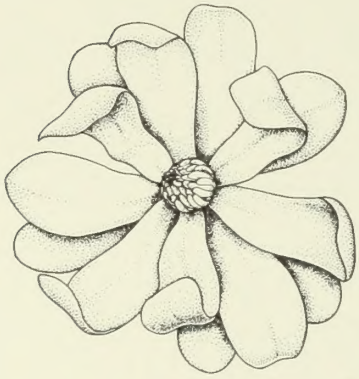

The Gardens' Bulletin

Singapore

VOL. 53 (Part 1 & 2) July 2001 ISSN 0374-7859

NATIONAL PARKS BOARD
Singapore Botanic Gardens Cluny Road Singapore 259569 Tel: 4741165 Telefax: 4754295

THE GARDENS' BULLETIN

The Gardens' Bulletin Singapore publishes papers on plant taxonomy (including revisions), horticulture, phytogeography, floristics, morphology, anatomy and related fields with emphasis on plants in the West Malesian region.

EDITORIAL BOARD

The Gardens' Bulletin is published twice yearly by the National Parks Board, Singapore. Neither the National Parks Board nor the Editorial Board is responsible for the opinions or conclusions expressed by the contributing authors.

The annual subscription for the Gardens' Bulletin is Singapore $100.00 including postage. Overseas subscribers are required to make payment in the form of bank drafts or international money orders in Singapore currency payable to *National Parks Board, Singapore.*

Instructions for contributing authors are found on the inside backcover.

The Gardens' Bulletin

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VOL. 53 (Parts 1 & 2) July 2001 ISSN 0374-7859

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Date of Publication: 31 July 2001

Published by

National Parks Board
Singapore Botanic Gardens
Cluny Road
Singapore 259569

Printed by **Oxford Graphic Printers Pte Ltd**

Gardens' Bulletin Singapore **53** *(2001) 1–7.*

Contributions to the Flora of Mount Jaya VI. A New Banana, *Musa johnsii* (Musaceae) from New Guinea

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Abstract

A new species of banana, *Musa johnsii* Argent, is described and illustrated from Papua (formerly Irian Jaya), Indonesian New Guinea, and its possible position in the genus is discussed.

Introduction

New Guinea is an important centre of diversity for the genus *Musa.* With the addition of this new species, there are ten wild species recorded most of which are endemic. The area is also arguably the richest place in the world for indigenous cultivars (Simmonds 1966), many of which are diploids and potentially important as a gene reservoir. This new banana has all the attributes of a wild species in that it has a non-parthenocarpic seedy fruit and regenerates naturally from seed distributed by animals, yet it has a sterile, non-seedy terminal portion and was cultivated in at least one village (Utekini) for its use as a vegetable.

Terminology and description follow previous tradition as used by Simmonds (1962, 1966) and Argent (1976).

Musa johnsii Argent *sp. nov.*

Species insignis propfer infructescentia densum paene sphaericum fructuum subsessilium primo ad apices truncatis demum irregulariter schizocarpicis. Ab omnibus species *Musae* differt fructu maturo cum tertia parte distali medullae sterilis composita.

Typus: Indonesia: Papua, Freeport mining concession above Timika. 1st Nov 2000 Argent *et al. 00562* (holo BO; iso K, E).

Fig 1 & 2.

Clump forming herbaceous plant. Pseudostem to 4 m tall, 28 cm diam. near the base. Predominantly brown with dead clinging pseudostems,

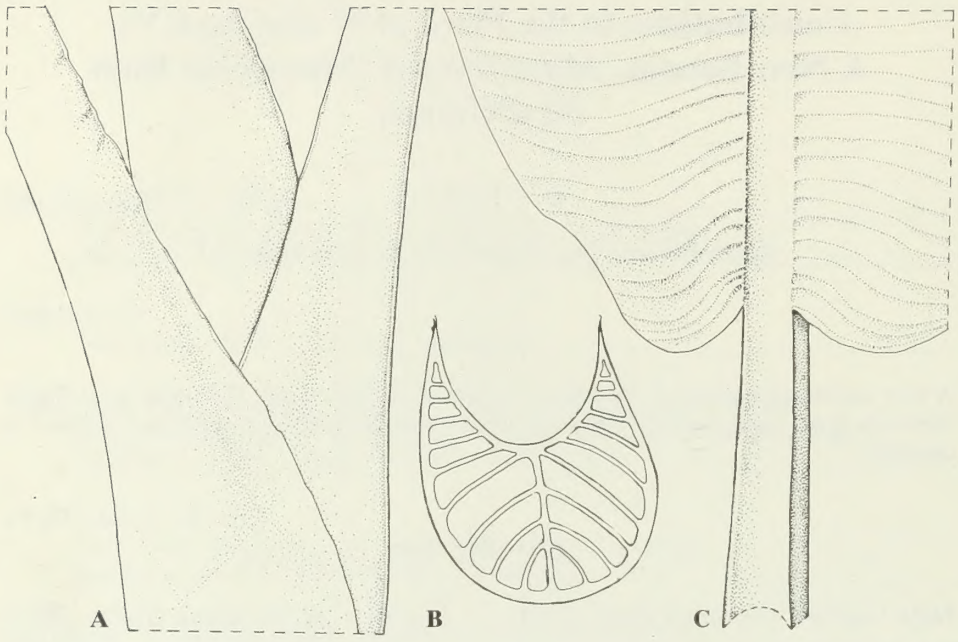

Figure 1. *Musa johnsii*, vegetative features: A. petiole bases x $^1/_4$, B. T.S. petiole x $^2/_3$, C. leaf base x $^1/_4$.

otherwise green with some dark brown coloration in the upper parts, no wax; undersheath cream to white, juice milky white or creamy. Suckering moderate, arising alongside or up to 20 cm from parent, erect or nearly so. Sucker leaves mostly auriculate. Shoulder brown or green, entire, smooth and appressed, without any scarious margin. Fourth last leaf 242 x 88 cm, right handed to c. 8 mm, (almost symmetrical), the base cordate to weakly auriculate. Other leaves often left-handed and predominantly strongly auriculate, all green, hardly different in colour above and below, slightly paler beneath and with the prominent midrib, mostly pale yellow, sometimes with a little brown proximally without obvious wax. Petiole 52 x 4.5 cm, the adaxial channel green, open with only slightly incurved or erect margins which are green, not or only narrowly (to c. 1 mm) scarious, abaxially the petiole dark chocolate brown TS ratio 0.78 (see Argent 1976). PB ratio 4—5.

Peduncle stout, green, glabrous, densely scarred. Bunch horizontal, diagonal or occasionally held completely vertically downwards. The female bracts lanceolate to 54 x 12 cm, yellow, shiny outside, dull yellow and slightly paler inside, acuminate the apical 12 cm with the margins strongly inrolled, completely and quickly deciduous. Female flowers with a few staminodes

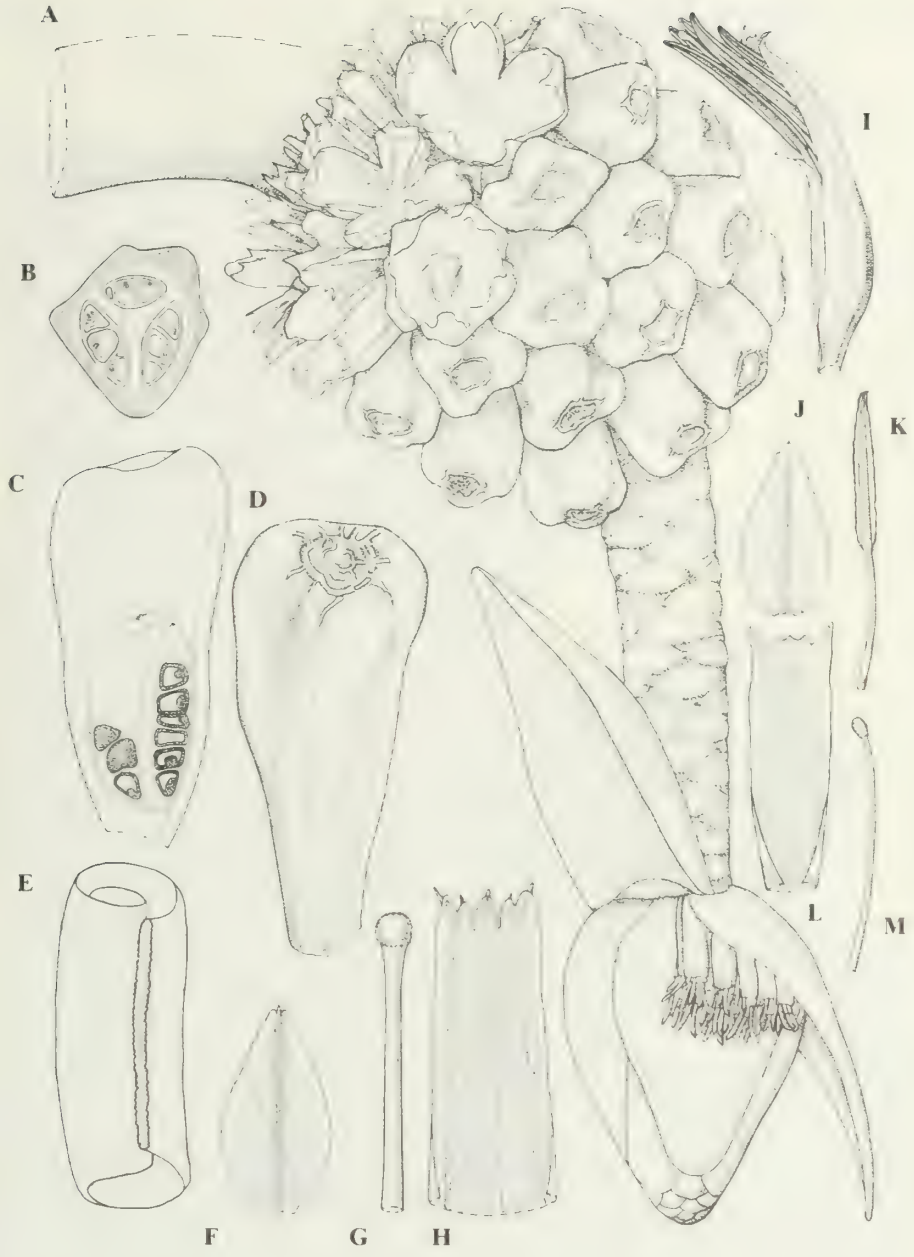

Figure 2. *Musa johnsii*, fertile features: A. habit of fruit bunch with male bud x 1/4. B. T.S. fruit x 1/2. C. L.S. fruit x 1/2. D. whole fruit x 1/2. E. female bract after dehiscence x 1/2. F. free tepal of female flower x 1. G. style and stigma of female flower x 1. H. compound tepal of female flower x 1. I. male flower x 1. J. free tepal of male flower x 1. K. stamen from male flower x 1. L. compound tepal of male flower x 1, M. style and stigma from male flower x 1.

mostly less than half the length of the style, free tepal flushed purple. Ovary trilocular, each locule with the ovules in two rows.

Male peduncle growing vertically downwards. The male bud up to 14 x 11 cm, shiny yellow, imbricate for c. 2 cm from the tip. Male bracts 13 x 7 cm, shiny rich yellow outside, slightly darker near the margins, the tips pale green, shiny yellow inside although becoming dull inside after falling, with broadly rounded, obtuse apices, lifting to a high angle c. 45° to the axis; after falling only recurved at the base not revolute from the apex or margins. Male flowers, two-rowed, falling in a group, cream, the free tepal translucent white, with a rounded, erose upper margin and no wrinkle, just over half as long as the compound tepal. Compound tepal cream with pale yellow apices, the two longest points with irregular papillose to subdenticulate margins.

Fruit bunch dense, sub-spherical in shape to 17 x 18 cm. Fruit two-rowed, the second hand with 14 fruits. The fruits irregular, apparently ageotropic as they show no curvature in any part of the bunch, ripening orange but the surface becoming mostly blackish by full maturity, 8—9 x 2.5—3.5 cm, 3-, 4- or 5-angled, broadly truncate at the apex with large scars up to 2 cm diam., splitting irregularly to reveal pale pinkish orange pith and similarly coloured or yellowish flesh around the seeds in the carpel chambers, the pith white at the base of the fruit; yellow latex exuding from the cut skin of the immature fruit. Pedicel c. 2—3 mm, the fruits almost sessile. Seeds dark brown, 4—5 mm diam., irregular with rounded angles and with a distinctly domed boss opposite the hilum which is c. 2 mm in diam. and vertically striate, also with a raised band on one side from hilum to boss.

Vernacular name: Mel in the Amungkal language of the Amungme Tribe.

Uses: The Amungme people eat this species raw as a vegetable, slicing the young stalks and mixing them with local *Begonia* leaves (*nilmanep*) and salt.

Notes: Named in honour of Professor R.J. Johns who has made a lifetime study of the plants of New Guinea and who first drew my attention to this species.

This new species was a very surprising find on the southern side of the main range north of Timika. It is very distinctive in the dense subspherical bunch of almost sessile fruits, which are rather irregularly schizocarpic, and are truncate at the apex. Unlike any other *Musa* species, it has a sterile mucilaginous pith chamber in the distal third of the mature fruit.

Figure 3. Professor R.J. 'Bob' Johns with the fruit bunch and male bud of *Musa johnsii*.

Two populations were seen. The first where it was semi-cultivated for the edible leaf stalks near Utekini below Tembagapura at about 1600 m. The second was on the Darnell Ridge below the Hanekam Tunnel between 1000—1500 m altitude, where several groups of plants occurred along the roadside well away from any indigenous habitation. The largest of these populations of more than a hundred plants displayed all stages from abundant small seedlings to young clumps, plants flowering in the female phase and older ones with mature fruit and male inflorescences. They thus appear to be totally non-seasonal.

The fruits are puzzling. The distal pith chamber could be an attractive lure to the fruit but, for a wild banana, the number of seeds in the very restricted loculi is very low (an average of 46 for the 5 fruits for which seeds were counted) compared with many hundreds in most other wild *Musa* species. The flesh of this species in either the pith chamber or around the seeds in the loculi did not seem to be particularly palatable and the local people are not reported to eat the fruit at any stage. Animals were certainly visiting the ripe fruits and removing the contents and many of the seeds were damaged in the process. The fact that the female bracts are completely deciduous is remarkable in that the mature fruits are tightly packed in a very dense bunch in the sense of Argent (1976). This is no doubt achieved because of the strong revolution of the bracts from both base and apex, which results in their falling in tight rolls.

This species grows at the highest altitude of the three wild bananas encountered in the Freeport project area around Timika. *Musa banksii* F. Muell. was common in the lowland areas not too swampy and waterlogged. *M. lolodensis* Cheesman occurred mainly at the upper margin of the heath forest at about 500 m altitude, although one clump was seen growing with *Musa banksii* at less than 100 m. Both these species can be easily distinguished from *M. johnsii* even in the sterile state, as they both have broad scarious margins at the upper edge of the leaf sheath or 'shoulders' (Argent 1976). The intense green colour of the foliage and orange colour of the fruit indicate that this species probably belongs in section *Australimusa*. It would appear to be closely related to *M. lolodensis*. The seeds of the two species are remarkably similar. Apart from the vegetative difference mentioned, the fruit of these two species are very different. *M. lolodensis* has a lax bunch of distinctly long pedicellate fruit, which splits in a much more regular fashion on ripening than this new species.

There was another wild banana reported from Mt Jaya, which could be *Musa ingens* Simmonds, but this was not seen by the author. It is very distinct from this new species as it has glaucous waxy pseudostems, a reflexed 'shoulder' and a long pedicillate fruit with much larger seeds 8—9 mm in diameter.

Acknowledgements

This work was made possible with the logistical and financial assistance from PT Freeport Indonesia and Rio Tinto in conjunction with Herbarium Bogoriense, Kebun Raya Bogor and The Biodiversity Centre, Cenderawasih University, Manokwari. I am also grateful to the Royal Botanic Gardens, Kew for permission to join their expedition and to Prof R. J. Johns and Dr T. Utteridge for their companionship and tireless support in organising the expedition. Dr Carolyn Cook provided the local names and much valued help at Tembagapura. The Royal Botanic Garden, Edinburgh gave permission for me to participate in the fieldwork and Ms Christina Oliver ably interpreted the specimens, photographs and crude field drawings. I am indebted to Dr Robert Mill for the translation of the Latin diagnosis.

References

Argent G.C.G. 1976. The wild bananas of Papua New Guinea. *Notes Royal Botanic Garden Edinburgh*. **35**: 77—114.

Simmonds, N.W. 1962. *The Evolution of the Bananas*. Longmans, U.K.

Simmonds, N.W. 1966. *Bananas*. 2nd ed. Longmans, U.K.

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A New *Cryptocoryne* Hybrid (Araceae) from the Bukit Timah Nature Reserve, Singapore

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Abstract

A *Cryptocoryne* from the Bukit Timah Nature Reserve, Singapore, identified for many years as *C. griffithii* Schott, is recognized to be a new hybrid species: *Cryptocoryne xtimahensis* Bastmeijer. It is difficult to accurately determine its parents, but good candidates are *C. nurii* Furtado and *C. cordata* Griff., both native to Johore, Peninsular Malaysia.

Introduction

The first collections of *Cryptocoryne* from Singapore were made in 1890 by H.N. Ridley (1904, 1907, 1925), the first director of the Botanic Gardens Singapore. Two species were recorded: *C. griffithii* Schott from several freshwater localities and *C. ciliata* (Roxb.) Schott from tidal areas. Today, *C. griffithii* is still present in the MacRitchie Reservoir and Nee Soon swamp forest but *C. ciliata* is reported to have disappeared from Singapore (Tan, 1995). The latter is, however, a widespread species, occurring from India to Papua New Guinea, while *C. griffithii* is a rather narrow endemic being known from the south of Peninsular Malaysia (Malacca and Johore), as well as in Singapore. However, today there may be only a few localities left in southern Johore of the Malaysian population.

The main interest in *Cryptocoryne* is as an ornamental plant for aquascaping. This hobby of cultivating tropical plants and keeping fish in aquaria has become very popular in Europe, the USA, and Japan. From the 1950s, Singapore was the main port for shipping wild collected plants to these regions, and plant nurseries developed to satisfy this demand.

The attention of the first author was drawn to the problem of the identity of the Bukit Timah plant by a photograph of *C. griffithii* on the website of the Singapore Science Centre from an article by Tan *et al.*

(1994). The photograph presented there of *C. griffithii* did not match the European idea of *C. griffithii* very well. The same photograph appeared in Foulis *et al.* (1998). In June 1999, there was an opportunity to study the plant in question more closely in the Bukit Timah Nature Reserve. We found the plant flowering abundantly and collected some specimens for further investigations.

A Short History of *Cryptocoryne griffithii* Schott

The identity of the real *C. griffithii* has been in dispute, especially because of the erroneously named drawing in Hooker (1900). Ridley (1904) pointed out that the drawing actually represented his newly described *C. purpurea* Ridl.. In 1920, Engler gave a good description of both species. De Wit (1961) pointed to this problem again, and he was fortunate to get live plants from Malacca, from where Griffith had originally collected his plants. A detailed description of the true *C. griffithii* together with a nice drawing by Ike Zewald is found in De Wit (1961, 1971, 1990) and which closely matches Schott's unpublished drawing in Vienna (W) of *C. griffithii*.

One of the first commercial collectors of *C. griffithii* from Singapore was Y.W. Ong (*pers. comm.*), who collected the plants in the reservoirs and shipped them to Europe as far back as 1948. However, all publications in Europe on this plant in the hobby magazines we could find refer to *C. purpurea*. At that time there was also much confusion about *C. cordata* Griff., which was not well understood, see for example Hoedeman (1948), Wendt (1952), Oskam & Van Ramshorst (1954) and De Wit (1951, 1958a, b). The reason for the lack of notes on *C. griffithii* is probably very simple: the species is very difficult to grow and neither hobbyists nor professionals were able to grow them at that time. But from 1961 onwards, *C. griffithii* was at last a well-known species.

Around the 1970s, taxonomy in *Cryptocoryne* seemed to be resolved (De Wit, 1971), but in the following years the opposite became true. Jacobsen (1982, 1987) suggested a hybrid nature for *C. purpurea*. Jacobsen & Bogner (1986, 1987) gave a detailed review on the *Cryptocoryne* of the Malay Peninsula. Today, with more collections available and many experiments on cultivation, it appears that within some groups there is a near continuous variation, making it in some extreme examples, more or less a matter of taste how to interpret a newly imported plant. Furthermore, polyploidy and natural hybrids have proved to be rather common in *Cryptocoryne*. Today we know a couple of *C. griffithii*-like plants that show some variation. A recent review on *C. griffithii* and *Cryptocoryne* in general is found in Bastmeijer (2000).

With the variation of *C. griffithii* now understood, it is possible to be certain that the Bukit Timah plant is a distinct new hybrid differing, among other characters, from *C. griffithii* in its narrowly ovate leaves, the long apex of the spathe and large, irregular protuberances of the limb. The fact that its pollen fertility was less than 10% and that it had never been found in fruit strongly suggests that it is a hybrid.

Cryptocoryne xtimahensis Bastmeijer notosp. nov. (Araceae)

Lamina spathae protuberationibus irregularibus obtecta, longicaudata (in *C. griffithii* brevicaudata et dense verrucosa), basis laminae plus minusve auriculata (similiter in *C. nurii*), color laminae flavus protuberationibus atrorubis, fauce modice angusta (similiter in *C. nurii*). Folia eis speciei *C. cordata* simillima (sed *C. cordata* differt lamina spathae leavi tota flava) – Typus: Singapore, Bukit Timah Nature Reserve, Jungle Fall Stream. 18 January 2001, dammed pools. Alt. c. 120 m., *R. Kiew, S. Saifuddin, S. Teo & A.T. Gwee RK 5127.* (holo SING; iso C, K).

Rhizome creeping, 0.4—0.8 cm diam., stoloniferous, loosely rooted in the mud or firmly fixed in gravel. Leaves in a rosette; petiole (2.5—)10—15 cm (depending on water depth), dark green, sheathed in the lower part for nearly one fifth of its length; leaf blade ovate, 4.5—8 cm long and 2—4 cm wide, base rounded, margin flat to slightly undulate, apex acute, upper surface dark green, sometimes with dark purple transverse markings, or submerged leaves brownish green; pale green or sometimes tinged reddish beneath.

Peduncle 2—4 cm long. Spathe 10—15 cm long; limb of the spathe 4—5 cm long and c. 1.5 cm wide, apex long caudate, base auriculate and margins reaching each other, upper surface pale yellow with distinct dark red irregular protuberances; collar distinct with a rim and forming a narrow opening to the tube; tube 3—6 cm long and c. 0.5 cm in diameter, outside and inside white; kettle 2—2.5 cm long, and c. 0.7 cm in diameter, outside white, inside white without purple markings. Spadix usually with 6 female flowers at the base, these pale green; stigmas white, more or less elliptic; olfactory bodies small, yellow; naked axis between male and female flowers c. 0.5 cm long, white; male part cylindrical, yellow, male flowers 50 – 60, each male flower usually consisting of two stamens; appendix cone shaped, c. 2 mm long, white; flap above the male flowers white. Fruit and seeds not known.

Emersed cultivated plants much smaller; leaves c. 10 cm long; peduncle c. 1 cm long; spathe c. 6 cm long.

1a. Dammed pools on the Jungle Fall Stream in the Bukit Timah Nature Reserve, Singapore.

photo Bastmeijer

1b. Limb of the spathe of *Cryptocoryne* x*timahensis*.

photo Bastmeijer

1c. Cultivated plant of *Cryptocoryne* x*timahensis*.

photo van Wijngaarden

1d. Opened kettle showing the female (bottom) and male flowers (top).

photo van Wijngaarden

Figure 1. A new *Cryptocoryne* hybrid from the Bukit Timah Nature Reserve, Singapore

Chromosome number: 2n = 54. Pollen fertility < 10%. Vouchers at Copenhagen (C).

Other collections examined: All from Bukit Timah in Jungle Fall Valley – the type and *J. Bastmeijer 807* (L), *P. Blanc 91-1* (SING), *K.S. Chua 333* (SINU), *D. Nicolson 1367* (US) and *J. Sinclair 5200* (E).

Discussion

While plants identified as *Cryptocoryne griffithii* are known from several localities from Singapore, this new hybrid has only been collected from Bukit Timah. (There is just one collection, *Ridley s.n.* 1892 (SING), from Bukit Timah that may be *C. griffithii*). All collections of *C. xtimahensis* are from the Jungle Fall Valley, where the plant grows in two pools formed up- and down-stream by an artificial dam in the tiny stream (Fig. 1a). Constructed during the Japanese Occupation, it is currently silted up. The hybrid appears to be restricted to these pools.

The first systematic analyses of pollen fertility and chromosome numbers in *Cryptocoryne* were made by Jacobsen (1977) and Arends *et al.*(1982). With pollen fertility near zero for this plant, we are no doubt dealing with a hybrid. In addition, compared with *C. griffithii* in Singapore, for which half the herbarium specimens were collected in fruit, none of the herbarium specimens of this Bukit Timah population have fruits nor have fruits been observed in the field.

The hybrid status is not, however, unique for *Cryptocoryne*. The popular aquarium species *C. xwillisii* Reitz from Sri Lanka forms a complex of hybrids in which *C. parva* De Wit is one of the parents, the other parent may be *C. beckettii* Trimen, *C. walkeri* Schott or *C. undulata* Wendt (Jacobsen 1981a,b). Another example is found in Tasek Bera, Peninsular Malaysia, where a very big population of *C. purpurea* grows (often erroneously ascribed to *C. griffithii*), which also has a pollen fertility of about zero and is today regarded as a hybrid between *C. cordata* and *C. griffithii* (Jacobsen 1987).

In classifying *Cryptocoryne* species, the main characters used are those of the limb of the spathe. *C. xtimahensis* has large, irregular, red protuberances on the limb of the spathe, the collar is very pronounced and the base of the limb is cordate (Fig. 1b). These characters are distinct from those of *C. nurii*, where the limb of the spathe is rather elongated and has a yellow background, characters shared by *C. cordata*.

In addition, the leaves of *C. xtimahensis* are narrowly ovate with a rounded to cordate base and an acute tip as are those of *C. cordata*. The

transverse markings on the upper leaf surface of most plants of C. x*timahensis* (Fig. 1c) are also a character of *C. nurii*.

The combination of these characters makes *C. griffithii* less likely as one of the parents. The limb of *C. griffithii* is verrucose with small, regular bumps, although the collar is very pronounced too. However, the leaves of *C. griffithii* are broadly ovate. Both *C. nurii* and *C. cordata* grow in the southern part of Johore, Peninsular Malaysia but have never been recorded from Singapore. An artificial cross between these two species would be very interesting but would be very difficult to perform, because neither of the species is easy to cultivate. DNA analysis should be able to elucidate the exact parentage.

Base chromosome numbers in *Cryptocoryne* are x = 10, 11, 14, 15, 17 and 18. Polyploidy is rather common in *Cryptocoryne* and even rather long polyploid series exist (Arends *et al.*, 1982). The chromosome number of this new hybrid, 2n = 54, is remarkable because it could indicate that this plant is of triploid origin with base number 18. This number is known only from three Sri Lankan species, the *C. crispatula*-group from mainland Asia, and the tidal species *C. lingua* Engl. from Sarawak. All known species from the Malay Peninsula have base number 17, except for the distinct *C. longicauda* Becc. *ex* Engl. (also known from Sumatra and Borneo), which has base number 15 and the tidal species *C. ciliata*, which has base number 11. The number 2n=54 may be explained as originating from a triploid number with 2n = 51 after which a second generation of aneuploid segregation may have occurred (Ørgaard *et al.* 1995).

The Future of *Cryptocoryne* Habitats in Singapore

The status of the Bukit Timah Nature Reserve provides a safe habitat for this plant. However, *C.* x*timahensis* occupies a very restricted area c. 10 m long and 3 m wide. It is therefore extremely vulnerable to any hydrological changes to this one particular stream. *C. griffithii* seems to be rather common in the reservoirs (Chan, 2000), and provided there is no change in land use will not be threatened.

C. ciliata, the other native *Cryptocoryne* of Singapore, is said to have been re-introduced with material originating from southern Johore.

On the other hand, several species of *Cryptocoryne* have been introduced in the past, for example *C. wendtii* De Wit, *C.* x*willisii* Reitz from Sri Lanka, and *C. lingua* from Sarawak (Chan, 2000). They probably 'escaped' by accident from the numerous nurseries, which produced - from the 1960's onwards - large quantities of these popular plants for aquascaping, mainly for export. It will be interesting to investigate the flora of Singapore in this respect.

