterness in the taste while *Z. montanum* has not. In Malaysia *Z. montanum* is called “bungla” or “bola”.

Notes: Koenig’s specimens from Phuket have long been considered lost at sea and it was impossible to verify the species he named from his rather short descriptions. Recently some of his collections were rediscovered in the herbarium in Copenhagen including a collection of this species to which Koenig then gave the name *Amomum montanum* providing the first valid epithet. Notwithstanding the above findings the species has for long wrongly been named *Z. cassumunar*. As Roscoe described the species in 1807 as *Z. purpureum* this provides an earlier epithet than *cassumunar* used by Roxburgh three years later in 1810.

Affinity: This species is related to *Z. zerumbet* but can be easily distinguished
by the linear leaves and very short ligules as well as the brown bracts.


   **Leafy shoots** to 2 m tall. **Ligula** bilobed, 4 mm, pubescent. **Leaves** linear, 20-30 by 2.0-2.8 cm, lower surface and the midrib towards the base pubescent. **Scape** to 30(-40) cm long. **Spike** slender fusiform, 10-20(-25) cm long and 2.0-2.5 cm wide. **Bracts** orange turning red, pubescent along margin. **Bracteoles** 2.5-3.0 cm **Calyx** about 2.5 cm long. **Corolla** 6.0 cm cream. Labellum deeply bifid, yellow.

   Type: Peninsular Malaysia, Penang. Apr. 1896, Ridley 9340 (SING lectotype!, K isotype!). Lectotype here selected.

   Collections: Burkill 1529. 3312; Burkill & Haniff 12712; Dr. King 7954; W. Fox 61; Mohd. Shah & Sanusi 2166: Ridley 7954. Aug. 1904, Dec. 1905.

   Affinities: Vegetatively **Z. elatior** resembles **Z. montanum**, a species native to India, in the linear leaves. **Z. elatior** is recognized by the somewhat narrower leaves, and the slender fusiform inflorescence with orange to red bracts.

   Malaysia: Johore, Penang, Perak, Selangor.

   Ecology: Up to 1150 m.

Notes: The plants here represent a distinct species as proposed by Ridley. Whether the lip has always the small red and black lines reported only by Burkill for SFN. 3312 is unknown.

(1841) 329.

Rhizome tuberous, internally pale to brighter yellow, aromatic. Leafy shoots 1.25-1.75 m. Leaf sheaths sparsely hairy. Ligula papery, 1.5–2.5 cm long, scarious. Petiole finely hairy. Leaves broadly lanceolate, 25-40 by 5-8 cm, apex acuminate. Scape radical, erect, 10–30 cm; sheaths green. Spike cylindric to ovate, 6–14 by 4–5 cm, apex obtuse. Bracts obovate, 3.0–4.0 by 2.5 cm, green when young, red when old, convex near upper edge, apex broadly rounded with a thin, papery margin. Bracteoles linear to lanceolate, 2.5–3.5 long. Calyx 2.5 cm long, shorter than bracteole, white. Corolla 5.5 cm long, lemon yellow; dorsal lobe 2.5 by 2.0 cm; lateral lobes 1.6 by 0.7 cm. Labellum 5.5 cm long, lemon yellow, margin crenate; midlobe oblong almost round, 1.5 cm long, apex cleft; side-lobes ovate, 0.8 cm long. Anther pale yellow. Capsule oblong, 1.5 cm long, red.

Type: Burma, Pegu, 1826, C.W. s.n. (K lectotype!). Lectotype here selected. No specimen in LINN or Herb. Cliff (BM).

Collections: Burkill & Haniff 13712, 13421; Collins 1053, 1611; Corner 31559; Curtis 1924; Zainudin 3826, 4466.

Distribution: Cultivated in India, China and throughout Southeast Asia. It is probably indigenous to India.

Malaysia: Kedah, Perak, Selangor, Johor.

Ecology: Cultivated or naturalized on margins of forests or waste ground near villages. Grown up to 1200 m alt, flowering June to September, fruiting October till January.

Uses: The rhizome is used as a spice as well as for medical purposes.

Vernacular names: India and Malaysia: “Lampoyang”. In Ayurvedic medicine Z. zerumbet is called called “stone ginger” in order to distinguish it from Z. montanum called “camphor ginger”. Z. zerumbet has some bitterness in the taste which Z. montanum lacks.

Notes: Valeton (1918) described three species from Java, Z. amaricans Z. aromaticum and Z. littorale, as closely allied to Z. zerumbet. It might be possible to distinguish Z. aromaticum by its fleshy white rhizome and stronger taste as described by Valeton. Unfortunately both characters require live material, which was not available for this study. In this treatment Z. amaricans Z. aromaticum and Z. littorale are regarded as varieties of Z. zerumbet.

Affinities: Z. zerumbet is allied to Z. ottensii but the bracts are green at anthesis and the labellum is lemon yellow without markings. Furthermore, Z. ottensii can be distinguished by the rhizome, which has a purplish color inside.

This cultivar is similar to the typical form except for the variegated leaves which are bright green with a broad white margin and oblique stripes of the same colour. Furthermore, the bracts of the inflorescence have whitish stripes near the margin.

Note: This cultivar is the only known *Zingiber* with variegated leaves and has great horticultural potential. *Z. zerumbet* cultivar *darceyi* was introduced to Kew in 1890 from Sydney Botanic Garden and is said to come from the South Sea Islands (Burtt 1972).