Acknowledgements

The National Parks Board of Singapore is acknowledged for permission to collect in the Bukit Timah Nature Reserve and to J. Lai and S. Saifuddin for showing JDB the population. The aquatic plant firms Tropica (Denmark) and Oriental (Singapore) were of great help during JDB's stay in Singapore. Gitte Petersen (Copenhagen, Denmark) made the chromosome counts. Dr. H. Roessler (Munich, Germany) translated the diagnosis into Latin. Piet van Wijngaarden cultivated the plants in the Netherlands and was able to flower them after a couple of months. Niels Jacobsen (Agricultural University, Copenhagen, Denmark) and Josef Bogner (Botanical Garden, Munich, Germany) are acknowledged for their great support in discussing taxonomic problems in *Cryptocoryne*, and for comments on the manuscript.

References

Arends, J.C., J.D. Bastmeijer and N. Jacobsen. 1982. Chromosome numbers and taxonomy in *Cryptocoryne* (Araceae).II. *Nordic Journal of Botany*. **2**: 453—463.

Bastmeijer, J.D. 2000. The Crypts Pages. http: users.bart.nl~crypts index.html

Chan, S.Y. 2000. The Freshwater Macrophytes of Singapore. http: molluscan.com/macrophytes

Engler, A. 1920. Araceae - Aroideae *Cryptocoryne*. *Das Pflanzenreich*. **IV.23.F**: 232—249.

Foulis, L. *et al.* (eds.) 1998. *Botanica*. 2nd ed. Periplus Editions, Singapore.

Hoedeman, J.J. 1948. Het geslacht *Cryptocoryne* Fischer, 1928. *Het Aquarium* **19**(3): 61—64.

Hooker, J.D. 1900. *Cryptocoryne griffithii*. *Botanical Magazine* **126**, pl. 7719.

Jacobsen, N. 1977. Chromosome numbers and taxonomy in *Cryptocoryne* (Araceae). *Botanisher Notiser*. **130**: 71–87.

Jacobsen, N. 1981a. *Cryptocoryne undulata* Wendt und Bemerkungen zu anderen Arten. *Aqua-Planta*. **6**(2): 31—38.

Jacobsen, N. 1981b. *Cryptocoryne undulata* Wendt und Bemerkungen zu anderen Arten – Ein Nachtrag. *Aqua-Planta.* **6**(4): 92—94.

Jacobsen, N. 1982. *Cryptocorynen*. Kernen Verlag. Stuttgart, Germany.

Jacobsen, N. 1987. *Cryptocoryne purpurea* Ridley. *Aqua-Planta* **12**(2): 61—62.

Jacobsen, N. and J. Bogner. 1986. Die Cryptocorynen der Malaiischen Halbinsel (1.Teil). *Aqua-Planta.* **11**(4): 135—139.

Jacobsen, N. and J. Bogner. 1987. Die Cryptocorynen der Malaiischen Halbinsel (2.Teil). *Aqua-Planta.* **12**(1): 13—20.

Ong, Y.W. 1999. *Private communication*. Singapore.

Ørgaard, M., N. Jacobsen and J.S. Heslop-Harrison. 1995. Molecular cytogenetics in the genus *Crocus* L. In: P.E. Brandham and M.D. Benneth (eds.). *Kew Chromosome Conference IV*, pp. 291-299. Royal Botanic Gardens, Kew, U.K.

Oskam, H.C. and J.D. van Ramshorst. 1954. *Cryptocoryne griffithii* Schott. *Het Aquarium.* **24**(7): 146—149.

Ridley, H.N. 1904. New Malayan Plants. *Journal of the Straits Branch of the Royal Asiatic Society* **41**: 44—45.

Ridley, H.N. 1907. *Cryptocoryne. Materials for a Flora of the Malayan Peninsula*. Pp. 3-6.

Ridley, H.N. 1925. *Cryptocoryne. The Flora of the Malay Peninsula*. **5**: 86—88.

Schott, H.W. 1856. Aroideae. *Synopsis Aroidearum.* **1**: 1—3.

Tan, H.T.W. 1995. *A Guide to the Threatened Plants of Singapore*. Singapore Science Centre, Singapore.

Tan, H.T.W., I.M. Turner, Y.C. Wee and K.S. Chua. 1994. Plants in the Singapore Red List. *Singapore Scientist.* **72**: 26—32.

Wendt, A. 1952-1958. Die Gattung *Cryptocoryne* Fischer. *Die Aquarienpflanzen in Wort und Bild.* Stuttgart, Germany.

Wit, H.C.D. de. 1951. *Cryptocoryne cordata, Cryptocoryne griffithii. Het Aquarium.* **22**(6): 128—129.

Wit, H.C.D. de. 1958a. *Cryptocoryne griffithii*. *Fishkeeping*. January: 138.

Wit, H.C.D. de. 1958b. *Cryptocoryne griffithii* and its allies. *Fishkeeping*. February: 230.

Wit, H.C.D. de. 1961. Het genus *Cryptocoryne* (17). *Het Aquarium*. **31**(10): 232—233.

Wit, H.C.D. de, 1971. *Aquarienpflanzen*. Ulmer, Stuttgart, Germany.

Wit, H.C.D. de, 1990. *Aquarienpflanzen*. 2nd ed. Ulmer, Stuttgart, Germnay.

Gardens' Bulletin Singapore **53** *(2001) 19–74.*

The Genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae-Monstereae) in Borneo

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Abstract

An alpha-taxonomic account of Bornean *Rhaphidophora* is presented as a precursor to the forthcoming Flora Malesiana *Araceae* treatment. Thirteen species are recognized, none novel. *Rhaphidophora elliptica* Ridl. 1905 (*non* 1908 = *R. elliptifolia* Merr.) and *R. megasperma* Engl., treated respectively as synonyms of *R. montana* (Blume) Schott and *R. puberula* Engl. by Boyce (1999), are resurrected as Bornean endemics. New synonyms are: *Scindapsus havilandii* Ridl., *Rhaphidophora jaculiformis* Alderw., *R. subfalcata* M. Hotta into *R. megasperma*, and *R. nigrescens* Ridl. into *R. sylvestris* (Blume) Engl. A dichotomous key to species is provided. All species are illustrated.

Contents

Introduction

Rhaphidophora Hassk. (including *Afrorhaphidophora* Engl.; c. 3 species in tropical Africa) comprises c. 100 species of small to large, occasionally enormous, root-climbing lianes (*sensu* Schimper, 1903), rarely rheophytes, distributed from tropical West Africa eastwards to the western Pacific, north to southern Japan (Ryukyu Islands) and south to Northern Australia. *Rhaphidophora* is one of the largest aroid genera represented in tropical Asia and has several nodes of diversity; the Himalaya (SE Nepal to NE Vietnam, roughly 17°—23° N), West Malesia (including southernmost peninsular Thailand), the Philippines, and East Malesia.

This is the fifth in a series of papers intended to present a complete

alpha-taxonomy of the genus *Rhaphidophora* in Asia. Accounts for Peninsular Malaysia and Singapore, the southern and western Indonesian archipelago and the Philippines have been published recently (Boyce, 1999, 2000a, 2000b) together with a partial account for New Guinea (Boyce & Bogner, 2000) and an account for Papuasia and the tropical Western Pacific appears elsewhere in this journal (Boyce, 2001). Accounts for the Himalaya, and Thailand and Indochina are being prepared and will be published separately. All morphological terms employed follow Stearn (1992).

The last complete revision of *Rhaphidophora* was that of Engler & Krause (1908). A summary of the taxonomic and nomenclatural history of *Rhaphidophora* was presented in Boyce (1999) and a partial infrageneric classification with an overview of informal morpho-taxonomic groups was proposed by Boyce (2000a). Boyce (1999) provides a detailed discussion of structure, generic limits, together with keys to the genera of monsteroid and anadendroid aroids in Malesia.

Synonymy cited is for the species, not for the review area. The reason for this is that synonymic names based on types from outside the review area are frequently applied to specimens in local herbaria.

Geography and Endemism

Borneo has a relatively poor *Rhaphidophora* flora, with comparatively few species recorded, although how much this is a reflection of inadequate collecting is not clear. However, of the 13 species recognized for the island five are endemic (compared with 2/15 in Peninsular Malaysia; 4/15 in Sumatera) and thus Borneo has, with the exception of the Philippine islands (7/11), the highest level of endemism in Sunda.

Two of the five Bornean endemics, *R. elliptica* Ridl. and *R. elliptifolia*, belong to the Indo-Malesian Hongkongensis Group (see Boyce, 2000a). Both Bornean endemics are morphologically close to west Malesian species (*R. elliptica* to *R. montana* (Blume) Schott; *R. elliptifolia* to *R. maingayi* Hook.*f.*) and are presumably endemic segregates. Another species from this group, the widespread *R. sylvestris* (Blume) Engl. (Sumatera, Peninsular Malaysia, Thailand, east to Borneo) is widespread and common in Borneo. The other Bornean endemics are *R. latevaginata* M. Hotta, *R. megasperma* Engl. and *R. cylindrosperma* Engl. & K. Krause.

Rhaphidophora latevaginata M. Hotta is a neotenic shingling species that might conceivably have arisen from a species with a pronounced heteroblastic development, e.g., *R. korthalsii* Schott (see Boyce, 2000a).

Rhaphidophora megasperma is of uncertain affinity in Sundaic Asia but has morphological similarities, e.g., clustered inflorescences subtended

by chartaceous cataphylls, to certain New Guinea species (e.g., *R. versteegii* Engl.) and is tentatively included in the Hollrungii Group (note that this group had its name changed in Boyce, 2001).

Rhaphidophora cylindrosperma is another morphologically isolated species in Sunda but with similar species (e.g., *R. schlechteri* K. Krause) east of Wallace's Line and belongs to the Neoguineensis Group. It is interesting that two of the Borneo endemic *Rhaphidophora* appear to be morphologically closer to species in Wallacean New Guinea than to any Sundaic species.

RHAPHIDOPHORA

Rhaphidophora Hassk., Flora 25 (2) Beibl. 1 (1842) 11; Schott, Gen. Aroid. (1858) 77 & Prodr. Syst. Aroid. (1860) 377—388; Miquel, Ann. Mus. Bot. Lugd.-Bat. 3 (1867) 81—82; Engl. in A. & C. DC., Monogr. Phan. 2 (1879) 238—248; Engl. in Beccari, Malesia 1 (1882) 266—272, Tab. xix 6—9, xx 1—5; Benth. & Hook. f., Gen. Pl. 3(2) (1883) 993 - 993; Engl. & Prantl, Nat. Pflanzenfam. T. 2, Ab. 3 (1889) 119—120; Engl. & Prantl, Nat. Pflanzenfam. Nachtr. 1 (1897) 58; Ridl., J. Straits Branch Roy. Asiat. Soc. 44: 185—187 (1905); Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 17—53; Engl. & Prantl, Nat. Pflanzenfam. Nachtr. 3 (1908) 29; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 88—90; Schott, Icones aroideae et reliquiae (IDC Microfilm) (1983) fiche nos. 28—31, 121; Mayo *et al.*, Genera *Araceae* (1997) 118—121, Pl. 14, 109 D. — *Scindapsus* Schott subgen. *Rhaphidophora* (Hassk.) Miq., Flora Ned. Indië 3 (1856) 185. — Type: *Rhaphidophora lacera* Hasskarl, *nom. illeg. pro. Pothos pertusus* Roxb. [= *Rhaphidophora pertusa* (Roxb.) Schott]

Scindapsus Schott subgen. *Pothopsis* Miq., Flora Ned. Indië 3 (1856) 187. — Type: *Scindapsus sylvestris* (Blume) Kunth [= *Rhaphidophora sylvestris* (Blume) Engl.]

[*Raphidophora* Hassk., Cat. Hort. Bogor. (1844) 58, *orth. var.*]

Medium-sized to very large, occasionally enormous, slender to robust, leptocaul or pachycaul, homeophyllous or heterophyllous, rarely neotenic [e.g., some populations of *R. beccarii* (Engl.) Engl.], root-climbing lianes, very seldom clustering and rheophytic (e.g., *R. beccarii*) and then always with a creeping juvenile stage; cut surfaces producing clear, odourless sticky juice either drying ± invisible or coagulating into yellowish, translucent jelly and eventually hardening to a brittle amber-like mass; *seedling stage*

mostly not observed but where known either leafy at germination and skototropic (see Strong & Ray, 1975) by an alternating series of congested leafy and elongated leafless shoots (e.g., *R. angustata* Schott) or germinating to give rise to a non-skototropic shingling juvenile shoot (e.g., *R. korthalsii*); *pre-adult plants* often forming modest to extensive terrestrial colonies of varying morphological and physiological form (descriptive generalisations are nearly impossible), largest terrestrial colonies generally occurring in places of less than optimum adult growth potential (e.g., depauperate tree canopy, dry, exposed sites); *adult shoot architecture* broadly divisible into three types: i. physiognomically unbranched clinging non-flowering stems rooting along their entire length giving rise to variously elaborated free lateral flowering stems (e.g., *R. lobbii* Schott, *R. puberula* Engl.), *or* ii. all stems physiognomically unbranched clinging and flowering (e.g., *R. korthalsii*), *or* iii. physiognomically unbranched leader and lateral stems clinging but only lateral stems flowering (e.g., *R. foraminifera*); *stems* with internodes of various lengths separated by variously prominent leaf scars, smooth or asperous or densely pubescent to ramentose (the last not in the review area), older stems subwoody or somewhat corky or with distinctive matt to sublustrous pale brown papery epidermis, with or without variously textured prophyll, cataphyll and petiolar sheath fibre either at the tips or along the newer sections, rarely with cataphylls and prophylls deliquescing to black mucilage later drying to leave fragmentary parchment-like remains on petioles, developing laminas and inflorescences; *flagellate foraging stems* occurring in some species, often exceedingly long, reaching the ground then rooting, variously foraging and climbing again; *clasping roots* sparsely to densely arising from the nodes and internodes, clinging to substrate; *feeding roots* rare to abundant, smooth, pubescent or prominently scaly, later often becoming woody, clinging to substrate or free; *leaves* distichous or weakly spiralled, evenly distributed or scattered or clustered distally; *cataphylls and prophylls* subcoriaceous to membranous, either soon drying and falling or degrading or deliquescing to variously textured sheaths and fibres, these where present variously clothing upper stem before eventually decaying and falling; *petiole* canaliculate to weakly carinate, smooth or pubescent, with variously prominent apical and basal genicula; *petiolar sheath* prominent, nearly reaching to overtop the geniculum, occasionally one side greatly expanded and auriculate, especially in juvenile plants, at first membranous to coriaceous, soon completely or along the margins drying chartaceous, sometimes degrading to untidy variously netted or simple fibres and later variously falling to leave a scar or disintegrating marginally or completely; *lamina* submembranous to stiffly chartaceous or coriaceous, lanceolate or oblong, ± oblique, base decurrent to unequal or cordate, apex acute to acuminate, entire to regularly pinnatifid or

perforated, if pinnate then divisions pinnatifid to pinnatisect (Stearn, 1992: 324), midrib often ± naked between segments, lamina occasionally with small to well developed perforations adjacent to the midrib and primary veins, these sometimes extending to lamina margin (fenestrations then occasionally additional to fully developed pinnae), rarely abaxially pubescent when expanding, rarely strongly concolorous at maturity; *midrib* usually prominent raised abaxially and prominently sunken, sometime flush, rarely slightly raised adaxially; *primary venation* ± pinnate; *interprimaries* mostly present, subparallel to primaries and sometimes indistinguishable from them (e.g., *R. monticola* - Philippines) but usually less prominent and often drying paler, usually glabrous, occasionally pubescent with domatia in the axils of the primary and secondary veins; *secondary venation* striate (e.g., *R. monticola*—Philippines) to reticulate (e.g., *R. korthalsii*), variously prominent, often very difficult to distinguish from primary venation (e.g. *R. angustata*); *tertiary venation* where visible reticulate to tessellate; *inflorescences* solitary to several together, first inflorescence subtended by a (usually fully developed) foliage leaf and or a very soon disintegrating cataphyll, subsequent inflorescences usually each subtended by a prophyll and cataphyll, more rarely by a prophyll and partially to almost fully formed foliage leaf, inflorescences at male anthesis naked by disintegration of subtending cataphyll or partially to almost completely obscured by netted and sheet-like fibres; *peduncle* terete to laterally compressed; *spathe* ovate to narrowly or broadly canoe-shaped, stoutly to rather weakly beaked, barely gaping to opening almost flat at male anthesis and then usually deciduous before male anthesis is complete, occasionally persisting into the early stages of infructescence development (e.g., *R. angustata*), rarely drying and persistent (e.g., *R. megasperma*), stiff to rather softly or stoutly coriaceous, dirty-white, greenish, cream or yellow; *spadix* subglobose to clavate-cylindrical, cylindrical or fusiform, sessile or stipitate, often obliquely inserted on peduncle, tapering towards the apex; *flowers* bisexual, naked; *ovary* 1- to partially 2-locular, lower part ± bilaterally compressed, upper part ± cylindrical and variously angled, most often rhombohexagonal, those upper- and lower-most on the spadix often sterile and bereft of stigma, those uppermost frequently either scattered or partially fused to each other and forming a rudimentary appendix; *ovules* few to many, anatropous, funicle long, placentae parietal to basal, sometimes ± subaxile, partial septa variably intrusive; *stylar region* well developed, usually broader than ovary, usually truncate apically, rarely elongate-conic; *stigma* sticky at female male anthesis, punctiform, broadly elliptic or oblong, orientation circumferential or longitudinal; *stamens* 4—6; *filaments* strap-shaped; *anthers* usually prominently exserted from between ovaries at male anthesis, rarely not exserted and pollen extruded from between ovaries, thecae dehiscing

by a longitudinal slit; *infructescence* with stylar regions greatly enlarged, transversely dehiscent, the abscission developing at the base of the enlarged to massive stylar region and this falling to expose the ovary cavity with the many seeds embedded in variously coloured sticky pulp; *seeds* oblong, testa thin, smooth, embryo axile, straight, endosperm copious; *pollen* dicolpate, extended monosulcate to fully zonate, ellipsoid or hamburger-shaped, medium-sized (mean 33 µm, range 24—55 µm) (Mayo *et al*, 1997), exine foveolate, subreticulate, rugulate, fossulate, scabrate, retiscabrate, verrucate, or psilate; *chromosomes* 2n = 60, 120 (42, 54, 56) (Mayo *et al*, 1997).

Distribution: About 100 species from tropical Africa, South and South East Asia, Australia and the Pacific with extensions into the subtropical Himalaya, southern China and the southernmost islands of Japan.

Habitat: Lianescent bole-climbers, lithophytes, rarely rheophytes, usually in well drained subtropical and tropical wet, humid, or seasonally moderately dry primary and established secondary evergreen forest at low to mid-montane elevations.

Etymology: Greek *rhaphis*, *rhaphidos* (needle) and *pherô* (I bear); refers to the macroscopic (to 1 cm long), needle-like unicellular trichosclereids present in tissues.

Key to Adult Flowering Rhaphidophora in Borneo

1a. Mature leaf lamina pinnately divided 2
1b. Mature leaf lamina entire, without or without perforations, but never pinnately divided 3

2a. Flowering plants usually rheophytic, rarely low-climbing on trees beside torrential streams. Plants always associated with sandy or rocky forest streams. ..... **1. R. beccarii**
2b. Flowering plants high-climbing on forest trees. Plants not specifically associated with watercourses ..... **7. R. korthalsii**

3a. Geniculum and abaxial surface of lamina pubescent 4
3b. Geniculum and abaxial surface of lamina glabrous 5

4a. Flowering on clinging stems. Leaves of mature plants extensively perforated. Active shoot tips with black mucilage .....

..... **6. R. foraminifera**

4b. Flowering on free lateral stems. Leaves of mature plants lacking or with only with scattered, perforations. Active shoot tips lacking black mucilage ..... **12. R. puberula**

5a. Leaves always shingling, even in flowering individuals; leaf laminas stiffly coriaceous, broadly oblong-ovate-elliptic, 8—48 x 6.5—20.5 cm, bright green, slightly to markedly glaucous, base truncate-cordate to broadly cuneate. Flowering on clinging shoots .....
..... **8. R. latevaginata**

5b. Leaves spreading in adult and flowering individuals; leaf laminas variously coloured but never glaucous. Flowering on free or clinging shoots 6

6a. Stems scabrid to asperous. Spathe exterior minutely puberulent ....
..... **9. R. lobbii**

6b. Stems smooth. Spathe exterior glabrous 7

7a. Clinging stems square or rectangular in cross-section; tips of active stems with netted prophyll, cataphyll and petiolar sheath fibre .....
..... **4. R. elliptica**

7b. Clinging stems variously shaped in cross-section, including square or rectangular; tips of active stems without fibres 8

8a. Spadix stipitate; leaf lamina thickly coriaceous.... **2. R. conocephala**

8b. Spadix sessile; leaf lamina variously textured but never thickly coriaceous 9

9a. Inflorescences two, three or more together, each subtended by a prominent chartaceous prophyll and one or more chartaceous cataphyll; leaf lamina oblong-lanceolate or oblong-elliptic, entire to slightly perforated, glabrous..... **10. R. megasperma**

9b. Inflorescences almost always solitary, if two together then inflorescences not subtended by prominent chartaceous prophylls and cataphylls; leaf lamina variously shaped and almost never perforated, if perforated then apical geniculum and abaxial surface of lamina pubescent..... 10

10a. Clinging stems rectangular in cross-section 11

10b. Clinging stems more-or-less terete in cross-section 12

11a. Leaf lamina lanceolate-elliptic to falcate-lanceolate, 4.5—32 x 1.75—8.5 cm. Spadix cylindric to weakly clavate-cylindrical, 3—6 cm long ..... **13. R. sylvestris**

11b. Leaf lamina narrowly elliptic to narrowly elliptic-oblong, 20—29 x 4.5—7 cm. Spadix cylindrical, c. 5 x 1 cm ..... **5. R. elliptifolia**

12a. Leaf lamina narrowly falcate-elliptic to falcate-lanceolate or falcate-oblanceolate, 2.5—16 x 1.2—3 cm, drying uniformly pale straw-coloured. Spadix slender cylindrical, 2.5—7 cm long ... **11. R. minor**

12b. Leaf lamina subfalcate-lanceolate or oblong-elliptic, oblique, 10—19.5 x 2.5—6.5 cm, drying very dark brown. Spadix cylindrical-obtuse, 3—10 x 1 cm (fruiting specimen only) ..... **3. R. cylindrosperma**

The Species

1. Rhaphidophora beccarii (Engl.) Engl.

Rhaphidophora beccarii (Engl.) Engl. in Bot. Jahrb. Syst. 1 (1881) 181 & in Beccari, Malesia 1 (1882) 270, Tab. xix 6—9; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 46; Alderw., Bull. Jard. Bot. Buitenzorg III, 1 (1920) 382; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 88; Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 341. — *Epipremnum beccarii* Engl., Bull. Soc. Tosc. Ortic. 4: 268 (1879). — Type: Malaysia, Sarawak, Kuching, Oct. 1865, *Beccari PB 833* (cited as '*832*' by Engler, 1879) (FI, holo).

Rhaphidophora borneensis Engl. *Araceae exsicc. et illustr. n.* 195 & in Bot. Jahrb. Syst. 7, Beibl. 15 (1886) 1. — Type: Indonesia, Kalimantan, Mindai to Pramassan, 19 June 1882, *H. Grabowski s.n.* (B†, BM).

Rhaphidophora fluminea Ridl., J. Straits Branch Roy. Asiat. Soc. 44 (1905) 186; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 37; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 89. — Type: Malaysia, Sabah, Bongaya, Dec. 1897, *Ridley s.n.* (SING, holo).

Figure 1

Small to medium-sized, heterophyllous, sometimes homeophyllous, creeping rheophyte, very rarely short liane, to 75 cm; *seedling stage* a non-skototropic shingling shoot, soon becoming spreading-leafy; *pre-adult plant* initially with ± appressed shingle-leaves, later with leaves erect or spreading and at this stage plants resembling adults in all but overall size and leaf division;

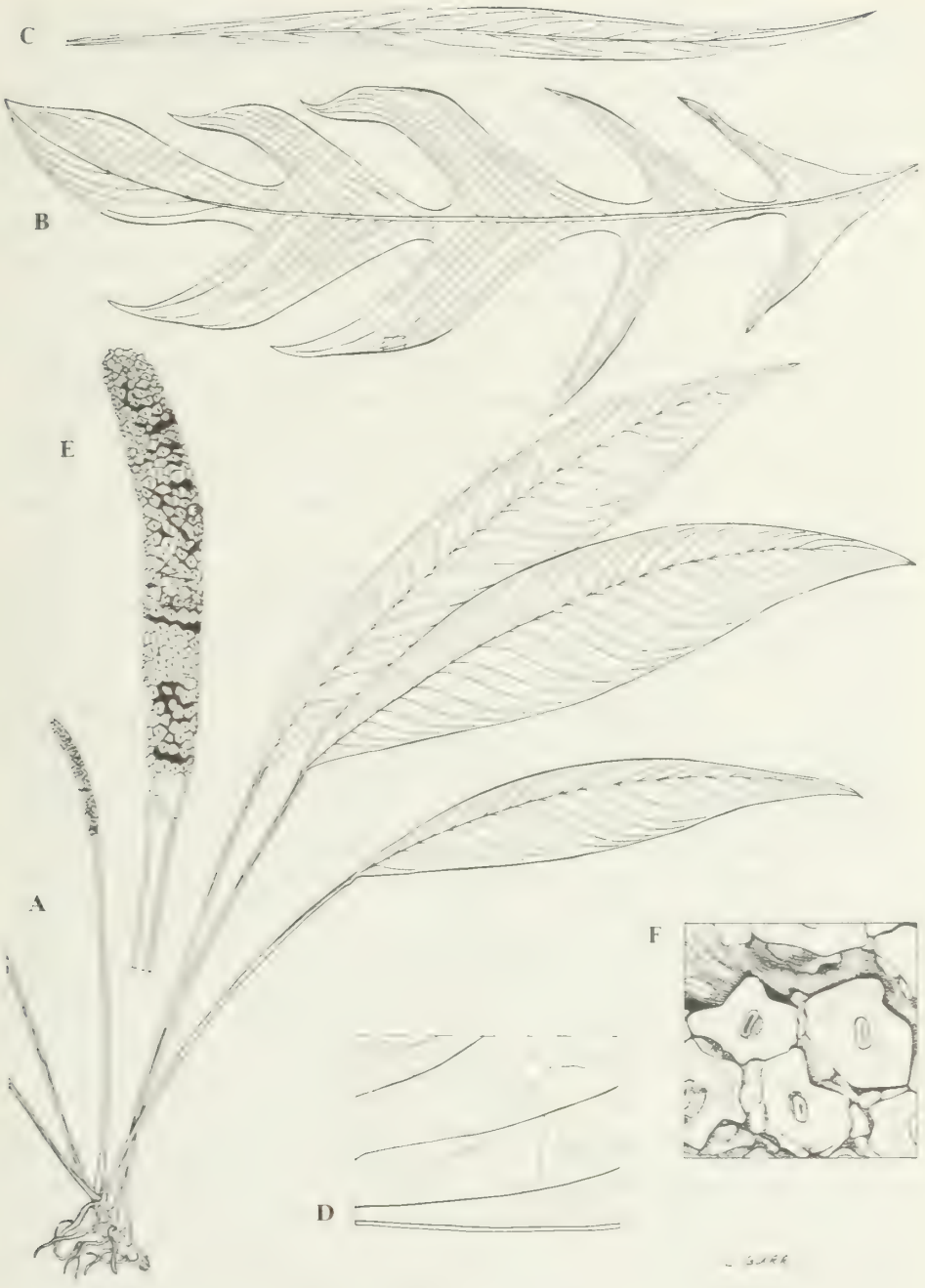

Figure 1. Rhaphidophora beccarii (Engl.) Engl.
A, habit x ½; B, leaf lamina x ½; C, leaf lamina x ½; D, venation detail x 4; E, inflorescence, spathe fallen x 1; F, spadix detail, post-female anthesis, pre-male anthesis x 8. A, E & F from *Stone 9637*; B & D from *Ridley s.n.*; C from *Kiew 1982*.

adult shoots clinging and flowering but main axis comprised of longer modules than axillary axes; *stems* smooth, mid- to dark green, with very sparse petiolar sheath fibre, internodes 1—7 x c. 1 cm, separated by variously prominent slightly oblique leaf scars; *flagellate foraging stems* absent; *clasping roots* very densely arising from the nodes and internodes of clinging stems, pubescent; *feeding roots* clinging, densely scaly; *leaves* distichous, appressed and shingling to erect or spreading and scattered on pre-adult shoots, tending to become distally clustered on adult shoots; *cataphylls and prophylls* membranous, soon drying and falling; *petiole* narrowly canaliculate to carinate, 8—31 x 0.3—1.5 cm, smooth, apical and basal genicula prominent; *petiolar sheath* prominent, extending to the apical geniculum, variably persistent and mostly degrading into semi-persistent weak fibres; *lamina* entire in seedling and pre-adult individuals, entire, pinnatipartite or pinnatisect in adult plants, narrowly lanceolate to oblong-elliptic, slightly oblique, 21—51 x 2—23 cm, subcoriaceous to slightly fleshy, base decurrent, apex acuminate with a moderately prominent apicule; *midrib* prominently raised abaxially, sunken adaxially; *primary venation* pinnate, raised abaxially, slightly impressed adaxially; *interprimaries* subparallel to primaries, slightly raised abaxially, ± flush adaxially, often forming a weak reticulum; *secondary venation* prominently reticulate, slightly raised; *tertiary venation* a network of broadly spaced tessellate veins arising at c. 90° from the midrib and crossing the primaries and interprimaries; *inflorescences* one to three together, subtended by a prominent cataphyll degrading to fibres before male anthesis; *peduncle* terete, 8—12 x 0.2—0.4 cm; *spathe* narrowly canoe-shaped, stoutly beaked, 6.5—7 x 1—1.5 cm, stiffly fleshy, greenish to dull white, soon falling at male anthesis; *spadix* cylindrical, sessile, inserted perpendicular to peduncle, 4.5—7 x 0.6—1 cm, dull whitish; *stylar region* rather well developed, mostly rhombohexagonal, c. 1—1.5 x 1—1.5 mm, truncate; *stigma* elliptic, longitudinally orientated, occasionally almost circular, c. 0.5 x 0.3 mm, often very prominent especially in dried material; *anthers* exserted at male anthesis; *infructescence* 7—9 x 1—2 cm, mid-green when ripe.

Distribution: Southern Thailand, Peninsular Malaysia, Sumatera (including the Lingga Archipelago) and Borneo (Sarawak, Brunei Darussalam, Sabah, West and East Kalimantan).

Habitat: Along rocky or sandy stream banks, often on rocks in stream or at waterfalls in primary to slightly disturbed or old secondary lowland forest, peatswamp forest, occasionally persisting briefly in logged over areas, occurring on a variety of substrates. Sea level to 300 m altitude.

Notes: 1. One of possibly two obligate rheophytic species (the other is *Rhaphidophora araea* P.C. Boyce - Sumatera), *R. beccarii* is immediately recognizable by its adult growth form, creeping along watercourses or attached on rocks in the water, and by the usually pinnately divided leaf laminas. Occasionally plants are seen climbing up tree trunks on the bank of torrential streams.

2. Although the pinnately divided leaf is typical of adult plants, entire leaved stenophyllous to lanceolate-leaved flowering plants are not rare. Such plants have been referred to as *R. fluminea* and occur either as pure stands or as mixed populations with the pinnate-leaved form. They are treated here as a neotenic manifestation of *R. beccarii*.

3. *Rhaphidophora borneensis*, based on a Grabowski specimen from Kalimantan, is a broad-leaved form of typical (i.e., divided-leaf) *R. beccarii*.

Other Bornean specimens seen: SARAWAK. 1st Div.: Setapok F.R., 6 miles south of Kuching, *Bogner 1507* (K, M); Sg. Entabai, *Bogner 1562* (M, US); Matang Family Park, Sg. Cina, *Boyce 719* (K); Lundu, *Brooke 8409* (L);13th Mile, Matang, *Brooke 9459* (L); Lundu, G. Gadin, *Clemens & Clemens 21934* (K); Matang F.R., 10 miles west of Kuching, *Nicolson 1282* (US); Setapok F.R., 6 miles south of Kuching, *Nicolson 1343* (L, US); Matang, *Ridley s.n.* (BM); Padawan, G. Merubong, Ulu Sg. Sluba, *Yii S51363* (K, L, SAR, US); 2nd Div.: Simanggang, *Brooke 10729* (BM, L); 3rd Div.: Kapit District, S. Bena area, *Burtt 13001, 12938* (E); 4th Div.: Lambir N.P., Mile 18, *Chai S39439* (K, KEP, L, SAR, US); 5th Div.: 8 - 9 miles from Limbang, Sg. Bakol, *Bogner 1504* (M, US); 7th Div.: En route (survey highway) from Sg. Mah to Sg. Shinonok, Ulu Sg. Minah, Bintulu District, *Hirano & Hotta 14082* (KYO); Sg. Bejangung, a branch of the Sg. Anap, Bintulu District, *Hirano & Hotta 1174* (KYO); not located: Sg. Entabai, *Bogner 1346* (K, M, US); Sg. Engkramut, *Bogner 1393* (M, US). BRUNEI DARUSSALAM. Belait: Labi, Kg. Teraja, path along Sg. Teraja, *Boyce 245* (BRUN, K, L); Temburong: Sg. Temburong at Kuala Belalong, *Boyce 396* (BRUN, K, L); Sg. Temburong near Kuala Belalong, *Jacobs s.n.* (BRUN, K, L); Sg. Temburong, just downstream from Kuala Belalong, *Wong 242* (BRUN, K, L). SABAH. Kudat: Ranau, Kg. Puas area, *Amin et al. SAN 94681* (K, KEP, L, SAN, SAR, SING); Pantai Barat: Keningau, Ulu Sg. Pingas Pingas, *Jimpin SAN 122024* (K, KEP, SAN); Keningau, Shang Lian logging area, Lanas, *Kuspinus SAN 118444* (K, SAN); Keningau, Camp C area, Tiulan, *Lantoh SAN 102053* (K, KEP, L, SAN); Keningau, Ulu Sg. Matud, *Tangki SAN 119596* (K, L, SAN, SAR); Sandakan: Lamag, Ulu Sg. Lokan, *Aban & Petrus SAN 90675* (K, SAN); Sg. Lokan, *Amin et al. SAN 97483* (K, L, SAN, SAR); VJH 45 A Lungmanis, *Dewol et al. SAN 118075* (K, KEP, L, SAN); Beluran, Sg. Baba *Gibot SAN 90040* (K, L, SAN); Labuk and Sugut, western side of Bt. Doji and pass way from Telupid to Ulu Karamuak, *Kokawa & Hotta 471* (KYO, L); Telupid, Labuk and Sugut, along Sg. Meliau, foot of G. Tawai, *Kokawa & Hotta 110* (KYO, L); Mile 45 Labuk road, *Meijer SAN 44014* (K, L, SAN); KALIMANTAN. West Kalimantan: Selimban Kapuas, *Mam (sub. Polak) 2092* (L); Bt. Ubili, *Nieuwenhuis 97* (BO); East Kalimantan: W. Koetai, No. 29 near L. Liah Leng, *Endert 3013* (BO, K, L); W. Koetai, No. 5 near Lahoem, *Endert 1860* (BO, K, L); Kelassar (Kelasen?), *Hallier 1555* (BO); Pulau Nibung, W. Koetai, Sg. Loewai, near Padang Loewai, *Posthumus 2173* (BO); Samarinda, mouth of Batang Mahakam, Sg.

Mukun, near Sanga Sanga, *Meijer 1136* (BO, L); No further data, *Hallier 999* (BO); Batu Lesoena, *Nieuwenhuis 219* (BO).

2. Rhaphidophora conocephala Alderw.

Rhaphidophora conocephala Alderw., Bull. Jard. Bot. Buitenzorg III, 1 (1920) 384. — Type: Indonesia, Sumatera, North Sumatera, Sibolangit, 10 May 1917, *Lörzing 5137* (BO, holo; K, L, iso).

Figure 2

Large, moderately robust, semi-pachycaul homeophyllous liane to 15 m; *seedling stage* a non-skototropic shingling shoot; *pre-adult plants* forming small terrestrial colonies of appressed shingling shoots; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and moderately elaborated, free, moderately leafy, flowering stems; *stems* smooth, climbing stems rectangular in cross-section, free stems more or less terete to very weakly four-angled in cross-section, larger shoot systems pendent under their own weight, without prophyll, cataphyll and petiolar sheath fibre, internodes to 7 x 1.5 cm on clinging shoots, shorter and less stout on free shoots, separated by prominent oblique leaf scars, older stems woody; *flagellate foraging stems* absent; *clasping roots* densely arising from the nodes and internodes of clinging stems, densely pubescent; *feeding roots* rare, clinging, pubescent; *leaves* weakly spiralled on clinging shoots, slightly scattered-distichous on flowering shoots; *cataphylls and prophylls* membranous, very soon drying and falling; *petiole* shallowly canaliculate adaxially, 4—7 x 0.1—0.2 cm, smooth, with a slight apical and rather prominent basal geniculum; *petiolar sheath* prominent, extending to and encircling the apical geniculum, very soon drying and falling to leave a thin continuous scar from the petiole base, around the top of the apical geniculum and back to the base, occasionally newest leaves with parchment-like sheath remain briefly adherent; *lamina* entire, falcate-lanceolate to falcate-oblong or falcate-oblanceolate, 10—29.5 x 1.5—7 cm, coriaceous, upper surfaces slightly glossy, lower surfaces less so, base minutely cordate to subovate to acute or briefly decurrent, apex subacute with a prominent apiculate apicule, margins slightly revolute in dried material; *midrib* raised abaxially, very slightly sunken adaxially; *primary venation* pinnate, raised abaxially and adaxially; *interprimaries* parallel to primaries, slightly raised abaxially and adaxially; *secondary* and *tertiary venation* slightly raised in dried specimens; *inflorescence* solitary, subtended either by a fully developed foliage leaf or by one or more subfoliar (i.e., developed petiole but atrophied lamina) cataphyll; *peduncle* slightly compressed-cylindric, 3—6 x 0.3—0.5 cm; *spathe* cigar-shaped,

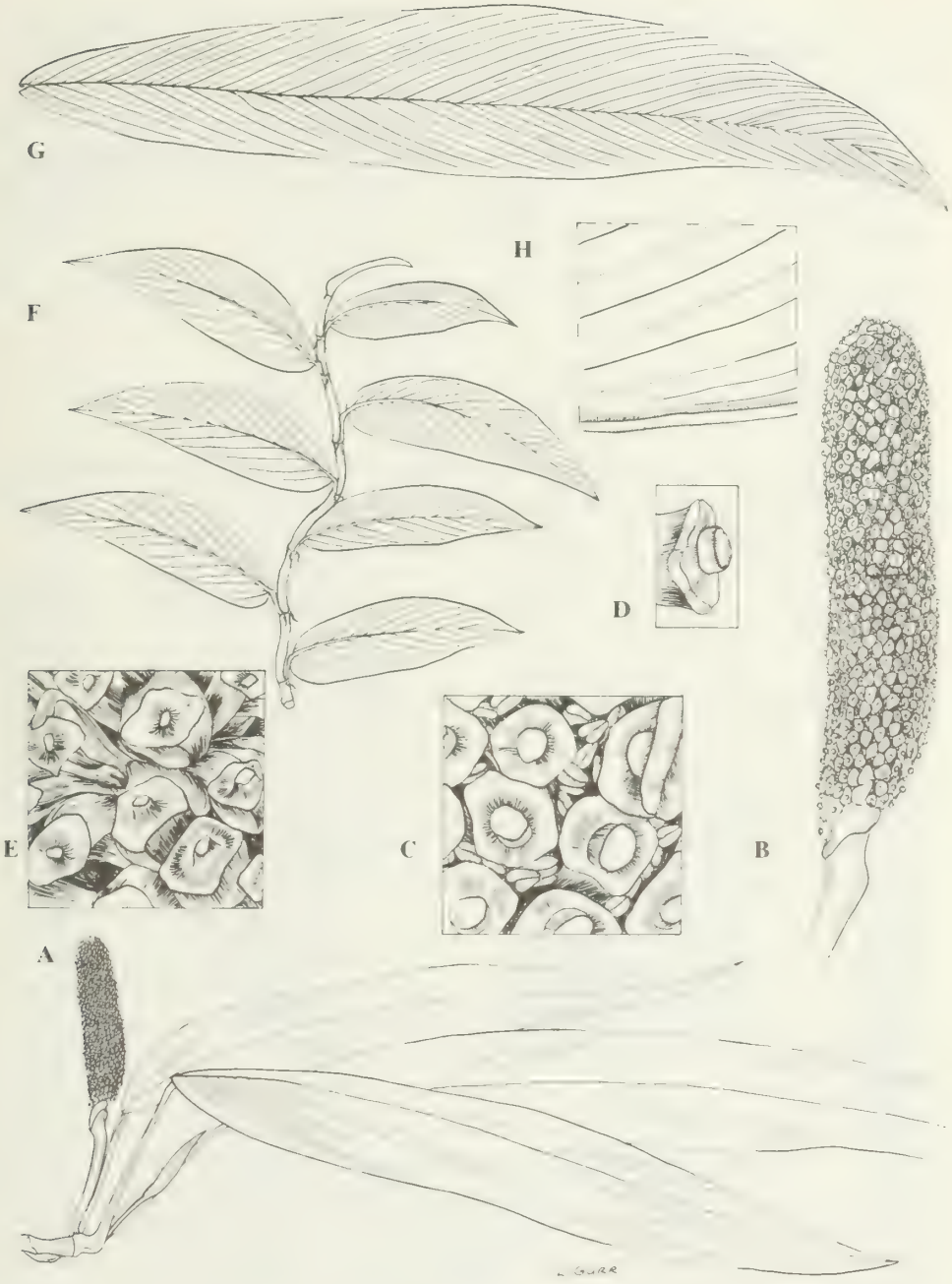

Figure 2. Rhaphidophora conocephala Alderw.
A. flowering shoot x ½; B. inflorescence, spathe fallen x 1½; C. spadix detail, female anthesis x 10; D. gynoecium, three quarter view x 6; E. spadix detail, post-male anthesis x 10; F. portion of pre-adult sterile shoot x ½; G. leaf lamina x ⅛; H. venation detail x 3. A – E, G. & H from *Nur SFN 7369*; F from *Lörzing 11750*.

stoutly short-beaked, 7—9.5 x 2—3.5 cm, thickly fleshy, exterior light yellow, interior darker, soon (?) falling at female anthesis; *spadix* cylindrical to slightly clavate, very shortly stipitate, light yellow, 4—5.3 x 1.2—1.5 cm; *stipe* c. 2 mm long; *stylar region* well developed, mostly rounded to rhombohexagonal, 1.2—1.3 x c. 1.2 mm, conical; *stigma* conspicuously raised-punctiform, c. 0.2 mm diam.; *anthers* slightly exserted at male anthesis; *infructescence* stoutly cylindrical, 6.5—7.5 x 1.8—2 cm.

Distribution: Sumatera, Kalimantan (East) and into the Philippines (Palawan).

Habitat: Damp primary and old secondary forest. 450—1000 m altitude.

Note: Very close to and possibly indistinguishable from *Rhaphidophora sylvestris* but consistent in the conical style topped with a prominent, raised button-like stigma and the notably more coriaceous leaves.

Other Bornean specimens seen: KALIMANTAN. East Kalimantan: Batu Penalong, Mahakam, *Wiriadinata 850* (BO, L).

3. Rhaphidophora cylindrosperma Engl. & K. Krause

Rhaphidophora cylindrosperma Engl. & K. Krause, Pflanzenr. 37 (IV.23B) (1908) 28; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 88. — Type: Indonesia, northern West Kalimantan, between the greater and lesser arms of the S. Sambar, *Hallier 1164* (BO, holo).

Figure 3

Moderate leptocaul homeophyllous liane to unknown ultimate height; *seedling stage* and *pre-adult plants* not observed; *adult shoot architecture* not fully observed, flowering stems, moderately branched and leafy, apparently pendent; *stems* smooth, terete, with cataphylls and prophylls soon falling, internodes 2—3.5 x 0.8—1.2 cm, separated by prominent straight to slightly oblique leaf scars; flagellate *foraging stem* not observed; *roots* not observed; *leaves* spiro-distichous; *cataphylls and prophylls* membranous, soon falling; *petiole* canaliculate, 5—14 x 0.2—0.4 cm, basal geniculum very large and prominent, apical geniculum less so; *petiolar sheath* narrow and not prominent, extending to apical geniculum, ± short-persistent; *lamina* entire, subfalcate-lanceolate or oblong-elliptic, oblique, 10—19.5 x 2.5—6.5 cm, membranous, base acute, apex acuminate; *midrib* prominently raised abaxially, slightly impressed adaxially; *primary venation* pinnate, prominently raised abaxially, impressed adaxially; *interprimaries*

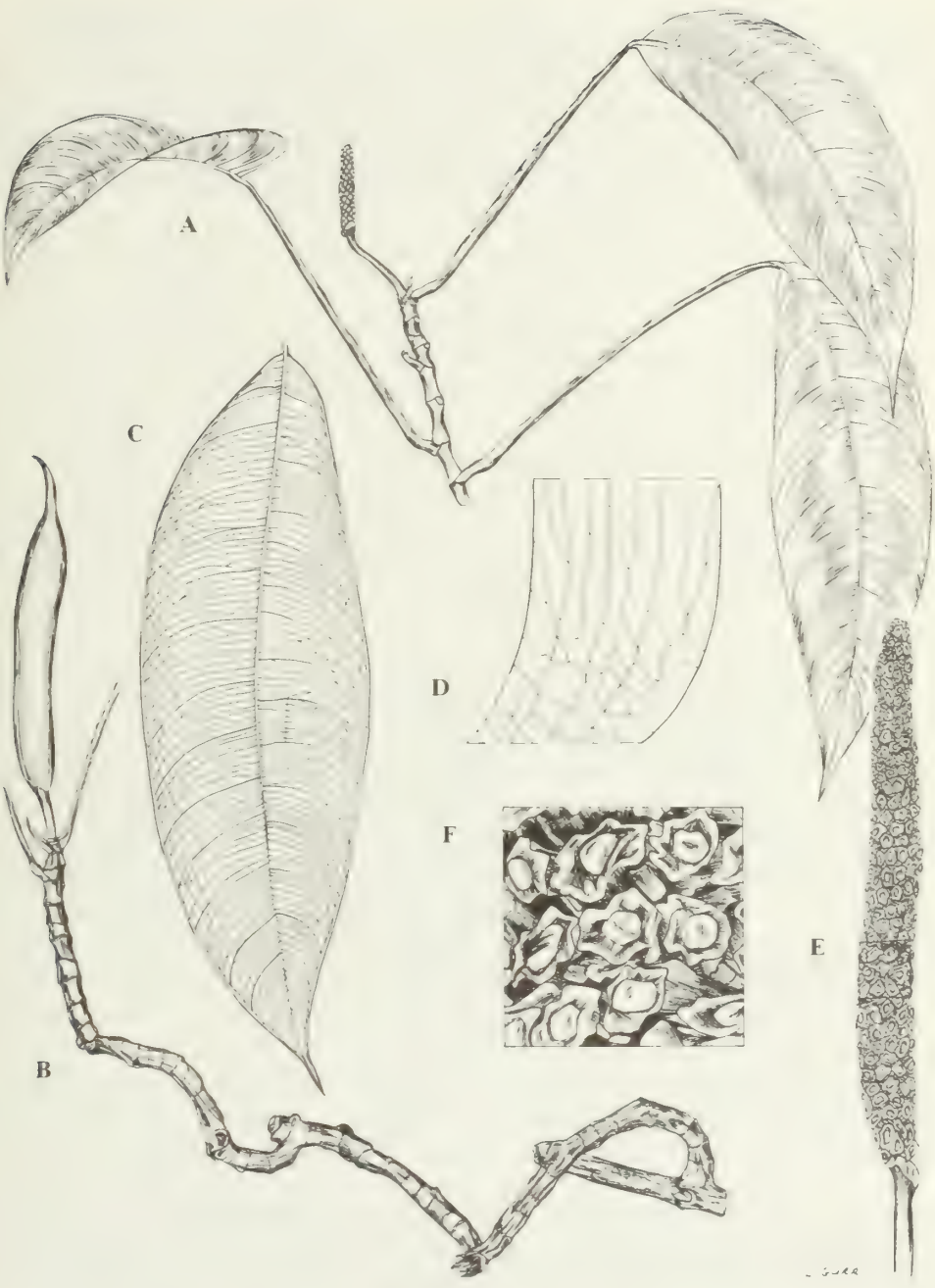

Figure 3. Rhaphidophora cylindrosperma Engl. & K. Krause
A. flowering shoot x ; B. flowering shoot x ; C. leaf lamina x ; D. venation detail x 2; E. inflorescence, spathe fallen x 1; F. spadix detail, post-male anthesis x 6. A, C – D from *Church et al. 1573*; B, E – F from *Sidiyasa PBU 650*.

subparallel to primaries, slightly less prominent; *secondary venation* reticulate, slightly raised abaxially; *inflorescence* solitary, subtended by a ± fully developed foliage leaf and one or more cataphylls; *peduncle* terete, 2—4 x 0.3—0.4 cm; *spathe* slender, 9—11 x 0.5 cm, apically tapering and ultimately stout beaked; *spadix* cylindrical-obtuse, sessile, inserted ± on peduncle, 3—10 x 1 cm (fruiting specimen only); *stylar region* moderately developed, slightly rhombohexagonal, c. 1.8 mm diam., ± truncate; *stigma* punctiform, raised, c. 0.3 mm diam.; *anthers* not observed; *infructescence* 3—10 x 1—1.5 cm.

Distribution: Endemic to Borneo. Sarawak (1st Division), Brunei Darussalam (Belait), Kalimantan (West, Central and East).

Habitat: Lowland primary to lightly disturbed forest. 25—200 m altitude.

Notes: 1. Superficially similar to *Rhaphidophora puberula* but differing in leaves completely glabrous and never perforated, by the smaller, more slender spadix and in flowering on long, free shoots.

2. Among the Sundaic Asian species, it is not immediately apparent to what *R. cylindrosperma* is related. The superficial similarity to species in the Hookeri Group (e.g., *R. puberula and R. foraminifera*) is not borne out by closer examination. The growth form with inflorescences often carried at the tips of short shoots arising from much longer pendent stems is reminiscent of *R. lobbii*, but *R. cylindrosperma* differs in more coriaceous leaves, different leaf venation and in having a longer, externally glabrous spathe. The long, pendent terete stems with upturned tips and small leaves recall some New Guinea species, in particular *R. schlechteri* K. Krause and I have provisionally included *R. cylindrosperma* in the Neoguineensis Group to which those species are assigned (see Boyce 2000a).

3. *Boyce 345* is provisionally included in *R. cylindrosperma* although it has much more coriaceous leaf laminas with closer venation. It may represent an undescribed species but the material is inadequate to make a decision.

Other specimens seen: SARAWAK. 1st Div: Kuching, *Hewitt s.n.* (SING). BRUNEI DARUSSALAM. Belait: Sg. Deriam, *Boyce 345* (BRUN, K, L). KALIMANTAN. West Kalimantan: Serawai, 8 km NE of Desa Jelundung, Batu Lintang, 1 km S of camp along hunting trail, *Church, Mahyer & Afriastini 1573* (BO, E, GH, K); Bt. Raya, *Nooteboom 4327* (BO, L); Central Kalimantan: Barito Ulu, P.T. Pamenang logging concession road, km 20, *Sidyasa PBU 650* (BO, K, L); East Kalimantan: Wanriset research area, road Balikpapan to Samarinda, km 15, Sg. Wain area, *Ambri & Arifin 354* (BO, L, K).

4. Rhaphidophora elliptica Ridl.

Rhaphidophora elliptica Ridl., J. Straits Branch Roy. Asiat. Soc. 44 (1905) 186; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 39—40; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 88. — Type: Malaysia, Sarawak, 1st Div., Bau, July 1903, *Ridley* s.n. (SING, holo).

Figure 4

Large, occasionally very large, robust, pachycaul homeophyllous liane to 30 m; *seedling stage* a non-skototropic shingling shoot; *pre-adult plants* occasionally forming small terrestrial colonies of appressed shingling shoots; *adult shoot architecture* comprised of greatly elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and long, moderately elaborated, free, leafy, flowering stems later pendent under their own weight; *stems* smooth, climbing stems broadly rectangular in cross-section, the angles often slightly winged, the surfaces between convex, free stems spreading, rectangular in cross-section, branching, growing to considerable lengths, green, later mid-brown, without fibre at the tips of active shoots, internodes to 16 x 1—2.5 cm on clinging shoots, usually shorter and less stout on free shoots, separated by large oblique leaf scars, older stems woody; *flagellate foraging stems* frequent, often of great length, ± rectangular in cross-section; *clasping roots* densely arising from the nodes and internodes of clinging stems, densely pubescent; *feeding roots* rare, clinging, pubescent; *leaves* distichous and ascending on clinging and free shoots; *cataphylls and prophylls* membranous, very soon drying and falling; *petiole* deeply grooved adaxially, 10—21.5 x 0.2—1 cm, smooth, apical and basal genicula weakly defined; *petiolar sheath* very prominent but soon falling, extending to and encircling the apical geniculum, ligulate, very soon drying and falling to leave a continuous conspicuous scar from the petiole base, around the top of the apical geniculum and back to the base; *lamina* entire, elliptic to elliptic-lanceolate or falcate-oblong, weakly channelled along midrib, 16—25 x 2.5—8 cm, coriaceous, upper surfaces semi-glossy, lower surfaces semi-matt, base subacute to rounded or very slightly cordate, apex subacute with a somewhat prominent apiculate apicule, margins very slightly revolute in dried material; *midrib* raised abaxially, slightly sunken adaxially; *primary venation* pinnate, slightly raised abaxially and adaxially but barely visible in fresh material; *interprimaries* parallel to primaries and only slightly less prominent, very slightly raised abaxially and adaxially, ± obscure in fresh material; *secondary* and *tertiary venation* ± obscure in fresh material, visible as a very faint reticulum in dried specimens; *inflorescence* solitary, subtended by a fully developed foliage leaf and one or more membranous, soon falling cataphylls; *peduncle*

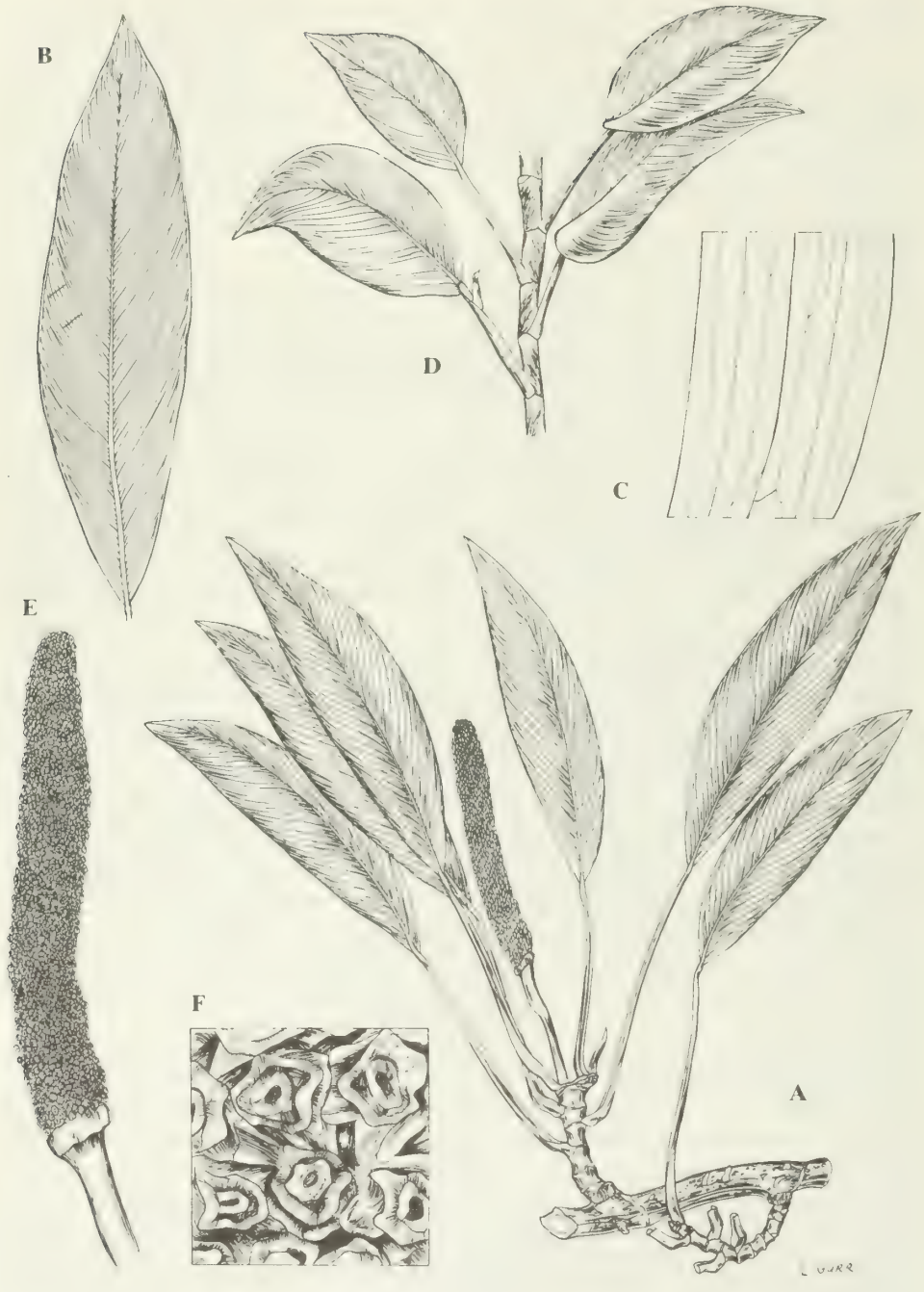

Figure 4. Rhaphidophora elliptica Ridl.
A. flowering shoot x $^{1}/_{6}$ B. leaf lamina x $^{1}/_{3}$; C. venation detail x 3; D. portion of adult sterile stem x $^{1}/_{6}$; E. inflorescence, spathe fallen x $^{1}/_{3}$; F. spadix detail, post-male anthesis x 4. A - C, E – F from *Mamit S 37665*; D. from Kew LCD acc. no. 1965-49804.

compressed-cylindric, 4—11 x 0.3—0.5 cm; *spathe* canoe-shaped, stoutly very short-beaked, 6.5—16 x 2—3.5 cm, thickly stiff-fleshy, dull yellow, paler internally, soon falling at female anthesis; *spadix* tapering-cylindrical, ± sessile, inserted level on peduncle, 8—14 x 1.5—2 cm; *stylar region* weakly rhombohexagonal, 1.8—2.2 x 1.9—2.1 mm, ± truncate; *stigma* punctiform, raised, c. 0.3 mm diam.; *anthers* barely exserted at male anthesis, pollen extruded from between ovaries; *infructescence* 10—15 x 2—2.5 cm.