*Leafy shoots* 0.5-1.2 m tall. *Leaf sheaths* pubescent, indumentum increasing towards the petiole. *Petiole* 2-3 mm long, pubescent. *Ligula* bilobed, lobes broadly rounded, 3 mm long, pubescent, margin scarious, dotted. *Leaves* broadly lanceolate or ovate, 15 by 5 cm to 20(-25) by 8 cm, upper surface smooth, lower surface and midrib sericeous, finely dotted throughout, base broadly to narrowly cuneate, apex mucronate, sidenerves finely raised in dotted lines when dried giving a finely ribbed appearance. *Scape* radical, more or less erect, 4-10(-15) cm. *Spike* 10-15 by 1.5-3.5 cm, fusiform when young, wider and nearly evenly cylindric when in fruit, apex acuminate. *Bracts* elliptic, 2.5-4.0 by 1.5-2.5 cm. thin, pink turning red, finely hairy. *Bracteoles* absent. *Calyx* 2.5 cm long, longer than the bracteole. *Corolla* 5.0 cm long, white to cream; dorsal lobe 2.0 by 1.0 cm; lateral lobes joined together for nearly half their length below the lip. *Labellum* white to cream; midlobe triangular. 1.7 by 0.6 cm, apex acute or sometimes cleft; lateral staminodes ovate, 0.8 by 0.4 mm, tips rounded. *Capsule* glabrous, flowers persisting on top of the fruit. *Seeds* maroon. *Pollen* globose, sculpturing cerebrid.

Type: Peninsular Malaysia, Malacca. Griffith, Kew Distrib. 5731 (K lectotype).

Collections: Burkill 1170, 4485: Corporal s.n. Feb. 1890; Goodenough 1434, s.n. (12 Feb. 1890); Holttum 9393, 10926: s.n. 10 Apr. 1890; Lake & Kelsall s.n. 22 Oct 1892. Latiff 856. 3151; Mohd. Shah et al. S.1700, 3633; Ridley s.n., s.n. (20 Aug. 1892), 6011, 9188; Sinclair 5105, s.n. 25 Feb. 1950. 10616: Smith 11; Symington 22750, 25669.

Distribution: Peninsular Thailand, Malaysia and Singapore

Malaysia: Johore, Melaka, Negri Sembilan, Pahang, Selangor, Terengganu.

Ecology: Lowland evergreen forest or secondary forest in damp, shady places in humus rich soil. Common in lowland forests in the southern half the Malay Peninsula.
Uses: The plant may be used for poulticing.


Notes: *Z. griffithii* is well characterized by its broad leaves with silky hairs on the lower surface and finely raised veins when dried. Holttum regarded *Z. griffithii* var. *major* as a synonym to *Z. puberulum* and his view has been followed in this treatment.

Affinities: *Z. griffithii* is closely related to *Z. puberulum* and *Z. gracile*, but the leaves are broader and the inflorescence is more cylindric than either of these. Furthermore, the bracts in *Z. griffithii* are much less tough than in *Z. puberulum* and *Z. gracile*.


Leafy stem 0.5–0.6 m, flushed with purple. Leaf sheath usually glabrous, margin scarious. Ligula entire, 2–4 mm long, glabrous. Petiole 2 mm, sparsely hairy. Leaves lanceolate to ovate, 24–30 by 8–10 cm, sparsely sericeus, base cuneate, apex acuminate. Scape radical, erect, 7.0 cm long. Spike cylindric, 12–15 by 4–5 cm, apex acute. Bracts densely imbricate, elliptic to ovate, 3.5–4.0 by 2–3 cm, lemon yellow turning pink to red in fruit, glabrous or sparsely pilose, margin scarious, apex acute. Bracteoles absent. Calyx 2.5 cm long, translucent–yellow. Corolla 5.6 cm long, white to yellow: dorsal lobe 2.4 by 0.8 cm. Labellum 5.4 cm, white to yellow; midlobe elliptic, 1.0 by 0.6 cm, apex bifid; lateral staminodes 0.5 by 0.4 cm.

Type: Peninsular Malaysia, Genting Bidai, May 1896. Ridley 7797a (K lectotype!). Lectotype here selected.

Collections: Burkill & Haniff 16444; Foxworthy & Burkill 1921; Holttum 9621; Dr Kings coll. 10263; Lake & Kelsall 1892; Ridley s.n. (1900), s.n. 1899.

Malaysia: Johor, Negri Sembilan, Perak, Selangor.,

Ecology: On rich soil, 120–180 m, flowering in May–June.

Vernacular name: “Tepus tenok” meaning tapir’s gingerwort (Ridley 1924).

Notes: Easily recognized by the lemon yellow bracts. Ridley’s drawing of the plant brought from Dusun Tua is found at Kew. Holttum (1950) considered it doubtful whether the large leaves were always associated with the lemon colour of the bracts and included *Z. citrinum* in *Z. griffithii*.

Affinities: *Z. citrinum* is has affinity to *Z. griffithii*. It is distinguished by the larger leaves, the broader inflorescence and the lemon yellow bracts.

*Leafy shoots* to 0.7 m tall. *Petiole* 3-4 mm, yellowish pubescent. *Ligula* 4-6 mm, biparted, hairy when young. *Leaves* ovate, 12-14 by 4.0-4.5 cm, glabrous above, hairy below. *Scape* 5-10(-15) cm long. *Spike* fusiform, slender, 8-10 by 1.5 cm. apex acuminate. *Bracts* ovate. 3.5 by 1.5 cm. sulphur yellow later turning pink. pubescent, apex acute. finely dotted along the margin when dried. *Bracteole* absent. *Calyx* 2.3 cm long, pale yellow. *Corolla* 5.5 cm long, pale yellow; dorsal corolla lobe 2.3 by 0.4 cm; lateral corolla lobes 1.8 by 0.3 cm *Labellum* 5.0 cm long, pale yellow; midlobe oblong, 1.3 by 0.4 cm, retuse; side-lobes 0.5 by 0.4 cm. oblong, total width when flattened 1.5 cm. *Anther* pale yellow. *Pollen* globose with cerebroid sculpturing.

Type: Peninsular Malaysia, Pahang, Gunung Tahan. 1150 m, 18 June 1922, Haniff & Nur SNF 8016 (K holotype!, SING isotype!).


Distribution: Malaysia in Pahang state. Localities: Taman Negara, Gunung Senyum, Fraser’s Hill.

Ecology: Evergreen rain forest, on granite or limestone, 50-1200 m. Flowering June to August.

Notes: *Zingiber sulphureum* is closely related to *Zingiber griffithii* and *Zingiber aurantiacum* but it is a smaller plant than either of these. *Zingiber sulphureum* is recognized by the small ovate leaves, the short, narrow spike with sulphur yellow bracts and the short calyx. Burkill used the epithet *sulphureum* on herbarium specimens SNF 8016.


*Leafy shoots* to 1 m tall. *Ligula* about 1.8 cm, bilobed, scarious, with black dots. *Leaves* lanceolate, to 18 by 4.0 cm, upper surface smooth, lower surface and midrib pubescent or sericeous. base cuneate, apex acuminate. *Scape* to 10-20 cm. *Inflorescence* cylindrical about 15 by 1.5 cm. *Bracts* ovate, 3.5-5.0 by 2.0 cm, pink or orange when young later turning red, pubescent, apex acute. *Bracteole* 2.0-2.5 cm shorter than calyx. *Calyx* 2.5-3.0 cm long. *Corolla* 6.0 cm; lobes 1.5-2.0 cm long. cream. *Labellum* to 6.0 cm, cream; midlobe oblong. 2.2 cm long, apex retuse or bifid; side-lobes 0.2 cm long, oval. *Capsule* 2.5 cm long, glabrous; seeds maroon. *Pollen* globose, sculpturing cerebroid.

Type: Peninsular Malaysia. Penang. Waterfall. Apr. 1890, Curtis (SING lectotype!). Lectotype here selected. No authentic specimens of Jack’s plants exist.

Collections: Burkill 16141; Fox 12708; Foxworthy & Burkill Nov. 1921; Mohd. Shah 2460; Ridley 1640, 7235, 12700.
Malaysia: Johore, Malacca, Pahang, Penang, Perak, Selangor.

Uses: The use of the name “mempoyang” for “lempoyang” suggests that it may be a substitute for other gingers. The name was obtained by Ridley and Goodenough in Malacca (Burkill 1966).

Note: This is the species that corresponds to Jack’s original description. Holttum recognized in addition to the typical form three varieties of Z. gracile. In this treatment they have been ranked as separate species. Z. gracile is distinct by the long thin ligule; the lanceolate leaves and the short scape and spike. It is probably closely related to Z. griffithii.

King’s 7954 and Hullett’s 854, cited by Baker (1892) as probably Z. gracile, have been identified as Z. elatior and Z. aurantiacum.


Leafy shoots 1.5 to 2 m tall. Ligula 5 mm long. Leaves narrowly lanceolate, to 27 by 3.5 cm. Scape 15 to 35 cm. Spike slender. 15-20 cm long and 2.5 cm wide. Bracts bright orange turning red when fruiting. Bracteole 2.5 cm long. Calyx 2.5-3.0 cm long. Corolla 6.0 cm; lobes 2.0 cm long, cream. Labellum to 6.0 cm, cream; midlobe oblong, 2.2 cm long, apex retuse or bifid; side-lobes oval. Capsule to 2.5 cm long, glabrous; seeds maroon. Pollen globose, sculpturing cerebroid.

Type: West Malaysia, Pahang, Fraser’s Hill, Burkill & Holttum SFN. 8806 (SING lectotype!). Lectotype here selected.


Malaysia: Johore, Malacca, Negri Sembilan, Pahang, Selangor.

Ecology: Common at moderate elevations on the southern part of the Main Range in Cameron Highlands (Holttum, 1950).

Note: This species is distinguished by the long, slender inflorescence, and the orange bracts later turning red. It has affinity to Z. gracile but differs in being a larger plant with a short ligule. The long and slender inflorescence approaches Z. petiolatum but the leaves are much smaller.


Leafy shoots to 2.5 m tall. Petiole 10-15 mm. Ligula bilobed, 3-4 mm. Leaves lanceolate, to 40 by 8 cm, lower surface glabrous. Scape to 75 cm long. Spike 30-45 cm long, fusiform. Bracts lanceolate, 7.0 by 3.0 cm, tough, rose-pink, apex acute. Bracteole to 3.0 cm long. Corolla 6.0 cm; lobes 2.0 cm long, cream. Labellum
to 6.0 cm. cream; midlobe oblong, 2.5 cm long, apex retuse or bifid; side-lobes 0.3 cm long, oval.

Type: Peninsular Malaysia, Kedah. Pass from Kroh to Baling. 350 m. Corner S.F.N. 31570 (SING holotype!, E!, K! and L isotypes).

Collections: Henderson 21794; Kerr 7353; Md. Nur 34284; Ridley s.n. Aug. 1891, s.n. 18 Mar. 1893.

Distribution: Peninsular Thailand and Peninsular Malaysia.

Malaysia: Kedah, Pahang.

Ecology: Evergreen forest at low elevations.

Note: *Z. petiolatum* is distinct by the large leaves, the long petiole, the extremely long scape and the long, slender spike with large tough bracts. In the large leaves and tough bracts *Z. gracile* var. *petiolatum* approaches *Z. puberulum*.