Distribution: Endemic to Borneo. Sarawak (1st and 3rd Divisions), Brunei Darussalam (Muara, Temburong), Sabah (Sandakan).

Habitat: On trees and cliffs in primary to disturbed primary lowland dipterocarp and swamp forest, on a variety of substrates including limestone and shale. Sea level to 115 m altitude.

Notes: 1. Boyce (1999) treated *Rhaphidophora elliptica* as a synonym of *R. montana*, and comparison of the description above with that of *R. montana* will reveal rather few morphological differences. However, more detailed study of *R. elliptica* has demonstrated subtle but consistent differences between it and *R. montana* such that I am now recognizing the Bornean plants to be a distinct, endemic species. In particular, *R. elliptica* is distinctive in having the leaves distichous and ascending with the lamina shallowly channelled along the midrib (leaves spiro-distichous and spreading with the lamina flat in *R. montana*) and in having clinging stems considerably wider then deep (c. 4:1 v. c. 2:1 in *R. montana*). These differences, so obvious in the field, are almost completely obscured in herbarium specimens unless, as is seldom the case, they are recorded by comprehensive field data.

2. *Rhaphidophora elliptica* belongs to the taxonomically difficult the Hongkongensis Group defined by clinging, occasionally free, stems square to rectangular in cross-section, by simple, rather stiff leaves and conspicuous, membranous ligulate petiolar sheaths extending to the apical geniculum and soon falling to leave a horseshoe-shaped scar at the junction of the petiole and lamina. The use of traditional herbarium morphology has proved a woefully unsatisfactory method for delimiting species in this group and it is hoped that the establishment of an alpha-taxonomy will provide a stimulus for further study of the complex using macromolecular data, field observations and morphometric techniques.

Other specimens seen: SARAWAK. 1st Div.: Along road between Kuching and Padawan, 10 miles SW of main Kuching - Serian highway *Croat 53186* (MO); Kuching, Setapok F.R.,

Mamit S 37665 (K, KEP, L, US); One mile west of Bau, *Nicolson 1293* (US); Setapok F.R., 6 miles south of Kuching, *Nicolson 1348* (US); Bau, *Purseglove 4473* (K, L, SING); 3rd Div.: Kapit, Upper Batang Rejang, *Clemens & Clemens 21929* (GH, K, MO). BRUNEI DARUSSALAM. Muara: *Hotta 13214* (KYO, L); Temburong: Batu Apoi F.R., ridgetop west of Kuala Belalong Field Studies Centre, *Poulsen 150* (AAU, BRUN, K). SABAH. Sandakan: Sg. Lantoh, *Lantoh SAN 87848* (K, KEP, L, SAN, SAR); Kinabatangan Road, Batu Puteh, Pin-Supu F.R., Bt. Supu, *Lim et al. LSP 766* (SAN, SING).

5. Rhaphidophora elliptifolia Merr.

Rhaphidophora elliptifolia Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 88. — [*Rhaphidophora elliptica* Ridl., J. Straits Branch Roy. Asiat. Soc. 49 (1908) 52, *nom. illeg., non* Ridl. (1905)]. — Type: Malaysia, Sarawak, 1st Div., Kuching, Oct. 3 1905, *Hewitt* 12 (SING, holo).

Figure 5

Large, robust, pachycaul homeophyllous liane to 10 m; *seedling stage* a non-skototropic shingling shoot; *pre-adult plants* occasionally forming small terrestrial colonies of appressed shingling shoots; *adult shoot architecture* comprised of greatly elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and long, moderately elaborated, free, densely leafy, flowering stems; *stems* smooth, climbing stems prominently rectangular in cross-section, the surfaces slightly convex, free stems spreading, irregularly four-angled in cross-section, sometimes irregularly terete, with untidy prophyll, cataphyll and petiolar sheath fibre at the tips of active shoots, internodes to 7 x 1.5 cm on clinging shoots, shorter and less stout on free shoots, separated by large oblique to almost straight leaf scars, older stems sub-woody; *flagellate foraging stems* not observed (absent?); *clasping roots* densely arising from the nodes and internodes of clinging stems, pubescent; *feeding roots* rare, clinging, pubescent; *leaves* spiro-distichous on clinging and free shoots; *cataphylls and prophylls* membranous, soon drying and degrading into netted and tangled fibres; *petiole* deeply channelled adaxially, 10—13 x 0.3—0.4 cm, smooth, apical geniculum well defined, basal genicula rather weakly defined; *petiolar sheath* prominent, extending to and encircling the apical geniculum, briefly ligulate, soon drying and degrading into netted fibres, eventually falling to leave a continuous slight scar from the petiole base, around the top of the apical geniculum and back to the base; *lamina* entire, narrowly elliptic to narrowly elliptic-oblong, 20—29 x 4.5—7 cm, coriaceous, upper surfaces semi-glossy, lower surfaces matt, base acute to decurrent, apex attenuate with a slight apiculate apicule, margins revolute in dried material; *midrib* raised abaxially, sunken adaxially; *primary venation* densely pinnate, raised abaxially and adaxially; *interprimaries* parallel to primaries and barely less prominent,

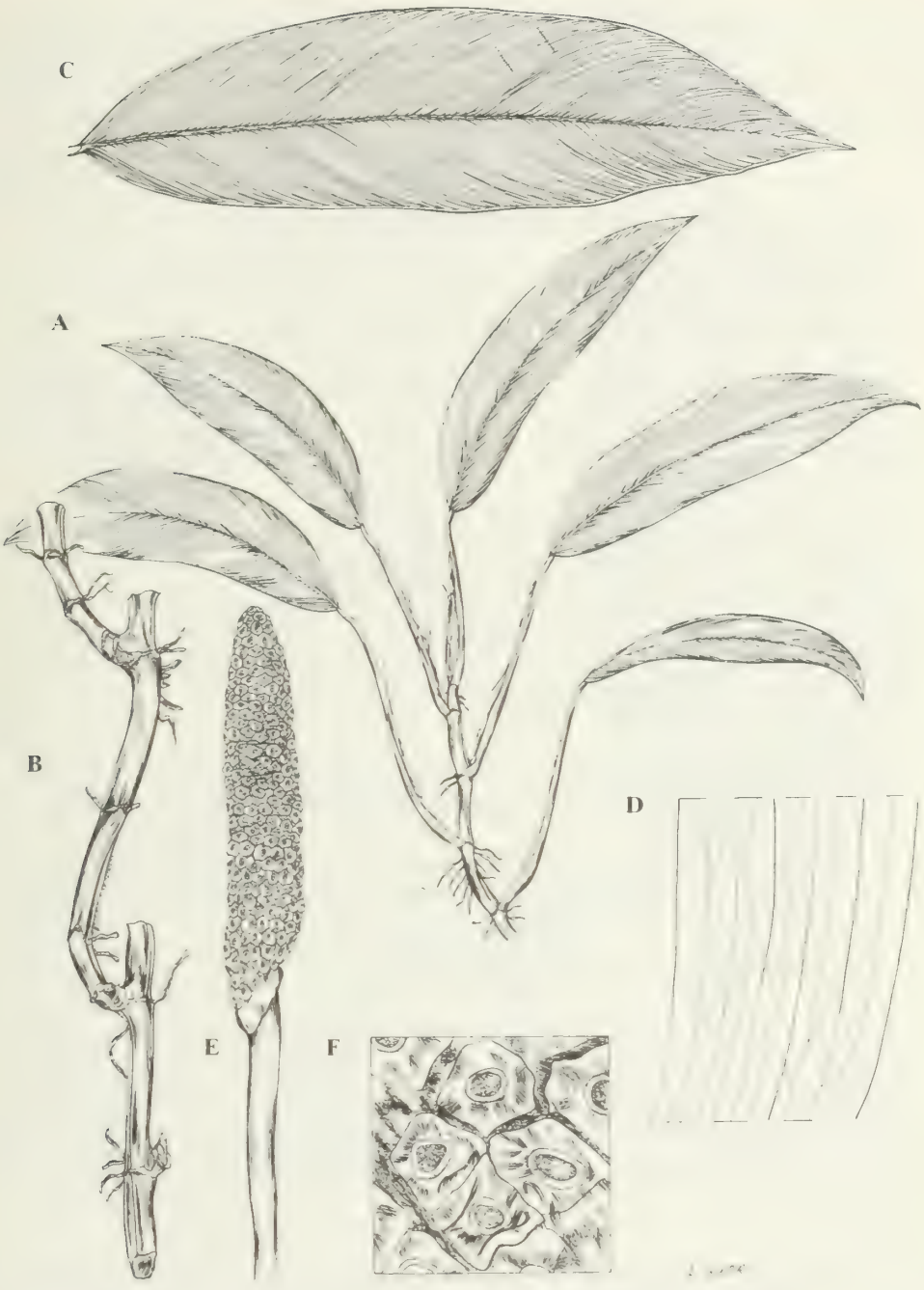

Figure 5. Rhaphidophora elliptifolia Merr.
A. portion of adult sterile stem x ⅛; B. portion of older, leafless stem x ⅛; C. leaf lamina x ⅛; D. venation detail x 4; E. inflorescence, spathe fallen x 1; F. spadix detail, post-female anthesis, pre-male anthesis x 8. A & B from *Meijer 2101*; C – F from *Hewitt s.n.*

slightly raised abaxially and adaxially; *secondary* and *tertiary venation* ± obscure in fresh material, visible as a very faint reticulum in dried specimens; *inflorescence* solitary, subtended by a fully developed foliage leaf and netted petiolar sheath, prophyll and cataphyll fibre; *peduncle* compressed-cylindric, 5.5 x 0.3 cm; *spathe* broadly canoe-shaped, stoutly short-beaked, 6—6.5 x 2—2.5 cm, thickly stiff-fleshy, dull yellow, persistent into early fruiting; *spadix* cylindrical, ± sessile, inserted level on peduncle, c. 5 x 1 cm; *stylar region* rhombohexagonal, 1.7—2 x 1.7—2 mm, truncate; *stigma* rounded, raised, c. 0.3 mm diam.; *anthers* not exserted at male anthesis; *infructescence* c. 7 cm long (known from partial material only).

Distribution: Endemic to Borneo. Sarawak (1st Division), Kalimantan (East).

Habitat: Primary dipterocarp forest. Less than 100 m altitude.

Notes: 1. *Rhaphidophora elliptifolia* resembles Peninsular Malaysian/ Sumateran *R. maingayi* (see Boyce, 1999) in the persistent fibrous remains at the tips of active stems and the stems rectangular in cross-section, but differs in the smaller inflorescences (12—22 v. 6—6.5 cm), the spathe persistent into fruiting and the narrower, more coriaceous leaves. *Rhaphidophora elliptifolia* replaces *R. maingayi* in Borneo.

2. Confusion with *R. elliptica* is possible, although the smaller inflorescences and persistent fibre at the shoot tips readily distinguish *R. elliptifolia*.

Other specimens seen: SARAWAK. No further data, *Hewitt s.n.* (SING). KALIMANTAN. East Kalimantan, Pulau Nunukan, north of Tarakan, *Meijer 2101* (L, BO).

6. Rhaphidophora foraminifera (Engl.) Engl.

Rhaphidophora foraminifera (Engl.) Engl., Pflanzenr. 37 (IV.23B) (1908) 45; Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 197. — *Epipremnum foraminiferum* Engl. in Bot. Jahrb. Syst. 25 (1898) 11. — Neotype: Malaysia, Perak, Taiping, base of Maxwell's Hill Station road, *Nicolson 1047* (US, neo; L, BH, BO isoneo; designated by Boyce, 1999).

Figures 6 & 7

Moderate to large, robust, pachycaul, homeophyllous liane to 15 m; *seedling stage* not observed; *pre-adult plants* frequently (always?) forming extensive terrestrial colonies; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, densely leafy, non-flowering (always?) stems and shorter clinging, densely leafy, flowering stems; *stems* smooth, mid-

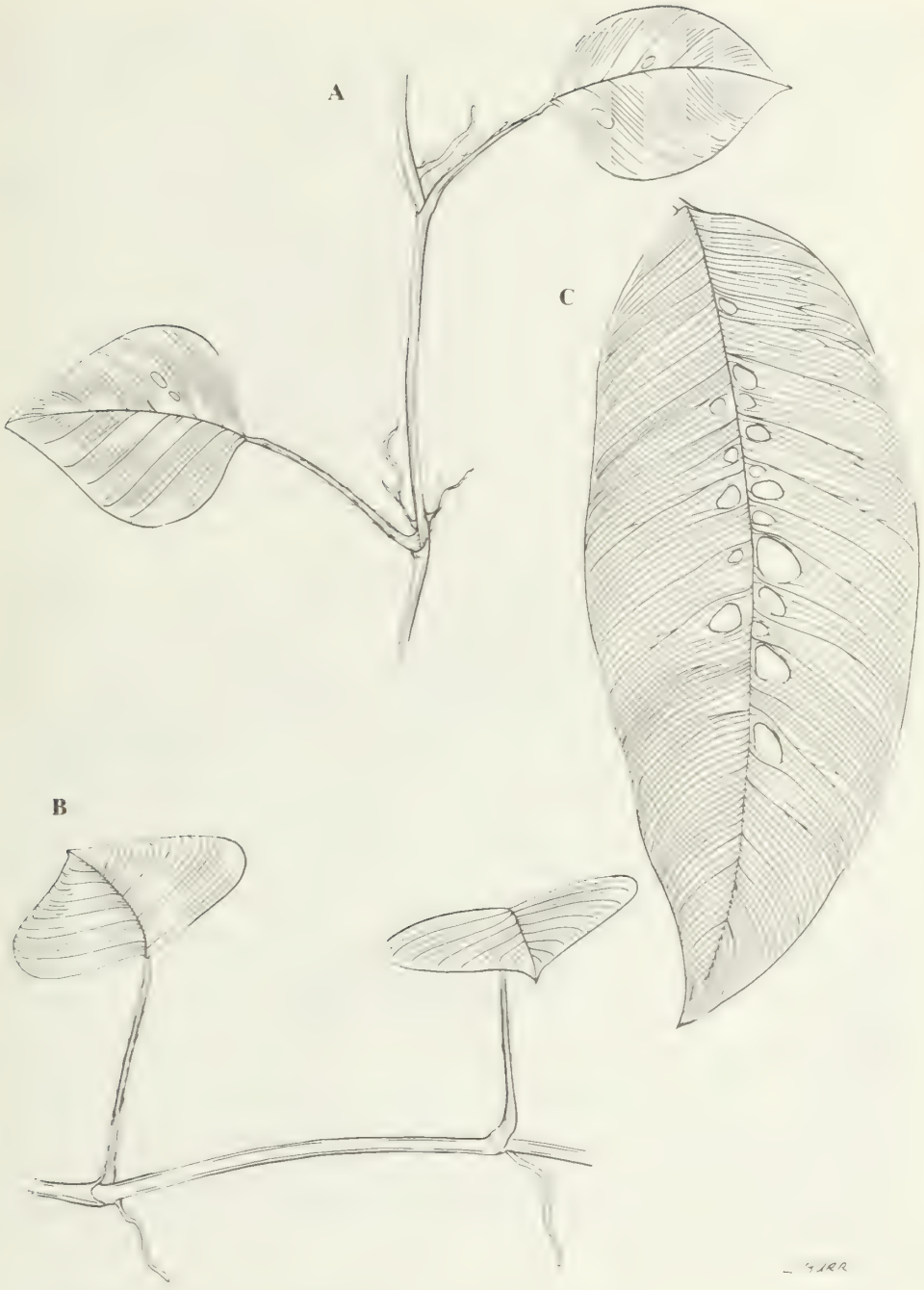

Figure 6. Rhaphidophora foraminifera (Engl.) Engl.
A. pre-adult climbing shoot x 1/4; B. pre-adult terrestrial shoot x 1/3; C. leaf lamina x 1/2. A & B from *Nicolson 941*; C from *Boyce 722*.

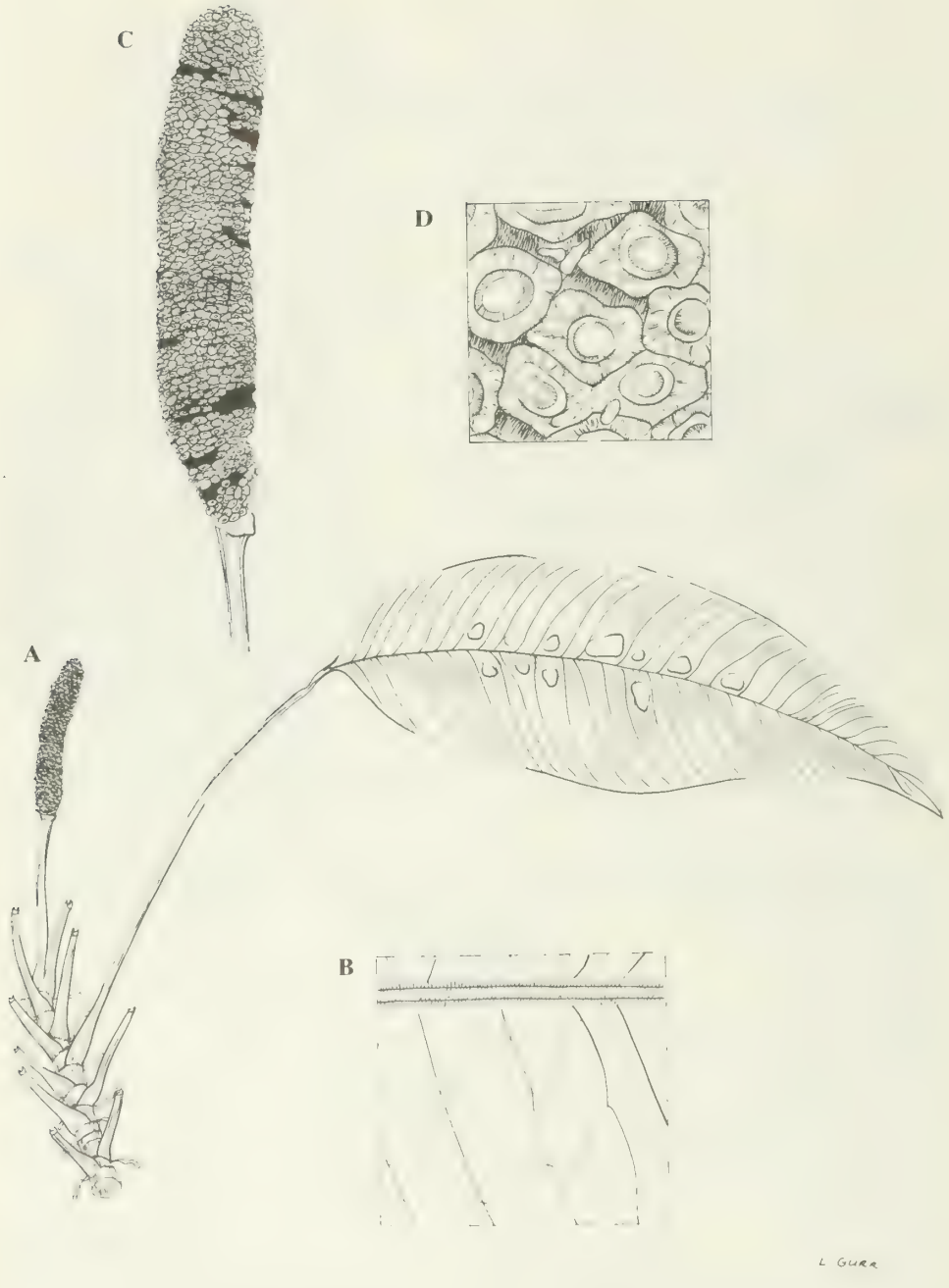

Figure 7. Rhaphidophora foraminifera (Engl.) Engl.
A. flowering shoot x $^{2}/_{15}$; B. venation detail x 6; C. inflorescence, spathe fallen x $^{2}/_{3}$; D. spadix detail, male anthesis x 6. A, C & D from *Boyce 722*; B from *Croat 53118*.

green, with cataphylls and prophylls deliquescing to black mucilage drying to leave fragmentary parchment-like remains on petioles, developing laminas, inflorescences, internodes 1—7 x 0.5—3.5 cm, separated by prominent straight to slightly oblique leaf scars; *flagellate foraging stem* absent; *clasping roots* densely arising from the nodes and internodes, pubescent; *feeding roots* clinging, exceedingly robust, densely pubescent with dense verticils of prominent corky ramenta; *leaves* distichous; *cataphylls and prophylls* membranous, soon deliquescing; *petiole* canaliculate, 22—52 x 0.4—1 cm, smooth for the most part but upper 2—4 cm and apical geniculum densely pubescent, apical geniculum prominent, basal geniculum less so; *petiolar sheath* prominent, extending to apical geniculum, ± short-persistent, degrading to weak, slightly netted fibres; *lamina* entire to slightly or extensively perforated, perforations round to rhombic, extending c. + of lamina width on each side of the midrib, ovate to oblong-lanceolate or oblong-elliptic, slightly oblique, pubescent abaxially when young, 7—53 x 6—19 cm, membranous to subcoriaceous, base rounded, acute to slightly decurrent, apex acute to acuminate; *midrib* prominently raised and densely pubescent abaxially, ± flush adaxially; *primary venation* pinnate, slightly raised abaxially and adaxially, the leaf appearing slightly quilted, pubescent in younger leaves, this indumentum mostly shed in older leaves; *interprimaries* subparallel to primaries, less prominent, slightly raised abaxially, slightly impressed adaxially; *secondary venation* reticulate, slightly raised; *tertiary venation* tessellate, slightly raised; *inflorescence* mostly subtended by one or two large cataphylls, these soon deliquescing into black mucilage, this drying and adhering patchily to developing spathe, rarely subtended by a ± fully developed foliage leaf; *peduncle* terete, 3—13 x 0.5—1.5 cm; *spathe* canoe-shaped, stoutly beaked, 10—27 x 1.5—13 cm, stiffly fleshy, dull pale to dark yellow, wide gaping at male anthesis and then briefly persistent though maturation of the stamens, eventually falling to leave a large ± scar at the base of the spadix; *spadix* cylindrical, sessile, slightly obliquely inserted on peduncle, 7—17 x 1.3—2.5 cm, dull greenish yellow; *stylar region* moderately developed, rounded to rhombohexagonal, 1—2 x 1—1.5 mm, shortly conical when fresh, drying truncate; *stigma* punctiform or elliptic and transversely orientated, raised at male anthesis but excavated in dry material, c. 0.3 mm diam.; *anthers* slightly exserted at male anthesis; *infructescence* 8—15 x 2—3 cm, dark green before ripening to greenish yellow.

Distribution: Sumatera, Peninsular Malaysia, Borneo - Sarawak (1st and 6th Divisions, but doubtless more widespread), Brunei Darussalam (Belait) and Sabah (Pantai Barat).

Habitat: On trees, rocks and cliffs in primary to disturbed secondary lowland to moist hill dipterocarp forest, on a variety of substrates including limestone and shale. 10—700 m altitude.

Notes: 1. Confusion can occur between *Rhaphidophora foraminifera* and *R. puberula*. They may be distinguished by the position of the inflorescence (on short clinging shoots in *R. foraminifera*, on short free shoots in *R. puberula*), by the presence of black mucilage produced by the deliquescing cataphylls and prophylls (present in *R. foraminifera*, absent in *R. puberula*), in leaf size of mature flowering-sized plants (to 53 x 19 cm in *R. foraminifera*, to 34 x 10.5 cm in *R. puberula*), by the more or less rounded (*R. foraminifera*) v. oblong (*R. puberula*) stylar regions, and in overall size of the plant (*R. foraminifera* is a bole climber to 15 m whereas *R. puberula* seldom climbs higher than 3 m and frequently forms large, spreading masses on rocks.)

2. Perforated leaves occur in a number of otherwise rather different-looking *Rhaphidophora* species (e.g., *R. foraminifera*, *R. puberula*, *R. versteegii*) suggesting that while a useful diagnostic tool, lamina perforation cannot be used to circumscribe taxonomically meaningful groups within *Rhaphidophora*.

Other Bornean specimens seen: SARAWAK. 1st Div.: Road between Kuching and Padawan, 10 m SW of main Kuching to Serian highway, *Croat 53182* (MO); 1 mile from Bau, *Nicolson 1288* (US); 6th Div: Ulu Balingian, road from Sibu to Bintulu, *Boyce 722* (K, M). BRUNEI DARUSSALAM. Belait: Labi, Kp Teraja, path along the Sg. Teraja, *Boyce 235* (BRUN, K, L, MO). SABAH. Pantai Barat: Road from Kota Kinabalu to Tambunan, Ulu Moyog, *Boyce 1391*, *1400* (K, SNP); Tambunan District, Road to Kg Tondulu, *Boyce 1414* (K, SNP); Moyog District, along road between Kota Kinabalu and Tambunan, 21 miles SE of Kota Kinabalu, W slopes of Crocker Range, *Croat 53118* (MO); Kinabatangan, Tamegang Timber Camp near Kg Pangkaian, *Hotta 1416* (KYO, L).

7. Rhaphidophora korthalsii Schott

Rhaphidophora korthalsii Schott, Ann. Mus. Bot. Lugd.-Bat. 1(1863) 129; Engl. in A. & C. DC., Monogr. Phan. 2 (1879) 246; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 49—51, Fig. 21; Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 341. — Type: Indonesia, Java, *P.W. Korthals s.n.* (L, holo; L, P, iso).

Pothos celatocaulis N.E. Br., Gard. Chron. 13 (1880) 200. — *Rhaphidophora celatocaulis* (N.E. Br.) Alderw., Bull. Jard. Bot. Buitenzorg III, 1 (1920) 382 & Bull. Jard. Bot. Buitenzorg III, 4 (1922) 198. — Type: Malaysia,

Sabah, *Burbidge s.n., Hort. Veitch no. 215* (K, holo; K, iso).

Rhaphidophora maxima Engl., Bull. Soc. Tosc. Ortic. 4 (1879) 269 & in Beccari, Malesia 1 (1882) 271, Tab. xx 1—5; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 48—49; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 89. — Type: Sarawak, G. Gading, July 1866, *Beccari PB 2314* (FI, lecto, selected by Boyce, 1999).

Rhaphidophora tenuis Engl., Bot. Jahrb. Syst. 1 (1881) 181 & in Beccari, Malesia 1 (1882) 271—272; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 53; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 90. — Types: Malaysia, Sarawak, *Beccari PB 1977* (FI lecto; B isolecto; lecto selected by Boyce, 1999).

Rhaphidophora korthalsii Schott *var. angustiloba* Ridl. *ex* Engl. & K. Krause in Engler, Pflanzenr. 37 (IV.23B) (1908) 49; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 89. — Type: Malaysia, Sarawak, Matang, July 1903, *Ridley s.n.* (SING, lecto; lecto; selected by Boyce, 1999).

Rhaphidophora copelandii Engl., Bot. Jahrb. Syst. 37 (1905) 115; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 49. — Type: Philippines, Mindanao, Davao, Mt Apo, April 1904, *Copeland 1193* (PNH, holo†; B iso).

Rhaphidophora grandifolia K. Krause, Bot. Jahrb. 44, Beibl. 101 (1910) 11. — Type: Philippines, Negros, Negros Orientale, Dumaguete (Cuernos Mts), March 1908, *Elmer 9464* (PNH, holo†; B, E, K, L, LE, MO, iso).

Rhaphidophora trinervia Elmer, Leafl. Philipp. Bot. 8 (1919) 3073. — Type: Philippines, Laguna, Los Baños (Mt Maquiling), June—July 1917, *Elmer 18057* (PNH, holo†; FI, K, L, MO, P, iso).

Rhaphidophora ridleyi Merr., J. Straits Branch Roy. Asiat. Soc., special number (1921) 90. [*Rhaphidophora grandis* Ridl., J. Straits Branch Roy. Asiat. Soc. 49 (1907) 51, *nom. illeg., non* Schott 1858 (India) = *R. decursiva* (Roxb.) Schott]. — Type: Malaysia, Sarawak, Tambusan, Sept. 1905, *Ridley 12414* (SING, holo).

Rhaphidophora latifolia Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 341; K. Krause & Alderw., Nova Guinea 14 (1924) 213. — Type: Indonesia, Irian Jaya, Pionierbivak, 23 July 1920, *Lam 711* (BO, holo; L, iso).

Rhaphidophora palawanensis Merr., Philipp. J. Sci. 26 (1925) 451. — Type: Philippines, Palawan, Malampaya Bay, Oct. 1922, *Merrill BS 11570* (PNH, holo†; B, K, P, iso).

Rhaphidophora trukensis Hosok., J. Jap. Bot. 13 (1937) 195. — Type: Federated States of Micronesia, Chuuk (Truk) Island, near Orrip, 29 July 1939, *Hosokawa 8334* (TI , holo).

[*Epipremnum multicephalum* Elmer, Leafl. Philipp. Bot. 10 (1938) 3624, *nom. inval., descr. Angl.* — Based on: Philippines, Luzon, Sorsogon, Trosin (Mt Bulusan), May 1916, *Elmer 16061* (sheets seen at FI, K, L, MO, P, PNH†)].

Figures 8 & 9

Very large, occasionally enormous, slender to rather robust, pachycaul, heterophyllous liane to 20 m; *seedling stage* a non-skototropic shingling juvenile shoot; *pre-adult plants* never forming terrestrial colonies; *adult shoot architecture* comprised of greatly elongated, clinging, physiognomically unbranched, densely leafy, flowering stems; *stems* smooth, bright green, with sparse to copious prophyll, cataphyll and petiolar sheath fibre, especially at the stem tips, internodes to 15 x 3.5 cm, separated by prominent oblique leaf scars, older stems subwoody; *flagellate foraging stems* absent; *clasping roots* densely arising from the nodes and internodes, prominently pubescent; *feeding roots* abundant, clinging and free, very robust, densely ramentose-scaly; *leaves* distichous; *cataphylls and prophylls* membranous, soon drying and degrading to intricately reticulate persistent fibres; *petiole* shallowly grooved, upper part ± terete, (1—) 9—65 x 0.2—1.5 cm, smooth, apical and basal geniculа prominent; *petiolar sheath* prominent, membranous, strongly to slightly unequal on one side, extending almost to or reaching the apical geniculum, of ± short-duration, soon degrading into persistent netted fibres, these eventually falling to leave a prominent, slightly corky scar; *lamina* of seedlings overlapping in the manner of roof shingles, entire, lanceolate, 5—11 x 3.5—6 cm, base slightly cordate, lamina of pre-adult and adult plants free, entire, pinnatipartite, pinnatisect or pinnatifid, 10—44 x 14—94 cm, broadly oblong-elliptic to oblong lanceolate, slightly oblique, membranous to chartaceous or subcoriaceous, base truncate and very briefly decurrent, apex acute to acuminate, individual pinnae 1—10 cm wide, frequently perforated basally adjacent to the midrib, thus appearing stilted; *midrib* very prominently raised abaxially, slightly sunken adaxially; *primary venation* pinnate, raised abaxially, somewhat impressed adaxially, 2—4 primary veins per pinna; *interprimaries* subparallel to primaries, slightly raised abaxially, slightly impressed adaxially; *secondary*

Figure 8. Rhaphidophora korthalsii Schott
A. pre-adult shoot x ; B. pre-adult shingling shoot x . A from *Boyce 679*; B from *Nicolson 1712*.

venation strongly reticulate, slightly raised; *tertiary venation* invisible; *inflorescence* solitary to several together, first inflorescence subtended by a membranous prophyll and one or more cataphylls, these soon degrading to netted fibres, subsequent inflorescences subtended by one or more soon degrading cataphylls, the whole forming a mass of developing and open inflorescences and developing infructescences partially concealed by persistent netted cataphyll and prophyll remains; *peduncle* slightly laterally compressed to terete, 6—26 x 1—1.5 cm; *spathe* narrowly canoe-shaped, stoutly beaked, 10—30 x 3—5 cm, stiffly fleshy, greenish to dull yellow, gaping wide at female anthesis and then soon falling to leave a large straight scar at the base of the spadix; *spadix* cylindrical, sessile, inserted ± level on peduncle, 9—26 x 1.5—2 cm, dull green to dirty white; *stylar region* rather well developed, mostly rhombohexagonal, 1.5—2 x c. 2 mm, slightly conical; *stigma* punctiform to slightly elliptic, if the latter then mostly longitudinally orientated, c. 0.3—0.5 x 0.2—0.4 mm; *anthers* barely exserted at male anthesis; *infructescence* 14—27 x 3—3.5 cm, dark green ripening to dull orange, stylar tissue abscising to reveal orange ovary cavity pulp.

Distribution: Widespread in south tropical Asia from Sumatera and southern Thailand to Borneo and the Philippines eastwards through the tropical western Pacific. In Borneo, widespread in Sarawak, Brunei Darusslam and Sabah. In Kalimantan only recorded from East Kalimanatan.

Habitat: Primary to disturbed secondary lowland, hill and montane forest, moss forest, peatswamp forest, on trees, rocks and cliffs on a variety of substrates including limestone and ultrabasic soils. 20—1800 m altitude.

Notes: 1. *Rhaphidophora korthalsii* is a very widespread and variable species, hence the extensive synonymy. However, as with *Epipremnum pinnatum* (L.) Engl. (Boyce, 1998) there are several geographical elements that, given more intensive study, might warrant formal taxonomic recognition. Unfortunately, current herbarium material is inadequate to confirm these plants' status and more field observations are needed.

2. Sterile herbarium material lacking the pre-adult stage may prove difficult to distinguish from the *Epipremnum pinnatum* (in Borneo known wild only from east Sabah). Mature leaves of 'typical' *E. pinnatum* never have more than one primary lateral vein per pinna and the stems of *R. korthalsii* lack the prominent irregular whitish longitudinal crests and older stems the distinctive matt to sublustrous pale brown papery epidermis typical of *E. pinnatum*. The feeding roots of *R. korthalsii* are prominently scaly, while those of *E. pinnatum* are lenticellate-corky. The pre-adult stage of *R.*

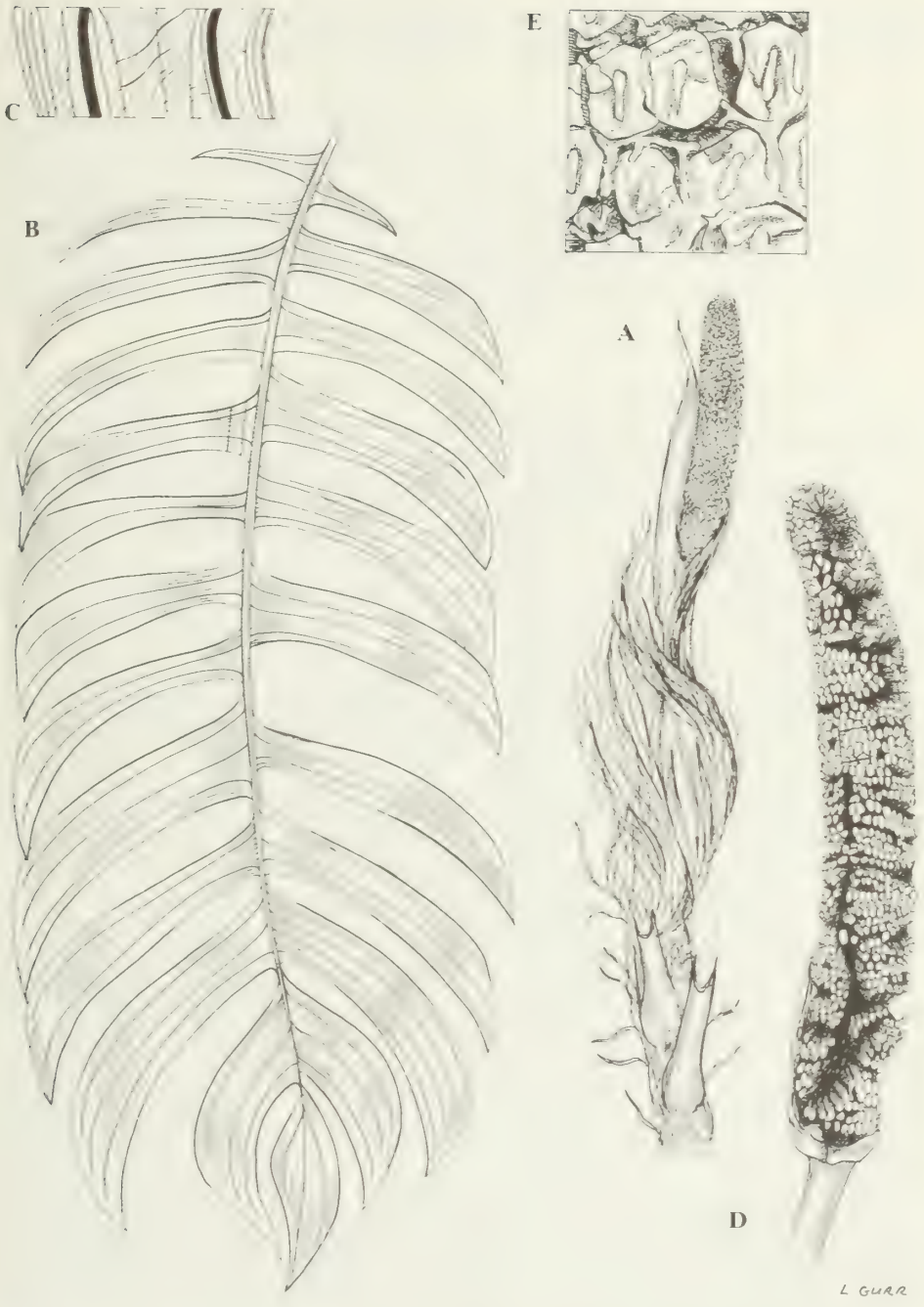

Figure 9. Rhaphidophora korthalsii Schott
A. flowering shoot, leaves removed x 1/3; B. leaf lamina x 1/10; C. venation detail x 2; D. inflorescence, spathe removed x 1; E. spadix detail, post-male anthesis x 8. All from *Kerr 15051*.

korthalsii is a shingle climber with oblong-elliptic to ovate, slightly falcate upwardly pointing leaves overlapping in the manner of roof tiles.

3. Fertile material of *R. korthalsii* and *Epipremnum pinnatum* is readily separated by the shape of the style apex (round v. trapezoid) and the shape and orientation of the stigma (± punctiform and circumferential v. strongly linear and longitudinal) and, if fruits are mature, by seed characters. The fruits of *R. korthalsii* each contain many small ellipsoid seeds with a brittle, smooth testa, whereas *E. pinnatum* has fruits with two large, strongly curved seeds with a bony and ornamented testa.

Other Bornean specimens seen: SARAWAK. 1st Div.: Bau, *Brooke 8998* (BM); Lundu, *Foxworthy 40* (SING); Three miles from Kuching, *Haviland & Hose 3605* (K); Kuching, *Hewitt 40* (SING); Semengoh F.R., 6 miles west of Kuching, *Nicolson 1252* (US); 1 mile west of Bau, *Nicolson 1301* (US); Bako N.P., 20 miles northeast of Kuching, Lintang Path, *Nicolson 1329* (US); Setapok F.R., 6 miles west of Kuching, *Nicolson 1341* (US); Kuching *Ridley s.n.* (SING); 3rd Div.: Hose Mountains, gorge of Sg. Simpurai, *Burtt & Martin 4926* (E); Bt. Raya, Kapit, *Soepadmo & Chai S28148* (KLU, SAR); 4th Div.: Niah, *Ahmed 64* (SAR, SING); Miri District, Niah, Sg. Sekaloh, G. Subis, *Anderson S31956* (E, K, L, SAR, SING, US); Kelabit Highlands, Apu Batu Buli, *Nooteboom & Chai 2216* (L, SAR, US); 7th Div.: Bintulu, Bt. Urang, *Brunig S 12093* (K, SAR); Eastern ridge of Bt. Kans, Bintulu district, *Hirano & Hotta 1432* (KYO); Sg. Ma'au, Dataran Tinggi Merurong, Tubau, *Othman et al. S 49050* (K, SAR); 9th Div.: Tebedu, mile 15, *Mohtar et al. S 49245* (K, SAR, US); Serian, G. Penrissen; *Paie S 16001* (K, LE, SAR). BRUNEI DARUSSALAM. Belait: Ulu Ingei, Bt. Batu Patam, lower slopes near Sg. Ingei, *Boyce 312* (BRUN, K); Temburong: Sg. Temburong above Kuala Belalong, *Argent et al. 9136* (E, K); Bt. Biang, *Ashton 154* (K, US); Sg. Temburong at Wong Nguan gorge, *Wong 1727* (BRUN, K). SABAH. Kudat: Ranau, Bt. Kulung, *Meijer SAN 122414* (SAN); Ranau, Bt. Kulung, *Meijer SAN 122429* (SAN); Ranau, Kinabalu road to Mesilau, *Mikil SAN 38691* (K, SAN); Mesilau, *Poore 131* (K); Sandakan: Paitan F.R., *Ampuria SAN 32773* (K, SAN, SING); Elopura, mile 15 Labuk Road, *Cuadra A 2237* (K, KEP, SAN, SING); Sandakan, Segalid Lokan F.R., *Gibot SAN 80977* (K, L, SAN); Lamag, Batu Puteh, *Majawat & Lasan SAN 88017* (KEP, SAN); Pantai Barat: Tambunan, road to Kg Tondulu, Kg Tondulu valley, *Boyce 1421* (K, SING, SNP); Papar, Kimanis road, *Boyce 1443* (K, SNP); Dallas, *Clemens & Clemens 26405* (BM, SING); Dallas, *Clemens & Clemens 26495* (BM, L, UC); Tenompok, *Clemens & Clemens 28813* (BM, K, SING); Upper Kinabalu, *Clemens & Clemens 29146* (BM, BO, K, L, SING, UC); Upper Kinabalu, Lilau Basin, Mesilau, Meneringtan, *Clemens & Clemens 29146a* (BM, K, L, SING); Penibukan, *Clemens & Clemens 31150* (BM, K, SING); Penataran river, *Clemens & Clemens 34298* (BM, BO, K, L, UC); Mount Kinabalu N.P., along road to summit, *Croat 53131* (MO); Lamag, Sg. Pin, *Dewol & Harum SAN 89922* (K, SAN); Ulu Segama, Danum Valley, path to Rhino Ridge, *Dransfield 6302* (K); Pedalaman: Tenom, north ridge of G. Malutut, c. 15 km north of Tenom, *Kokawa & Hotta 2455* (KYO, L); Tawau: cutting area of Luasong Camp, N.B.T. about 60 km NW of Tawau, *Kokawa & Hotta 631* (K, KYO), *Kokawa & Hotta 797* (K, KYO, P); Lahad Datu, Ulu Sg. Sanum, south of camp 111, *Stone et al. SAN 85269* (KLU, SAN); Lahad Datu, Ulu Sg. Sanum, just north of camp 111, *Stone et al. SAN 85310* (KLU, SAN). KALIMANTAN. East Kalimantan: Wanariset research area, road Samboja to Semoi, km 11, *Ambri & Arifin 331* (L); Berau, Tandung Redeb, Sg. Kelai near Long Lanuk, *Kostermans 21125* (BO, L); Berau, near Tandung Redeb,

Kostermans 21725 (BO, L, US); Danan Pentulak, Bt. Pegah, *Main (sub. Polak) 1957* (BO); Pulau Nunukan, Tarakan, *Meijer 2600* (BO); North of Tarakan, Simengkadu, *Meijer 2389* (BO).

8. Rhaphidophora latevaginata M. Hotta

Rhaphidophora latevaginata M. Hotta, Acta Phytotax. Geobot. 22 (1966) 4. — Type: Malaysia, Sarawak, 4th Division, Bintulu District, about 4 km east from Minah Camp, Sg. Kakus, 4 Oct. 1963, *Hirano & Hotta 140* (KYO, holo).

Figure 10

Moderate to very large, robust, pachycaul, homeophyllous neotenic liane to 12 m; *seedling stage* a non-skototropic shingling juvenile shoot; *pre-adult plants* forming small terrestrial colonies of shingling closely appressed leaves; *adult shoot architecture* comprised of clinging, physiognomically unbranched, shingling to very densely leafy, sterile stems and almost identical fertile stems; *stems* weakly compressed-terete to weakly rectangular in cross-section, smooth, dark green, without prophyll and cataphyll fibre but with at least upper parts with thin, black adherent petiolar sheath tissue, internodes to 12 x 2 cm, separated by prominent straight scars, but scars obscured by leaf bases on all but the oldest stems, lower parts of stem later sub-woody with slightly shiny cracking epidermis; *flagellate foraging stems* moderately well developed although often somewhat short and leafy; *clasping roots* arising densely from the nodes and internodes, prominently scaly; *feeding roots* c. 3 mm diam., brown, minutely pubescent; *leaves* distichous, appressed, ascending and shingling, becoming slightly scattered and spreading (often litter-trapping) towards fertile tips; *cataphylls and prophylls* membranous, soon drying black and persisting briefly before falling; *petiole* deeply canaliculate and winged, 3—22 x 0.5—2 cm, smooth, apical and basal geniculum almost obscure in young leaves, later becoming prominent, especially the basal geniculum; *petiolar sheath* very pronounced, up to 2.5 cm wide, rather thickly membranous, prominently ligulate, outer sheath (away from climbing surface) greatly expanded and partly to completely obscuring stem, sheath turning black but persisting some considerable time, eventually rotting away to reveal two large scars extending to the top of the petiole; *lamina* broadly oblong-ovate-elliptic, 8—48 x 6.5—20.5 cm stiffly coriaceous, bright green, slightly to markedly glaucous, base truncate-cordate to broadly cuneate, very briefly decurrent, apex rounded to acute with a tiny apicule; *midrib* prominently raised abaxially, slightly sunken adaxially; *primary venation* pinnate, slightly raised

abaxially, more so adaxially; *interprimaries* sub-parallel to primaries, slightly raised on both leaf surfaces; *secondary venation* tessellate-reticulate, slightly raised abaxially, ± flush adaxially, all veins much more prominent in dried material; *inflorescence* solitary on a clinging shoot, subtended by a fully developed foliage leaf and one or more cataphylls; *peduncle* laterally compressed-cylindrical, 6.5—11 x 0.5—0.7 cm; *spathe* not observed; *spadix* stoutly cigar-shaped, sessile; *spadix* inserted ± level on stipe, 17.5 x 1.5 cm, pale green; *stylar region* rhombohexagonal, c. 2 x 1 mm, truncate; *stigma* slightly raised, elongated, longitudinally orientated, c. 0.75 x 0.2 mm; *anthers* not exserted at male anthesis; *infructescence* stoutly cigar-shaped, 15 x 2 cm, stylar region becoming convex at fruit maturity.

Distribution: Endemic to Borneo. Sarawak (1st and 7th Division), Brunei Darussalam (Temburong), Sabah (Pantai Barat and Sandakan), Kalimantan (localities not traced).

Habitat: Primary to secondary moist lowland to hill dipterocarp forest on clay and sandstone. 50—840 m altitude.

Notes: 1. Despite its remarkable appearance with densely glaucous-leafy shingling shoots ascending, often spirally, high into the canopy, and furthermore being widespread and not uncommon in Borneo, *R. latevaginata* was described only relatively recently and, remarkably, is known from only 13 herbarium specimens only two of which are more than 50 years old. Given the plant's striking appearance, it seems inconceivable that it was not noticed by early fieldworkers although quite possibly its overall similarity to the juvenile stages of the common and widespread *R. korthalsii* may have led to it being passed by as not worth collecting.

2. It is not at all clear to what *Rhaphidophora latevaginata* is related. It is the only large neotenic lianescent aroid in Borneo, although neoteny in *Rhaphidophora* occurs in three groups (Boyce, 1999; Boyce & Bogner, 2000). The similarity of the plant to the juvenile stage of *R. korthalsii* might seem compelling and the shared scaley feeding roots suggest a relationship. However, the inflorescences are quite different; the style of *R. latevaginata* is rhombohexagonal and the stigma longitudinally orientated (v. style round and stigma ± punctiform in *R. korthalsii*.)

Other specimens seen: SARAWAK. 1st Div.: Matang F.R., 10 miles west of Kuching, *Nicolson 1262* (L, US); 7th Div.: Sibu-Bintulu road, 2.3 km after bridge over the Batang Kemena, *Boyce 728* (K, M); Bintulu, about 2 - 4 km east from of Minah Camp, Sg. Kakus, *Hirano & Hotta 41* (KYO), *Hirano & Hotta 149* (KYO); Vicinity of Minah Camp (timber camp of

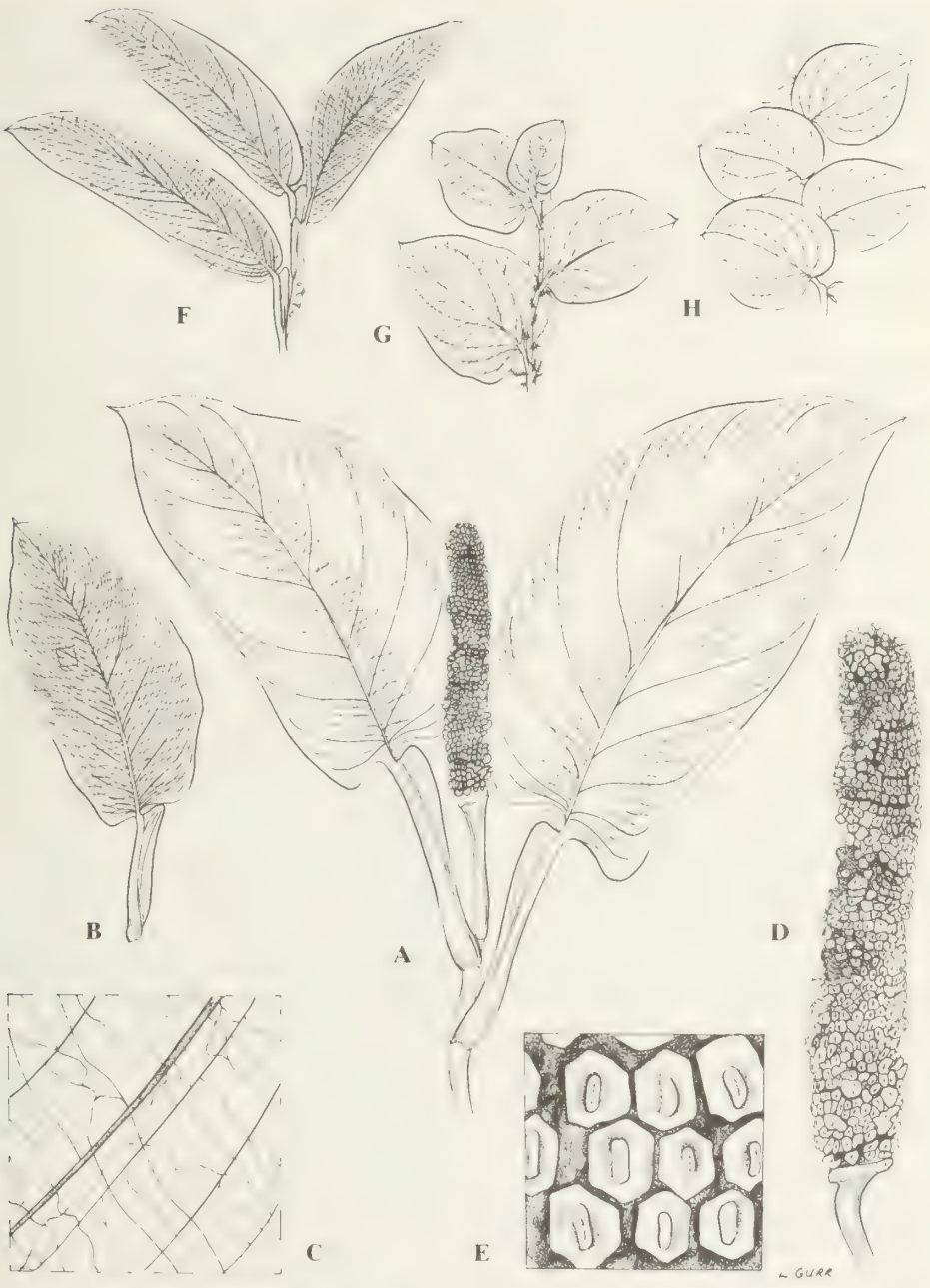

Figure 10. Rhaphidophora latevaginata M. Hotta
A. flowering shoot x $^{1}/_{6}$; B. adult leaf lamina x $^{1}/_{3}$; C. venation detail x 3; D. inflorescence, spathe fallen x $^{1}/_{3}$; E. spadix detail, early fruiting x 4; F. pre-adult terrestrial shoot x $^{1}/_{3}$; G. pre-adult terrestrial shoot x $^{1}/_{3}$; H. pre-adult terrestrial shoot x $^{1}/_{3}$. A, D & E from *Hirano & Hotta 140*; B & C from *Dewol & Meijer 131653*; F & G from *Hirano & Hotta 149*; H from *Hirano & Hotta 41*.

L.L.B.T.C.), Sg. Kakus, *Hotta 15717* (KYO). BRUNEI DARUSSALAM. Temburong: Sg. Temburong at Kuala Belalong, *Boyce 402* (BRUN, K, L, SING, MO); Batu Apoi F.R., ridge west of Kuala Belalong Field Studies Center slope, between Danish Plot and Sg. Belalong, *Poulsen 165* (AAU, BRUN, K). SABAH. Pantai Barat: Road from Kota Kinabalu to Tambunan, Ulu Moyog, *Boyce 1389* (K, SNP); Sandakan: Phenological trail above sawmill, *Dewol & Meijer SAN 131653* (SAN); Kinabatangan District, Kg. Bilit, Bt. Bilit, *Lim et al. 1272* (SING). KALIMANTAN. Locality not traced: Batu Makele, Batu Eilander, *Raap 118* (BO); G. Dansu, Pentaclale, Pegah, *Main (sub. Polak) 1958* (BO).

9. Rhaphidophora lobbii Schott

Rhaphidophora lobbii Schott, [Bonplandia 5(2) (1857) 45, *nom. nud.*], Prodr. Syst. Aroid. (1860) 379; Engl. in A. & C. DC., Monogr. Phan. 2 (1879) 240; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 33—34; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 89. — *Scindapsus lobbii* (Schott) Ender, Index Aroid. (1864) 74. — Type: Singapore, *Lobb 44* (K, holo).