Key to varieties:

1a. Inflorescence ovoid, apex rounded .......................................................... var. *ovoideum*
1b. Inflorescence fusiform to ovoid tapering to a pointed apex ................................. 2

2a. Leaf sheaths velutinous with brownish hairs, bracts pink .................................. var. *puberulum*
2b. leaf sheaths slightly hairy, bracts yellow ...................................................... var. *chryseum*

**var. puberulum**

Leafy shoots 2-3 m tall. *Leaf sheaths* brownish velutinus. *Ligula* entire. to 5 mm long, yellowish hairy or velutinus. *Leaves* lanceolate or widest above the middle. 25-55 by 6-10 cm, upper surface smooth, rather grey-green, lower surface sometimes pubescent throughout, densely so on midrib towards the base, hairs yellowish-brown, margin hairy, apex acuminate. *Scape* radical, erect, 10-25 cm long. *Spike* 10-15 by 2.5-3.5 cm, fusiform to ovoid tapering upwards to a pointed apex. *Bracts* ovate, 3.5-5.0 by 2.0-3.0 cm. texture firm, pink, pubescent, apex obtuse, margin scarious. usually conspicuously hairy. *Bracteole* ensiforme, 1.5-2.0 by 2.4-2.8 cm. *Calyx* 2.5-3.3 cm long. *Corolla* to 6.5 cm. white to cream; dorsal lobe 2.5 by 0.7 cm wide; lateral lobes 2.0 by 0.4 cm. *Labellum* nearly as long as the corolla lobes, cream; midlobe about 1.2 by 0.7 mm. apex obtuse with a crenate margin; side-lobes oblong, reaching nearly half the total length of lip, spreading to a total width of 1.6 cm when flattened. *Anther* yellow. *Capsule* 2.5 cm long, pubescent. *Pollen* globose, sculpturing cerebroid.

Type: Singapore, Bukit Timah. Ridley s.n. 1894, (K lectotype!, SING isotype). Lectotype here selected.
Collections: Burkill 2670, 5990; Corner 30112, 30266; 30969, 31477; Curtis 3037; Dr Kings Coll 2163; Henderson 22380, 25003, 36608; Holttum 10842; Maxwell 81-96, 81-133; Md. Nur sn. 1937; Ridley s.n. Bukit Timah 1892, s.n. Bukit Tangga 1920, 4613; Sinclair 10616, 10622; Stone 10877.

Distribution: Peninsular Thailand, Peninsular Malaysia, and Singapore.

Malaysia: Penang, Perak, Terengganu, Pahang, Selangor, Johore.

Ecology: Evergreen forest in damp places, peaty soil in fresh-water swamp forest, up to 600 m.

Vernacular name: “Lempoyang anjing” or dog’s “lempoyang” (Burkill 1966).

Notes: The indumentum of var. puberulum is very variable, but it is always hairy on the ligule and leaf sheaths. According to Ridley (1899) Z. griffithii var. major differs from var. puberulum in the glabrous leaf sheaths. In Ridley’s type specimen of Z. griffithii var. major (s.n. July 1891, Kuala Sembiling, Pahang) the leaf sheaths and petioles was found to be hairy though the indumentum was missing in some parts of the leaf sheaths. Holttum (1950) considered Z. griffithii var. major Ridl. to be a synonym to Z. puberulum and his view is followed here.

Affinities: var. puberulum is closely allied to Z. griffithii and Z. petiolatum. but has larger leaves than the former, smaller inflorescence than the latter, and is easily recognized by the velutinus leaf sheaths and ligules.

var. ovoideum (Ridl.) Holttum, Gdns’ Bull. Singapore 8 (1950) 63.

This variety is rarely, if ever, as hairy as the typical form, but otherwise it is indistinguishable vegetatively. It differs from the typical form in the following: Scape 5-10 cm long. Spike ovoid, about 8 cm long, apex rounded.

Type: Peninsular Malaysia, Pahang, river Tahan, Ridley s.n. Aug. 1891 (SING lectotype!). Lectotype here selected.

Henderson S.F.N. 21781, 21857, 22554, 19566; Moysey & Kiah 33732; Ridley s.n. 1892.

Malaysia: Kelantan, Perak, Pahang.

Notes: This variety has been collected mainly in Pahang. The less hairy character, the short scape and the short, ovoid inflorescence with rounded apex seems to be constant.


Differs from the typical form in having pale yellowish bracts and in the whole plant being almost glabrous.
Type: Singapore, Stagmount, Ridley 13330, 1908 (SING holotype!, K isotype!)
Collections: Corner 30658 Sungai Panti. Pahang.
Distribution: Pahang and Singapore. The type specimen was collected in a wood at Stagmount in 1908 but the habitat was cleared and burnt a year or so later (Ridley, 1924).
Ecology: lowland forest, up to 200 m.
Notes: In size and shape of the leaves and inflorescence it does not differ in any way from var. puberulum, and the flowers are described in same terms by Ridley. Var. chryseum differs in the pale yellowish bracts and in the whole plant being almost glabrous. Whether the yellow bracts and general glabrous character is always associated is not known.

References
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The drawings of Zingiber curtisii (Fig. 4) and Z. chrysostachys (Fig. 5) are in the collection of the Singapore Botanic Gardens and are used here with permission.

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The Angiosperm Flora of Singapore Part 4

SCHISANDRACEAE

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Kadsura Juss.


Sarcocarpon Blume

Woody, monoecious lianes. Leaves simple, alternate; exstipulate; lamina elliptic to ovate, papyraceous to coriaceous, apex acute or acuminate, margins denticulate to entire, base cuneate (especially when young), obtuse or truncate; petioles grooved adaxially. Flowers unisexual: in axils of leaves or fugaceous bracts, generally solitary, occasionally with a secondary flower growing in the axil of the prophyll, or in clusters of 2-4 forming glomerules, occasionally cauliflorous; tepals 7-24, imbricate at anthesis, suborbicular, elliptic or ovate, rarely obovate, outermost and innermost tepals ± reduced, inner and middle tepals white, cream, yellow, pink or red, outer tepals often green; stamens 13-80, either essentially free but connate at the base of the filaments (occasionally with subulate appendages at the distal apex of the receptacle), or else stamens aggregated into a compact subglobose head with very broad connectives; pollen hexacolpate, distally syncolpate; carpels 17-300, free; ovaries with 2-5(-11) pendulous or ventrally attached ovules. Fruit a subglobose aggregate of berries attached to an ellipsoid or clavate receptacle: berries ripening red or yellow. Seeds 1-4(-11) per berry, smooth, hilum lateral or apical.

Distribution - There are 16 species in Kadsura, with a southern Chinese and Indo-Chinese centre of distribution. extending from southern Japan in the northeast, to Sulawesi and Java in the south-east, and Sri Lanka in the west (Smith, 1947; Saunders, in press). Only K. scandens is found in Singapore.

Ecology - Scrambling and twining woody vines of warm and subtropical broad-leaved forests, with some species extending into humid montane forests of up to 2400 m altitude.

Uses - See under K. scandens.

Notes - The most recent monograph of Kadsura is by Saunders (in press). A detailed review of the palynology of the family has been published by Praglowski (1976).
Fig. 1. *Kadsura scandens* (Blume) Blume. a. Flowering branch. b. Female flower with perianth removed, showing gynoecium. c. Isolated carpel (lateral view). d. Male flower with perianth removed, showing androecium. e. Isolated stamen (lateral view). f. Fruit. g. Seed. [a. H.N. Ridley 6354 (SING); b.-c. M. Nur 26103 (SING); d.-e. P.W. Korthals s.n. (L); f. redrawn from van Steenis (1972: fig. 29.3); g. N. Wirawan 134 (L)]. Del. H.L. Wilks. (Reproduced with permission from *Flora Malesiana* 13).
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References


The Angiosperm Flora of Singapore Part 5

BURMANNIACEAE

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Small saprophytic or autotrophic, annual or perennial herbs, often growing from rhizomes or tubers. Leaves simple, extipulate, usually alternate, lamina entire; autotrophic spp. with basal rosette of linear or lanceolate green leaves; saprophytic spp. with colourless to yellowish or reddish, scale-like leaves. Flowers bisexual, usually actinomorphic, solitary or in terminal cymes or racemes; perianth (3-6)-lobed, corolline, tubular or campanulate, tube occasionally 3-angled or 3-winged, outer parts (sepals) valvate, inner parts (petals) generally smaller, induplicate-valvate, occasionally absent, 3 or all 6 of the lobes often each with an elongate, slender, terminal appendage; stamens 3 or 6, if 3, then subsessile in the perianth throat, with anther dehiscence by horizontal slits if 6, then pendant in perianth tube, with anther dehiscence by longitudinal slits; connectives large, often appendiculate; ovary inferior, 1-loculate with parietal placentation. or 3-loculate with axile placentation, ovules numerous, anatropous, bitegmic; style filiform, shortly cylindrical or conical; stigmas 3, sometimes connate. Fruit capsular, occasionally fleshy, with either persistent perianth tube and style or persistent basal ring of perianth only, dehiscence irregular or by transverse ventral slits. Seeds small, subglobose to linear, numerous, sometimes with a loose reticulate testa; endosperm present. x = 6 or 8 (Rübsamen. 1986).

Distribution - C. 20 genera and 130 spp., with an essentially pantropical distribution but also extending into temperate regions (Jonker. 1938).

Ecology - The Burmanniaceae consist of both saprophytes and autotrophs (semi-saprophytic). The autotrophic spp. generally occur as sparse individuals in open fields and savannahs, whereas the saprophytes occur almost exclusively on decaying leaves, wood and roots in the deep shade of wet tropical forests (Jonker. 1938). The seeds are tiny, with little food reserve, but are produced in very large quantities. Spp. in open grassland habitats therefore presumably disperse their seeds by wind, whereas water may be the primary means of dispersal in spp. of forested areas (Maas et al., 1986).

Uses - The Burmanniaceae are of no known economic importance.
Notes - The phylogenetic relationships of the family are rather unclear, due in part to convergence in evolution of achlorophyllous plants. The Burmanniaceae are clearly isolated, but possess greatest similarities with the Orchidaceae, although not with the subfamily Apostasioideae (Rübsamen, 1986), as previously suggested.

The Burmanniaceae have been classified into 3 tribes (Burmanniaceae, Thismieae and Corsieae) based on the inflorescence type, and stamen number and attachment, although the Corsieae are generally elevated to the segregate family Corsiaceae (e.g., Jonker, 1938; Rübsamen, 1986). The Thismieae have also been isolated as a distinct family (e.g., Dahlgren et al., 1985), although the present account follows most other recent treatments in describing the family Burmanniaceae sensu lato.

**Key to the Genera**

1a. Perianth tube cylindrical or trigonous. Style of ± equal length as the tube. Stamens 3 ................................................................. 2

1b. Perianth tube urceolate, circumscissile. Style very short. Stamens 6 ................................................................. *Thismia*

2a. Perianth persistent after anthesis, together with ovary often prominently 3-winged, sometimes 3-costate or wingless. Ovary and capsule 3-loculate with axile placentation ........................................................... *Burmannia*

2b. Perianth caducous after anthesis, together with ovary wingless. Ovary and capsule 1-loculate with parietal placentation .................................................. *Gymnosiphon*

**Burmannia L.**


Achlorophyllous saprophytic or green autotrophic, annual or perennial herbs; autotrophs with basal rosette of green leaves, and smaller green leaves appressed to the stem; saprophytes with only small bract-like, achlorophyllous, stem leaves. *Flowers* solitary or in terminal cymes; perianth persistent after anthesis, often 3-winged, occasionally wingless, tube generally 6-lobed, cylindrical to trigonous, outer segments relatively large, inner segments often minute, occasionally lacking; stamens 3, sessile or subsessile on perianth tube, connective occasionally with (1-) 2 apical glandular crests and/or a central, pendant, basal spur; ovary trigonous, 3-loculate, placentation axile; styles fused, branched towards the stigmas; stigmas 3, occasionally sessile, funnel-shaped. *Capsule* with persistent perianth, dehiscence generally irregular. *Seeds* numerous, oblong or ellipsoidal.