Figure 11

Small to moderate, somewhat slender, leptocaul, homeophyllous liane to 5 m; *seedling* leafy at germination and skototropic by alternating series of congested leafy and elongated leafless shoots; *pre-adult plants* forming diffuse terrestrial colonies; *adult shoot architecture* comprised of greatly elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and long moderately elaborated, free, densely leafy, flowering stems; *stems* puberulent-scabrid to asperous, especially on older growth, climbing stems weakly rectangular to ± terete in cross-section, free stems ± terete in cross-section, often branching extensively and growing to moderate lengths pendent under their own weight, dull brown, without prophyll, cataphyll and petiolar sheath fibre, internodes to 13 x 0.6 cm on clinging and free shoots, flowering shoots with much shorter internodes, separated by weak to rather prominent, slightly oblique leaf scars, older stems woody; *flagellate foraging stems* absent; *clasping roots* sparsely arising from the nodes and internodes of clinging stems, densely pubescent; *feeding roots* rather rare, sometimes clinging but often free, pubescent; *leaves* weakly spiralled and often sparsely arranged on clinging and proximal portions of free shoots, densely spirally-distichous distally on flowering shoots; *cataphylls and prophylls* membranous, very soon drying and falling; *petiole* grooved adaxially, 4—9.5 x 0.2—0.3 cm, smooth, with a moderate apical and prominent basal geniculum; *petiolar sheath* slightly prominent, extending beyond the apical geniculum by two ligules, very soon drying and falling in strips to leave a continuous scar from the petiole base, around the top of the apical geniculum and back to the base; *lamina* entire, narrowly elliptic

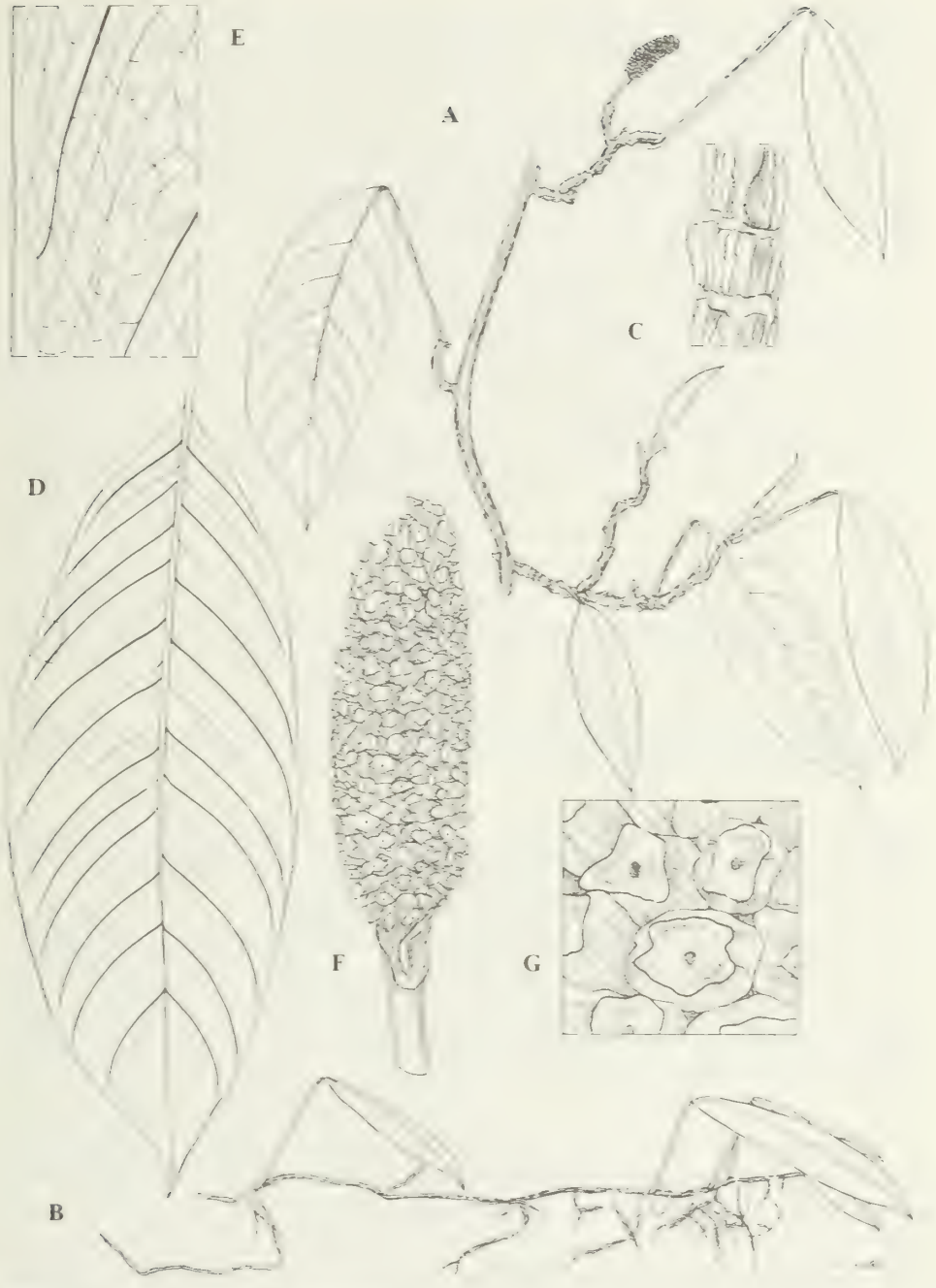

Figure 11. Rhaphidophora lobbii Schott
A, portion of stem with two flowering shoots x ; B, pre-adult terrestrial shoots x ; C, stem detail x 3; D, leaf lamina x ; E, venation detail x 4, F, inflorescence, spathe fallen x 2, G, spadix detail, early fruiting x 8. A & C from *Kunstler (Dr King's Collector) 10571*; B from *Boyce 995*; D & E from *Nauen s.n.*; F & G, from *Alvins 270*.

to elliptic-lanceolate to oblong or oblanceolate, 6—24 x 2—10 cm, very softly coriaceous, upper surfaces slightly glossy, lower surfaces pale satin-matt, drying markedly discolorous, dark brown above, pale brown below, base cuneate to acute or subovate, briefly decurrent, apex acute to ovate-acuminate, with a prominent apiculate apicule; *midrib* slightly raised abaxially, slightly sunken adaxially; *primary venation* pinnate, slightly raised abaxially, prominent (dark veins against pale lamina) in dried material; *interprimaries* parallel to, but much less distinctive than, primaries, very slightly raised abaxially; *secondary and tertiary venation* ± invisible in fresh material, barely visible in dried specimens, reticulate; *inflorescence* solitary, subtended by a fully developed foliage leaf and a very soon falling cataphyll; *peduncle* compressed-cylindric, 1.5—5 x 0.15—0.4 cm; *spathe* cigar-shaped, stoutly long-beaked, 3—5 x 0.4—1 cm, thickly fleshy, exterior minutely puberulent, dull green to yellowish, soon falling at female anthesis to leave a substantial, slightly oblique, scar; *spadix* slender cylindrical, sessile, inserted level on peduncle, 3—3.5 x 0.4—0.5 cm, dull yellow-white; *stylar region* rather well developed, mostly rhombohexagonal, 1.9—2.4 x c. 2 mm, truncate; *stigma* punctiform, c. 0.3 mm diam., prominent in dried material; *anthers* barely exserted at male anthesis, pollen extruded from between ovaries; *infructescence* oblong-cylindric, 2.5—4 x 1—1.2 cm.

Distribution: Southern Thailand, Peninsular Malaysia, Singapore, Sumatera, North Borneo and into Sulawesi.

Habitat: Primary to disturbed secondary lowland dipterocarp and peatswamp forest on wet to inundated soils. Sea level to 250 m altitude.

Notes: 1. A climber distinctive by the slender, asperous stems, softly leathery leaves and minutely puberulent spathe exterior, a combination of characters unknown in any other Malesian *Rhaphidophora*. In dry material the strongly discolorous leaves, combined with the primary veins prominently darker than the abaxial leaf surface, are unmistakable.

2. In Borneo, confusion with *R. cylindrosperma* is possible although the latter differs in its more coriaceous leaves, different leaf venation and in having a longer, externally glabrous spathe.

3. *Rhaphidophora lobbii* is habitually found in wet to inundated ground, an unusual habitat for a monsteroid liane, cf. *Epipremnum amplissimum* Schott, and *E. giganteum* (Roxb.) Schott.

Other Bornean specimens seen: SARAWAK. 1st Div.: Setapok F.R., 4 miles south of Kuching,

Anderson S 23496 (SAR): Semengoh F.R., 6 miles west of Kuching. *Nicolson 1258* (US): Setapok F.R., 6 miles south of Kuching. *Nicolson 1359* (US); 2nd Div.: Simanggang, Triso P.F., *Anderson 14547* (SING); 8th Div.: Binatang, Pulau Bruit. *Anderson 8932* (SING). Sg. Kelepu, Pulau Bruit. *Anderson 8007* (L, SING). Baram. *Anderson S 5084* (SAR, SING). BRUNEI DARUSSALAM. Temburong: Selapon, village margin, *Dransfield 6917* (BRUN, K, L): Batu Apoi F.R., on ridge between Kuala Belalong and Bt. Belalong, in permanent Plot 2. *Poulsen 362* (AAU, BRUN, K); Belait: Melilas, Ulu Inger, path from Ulu Inger to Sg. Tupai. *Sands 5919* (BRUN, K, L): Rasau. *Van Nie 4250* (L, MO). SABAH. Sandakan: Sepilok F.R., *Gaminating SAN 94588* (K, L, SAN): Sg. Dagat. *George et al. SAN 120521* (K, SAN); Kinabatangan, Tamegang Timber Camp near Kg. Pangkalan. *Kokawa & Hotta 1417* (KYO, L): Labuk Road. *Meijer SAN 38784* (K, L, SAN): Below waterfall: Kebun Cina F.R., *Meijer & Dewol SAN 131749* (SAN): Bongaya F.R., *Kedoh & Aban SAN 82024* (K, L, SAN, SAR, SING). KALIMANTAN. West Kalimantan: Pontianak, *Polak 308* (BO); Sg. Banghong, *Polak 645* (BO, K): Bt. Raya, Tumbang Riang, *Veldkamp 7910* (BO, L). East Kalimantan: Wanariset, Balikpapan, *Atmosuma 116* (BO): Km 79 on road from Sangui Sg. Mantaya, Kab. Kotawaringin Timur, *Argent et al. 93138* (B, E): Berau, Tandung Redeb, Sg. Kelai near Long Lanuk, *Kostermans 21135* (BO, L): Munukan, north of Tarakan, *Meijer 2034* (BO): 'Borneo', *Korthals 149* (L) & *Korthals s.n.* (L).

10. Rhaphidophora megasperma Engl.

Rhaphidophora megasperma Engl., Bot. Jahrb. Syst. 25 (1881) 8; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 29, Fig. 9; Alderw., Bull. Jard. Bot. Buitenzorg III. 1 (1920) 383; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 89. — Type: Indonesia. Kalimantan. Central Kalimantan. Tumbang Hiang, 2 Sept. 1881. *Grabowski 48* (B, holo).

Scindapsus havilandii Ridl., J. Straits Branch Roy. Asiat. Soc. 44 (1905) 184; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 75; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 91. **synon. nov.** — Type: Malaysia. Sarawak. 2nd Div., Saribas, July 1892. *Haviland 2089* (K, holo; SING, iso).

Rhaphidophora jaculiformis Alderw., Bull. Jard. Bot. Buitenzorg III. 4 (1922) 197. **synon. nov.** — Type: Indonesia. Kalimantan, no further data, 1893. *Jaheri s.n.* (BO, holo; BO, iso).

Rhaphidophora subfalcata M. Hotta, Acta Phytotax. Geobot. 22 (1966) 6. **synon. nov.** — Type: Malaysia. Sarawak. 7th Div., Bintulu, along Sg. Kakus from Sg. Tinggili to Sg. Puteh, 13 Nov. 1963, *Hirano & Hotta 1068* (KYO, holo).

Figure 12

Moderate sized, slender to slightly robust semi-leptocaul homeophyllous creeping and climbing liane to 5 m; *seedling stage* not observed; *pre-adult*

plants forming extensive terrestrial colonies; *adult shoot architecture* comprised of greatly elongated, clinging, physiognomically unbranched, sparsely leafy, non-flowering stems and short, little-branched, free, densely leafy, flowering stems; *stems* smooth, terete in cross-section, internodes to 10 x 1.7 cm on clinging shoots, much shorter on free shoots, separated by slightly oblique leaf scars, older stems subwoody; *flagellate foraging stems* absent; *clasping roots* sparsely arising from the nodes and internodes of clinging stems, pubescent; *feeding roots* rare, clinging, pubescent; *leaves* spiro-distichous on clinging shoots, distichous on free shoots; *cataphylls and prophylls* membranous, soon drying chartaceous and persisting at the tips of flowering shoots, then falling; *petiole* grooved canaliculate, 11—29 x 0.2—0.4 cm, apical and basal geniculum moderately prominent; *petiolar sheath* wide and membranous but very soon falling and thus usually not prominent, extending almost to or reaching apical geniculum, very soon drying and degrading into very sparse, soon-falling fibres; *lamina* entire to slightly perforated, perforations round to rhombic, extending c. $^{1}/_{4}$—$^{1}/_{2}$ of lamina width on each side of the midrib, oblong-lanceolate or oblong-elliptic, oblique, 12.5—42 x 3—10.5 cm, thinly coriaceous, base unequal, rounded, weakly acute to subrounded, apex acuminate; *midrib* prominently raised abaxially, ± sunken adaxially; *primary venation* pinnate, slightly raised abaxially and adaxially; *interprimaries* subparallel to primaries, much less prominent, slightly raised abaxially and adaxially; *secondary venation* prominently reticulate, raised abaxially, less so adaxially; *inflorescence* two, three or more, together, each subtended by a prominent chartaceous prophyll and one or more chartaceous cataphylls; *peduncle* slender to somewhat stout, terete, 4—1 x 0.2—0.3 cm; *spathe* broadly canoe-shaped, stout-beaked, 4—6 x 2—3.5 cm, stiff-fleshy, dull yellow on opening, persistent into early fruiting, eventually falling to leave a prominent scar; *spadix* stoutly to somewhat slender cylindrical, sessile, inserted obliquely on peduncle, 2.5—4 x 0.5—0.7 cm, dull cream; *stylar region* mostly hexagonal, 1.1—1.2 x 1—1.1 mm; *stigma* punctiform, very prominent, 0.1—0.2 x c. 0.3 mm; *anthers* exserted at male anthesis; *infructescence* stoutly oblong-cylindrical, 3.5—5 x 1.2—1.5 cm.

Distribution: Endemic to Borneo (Sarawak (1st, 3rd, 7th and 8th Divisions) and Kalimantan (West and Central).

Habitat: Primary to disturbed secondary lowland, often riverine, forest on clay-loam. 40—130 m altitude.

Notes: 1. Distinctive in Borneo by the short leafy free side shoots bearing clusters of inflorescences subtended and interspersed by prominent

Figure 12. Rhaphidophora megasperma Engl.
A. flowering shoot x [illegible]; B. leaf lamina x [illegible]; C. venation detail x 2; D. leaf lamina x [illegible]; inflorescence, spathe removed x 1[illegible]; E. spadix detail, post-male anthesis x 6; spadix detail, early fruiting x 4. A & F from *Ridley 14444*; B—E from *Burkill 6267*.

chartaceous prophylls and cataphylls and by the spathe drying and persistent into early fruiting. The clustered inflorescences subtended by chartaceous cataphylls recall some New Guinea species, notably *Rhaphidophora versteegii*.

2. Boyce (1999) merged *R. megasperma* with *R. puberula*. However, study of further Bornean specimens of both taxa clearly shows that this was in error and that *R. megasperma* is the earliest name for a Bornean endemic hitherto called *Scindapsus havilandii*, *Rhaphidophora jaculiformis* and *R. subfalcata*.

3. Hotta's name *R. subfalcata* has been applied to large plants of *R. megasperma* with perforated leaves. The presence of perforated and unperforated leaves in individuals of same species is not uncommon in *Rhaphidophora*; *R. puberula* is typical of such a phenomenon.

4. Both type sheets of Ridley's *Scindspaus havilandii* are fertile; so it is odd that Ridley should have considered it to belong to *Scindapsus* since the generic diagnostic characters, number and position of ovules (solitary and basal v. many on one or two parietal placentas), are readily observable.

5. The types of Aldrwerelt's *R. jaculiformis* match *R. megasperma* perfectly.

Other specimens seen: SARAWAK. 1st Div.: Matang, *Ridley s.n.* (K); 3rd Div.: Kapit, Sung, upper Sg. Katibas, Sg. Joh trail, *Zainudin et al. 4537* (K, UKMB); 7th Div.: Sg. Bejangung, a branch of the Sg. Anap, Bintulu District, *Hotta 15578* (KYO); 8th Div.: Bandar Sri Aman - Sibu road, 156 km before Sibu below bridge over the Sg. Undup, *Boyce 721* (K, M); Serian, Kg. Tebekang, *Othman & Munting S55097* (K, L, SAR). KALIMANTAN. West Kalimantan: Serawai, 8 km NE of Desa Jelundung, Batu Lintang, next to camp, *Church, Mahyer & Afriastini 1668* (BO, GH, K); Serawai, *Winkler 238* (E, L); Serawai, near Talok Nibung, *Winkler 1250* (E, L). Lake Tajan, *Main (sub. Polak) 1758* (BO, L); Upper Samba river, 60-80 km NNW of Tumbang Samba, Tumbang Habangoi to Tumbang Riang, *Mogea 3550* (BO, K, KEP, L); Central Kalimantan: Bt. Raya, *Nooteboom 4120* (L, BO);

11. Rhaphidophora minor Hook.f.

Rhaphidophora minor Hook.*f.*, Fl. Brit. Ind. 6 (1893) 544; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 21, Fig. 4; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 89. — Type: Malaysia, Malacca, *Griffith 5988* (K, lecto; K, P, isolecto, selected by Boyce, 1999).

Rhaphidophora celebica K. Krause, Notizbl. Bot. Gart. Berlin-Dahlem. 11 (1932) 331. —Type: Indonesia, Sulawesi, northwest of the island, near

Toli-Toli, Jan. 1910, *Schlechter 20698* (B, holo).

[*Rhaphidophora palawanensis* Furtado, *nom. nud. in sched. var., non.* Merr. (1925)]

Figure 13

Small to moderate, slender, leptocaul, homeophyllous liane to 6 m; *seedling* not observed; *pre-adult plants* forming diffuse terrestrial colonies; *adult shoot architecture* comprised of greatly elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and long moderately elaborated, free, densely leafy, flowering stems; *stems* smooth, flexuous, climbing stems ± terete, occasionally weakly 4-angled in cross-section, free stems somewhat laterally compressed in cross-section, often branching extensively, growing to considerable lengths and pendent under their own weight with flowering tips upturned, without prophyll, cataphyll and petiolar sheath fibre, internodes to 13 x 1.2 cm on clinging and free shoots, flowering shoots with much shorter internodes, separated by weak straight leaf scars, older stems woody; *flagellate foraging stems* absent; *clasping roots* arising sparsely or singly from the clinging stems, pubescent; *feeding roots* solitary from nodes, free, stout, slightly pubescent; *leaves* weakly distichous and sparsely arranged on clinging and proximal portions of free shoots, moderately densely distichous distally on flowering shoots; *cataphylls and prophylls* membranous, very soon drying and falling; *petiole* grooved adaxially, 3—6 x 0.1—0.25 cm, smooth, with a slight apical and prominent basal geniculum; *petiolar sheath* slightly prominent, extending beyond the apical geniculum by two small ligules, very soon drying and falling in strips to leave a continuous scar from the petiole base, around the top of the apical geniculum and back to the base; *lamina* entire, narrowly falcate-elliptic to falcate-lanceolate or falcate-oblanceolate, 2.5—16 x 1.2—3 cm, thinly coriaceous, drying pale straw-coloured, base cuneate to acute or subovate, apex acute with a prominent apicule; *midrib* raised abaxially, slightly raised adaxially; *primary venation* pinnate, slightly raised on both surfaces prominent (raised) in dried material; *interprimaries* subparallel to, but much less distinctive than, primaries, sometimes degrading into weakly reticulate venation, very slightly raised abaxially; *secondary and tertiary venation* ± invisible in fresh material, barely visible in dried specimens, reticulate; *inflorescence* solitary, subtended by a fully developed foliage leaf and a very soon falling cataphyll; *peduncle* compressed-cylindric, 3—4 x 0.3—0.5 cm; *spathe* cigar-shaped, stoutly long-beaked, 3—9 x 1—1.5 cm, thin, dull green to dull yellow, soon falling at female anthesis to leave a large, straight, scar; *spadix* slender cylindrical, sessile, inserted level on peduncle, 2.5—7 x 0.5—0.6 cm, dull yellow-white; *stylar region* rather well developed, mostly

rhombohexagonal, 1.4—2 x c. 2 mm, truncate; *stigma* punctiform, c. 0.3 mm diam., slightly prominent in dried material; *anthers* well-exserted at male anthesis; *infructescence* oblong-cylindric, 4.5—7 x 1—2.5 cm.

Distribution: Southern Thailand, Peninsular Malaysia, Singapore, Sumatera, throughout Borneo (widely scattered), Sulawesi and into the Philippines (Mindanao, Palawan).

Habitat: Lowland peatswamp forest, riverine forest, rear of freshwater mangrove. Sea level to 10 m altitude.

Notes: 1. In the fresh state confusion with *Rhaphidophora sylvestris* is possible, although the thinner, more prominently veined leaf and longer spathe beak of *R. minor* Hook.*f.* are diagnostic. Dried material of *R. minor* is notable for the uniformly pale straw coloured leaves.

2. In Borneo, *R. minor* is habitually found in swampy habitats whereas elsewhere in its range it tends to be in drier places.

Other Bornean specimens seen: BRUNEI DARUSSALAM. Belait: Kuala Belait, *Van Niel 3944* (L); Seria, *Van Niel 4138* (L); Sg. Belait, *Van Niel 4634* (L). SARAWAK. 1st Div.: Kuching, *Hewitt s.n.* (K); Kuching, *Ridley s.n.* (SING); Kuching, *Ridley s.n.* (K). 7th Div.: Ulu Bawan, Balingian, *Ashton S 19585* (GH, K, L, MO, SAR, SING, US); Sg. Tengah, *Brooks 1016* (BM); Batang Lassa, near Rhuma Jumbau, *Mamit S 33623* (K, L, MO, SAR, US). SABAH. Sandakan: Beluran, Sg. Mangkayok, near Sg. Kalagan, *Meijer SAN 51617* (SAN); Ulu Dusum, *Meijer SAN 122736* (E, SAN, US). KALIMANTAN. West Kalimantan: Mempaura, *Teysmann 8105* (BO); Central Kalimantan: Sampit, *Buwalda 7917* (BO); East Kalimantan, 20 km north of Wanariset, Kg. Padang, Samboja, *Sidiyasa 1111* (K, L); Cape Genderen, Pladjoe, *Amdjah 7* (BO, K, L, SING), *Amdjah 32* (BO, L), *Amdjah 951* (BO, K, L); G. Samenggaris, *Amdjah 1084* (BO, K, L); South Kalimantan: no further data, *Winkler 3448* (L); Locality not traced: *Hallier 35, 66* (BO); Long Lansiah (?), *Teysmann 11338* (BO, L);

12. Rhaphidophora puberula Engl.

Rhaphidophora puberula Engl., Bot. Jahrb. Syst. 1 (1881) 180 & in Beccari, Malesia 1 (1882) 269—270; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 30. — Type: Indonesia, Sumatera, West Sumatera, Padang, Ajer Mantjoer, Aug. 1878, *Beccari s.n.* (FI, holo; B, iso).

Rhaphidophora scortechinii Hook.*f.*, Fl. Brit. India 6 (1893) 545; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 23. — Type: Malaysia, Perak, *Scortechini 347* (K, holo; CAL, iso).

Rhaphidophora kunstleri Hook.*f.*, Fl. Brit. Ind. 6 (1893) 546; 548; Engl. &

Figure 13. Rhaphidophora minor Hook.*f.*
A, portion of adult, sterile shoot x 1/5; B, flowering shoot x 1/5; C, leaf lamina x 2/5; D, venation detail x 2; E, inflorescence, spathe just beginning to abscise x 1 1/2; F, spadix detail, post-female anthesis, pre-male anthesis x 8; G, spadix detail, early fruiting x 5. A & D from *Winkler 238*; B & from *Church et al. 1668*; E & F from *Hotta 1068*.

K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 30; Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 338. — Type: Malaysia, Perak, Bt. Larut, July 1883, *Kunstler 4538* (K, lecto, selected by Boyce, 1999).

Rhaphidophora gracilipes Hook.*f*., Fl. Brit. Ind. 6 (1893) 545; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 30, Fig. 10; Alderw., Bull. Jard. Bot. Buitenzorg III, 1 (1920) 384. — Type: Malaysia, Perak, June 1886, *Kunstler 10271* (K, lecto; BM, SING, isolecto, selected by Boyce, 1999).

Rhaphidophora batoensis Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 27. — Type: Indonesia, Sumatera, North Sumatera, Kepulauan Batu, 25 Sept. 1896, *Raap 370*, (B, lecto; BO, isolecto, selected by Boyce, 1999).

Rhaphidophora hallieri Alderw., Bull. Jard. Bot. Buitenzorg III, 1 (1920) 385; Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 196. — Type: Kalimantan, *Hallier 1187* (BO, holo; BO iso).

Rhaphidophora pilosula Alderw., Bull. Jard. Bot. Buitenzorg III, 1 (1920) 386; Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 196. — Type: Cult. Bogor Bot. Gard, June 1919, *Alderwerelt s.n.* (BO, holo).

Figure 14

Moderate to large, rather robust, semipachycaul homeophyllous liane to 5 m; *seedling stage* not observed; *pre-adult plants* often forming small terrestrial colonies; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and short, usually unbranched, free, densely leafy, flowering stems; *stems* smooth, terete in cross-section, with very sparse prophyll, cataphyll and petiolar sheath fibre, this soon falling, internodes to 13 x 1.5 cm on clinging shoots, usually shorter and stouter on free shoots, separated by large, straight, corky leaf scars, older stems woody; *flagellate foraging stems* absent; *clasping roots* sparsely arising from the nodes and internodes of clinging stems, pubescent; *feeding roots* rare, clinging, pubescent; *leaves* distichous on clinging and free shoots; *cataphylls and prophylls* membranous, soon drying and degrading into very sparse fibres, these soon falling; *petiole* deeply grooved to basally canaliculate, 9—33 x 0.2—3 cm, with the distal portion and apical geniculum minutely pubescent, especially when newly expanded, apical and basal geniculum moderately prominent; *petiolar sheath* very prominent, extending to just below the apical geniculum, soon drying and degrading into sparse, soon-falling fibres; *lamina* entire to slightly perforated, perforations round to rhombic, extending c. $^1/_5$—$^1/_4$ of lamina

width on each side of the midrib, ovate to oblong-lanceolate or oblong-elliptic, oblique to falcate, minutely pubescent abaxially when young, 8—34 x 3.5—10.5 cm, thinly coriaceous to subchartaceous, base unequal, rounded, acute to slightly decurrent, apex acute to acuminate; *midrib* prominently raised and pubescent abaxially, ± sunken adaxially; *primary venation* pinnate, slightly raised abaxially and adaxially, the leaf appearing slightly quilted, pubescent in younger leaves, indumentum mostly shed in older leaves; *interprimaries* subparallel to primaries, very slightly less prominent, slightly raised abaxially, slightly impressed adaxially; *secondary venation* tessellate to weakly reticulate, slightly raised; *tertiary venation* not visible; *inflorescence* solitary, very rarely two together, fragrant of frangipani and pineapple (*fide Hay et al.* 9029) subtended by a fully developed foliage leaf and, if more than one inflorescence, then second preceded by a large cataphyll; *peduncle* strongly compressed-cylindric, 4—9 x 0.4—0.6 cm; *spathe* canoe-shaped, stoutly long-beaked, 5.5—19 x 1—6.5 cm, stiff-fleshy, dull green to dull yellow, pale yellow to apricot-orange internally, falling (after?) female anthesis to leave a large, straight scar; *spadix* very weakly clavate cylindrical, sometimes slightly curved, sessile, inserted ± level on peduncle, 3—11.5 x 1—1.6 cm, cream; *stylar region* mostly hexagonal, 1.5—2 x 2.1—2.5 mm, truncate; *stigma* punctiform, prominent, 0.5—0.75 x 0.45—0.75 mm; *anthers* exserted at male anthesis; *infructescence* stoutly oblong-cylindrical, 4.5—14 x 1.5—2 cm, glaucous.

Distribution: Sumatera, Peninsular Malaysia, Nusa Tenggara and throughout Borneo.

Habitat: On trees and rocks in primary and secondary lowland to lower/upper montane transition forest, often on steep slopes, on granite and limestone. 90—1550 m altitude.

Notes: 1. Given the overall uniformity of this species, it is quite extraordinary that *Rhaphidophora puberula* should have been redescribed no fewer than seven times based mostly on minor differences of leaf shape.

2. Superficially similar to *R. foraminifera*, especially in the perforate-leaf forms, *R. puberula* can readily be distinguished from *R. foraminifera* by the production of inflorescences on free lateral shoots and in having the active shoot tips without the characteristic black mucilage of *R. foraminifera*. Generally, flowering plants of the perforate-leaved forms of *R. puberula* have smaller leaves that are noticeably *less* perforated than those of *R. foraminifera*.