Distribution - C. 60 spp., throughout the range of the whole family (Jonker, 1938) although with an Asian centre of diversity. Only *B. championii*, *B. coelestis* and *B. wallichii* have been recorded in Singapore.
Ecology - As with the family, most spp. of Burmannia are either autotrophs of wet areas of open savannahs, or saprophytes of wet tropical forests (Jonker, 1938), although 1 neotropical sp. is known to be epiphytic (Maas et al., 1986). Although the brightly coloured perianth, sepal nectaries and glandular staminal crests are indicative of entomophilia, no such system has ever been observed. Protandry has been demonstrated for some Burmannia spp. (Malme, 1896), and it has been suggested that the lower lip of the stigmatic lobes may be a means of avoiding autogamy. The stigmas and anthers are, nonetheless, located at the same height in the perianth tube, often almost occluding the throat of the tube, and Schoh (1920) believed that Burmannia must be autogamous since the stigmatic lobes prevent the dispersal of pollen from the thecae.

Notes - The distinction between autotrophic and saprophytic habits was previously believed to be of some taxonomic significance, but is now considered of little value due to the occurrence of pairs of closely related saprophytic and autotrophic spp. (Jonker, 1938), suggesting that saprophytism is polyphyletic in the genus. The pollen is mono- or biporate (Chakrapani & Raj, 1971).

Key to the Species

1a. Leaves in a basal rosette, green .............................................. B. coelestis

1b. Leaves not in a basal rosette, achlorophyllous ................................. 2

2a. Inflorescences (2)-3-9(-14)-flowered. Perianth tube without lateral wings ................................................................. B. championii

2b. Flowers generally solitary. Perianth tube with 3 lateral wings.... B. wallichii

1. B. championii Thwaites


B. capitata Makino; B. chionantha Schltr.; B. dalziellii Rendle; B. japonica Maxim. ex Makino; B. tuberosa Becc.

Saprophytic annual herbs, flowering at 9-27 cm tall; stem unbranched, filiform, growing from a tuberous rhizome, covered with hair-like roots, giving rise to small adventitious tubers. Stem leaves appressed, achlorophyllous, bract-like, linear to subulate, 2-8 mm long. Inflorescence of (2)-3-9(-14) flowers; bracts lanceolate, 2-6 mm long, apex acute. Flowers 3-11 mm long; perianth yellow-white to bright yellow, tube 3-costate, without lateral wings, outer lobes triangular. c. 1-2.5 mm
long, apex acute involute, inner lobes spathulate, to c. 0.75 mm long, apex rounded; staminal connective with single, central crest at apex, basal spur absent; gynoecium c. 3 mm long; ovary c. 2-3 mm long; flowers pedicellate or subsessile. Capsule dehiscing by fragmentation of the wall between costae. n = 6, 2n = 12 (Ernst and Bernard, 1912).

Distribution - Japan, southern China, Sri Lanka and Malesia (Malay Peninsula, Bangka, Java, Borneo and Papua New Guinea) (Jonker, 1938).

Ecology - Grows in wet lowland forests.

Notes - The pollen is monoporate (Chakrapani and Raj, 1971).

2. *B. coelestis* D. Don


*B. azurea* Griff; *B. borneensis* Gand.; *B. javanica* Blume; *B. malaccensis* Gand; *B. selebica* Becc.; *B. triflora* Roxb.

Autotrophic annual herbs, flowering at 7-40 cm tall; stem usually unbranched, robust. Leaves with basal rosette and stem forms; basal rosette leaves linear or lanceolate, 3-26 × 0.5-3.5 mm; stem leaves appressed, sometimes imbricate towards the base, linear to subulate, 3-30 mm long, apex acute. Inflorescence a solitary flower or cluster of 2-4(-6) flowers; bracts linear to subulate, 1-9 mm long, apex acute. Flowers 6-17 mm long; perianth blue, purple or white, often with yellow lobes, tube cylindrical-trigonom with lateral wings, c. 5 mm long, lateral wings half-elliptical to half-obovate. c. 10 × 2.5 mm, outer lobes ovate, to c. 1.5 mm long, double margined, apex apiculate. inner lobes lanceolate, to c. 0.5 mm long, double margined, apex apiculate; staminal connectives with 2 apical crests and a basal pendant spur; gynoecium c. 4 mm long; ovary c. 5 mm long; flowers subsessile. Capsule dehiscing ± irregularly, by transverse splits. n = c. 16 (Sarkar et al., 1973). - Fig. 1.

Distribution - Singapore: currently in MacRitchie Reservoir, Poyan Reservoir, Kent Ridge Park, etc. India, Nepal, southern China, Burma, Thailand, Indochina, and throughout Malesia (Jonker, 1938).

Ecology - Grows in wet areas of open grassland.

Notes - The pollen is monoporate (Chakrapani and Raj, 1971). Larsen (1963) reported a chromosome count of 2n = c.32 for *B. coelestis*; examination of the voucher specimen resulted in its redetermination as *B. chinensis* Gand.
Fig. 1. *Burmannia coelestis* D. Don. a. Habit. b. Complete flower. c. Half flower. d. Stamen, with lateral thecae and connective consisting of 2 apical crests and a pendant basal spur. e. 3 stigmas with united style. f. Ovary (TS), showing axile placentation. g. Seeds, with spirally striate testa. [a.-f. K.S. Chua & H.T.W. Tan 281 (Herbarium, The University of Hong Kong); g. Z. Teruya 2210 (SING)]. Del. R.J. Nicholls.


Saprophytic annual herbs, flowering at 4.5-11 cm tall; stem unbranched, filiform. Stem leaves ± appressed, achorophyllous, bract-like, subulate-triangular, sometimes keeled, 1-2.8 mm long, apex acute. Inflorescence a solitary flower or occasionally a pair; bracts lanceolate, c. 2.5-4 mm long. Flowers 6-9.5 mm long; perianth white or bluish; tube cylindrical, c. 3 mm long, lateral wings narrow, ± linear, c. 4.5 × 0.5 mm; outer lobes obtuse-triangular, to c. 1 mm long, inner lobes orbiculate, apex rounded; staminal connectives without apical crests, but with a short basal spur; gynoecium c. 3 mm long, ovary c. 2.5 mm long; flowers sub sessile. Capsule dehiscing ± irregularly by transverse splits. n = 16 (Larsen, 1963).

Distribution - India, Burma, Thailand, Indo-China, southern China and the Malay Peninsula (Jonker, 1938).

Ecology - *B. wallichii* is clearly saprophytic; otherwise little is known of its ecology.

Notes - *B. wallichii* has only been recorded from Singapore once, last century (Ridley’s collector s.n., Kranji [SING 074436]); as it has not been collected since, it is now probably extinct in Singapore.

**Gymnosiphon Blume**


Saprophytic annual herbs. Leaves achorophyllous, bract-like, small. Flowers borne in 3 to many-flowered racemes, rarely solitary; perianth tube 6-lobed, without lateral wings, tube from below point of insertion of stamens deciduous after anthesis, lower part persistent, outer lobes larger than the inner ones, slightly 3-lobed; anthers 3, sessile in the tube throat, dehiscing horizontally, connectives rather broad, inappendiculate or mucronulate at the top; ovary ovoid to globose, with 3 parietal placentas, placentas each with a large globose gland at both sides of the apex; style filiform, branching; stigmas 3, often appendiculate. Capsule with persistent perianth tube base, dehiscence generally irregular or by longitudinal slits. Seeds ovoid to globose, with a reticulate testa.

Distribution - C. 25 spp., occurring in the neotropics, tropical Africa and Madagascar and South-east Asia (Jonker, 1938). Only *G. aphyllus* has been recorded in Singapore.

Ecology - All spp. of *Gymnosiphon* are saprophytes of wet tropical forests.
Although cross-pollination has never been demonstrated for the genus, several floral structures are indicative of entomophily: coloured perianths; septal nectaries (Maas et al., 1986); stigmatic appendages that exceed the floral tube: putative protandry (Rübsamen, 1980): and reports of scented flowers in 2 spp. (Bentham, 1855; Vogel 1962, cited in Maas et al., 1986). Rübsamen (1986) has furthermore observed insect larvae within Gymnosiphon flowers. Autogamy is also possible, however, as the stigmas and anthers are located at the same height in the perianth tube, and are often intimately associated.

Notes - The upper region of the perianth tube (including the sessile anthers) is deciduous after anthesis, and so the identification of post-anthesis and fruiting specimens is therefore often impossible.

1. **G. aphyllus** Blume


**G. borneense** Becc.: **G. pedicellatum** Schltr.

Herbs, flowering at 8-17 cm tall: stem often branched. Leaves appressed, bract-like, narrowly ovate-triangular. 1-2.8(-4.5) mm long, apex acute. Inflorescence racemose, branched or not. many-flowered; bracts appressed, ovate-triangular. 1.2-3.5(-5) mm long, apex acute. Flowers with white to violet perianth. tube to 4 mm long, outer lobes ovate, c. 2-2.5 mm long, apex obtuse, with narrow, crenate lateral lobes, inner lobes linear-lanceolate, minute; anthers inserted immediately below the inner perianth lobes: stigmas curved. funnel-shaped. inappendiculate; pedicel 1.5-4.0 mm long. Capsule c. 3 mm long. dehiscing by perforation of the wall between costae. Seeds ovoid, with striate testa.

Distribution - Singapore: formerly collected from Bukit Timah, but now probably extinct in Singapore (Keng. 1987). Thailand and Malesia (Malay Peninsula, Java, Borneo, Sulawesi and New Guinea) (Jonker. 1938).

Ecology - Grows on decaying vegetation and humus. in wet shaded forests below 1500 m in its range.

**Thismia Griff.**

Saprophytic, fleshy, annual herbs with generally tuberous, coralliform or vermiform and creeping subterranean parts, stem usually short, rarely branched. Leaves achlorophyllous, bract-like, small. Flowers actinomorphic (occasionally zygomorphic): subtending bracts sometimes forming an involucre; perianth 6-merous, segments either free and of equal length, or else with very small outer lobes and larger inner lobes connivent or connate at the apex, forming an erect mitre with 3 holes; tube urceolate to campanulate, longitudinally striate, with a prominent annulus at the tube mouth; stamens 6, generally laterally connate, forming an anther tube, hanging from the annulus, occasionally free. Filaments filiform or taeniform, short; ovary 1-loculate, with 3 parietal placentas, obconical or obovoid; style cylindrical or conical, short, thick; stigmas 3, simple or bilabiate. Fruit fleshy, cupulate, crowned by the persistent, fleshy basal ring of the perianth tube and the style and stigmas, dehiscing by abscission of the apical lid. Seeds numerous, oblong, with reticulate testa.

Distribution - C. 30 spp., distributed in tropical regions of America and Indo-Malesia and temperate Australasia (Tasmania and New Zealand) (Jonker, 1938); 1 further sp., now extinct, was endemic to Illinois, U.S.A. Only T. aseroe and T. fumida have been recorded in Singapore.