Other Bornean specimens seen: SARAWAK. 1st Div.: Matang, *Ridley s.n.* (K); 4th Div.: Baram District, G. Mulu N.P., Hidden Valley, *Argent et al. 887* (L); 7th Div.: Bintulu, Segan F.R., *Chai S31999* (K, L, SAN, SAR, SING, US). BRUNEI DARUSSALAM. Belait: Labi, track to Rampayoh waterfall, *Ahmad 15* (BRUN, K). SABAH. Sandakan: Bettohan near Sandakan, *Kloss SFN 19099* (K, L, SING); Lamag, Kinabatangan, Ulu Sg. Pin, *Madani & Saigol SAN 90180* (K, L, SAN, SAR); Pantai Barat: Keningau, Sg. Labou, *Mantor SAN 110980* (GH, K, SAN); Tuaran District, below summit of Lawa Mandau, Telekom station east of Telipok, *Meijer et al. SAN 136186* (GH, SAN); Pedalaman: Kiau, Mount Kinabalu, *Clemens 10142* (UC); Gurulau Spur, Mount Kinabalu *Clemens 10772* (UC); Dallas, *Clemens & Clemens 26453* (BM, K, L, SING); Dallas, *Clemens & Clemens 26781* (BM); Dallas, *Clemens & Clemens 26876* (BM, BO, GH, K, L, SING, UC); Tenompok, *Clemens & Clemens 26900* (BM, BO, K, L, SING, UC); Kinabalu N.P., along the road between Park H.Q. and Tenompok, *Kokawa & Hotta 3089* (KYO); Tawau: *Elmer 21593* (BO, K, L, MO, SING, UC); Sabah Foundation logging area Umas-Umas, *Krispinus SAN 87213* (K, KEP, L, SAN, SAR); Kalabakan, km 41 Imbak road, Luasong, *Krispinus SAN 95680* (K, L, SAN, SAR); Lahad Datu, Madai Caves, Madai Baturong F.R., *Kokawa & Hotta 1097* (KYO, L). Locality not traced: Pandawan, Sg. Mesopo, *Fidilis & Sumbing SAN 113389* (K, KEP, SAN); KALIMANTAN. Cult. Bogor, Y70, from Kalimantan collection, *Ashton 12626* (BM, BO) & *Nicolson 942* (BO, L, US).

13. Rhaphidophora sylvestris (Blume) Engl.

Rhaphidophora sylvestris (Blume) Engl. in A. & C., DC, Monogr. Phan. 2 (1879) 239 & in Beccari, Malesia 1 (1882) 268; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 22—25, Fig. 6 (‘*silvestris*’); Alderw., Bull. Jard. Bot. Buitenzorg III, 1 (1920) 383; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 90 (‘*silvestris*’). — *Calla sylvestris* Blume, Catalogus (1823) 62. — *Scindapsus sylvestris* (Blume) Kunth, Enum. pl. 3 (1841) 64; Miq., Flora Ned. Indië 3 (1856) 187—188. — [*Scindapsus angustifolius* Hassk., Flora 25 (2), Beibl. 1 (1842) 12, *nom. illeg.* — *Rhaphidophora angustifolia* (Hassk.) Schott in Bonplandia 5 (1857) 45, *nom. illeg.* — based on the type of *Calla sylvestris* Blume]. — Type: Indonesia, Java, *Blume 178* (L, lecto; L, LE, isolecto, selected by Boyce, 1999).

Scindapsus lingulatus Hassk., Flora 25(2) Beibl. 1 (1842) 12; Schott, Prodr. Syst. Aroid. (1860) 378; Engl. in A. & C., DC, Monogr. Phan. 2 (1879) 248. — *Rhaphidophora lingulata* (Hassk.) Schott, Bonplandia 5 (1857) 45. — *Monstera lingulata* (Hassk.) C. Koch ex Ender, Index Aroid. (1864) 74. — Type: Indonesia, Java, *Hasskarl s.n.* (not traced, see Boyce, 1999).

Scindapsus aruensis Engl., Bull. Soc. Tosc. Ortic. 4 (1879) 270. — Type: Indonesia, Melaku, Aru Islands, Gabu-lengaw, May 1873, *Beccari s.n.* (FI, holo).

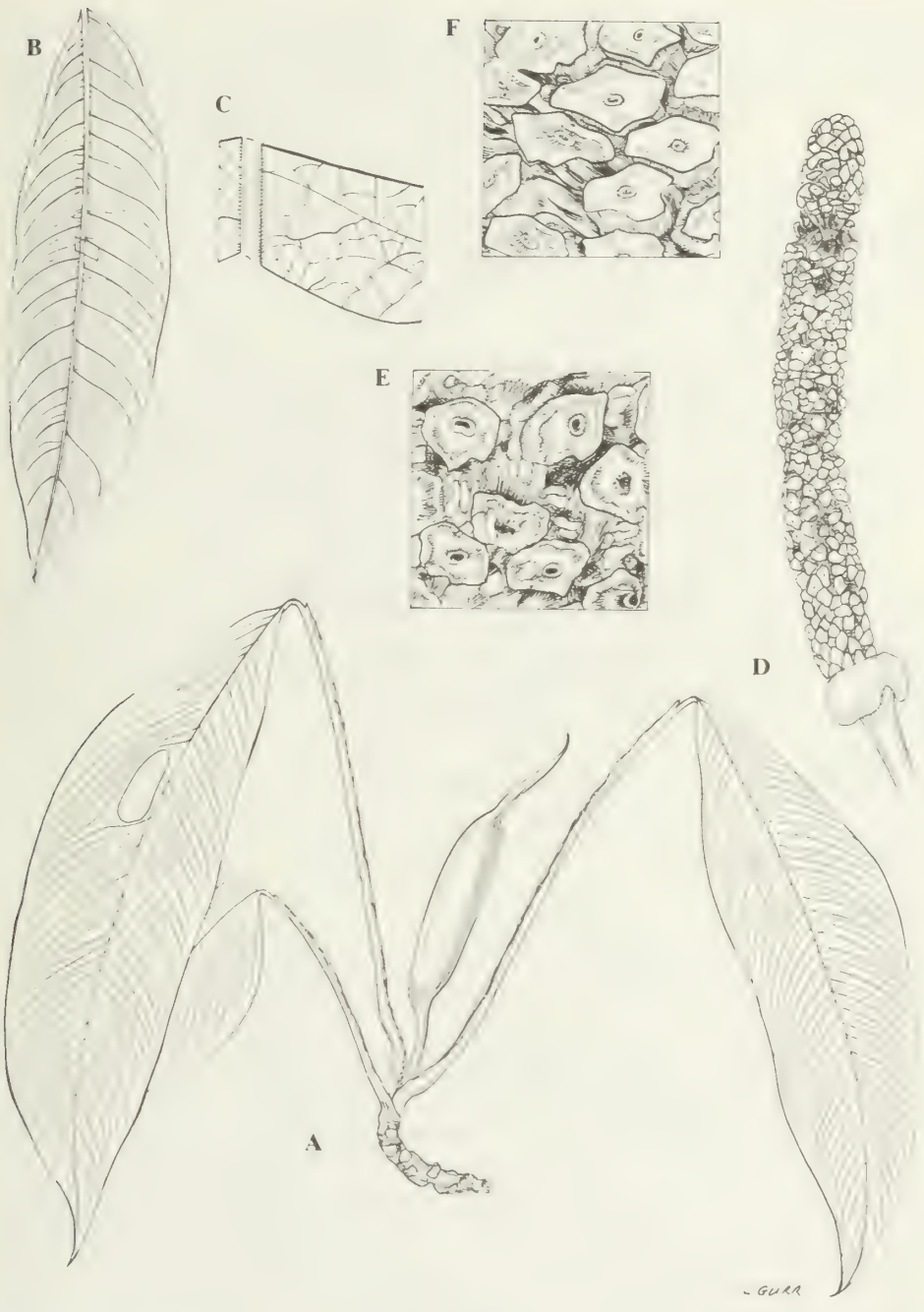

Figure 14. Rhaphidophora puberula Engl.
A. flowering shoot x ½; B. leaf lamina x ⅛; C. venation detail x 6; D. inflorescence, spathe removed x 2; E. spadix detail, post-male anthesis x 6; F. spadix detail, early fruiting x 4. A & F from *Ridley 14444*; B—E from *Burkill 6267*.

Rhaphidophora wrayi Hook.*f*., Fl. Brit. India 6 (1893) 544; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 34. — Type: Malaysia, Perak, Larut, Besar, April 1882, *Kunstler 2939* (K, lecto, selected by Boyce, 1999).

Rhaphidophora gratissima Becc., Nelle Foreste di Borneo (1902) 604. — *Rhaphidophora sylvestris* var. *obtusata* Engl., Malesia 1 (1883) 268 — Type: Malaysia, Sarawak, 1st Div., Kuching, Nov.1865, *Beccari PB 952* (FI, holo; FI spirit 423, K, iso).

Rhaphidophora nigrescens Ridl., J. Straits Branch Roy. Asiat. Soc. 44 (1905) 185 ('*migrescens*'), **synon. nov.** — Type: Malaysia, Sarawak, 1st Div., Matang, July 1903, *Ridley* s.n. (SING, lecto, selected here). Ridley cites two conspecific syntypes, that chosen is the best specimen for identification purposes. The other syntype is: Malaysia, Sarawak, 19 June 1893, *Bartlett* s.n. (SING).

Rhaphidophora motleyana Engl. & K. Krause in Engler, Pflanzenr. 37 (IV.23B) (1908) 25; Merrill, J. Straits Branch Roy. Asiat. Soc., special number (1921) 89. — Type: Indonesia, Kalimantan, South Kalimantan, Bangarmassin, 1857—1858, *Motley 741* (K, holo).

[*Scindapsus lanceolataus* Miq. *nom. nud. in sched.* BO]

[*Pothos cucculata* Zipp. *nom. nud. in sched.* L]

Figure 15

Medium to large, occasionally very large, moderately robust, leptocaul to semi-pachycaul homeophyllous liane to 20 m; *seedling stage* a non-skototropic shingling shoot; *pre-adult plants* very seldom forming small terrestrial colonies of appressed shingling shoots; *adult shoot architecture* comprised of greatly elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and long, moderately elaborated, free, densely leafy, flowering stems later pendent under their own weight; *stems* smooth, climbing stems rectangular in cross-section, the angles often slightly winged, the surfaces between slightly concave, free stems rectangular to subterete in cross-section, green, later mid-brown, without prophyll, cataphyll and petiolar sheath fibre, internodes to 2.5—5 x 0.5—1 cm on clinging shoots, usually less stout on free shoots, separated by weakly defined, slightly oblique leaf scars, older stems woody; *flagellate foraging stems* frequent, often of great length, ± rectangular in cross-section; *clasping roots* densely

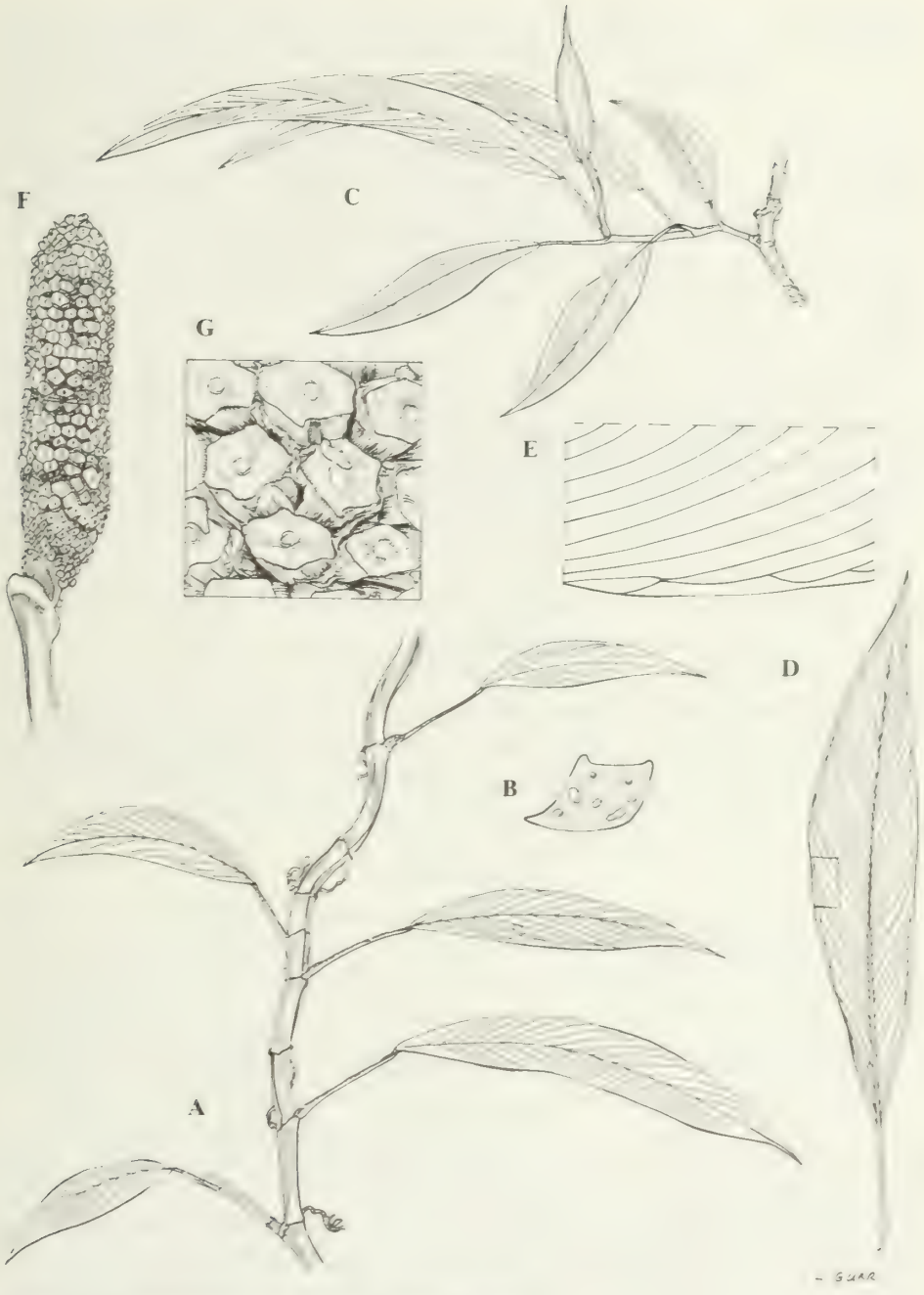

Figure 15. Rhaphidophora sylvestris (Blume) Engl.
A, portion of adult sterile stem x ; B, stem cross-section x 1; C, flowering shoot x ; D, leaf lamina x 1; E, venation detail x 4; F, inflorescence, spathe fallen x 1; G, spadix detail, post-male anthesis x 4. A & B from *Backer 11199*; C, F & G, from *de Wilde & de Wilde-Duyfjes 13830*; D & E from *Afriastini 2399*.

arising from the nodes and internodes of clinging stems, pubescent; *feeding roots* very rare, clinging, pubescent; *leaves* distichous on clinging and free shoots, those distal on flowering shoots densely so; *cataphylls and prophylls* membranous, very soon drying and falling; *petiole* deeply grooved adaxially, 1—8.5 x 0.15—0.3 cm, smooth, apical and basal genicula weakly defined; *petiolar sheath* very prominent, extending to and encircling the apical geniculum, briefly ligulate, very soon drying and falling to leave a continuous conspicuous scar from the petiole base, around the top of the apical geniculum and back to the base; *lamina* entire, lanceolate-elliptic to falcate-lanceolate, slightly to markedly oblique, 4.5—32 x 1.75—8.5 cm, thinly coriaceous, upper surfaces slightly glossy, lower surfaces semi-matt, base subacute to briefly truncate, apex acute to slightly attenuate, with a prominent apiculate apicule; *midrib* slightly raised abaxially, slightly sunken adaxially; *primary venation* pinnate, slightly raised abaxially and adaxially; *interprimaries* parallel to primaries and only slightly less prominent, very slightly raised abaxially and adaxially; *secondary* and *tertiary venation* ± obscure in fresh material, visible as a faint reticulum in dried specimens; *inflorescence* solitary, subtended by a fully developed foliage leaf; *peduncle* compressed-cylindric, 2—8.5 x 0.15—0.5 cm; *spathe* cigar-shaped, stoutly very short-beaked, 4.5—7.5 x 1—3 cm, thinly stiff-fleshy, dull yellow, paler internally, soon falling at female anthesis; *spadix* cylindric to weakly clavate-cylindrical, sessile, inserted ± level on peduncle, 3—6 x 1—2.5 cm; *stylar region* mostly rhombohexagonal, 1—2 x 1.5—2 mm, truncate; *stigma* punctiform, raised, c. 0.25—0.3 mm diam.; *anthers* exserted at male anthesis; *infructescence* 6—8 x 2—2.5 cm.

Distribution: Peninsular Malaysia, Sumatera, throughout Borneo, Java, Nusa Tenggara and Maluku.

Habitat: Primary to disturbed secondary lowland to lower montane forest on a variety of substrates including sandy loam and limestone. 120—1800 m altitude.

Note: *Rhaphidophora sylvestris* is more variable in Borneo than in other parts of its range (e.g. Peninsular Malaysia, Java) but the paucity of collections coupled with more or less continuous variation makes it impossible to be confident that more than one species is involved. Of particular note is the occurrence of plants with coriaceous leaf laminas that have variously been described as *Rhaphidophora gratissima* Becc. (syn. *R. sylvestris* var. *obtusata* Engl.) and *R. nigrescens* Ridl.. Such plants approach *R. conocephala* in appearance (and also resemble non-Bornean *R. crassifolia*), although the flat-topped styles readily distinguish them from

R. conocephala, while the juvenile shoots without conspicuously twisted stems separate them from *R. crassifolia*. Lamina thickness is not a consistent character, even between duplicates of the same collection.

Other Bornean specimens seen: SARAWAK. 1st Div.: G. Pueh (Mt Poi), base camp, *Clemens & Clemens 21935* (K); Matang, *Kochummen FRI 29145* (KEP, GH, K, L, SING); Kuching, *Ridley s.n.* (K); Puak, *Ridley 12413* (BM, K, SING); Kuching, Tiang Bekap, G. Maja, *W.L. Chew 714* (L, SING). SABAH. Pantai Barat: Ranau, Bt. Hampuan, *Amin & Jarius SAN 121155* (K, SAN); Mt Kinabalu, Bungal trail, *Clemens & Clemens s.n.* (SING); Dallas, *Clemens & Clemens 26720* (K, SING), *Clemens & Clemens 26921* (BM, BO, K, L, SING), *Clemens & Clemens 27030* (BM, BO, K, L, SING, US), *Clemens & Clemens 27312* (BM, BO, K, SING); Upper Kinabalu, Mementong, Mesilau Basin, *Clemens & Clemens 28487* (BM, K, L, SING); Tenompok, *Clemens & Clemens 29227* (BM, BO, K, L, SING, UC); Ranau, Mt Kinabalu, Mesilau valley, *Cockburn SAN 70108* (SAN); Kinabalu N.P., along Sg. Mesilau from Mesilau Camp to Mesilau Cave, *Kokawa & Hotta 3995* (KYO); Kinabalu, Penibukan, Sg. Tahubang, *Nooteboom & Aban 1582* (L). BRUNEI DARUSSALAM. Belait: Sg. Keduan, off Sg. Belait, *Forman 1174* (BRUN, K). KALIMANTAN. Central Kalimantan: Sintang, HPH km 70, west camp off main (new) logging road, *Church et al. 985* (BO, GH, K), 'Borneo', *Korthals 153, Korthals s.n.* (L).

Acknowledgements

Thanks are due to Linda Gurr for skillfully executing the illustrations that accompany this article. Thanks also to Dr Alistair Hay (NSW) who critically reviewed the manuscript and offered much useful advice.

References

Boyce, P.C. 1998. The genus *Epipremnum* Schott (Araceae—Monsteroideae—Monstereae) in west and central Malesia. *Blumea*. **43**: 183—213.

Boyce, P.C. 1999. The genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae-Monstereae) in Peninsular Malaysia, and Singapore. *Gardens Bulletin Singapore*. **51**: 183—256.

Boyce, P.C. 2000a. The genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae-Monstereae) in the Southern and Western Indonesian Archipelago. *Gardens Bulletin Singapore*. **52**: 101—183.

Boyce, P.C. 2000b. The genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae-Monstereae) in the Philippines. *Gardens Bulletin Singapore*. **53**: 213—256.

Boyce, P.C. and J. Bogner. 2000. An account of neotenic species of *Rhaphidophora* Hassk. (Araceae-Monsteroideae-Monstereae) in New Guinea and Australia. *Gardens Bulletin Singapore.* **52**: 89—100.

Boyce, P.C. 2001. The genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae- Monstereae) in New Guinea, Australia and the Tropical Western Pacific. *Gardens Bulletin Singapore.* **53**: 75—183.

Engler, A. and K. Krause 1908. Araceae-Monsteroideae. In A. Engler (ed.), *Das Pflanzenreich* **37** (IV.23B) 4—139. Engelman, Leipzig.

Mayo, S.J., J. Bogner and P.C. Boyce. 1997. *Genera of Araceae.* Royal Botanic Gardens, Kew, U.K.

Schimper, A.F.W. 1903. *Guilds in Plant-Geography upon a Physiological Basis.* Pt 2, ch. 2: 192—206. (English translation by W.R. Fisher, revised and edited by P. Groom & I.B. Balfour.) Clarendon Press, Oxford, U.K..

Stearn, W.T. 1992. *Botanical Latin*, 4th ed., pp. xiv + 546. David & Charles, Newton Abbot & London, U.K.

Strong, D.R. & Ray, T.S. 1975. Host tree location behavior of a tropical vine (*Monstera gigantea*) by skototropism. *Science.* **190**: 804—806.

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Gardens' Bulletin Singapore **53** *(2001) 75–183.*

The Genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae- Monstereae) in New Guinea, Australia and the Tropical Western Pacific

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Abstract

An alpha-taxonomic account of *Rhaphidophora* in New Guinea, Australia and the tropical western Pacific is presented as a precursor to the forthcoming Flora Malesiana *Araceae* treatment. Thirty species are recognized, of which 12 (*R. cravenschoddeana*, *R. cryptantha*, *R. fortis*, *R. gorokensis*, *R. guamensis*, *R. intonsa*, *R. intrusa*, *R. jubata*, *R. kokodensis*, *R. mima*, *R. pilosa* and *R. waria*) are novel. Twenty new synonomies are made: *R. hollrungii* and *R. iboensis* = *R. australasica*; *R. pallidivenia* = *R. conica*; *R. oreophila* = *R. discolor*; *R. wentii* = *R. geniculata*; *R. nutans* = *R. microspadix*; *R. buergersii*, *R. conferta*, *R. drepanophylla*, *R. obliquata* and *R. peekelii* = *R. schlechteri*; *R. apiculata*; *R. engleri* [syn. *R. palauensis* Engl. & K. Krause (1921) *non* Koidz. (1916)], *R. forbesii*, *R. kanehirae* and *R. palauensis* Koidz. (1916) = *R. spathacea*; *R. graeffei* and *R. reineckei* = *R. spuria*; *R. ledermannii* = *R. versteegii*. One species (*R. dahlii* Engl.) is treated as doubtful. A dichotomous key to species is provided. All species are illustrated.

Contents

Introduction

Rhaphidophora Hassk. (including *Afrorhaphidophora* Engl.; at least 3 species in tropical Africa) comprises c. 100 species of small to large, occasionally enormous, root-climbing lianes (*sensu* Schimper, 1903), rarely

rheophytes, distributed from tropical West Africa eastwards to the western Pacific (Samoa), north to southern Japan (Ryukyu Islands) and south to Northern Australia. *Rhaphidophora* is one of the largest aroid genera represented in tropical Asia and has several nodes of diversity; the Himalaya (SE Nepal to NE Vietnam, roughly 17°—23° N), West Malesia (including southernmost peninsular Thailand), the Philippines, and East Malesia. Thirty species occur in New Guinea, Australia and the tropical Western Pacific region.

The last complete revision of *Rhaphidophora* was that of Engler and Krause (1908) and a summary of the taxonomic and nomenclatural history of *Rhaphidophora* was presented in Boyce (1999).

This is the sixth in a series of papers intended to present a complete alpha-taxonomy of the genus *Rhaphidophora*. Accounts for Peninsular Malaysia and Singapore (Boyce, 1999), south and west Indonesia (Boyce, 2000a), the Philippines (Boyce, 2000b), Borneo (Boyce, 2001) and for neotenic species in New Guinea and Australia (Boyce & Bogner, 2000) have been published to date. Accounts for each of India, Sri Lanka and the Himalaya, Thailand and Indochina, and Africa are being prepared and will be published separately.

Synonymy cited is for the species, not for the review area. The reason for this is that synonymous names based on types from outside the review area are frequently applied to specimens in local herbaria.

Infrageneric Relationships

Boyce (2000a) proposed eight informal morpho-taxonomic groups for the *Rhaphidophora* of Indochina and Thailand, Sunda and Wallacea, each group named with the earliest accepted species epithet belonging to that group. It should be noted that these groups are a first, pragmatic attempt at creating morpho-taxonomic units. Molecular work underway at Cambridge will result in a better, infrageneric classification.

Of the eight groups proposed by Boyce (2000a), three occur in the New Guinea and Pacific region:

1. **Korthalsii Group** (*R. korthalsii* Schott).
2. **Neoguineensis Group** (*R. neoguineensis* Engl., *R. intrusa* P.C. Boyce, *R. mima* P.C. Boyce, *R. schlechteri* K. Krause).
3. **Spathacea (Hollrungii) Group** (*R. australasica* F.M. Bailey, *R. guamensis* P.C. Boyce, *R. spathacea* Schott, *R. versteegii* Engl. & K. Krause, *R. waria* P.C. Boyce). The Hollrungii Group is here renamed the Spathacea Group, following recognition of *R. spathacea* as the earliest described attributable species.

In addition, a further eight indigenous New Guinea Pacific groups are proposed and described here:

1. **Brevispathacea Group** (*R. brevispathacea* Engl. & K. Krause, *R. stolleana* Engl. & K. Krause, perhaps *R. geniculata* Engl.):- Long pendent stems (erect and clinging in *R. geniculata*) with much abbreviated inflorescence-bearing shoots arising in the leaf axils. Spathe marcescent.
2. **Discolor Group** (*R. discolor* Engl. & K. Krause, *R. stenophylla* K. Krause, *R. conica* Engl., *R. petrieana* A. Hay):- Flowering on free shoots. Spadix long stipitate. Rather to markedly narrow leaves.
   (Perhaps not a good group because free shoots and stipitate spadices recur throughout the genus but morphologically it is quite homogeneous.)
3. **Fortis Group** (*R. fortis* P.C. Boyce):- Extremely stout, clinging flowering shoots and short-petioled leaves. Inflorescences with appearance of being borne in the leaf axils.
4. **Jubata Group** (*R. jubata* P.C. Boyce):- Robust, pachycaul, flowering on adherent shoots. The crested reniform seeds are unique in the genus.
   (Similar in appearance to *R. intonsa* P.C. Boyce and *R. cravenschoddeana* P.C. Boyce, which are different in not having crested reniform seeds.)
5. **Microspadix Group** (*R. microspadix* K. Krause):- Long, very slender shoots flowering at the tip. Spathe small, marcescent.
   (May be part of the Neoguineensis Group).
6. **Okapensis Group** (*R. gorokensis* P.C. Boyce, *R. kokodensis* P.C. Boyce, *R. okapensis* P.C. Boyce & Bogner, *R. pilosa* P.C. Boyce):- Montane species with stiff coriaceous leaves with prominent petiolar sheathes that degrade into fibres, or fall completely. Inflorescences on adherent or free shoots. Spathe marcescent where known (perhaps early marcescent in *R. okapensis*).
7. **Pachyphylla Group** (*R. cryptantha* P.C. Boyce & C.M. Allen, *R. hayi* P.C. Boyce & Bogner, *R. pachyphylla* K. Krause (+ *R. parvifolia* Alderw. – Maluku):- Defined by neotenic shingling habit with petioles much shorter than the lamina.
8. **Spuria Group** (*R. intonsa*, *R. cravenschoddeana*, *R. spuria* (Schott) Nicolson):- Fibre-covered shoot apices, large inflorescences, often several together as in the Spathacea Group (*q.v.*) , but inflorescences subtended by fibrous, not chartaceous, remains.
   (Possibly heterogeneous).

Geography and Endemism

New Guinea, Australia and the western pacific region is remarkable for the high number of *Rhaphidophora* species, coupled with very high diversity and a high percentage of endemics (30 species of which 29 are endemic; only the widespread and common *R. korthalsii* is not endemic to the area). Apart from *R. guamensis* (endemic to Guam) and *R. petrieana* (endemic to Australia), all the rest occur on the island of New Guinea, of which 16 species are endemic to the island. These figures, compared with those for the other main nodes of diversity for the genus in tropical Asia -Borneo (5 endemics out of a total of 13 species), Peninsular Malaysia (2 out of 15), Sumatera (4 out of 15) and the Philippine islands (7 out of 11) - suggest *Rhaphidophora* is a genus of Gondwana origin.