Ecology - All Thismia spp. are saprophytic, predominantly occurring among leaf litter of the tropical forest floor. As with other genera in the Burmanniaceae, Thismia possesses several floral characteristics typical of entomophily: some spp. have a brightly coloured annulus with nectar guides directed towards the perianth tube; others have tentacle-like extensions of the perianth, which may act as access routes for insects of the forest floor; the stamens often form a guide, leading the pollinator to the stigma; many have specialized or restricted exit routes for pollinators, ensuring that they brush past the anthers; and some spp. have glandular swellings at the tip of the perianth segments, presumably acting as osmophores, or glands at the base of the perianth (Vogel, 1962, cited in Maas et al., 1986). Stone (1980) suggested that pollination of some spp. may be effected by flies, and cited the mitriform perianth apex with its openings as evidence of the myophilous syndrome. Self-pollination has also been demonstrated in many spp. (Maas et al., 1986). Abscission of the perianth tube following anthesis and the fragility of the membrane covering the ovarian chambers are indicative of seed dispersal by rain-splash (Stone, 1980).

**Key to the Species**

1a. Perianth tube brown to grey-yellow below and bright orange-yellow above, with bright orange-yellow lobes which are red basally; short extensions present between the lobes .................................................. **T. aseroe**

1b. Perianth tube white with pink stripes, and grey-green lobes; extensions between lobes absent ................................................................. **T. fumida**
1. *T. aseroe* Becc.


Herbs, flowering at up to c. 9 cm tall; stem usually unbranched, ± succulent, growing from the creeping white rhizome. *Leaves* appressed, lanceolate, c. 4 mm long, apex obtuse. *Flowers* solitary, terminal on branches; bracts lanceolate, forming an involucre at the flower base, apex acute: perianth tube brown to grey-yellow below bright orange-yellow above, obconic-campanulate, flaring into a narrow rim. c. 10-12 mm long, with a prominent raised annulus at the mouth, basal 5 mm of tube with transverse bars internally; perianth lobes bright orange-yellow with bright yellow or orange tentacles, red at base, triangular, equal-sized, c. 10 mm long, with short extensions of the tube present between the lobes; anthers pendulous from the annulus, with filaments near the top, laterally connate, forming a staminal tube, connective extensions forming broad, dorsal quadrangular wings on the outer margin, with 2 nectaries located in the furrows between extensions, the staminal tube base with several pendulous lobes; ovary obovoid, c. 3 mm long; style short; stigmas 3. *Capsule* c. 5 mm long, ribbed, with persistent style. pedicel lengthening c. 5-7 mm above the involucre. *Seeds* ellipsoid.

Distribution - Singapore: currently there is only 1 known population, in Fern Valley at the Bukit Timah Nature Reserve. Only known from the Malay Peninsula (Singapore and Perak) (Jonker. 1938).

Ecology - Grows in the leaf litter of dense forests.

Notes - The complex floral anatomy is described in detail and illustrated by Groom (1895).


Herbs, flowering at up to c. 10 tall; stem usually unbranched, ± succulent, growing from a brownish rhizome. *Leaves* appressed, lanceolate, apex acute to acuminate. *Flowers* solitary, terminal on branches, c. 5-10 mm long, bracts not
observed; perianth tube white with pink stripes, ± cylindrical, constricted above the ovary and broadened below the limb, without a noticeable apical ring, annulus prominent; perianth lobes grey-green, spreading, lanceolate, apex acute, extensions between lobes absent; anthers not observed; ovary obconical; style very short; stigmas 3, recurved. Capsules cupulate, ribbed, scabrid, crowned by the crenulate basal ring of the perianth. Seeds not observed.

Distribution - T. fimida has only ever been recorded from Petaling in Selangor, Malaysia and Chan Chu Kang in Singapore (Saunders, 1996a).

Ecology - Grows on rotting logs in dense forests.

Notes - The scarcity of collections and their poor quality prevents descriptions of some structures, including the bracts, anthers and seeds. The above description is consequently largely based on that of Ridley (1890) and his drawings, now held in the library of the Royal Botanic Gardens at Kew (published in Saunders, 1996a). As both collections were made in the last century, the sp. is now believed to be extinct in Singapore (Keng, 1987).

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References


OBITUARY

Edred John Henry Corner
12 Jan 1906 - 14 Sep 1996

E.J.H. Corner came out East as a young man in 1929 and served as Assistant Director of the Singapore Botanic Gardens under Professor R.E. Holttum till 1945. His research duties were mainly concerned with the fungi, a great diversity of which are found in the tropics. Through his wanderings in the forests of Singapore and the Malay Peninsula he amassed a great collection of fungi and he also gradually build up an extensive knowledge of trees and palms of the region.

In 1940 Corner published his first book, *Wayside Trees of Malaya*, in two volumes. This work written in his lucid and friendly style is full of detail that reveal a personal familiarity with the subject matter. Now in its third edition, this is still the best book on the common (and many not so common) trees of the area covered. To solve the problem of collecting botanical specimens from tall trees Corner developed an idea inspired by watching monkeys trained to pick coconuts. Acquiring some of these animals, he had them retrained as botanical specimen collectors - the first apes in the civil service.

During the Japanese occupation Corner remained in the Gardens where he was allowed to continue with his research. He left the Gardens in 1946, and after a short interlude with UNESCO in Brazil, took up a teaching position at Cambridge University where he remained until he retired in 1973 as Professor of Tropical Botany. Reputed to be an eloquent and persuasive teacher, he attracted to tropical
botany a steady stream of outstanding students, some of whom remain as leaders in the field.


To the Singapore Botanic Gardens, Corner left behind a legacy of research and scholarship; as part of the rich history and tradition of the Gardens he will continue to inspire new generations of botanists. The colonial bungalow in the Gardens where he lived as Assistant Director has been named E.J.H. Corner House in his honour.

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