There are no data for the conservation status of any of these endemic species and much remains to be done by way of field studies to ascertain whether any or all of these species are threatened. Nevertheless, it seems that several species have very restricted distributions (e.g., *R. kokodensis*, *R. gorokensis*, *R. jubata*), others are known from a single or very few collections (e.g., *R. pilosa*, *R. intrusa*).

RHAPHIDOPHORA

Rhaphidophora Hassk., Flora 25 (2) Beibl. 1 (1842) 11; Schott, Gen. Aroid. (1858) 77 & Prodr. Syst. Aroid. (1860) 377—388; Miquel, Ann. Mus. Bot. Lugd.-Bat. 3 (1867) 81—82; Engl. in A. & C. DC., Monogr. Phan. 2 (1879) 238—248; Engl. in Beccari, Malesia, 1 (1882) 266—272, Tab. xix 6—9, xx 1—5; Benth. & Hook. f., Gen. Pl. 3(2) (1883) 993—993; Engl. & Prantl, Nat. Pflanzenfam. T. 2, Ab. 3 (1889) 119—120; Engl. & Prantl, Nat. Pflanzenfam. Nachtr. 1 (1897) 58; K. Schum. & Lauterbach, Fl. Schutzgeb. Südsee (1900) 211; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 17—53; Engl. & Prantl, Nat. Pflanzenfam. Nachtr. 3 (1908) 29; Nicolson in A.C. Sm., Fl. Vitiensis Nova, 1 (1979) 443—445, Fig. 88; Hay in R.J. Johns & Hay, Students' Guide Monocot. Papua New Guinea. Part 1 (1981) 68—72 , Fig. 29; Schott, Icones aroideae et reliquiae (IDC Microfilm) (1983) fiche nos. 28—31, 121; Hay, Aroids of Papua New Guinea (1990) 83—87, Figs. 34, 35, Pl. XIVb, XV & Telopea 5 (1993) 293—300; Hay *et al.* Checklist & botanical bibliography of the aroids of Malesia, Australia and the tropical western Pacific. Blumea, suppl. 8 (1995) 111—127; Mayo *et al.*, Genera Araceae (1997) 118—121, Pl. 14, 109 D. — *Scindapsus* subgen. *Rhaphidophora* (Hassk.) Miq., Flora Ned. Indië 3 (1856) 185. — Type: *Rhaphidophora lacera* Hasskarl, *nom. illeg. pro. Pothos*

pertusus Roxb. [= *Rhaphidophora pertusa* (Roxb.) Schott].

Scindapsus Schott subgen. *Pothopsis* Miq., Flora Ned. Indië 3 (1856) 187. — Type: *Scindapsus sylvestris* (Blume) Kunth [= *Rhaphidophora sylvestris* (Blume) Engl.].

[*Raphidophora* Hassk., Cat. Hort. Bogor. (1844) 58, *orth. var.*].

Medium-sized to very large, occasionally enormous, slender to robust, leptocaul or pachycaul, homeophyllous or heterophyllous, rarely neotenic, root-climbing lianes, very seldom clustering and rheophytic and then with a creeping juvenile stage; *cut surfaces* producing clear, odourless sticky juice either drying ± invisibly or coagulating into yellowish, translucent jelly and eventually hardening to a brittle amber-like mass; *seedling stage* mostly not observed but where known either leafy at germination and skototropic (see Strong & Ray, 1975) by an alternating series of congested leafy and elongated leafless shoots or germinating to give rise to a non-skototropic shingling juvenile shoot; *pre-adult plants* often forming modest to extensive terrestrial colonies of varying morphological and physiological form (descriptive generalisations are nearly impossible), largest terrestrial colonies generally occurring in places of less than optimum adult growth potential (e.g., depauperate tree canopy, dry, exposed sites); *adult shoot architecture* broadly divisible into three types: i. physiognomically unbranched clinging non-flowering stems rooting along their entire length giving rise to variously elaborated free lateral lateral flowering stems, *or* ii. all stems physiognomically unbranched, clinging and flowering, *or* iii. physiognomically unbranched leader and sympodial lateral stems clinging but only sympodial lateral stems flowering; *stems* with internodes of various lengths separated by variously prominent leaf scars, smooth or asperous or densely pubescent to ramentose (the last not in the review area), older stems sub-woody or somewhat corky or with distinctive matt to sub-lustrous pale brown papery epidermis, with or without variously textured prophyll, cataphyll and petiolar sheath fibre either at the tips or along the newer sections, rarely with both cataphylls and prophylls deliquescing to black mucilage and later drying leaving fragmentary parchment-like remains on petioles, developing laminas and inflorescences; *flagellate foraging stems* occurring in some species, often exceedingly long, reaching the ground then rooting, variously foraging and climbing again; *clasping roots* sparsely to densely arising from the nodes and internodes, strongly adherent to substrate; *feeding roots* rare to abundant, smooth pubescent or prominently scaly, later often becoming woody, strongly adherent to substrate or free;

cataphylls and *prophylls* subcoriaceous to membranous, caducous or degrading or deliquescing to variously persistent, variously textured, sheaths and fibres, these where present variously clothing upper stem before eventually decaying and falling; *leaves* distichous or weakly spiralled, evenly distributed or scattered or clustered distally; *petiole* canaliculate to weakly carinate, smooth or pubescent, with variously prominent apical and basal genicula; *petiolar sheath* prominent, nearly reaching to overtopping the geniculum, occasionally one side greatly expanded and auriculate, especially in juvenile plants, at first membranous to coriaceous, then soon drying chartaceous completely or along the margins, sometimes degrading to untidy variously netted or simple fibres and later variously falling leaving a scar, or disintegrating marginally or completely; *lamina* submembranous to stiffly chartaceous or coriaceous, lanceolate or oblong, ± oblique, base decurrent to unequal or cordate, apex acute to acuminate, entire to regularly pinnatifid or perforated, if pinnate then divisions pinnatifid to pinnatisect (Stearn, 1992: 324), midrib often ± naked between segments, lamina occasionally with small to well developed perforations adjacent to the midrib and primary veins, these sometimes extending to lamina margin (fenestrations then occasionally additional to fully developed pinnae), rarely abaxially pubescent when expanding, rarely strongly concolorous at maturity; *midrib* usually prominently raised abaxially and prominently sunken, sometime flush or rarely slightly raised adaxially; *primary venation* ± pinnate; *interprimaries* mostly present, sub-parallel to primaries and sometimes indistinguishable from them but usually less prominent and often drying paler, usually glabrous, occasionally pubescent with domatia in the axils of the primary and secondary veins; *secondary venation* striate to reticulate, variously prominent, often very difficult to distinguish from primary venation; *tertiary venation* where visible reticulate to tessellate; *inflorescences* solitary to several together, first inflorescence subtended by a (usually fully developed) foliage leaf and/or a very swiftly disintegrating cataphyll, subsequent inflorescences usually each subtended by a prophyll and cataphyll, more rarely by a prophyll and partially to almost fully formed foliage leaf, inflorescences at male anthesis naked by disintegration of subtending cataphyll or partially to almost completely obscured by netted and sheet-like fibres; *peduncle* terete to laterally compressed; *spathe* ovate to narrowly or broadly canoe-shaped, stoutly to rather weakly beaked, barely gaping to opening almost flat at male anthesis, usually caducous before male anthesis is complete, occasionally marcescent into the early stages of infructescence development, stiff to rather soft- or stoutly coriaceous, dirty-white, greenish, cream or yellow; *spadix* subglobose to clavate-cylindrical, cylindrical or fusiform, sessile or stipitate, often obliquely inserted on peduncle, tapering towards the apex; *flowers* bisexual, naked;

ovary 1- to partially 2-locular, lower part ± bilaterally compressed, upper part cylindrical and variously angled, most often rhombohexagonal, those upper- and lower-most on the spadix often sterile and bereft of stigma, those uppermost frequently either scattered or partially fused to each other and forming a rudimentary appendix; *ovules* few to many, anatropous, funicle long, placentas parietal to basal, sometimes ± subaxile, partial septa variably intrusive; *stylar region* well developed, usually broader than ovary, usually truncate apically, rarely elongate-conic; *stigma* sticky at female male anthesis, punctiform, broadly elliptic or oblong, orientation circumferential or longitudinal; *stamens* 4—6; *filaments* strap-shaped; *anthers* usually prominently exserted from between ovaries at male male anthesis, rarely not exserted and pollen extruded from between ovaries, thecae dehiscing by a longitudinal slit; *infructescence* with stylar regions greatly enlarged, transversely dehiscent, the abscission developing at the base of the enlarged to massive stylar region and this shedding to expose the ovary cavity with the many seeds embedded in variously coloured sticky pulp; *seeds* oblong, testa thin, smooth, embryo axile, straight, endosperm copious; *pollen* dicolpate, extended monosulcate to fully zonate, ellipsoid or hamburger-shaped, medium-sized (mean 33 µm, range 24—55 µm) (Mayo *et al.*, 1997), exine foveolate, subreticulate, rugulate, fossulate, scabrate, retiscabrate, verrucate, or psilate; *chromosomes* 2n = 60, 120 (42, 54, 56) (Mayo *et al.*, 1997).

Distribution: About 100 species from tropical Africa, South and South East Asia, Australia and the Pacific with extensions into the subtropical Himalaya, southern China and the southernmost islands of Japan.

Habitat: Usually in well drained subtropical and tropical wet, humid, or seasonally moderately dry primary and established secondary evergreen forest at low to mid-montane elevations as lianescent bole-climbers, lithophytes, rarely rheophytes

Etymology: Greek *rhaphis, rhaphidos* (needle) and *pherō* (I bear); refers to the macroscopic (to 1cm long), needle-like unicellular trichosclereids present in tissues.

Key to Adult Flowering* Rhaphidophora plants in New Guinea, Australia and the Tropical Western Pacific

* juvenile vegetative phases included for species where confusion is possible

1a. Shingle climber (petiole much shorter than lamina, lamina appressed to substrate) 2
1b. Not as above 6

2a. Leaf lamina cordiform, chartaceous, base cordate, posterior lobes overlapping; primary venation strongly reticulate 3
2b. Leaf lamina variously shaped (not cordiform), membranous to stiffly coriaceous, base slightly cordate to truncate; primary venation pinnate 4

3a. Primary venation conspicuously silver-grey; inflorescences arising from behind appressed shingling leaves, carried on abbreviated shoots arising from the leaf axil. Papua New Guinea (not known with certainty) ..... **5. R. cryptantha**
3b. Primary venation not silver grey; plant never flowering in the shingling phase. Indonesian Papua, Papua New Guinea (including New Ireland) ..... **29. R. versteegii** (juvenile phase)

4a. Leaf lamina membranous, with c. 3 prominent veins per side, these running from near the base to the upper margin or tip and crossing over the reticulate minor venation; plant never flowering in the shingling phase. Throughout region ..... **16. R. korthalsii** (juvenile phase)
4b. Leaf lamina coriaceous to stiffly coriaceous, without prominent veins running from the base to the upper margin or tip; plant fertile in the shingling phase. 5

5a. Leaf lamina of flowering shoots with base truncate; spadix stoutly cigar-shaped, shortly stipitate, inserted ± level on stipe; stipe 4—6 x 3—3.5 mm; stigma elongated, longitudinally orientated; plant with disarticulating side shoots functioning as vegetative propagation units. Indonesian Papua, Papua New Guinea [including New Britain, New Ireland, Bougainville and Muyua (Woodlark) Island], and Australia (Eastern tropical Queensland) ..... **11. R. hayi**
5b. Leaf lamina of flowering shoots with base acute to cuneate; spadix narrowly cigar-shaped, long stipitate, inserted obliquely on stipe; stipe 6—10 x 2—2.4 mm; stigma punctiform; plant without

disarticulating side shoots. Indonesian Papua, Papua New Guinea. ..... **21. R. pachyphylla**

6a. Leaf lamina variously pinnately divided and/or perforated; roots smooth or pubescent 7
6b. Leaf lamina entire, if pinnate then with densely ramentose-scaly roots 8

7a. Leaf lamina of mature plants pinnatisect to slightly to extensively perforated, perforations round to rhombic, extending c. + of lamina width on each side of the midrib; shoot tips with prominent chartaceous prophyll and cataphyll remains. Indonesian Papua, Papua New Guinea (including New Ireland) ..... **29. R. versteegii**
7b. Leaf lamina of mature plants pinnatisect, the pinnae often perforated basally; active shoot tips with sparse to copious netted fibre. Throughout the region ..... **16. R. korthalsii**

8a. Inflorescences arising on clinging shoots 9
8b. Inflorescences arising on free shoots 17

9a. Shoot tips without variously textured cataphyll, prophyll and petiolar sheath fibre; lamina ovate, 2.5—8.5 x 0.9—4 cm, very stiffly coriaceous, base cordate to rounded and slightly notched, apex long-acuminate with a pronounced tubule. Papua New Guinea ..... **20. R. okapensis**
9b. Shoot tips with variously textured cataphyll, prophyll and petiolar sheath fibre; leaf laminas various, but not the above combination of characters 10

10a. Leaf lamina pinnatisect; feeding roots densely ramentose-scaly. Throughout region ..... **16. R. korthalsii**
10b. Leaf lamina entire; feeding roots smooth or pubescent 11

11a. Spadix sessile 12
11b. Spadix stipitate 16

12a. Inflorescences solitary; stylar region conical, stigma not prominent. New Guinea and Australia (eastern tropical Queensland) ..... **1. R. australasica**
12b. Inflorescences two or more together; stylar region truncate, stigma prominent 13

13a. Inflorescences subtended by netted fibre and copious sheet-like tissue, arising two or more sequentially between foliage leaves. Papua New Guinea ..... **7. R. fortis**

13b. Inflorescences each subtended by prominent chartaceous prophyll and one or more large cataphylls, the whole forming a synflorescence not interspersed with foliage leaves 14

14a. Prophylls and cataphylls subtending inflorescences soon degrading and falling; spathe caducous, 16—24 cm long, stiff, thin; spadix slender cylindrical, 13—21 x 1—3 cm, long decurrent (to 2 cm) at peduncle/spathe insertion. New Britain and Bougainville ..... **14. R. jubata**

14b. Prophylls and cataphylls subtending inflorescences drying chartaceous and persisting into fruit maturation; spathe marcescent, 5—13.5 cm long, stiff-fleshy, very thick-walled (up to 1 cm at tip); spadix stoutly cylindrical, 3—16.5 x 1—1.5 cm, inserted almost level on peduncle 15

15a. Leaf lamina drying pale grey-green, often (but not always) profoundly perforated; juvenile growth phase shingling. Indonesian Papua, Papua New Guinea (including New Ireland) ..... **29. R. versteegii**

15b. Leaf lamina drying strongly bicolored, adaxially dark brown, abaxially bright orange-brown with copious, minute tannin cells, never perforate; juvenile growth phase not shingling. Palau, Indonesian Papua, Papua New Guinea (including Woodlark (Muyua) Island), Federated States of Micronesia (Yap) ..... **25. R. spathacea**

16a. Inflorescence solitary, terminating short shoots arising singly in the axils of several adjacent leaves, each inflorescence subtended by a prophyll and several degraded, netted cataphylls; spathe ovoid-ellipsoid, 3.5—6.5 cm long; spadix ovoid-ellipsoid, 2.5—3.5 x 1.3—1.7 cm; stylar region prominently conical, hexagonal in plan view; stigma punctiform. New Guinea. ..... **8. R. geniculata**

16b. Inflorescences several close together in a synflorescence, each subtended by a prominent chartaceous prophyll and one or more chartaceous cataphylls, the entire synflorescence emerging from a mass of chartaceous cataphylls; spathe canoe-shaped, 4—5.5 cm long; spadix ylindrical, c. 3.2 x 0.9 cm; stylar region rounded-conical, almost circular in plan view; stigma deeply excavated. Indonesian Papua (Mimika Prov.) and Papua New Guinea (East Sepik Prov.) ..... **29. R. waria**

17a. Shoot tips with variously textured cataphyll, prophyll and petiolar sheath fibre 16
17b. Shoot tips without cataphyll, prophyll and petiolar sheath fibre 24

18a. Spadix stipitate 19
18b. Spadix sessile 20

19a. Flowering shoots extremely abbreviated, arising from axils of leaves, all but obscured by netted petiolar sheath and cataphyll fibre; spathe ovoid-cylindric, 3—4 cm long, thinly coriaceous; spadix slender cylindrical, 2.9—3.4 x 1.7—1.9 cm; stylar region depressed centrally; anthers exserted at male anthesis. Indonesian Papua (Mimika Digul Prov. Boundary ..... **2. R. brevispathacea**
19b. Flowering shoots elongated and leafy, not as above; spathe canoe-shaped, 20—23 cm long, stiffly very fleshy; spadix cylindrical to slightly cigar-shaped, 13.5—19 x 2.2—4 cm; stylar region truncate with a raised rim; anthers not exserted at male anthesis. Indonesian Papua (Yapen), Papua New Guinea (East & West Sepik, Milne Bay & Morobe Prov.) ..... **6. R. discolor**

20a. Leaf lamina narrowly lanceolate to narrowly lanceolate-elliptic, not exceeding 25 x 6 cm, stiffly coriaceous 21
20b. Leaf lamina ovate to oblong-elliptic or oblong lanceolate, slightly oblique, frequently exceeding 30 x 10 cm, up to 76 x 32, submembranous, subcoriaceous, only rarely coriaceous and then never stiffly so 22

21a. Cataphylls, prophylls and petiolar sheath degrading to simple robust fibres. Papua New Guinea (Kokoda & Port Moresby) ..... **15. R. kokodensis**
21b. Cataphylls, prophylls and petiolar sheath degrading to weak fibres and strips of soft felt-like tissue. Indonesian Papua (Kepala Burung – Arfak Mts) ..... **23. R. pilosa**

22a. Leaf lamina drying strongly bicolored, adaxially mid-brown, abaxially pale brown; inflorescences usually several together, occasionally solitary each subtended by a soon-degrading membranous prophyll and cataphyll; spathe 9.5—12 (–16 cm) long. Papua New Guinea (Western Prov.), Solomon Islands (Guadalcanal, New Georgia, San Cristobal and the Santa Cruz Group), Fiji, Western and American Samoa ..... **26. R. spuria**

22b. Leaf lamina not drying bicolored *or* if bicolored then abaxially greenish brown, adaxially dark brown with dense faint dark speckling; inflorescence always solitary, subtended by a ± fully developed foliage leaf and copious netted fibre and sheet-like tissue *or* a ± fully developed foliage leaf and one or more degrading papery cataphylls; spathe 17—22 long 23

23a. Leaf lamina subcoriaceous, drying concolorous, base subacute to slightly decurrent; inflorescence subtended by a ± fully developed foliage leaf and copious netted fibre and sheet-like tissue; spathe 17—20 cm long; spadix 10.5—18.5 x 1.7—2.3 cm; anthers not exserted at male anthesis. Papua New Guinea (Central & Morobe) ..... **12. R. intonsa**

23b. Leaf lamina submembranous, drying bicolored, abaxially greenish brown, adaxially dark brown and densely faint dark speckled, base oblique, one side rounded to almost truncate, the other subacute; inflorescence subtended by a ± fully developed foliage leaf and one or more degrading papery cataphylls; spathe c. 22 cm long; spadix 17—19 x 1.5—2 cm, yellow green; anthers long-exserted at male anthesis. Papua New Guinea (East Sepik, Morobe & Bougainville) ..... **4. R. cravenschoddeana**

24a. Spadix stipitate 25
24b. Spadix sessile 29

25a. Stylar region conical 26
25b. Stylar region truncate 28

26a. Spadix base with cochleate insertion; stigma glossy, black, at tip of long (c. 2 mm) slender stipe; anthers not exserted at male anthesis. Guam ..... **10. R. guamensis**

26b. Spadix base tapering to almost truncate; stigma not as above; anthers exserted at male anthesis. Papua New Guinea (including Louisiade Archipelago), Australia (Queensland) 27

27a. Petiolar sheath soon drying and eventually falling more-or-less entire leaving a conspicuous scar; inflorescence solitary, subtended by a partially developed foliage leaf and a membranous cataphyll; spathe 6—8 cm long; spadix stipe c. 1 x 0.6 cm. Australia (Queensland) ... . **22. R. petrieana**

27b. Petiolar sheath persistent through to leaf fall; inflorescence not solitary, subtended by a ± fully developed foliage leaf; spathe 11—

13 cm long; spadix stipe 2.5—3 x 3—0.4 cm. Papua New Guinea (including Louisiade Archipelago) ..... **27. R. stenophylla**

28a. Petiolar sheath extending beyond the apical geniculum by two ligules adaxially and by fused extensions along the *abaxial* midrib for up to half the leaf lamina length; leaf lamina oblong-elliptic, up to 16.5 cm long, submembranous; spathe apex truncate and extending into a very long, slender beak up to ½ length of entire spathe; spadix cigar-shaped; anthers not exserted at male anthesis. Indonesian Papua (Kepala Burung) ..... **13. R. intrusa**

28b. Petiolar sheath extending beyond the apical geniculum only by two tiny ligules; leaf lamina, lanceolate to oblong-lanceolate, up to 34 cm long and usually exceeding 18 cm, thinly coriaceous; spathe apex stoutly short-beaked, beak not exceeding ⅛ length of entire spathe; spadix cylindrical; anthers strongly exserted at male anthesis. Papua New Guinea (including Bismarck Archipelago), Solomon Islands .. .. **24. R. schlechteri**

29a. Stylar region conical. Primary lateral veins drying much paler than abaxial leaf lamina. Indonesian Papua (Kepala Burung & Mimika Prov.), Papua New Guinea (Muyua, New Britain) ..... **3. R. conica**

29b. Stylar region truncate. Primary lateral veins not as above 30

30a. Leaf lamina stiffly coriaceous, narrowly lanceolate; spathe 6—6.5 cm long; spadix cylindrical, 3.3—3.5 x c. 0.7 cm. Papua New Guinea (Eastern Highlands – Goroka; Southern Highlands – Mendi) .... **9. R. gorokensis**

30b. Leaf lamina membranous to thinly coriaceous, variously shaped but not narrowly lanceolate, *or* if narrowly lanceolate then not stiffly coriaceous and inflorescences borne on the tips of long, slender, pendent stems; spathe 2.5—3 cm long; spadix ovoid-globose to ovoid-cylindric, 1—1.5 x 0.5—0.6 cm 31

31a. Inflorescences arising from long, pendent shoots 32

31b. Inflorescences arising from short, spreading shoots 33

32a. Leaf lamina narrowly lanceolate to lanceolate falcate, 4—19 x 1—3 cm, thinly coriaceous, weakly bicolored, adaxially dull mid-brown, abaxially paler brown with dense tannin cells; inflorescences borne at tips of very long, slender flowering stems (c. 2 mm diam. in dried material); spathe ovoid-ellipsoid, stoutly long-beaked, 2.5—3 x 0.7—0.9 cm; spadix ovoid-globose to ovoid-cylindric, 1—1.5 x 0.5—0.6

cm. Indonesian Papua (Mimika Prov.), Papua New Guinea (Madang & Morobe Prov.) ..... **17. R. microspadix**

32b. Leaf lamina elliptic to oblong-elliptic, 20—29 x 8—13 cm, membranous, markedly bicolored, adaxially mid-brown, abaxially pale orange brown; inflorescences borne on short shoots arising from axils of leaves along long, pendent flowering stems c. 1 cm diam. in dried material; spathe elongate-cylindric, stoutly short-beaked, c. 10.2 x 1.7 cm; spadix slender cylindrical, 8 x 1.1 cm. Papua New Guinea (East Sepik Prov.) ..... **28. R. stolleana**

33a. Spathe cigar-shaped, 1—4.5 x 0.7—1.2 cm, caducous; spadix cylindrical, 1.5—2.5 x 0.5—0.8; anthers not exserted at male anthesis. Papua New Guinea (Bougainville & Manus), Solomon Islands..... **18. R. mima**

33b. Spathe globose to ovoid-ellipsoid, 1—2 x 1—2.5 cm, marcescent; spadix globose to ellipsoid-cylindrical, 1—1.5 x 0.7—1 cm; anthers well-exserted at male anthesis. Mainland New Guinea. ..... **19. R. neoguineensis**

The Species

1. Rhaphidophora australasica F.M. Bailey

Rhaphidophora australasica F.M. Bailey, Queensland Agric. J. 1 (1897) 452 & Fl. Queensland 5 (1902) 1697; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 28; Williams, Native Pl. Queensland 1 (1979) 252, unnumbered plate; Jones & Gray, Climbing Pl. Australia (1988) 316, unnumbered plate p. 322; Hay, Telopea 5 (1993) 296—297. — Type: Australia, Queensland, Cairns, *Cowley s.n.* (BRI, holo; K, iso).

Rhaphidophora hollrungii Engl. in K. Schum. & Hollrung, Fl. Kais.-Wilh. Land (1889) 19; Engl. in Bot. Jahrb. Syst. 25 (1898) 9; K. Schum. & Lauterbach, Fl. Schutzgeb. Südsee (1900) 211; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 44, Fig. 18, **synon. nov.** — Type: Papua New Guinea ('Kaiser Wilhelmsland'), West Sepik Prov., Augusta River, Sept. 1897, *Hollrung 746* (B, lecto; selected here). Engler cited two syntypes, the other (Papua New Guinea ('Kaiser Wilhelmsland'), Morobe Prov., Sattelberg, July 1890, *Lauterbach 588*) is missing from Berlin and presumed destroyed.

Rhaphidophora iboensis K. Krause, Bot. Jahrb. Syst. 49 (1912) 93, **synon. nov.** — Type: Papua New Guinea ('Kaiser Wilhelmsland'), Madang Prov., Ibo Range, 17 Dec. 1908, *Schlechter 18985* (B, holo).

Figure 1

Moderately robust, pachycaul, homeophyllous liane to 15 m; *seedling stage* not observed; *pre-adult plants* forming sparse terrestrial colonies; *adult shoot architecture* comprised of clinging, physiognomically unbranched, densely leafy flowering stems; *stems* smooth, later with lustrous papery epidermis, cataphylls and prophylls soon degrading into long, untidy fibres, internodes 1—5 x 0.5—1 cm, separated by prominent slightly oblique corky leaf scars; *flagellate foraging stem* absent; *clasping roots* densely arising from the nodes and internodes, minutely pubescent; *feeding roots* not observed; *leaves* spiro-distichous; *cataphylls* and *prophylls* chartaceous but soon degrading into long fibres; *petiole* deeply grooved, 9—22 x 0.25—0.3 cm, smooth, apical and basal geniculum prominent and drying slightly darker; *petiolar sheath* extending to apical geniculum, short-persistent, at first, chartaceous, soon degrading to fibres; *lamina* entire, lanceolate to elongate-lanceolate or elongate-oblanceolate, slightly falcate, 19—46 x 2.5—9.5 cm, subcoriaceous, base rounded to subacute, apex acute to acuminate; *midrib* raised abaxially, ± sunken adaxially; *primary venation* pinnate, slightly raised abaxially, much less-so adaxially; *interprimaries* sub-parallel to primaries, and almost indistinguishable from primary lateral veins; *secondary venation* reticulate, slightly to barely visible; *inflorescence* solitary, subtended by an incompletely developed leaf and much fibrous cataphyll remains; *peduncle* slightly robust, terete, 3.5—9.5 x 0.2—0.35 cm; *spathe* slender canoe-shaped, long beaked, 5—9.5 x 2—2.5 cm, stiff-fleshy, cream, caducous leaving a prominent scar; *spadix* cylindrical, sessile, inserted slightly obliquely on peduncle, 3.75—8 x 1—2 cm, cream; *stylar region* long-conical, weakly hexagonal in top view, drying longitudinally ribbed, 1.1—1.2 x 1—1.1 mm; *stigma* punctiform, minutely excavated, 0.1—0.2 x c. 0.3 mm; *anthers* exserted at male anthesis; *infructescence* oblong-cylindrical, 8—9 x 1.5—2 cm.

Distribution: New Guinea (widespread but scattered; often abundant where it occurs), Australia (eastern tropical Queensland).

Habitat: Rain forest. Sea level to 760 m altitude.

Other specimens seen: INDONESIAN PAPUA. Jayapura Prov.: Cyclop Mts, above Ifaar ('Ifar'), *McKee 1877* (L). PAPUA NEW GUINEA. Morobe Prov.: Lae, *White et al. NGF 1555* (L). AUSTRALIA. Queensland: Cook District, Mossman, entrance to Mossman Gorge,

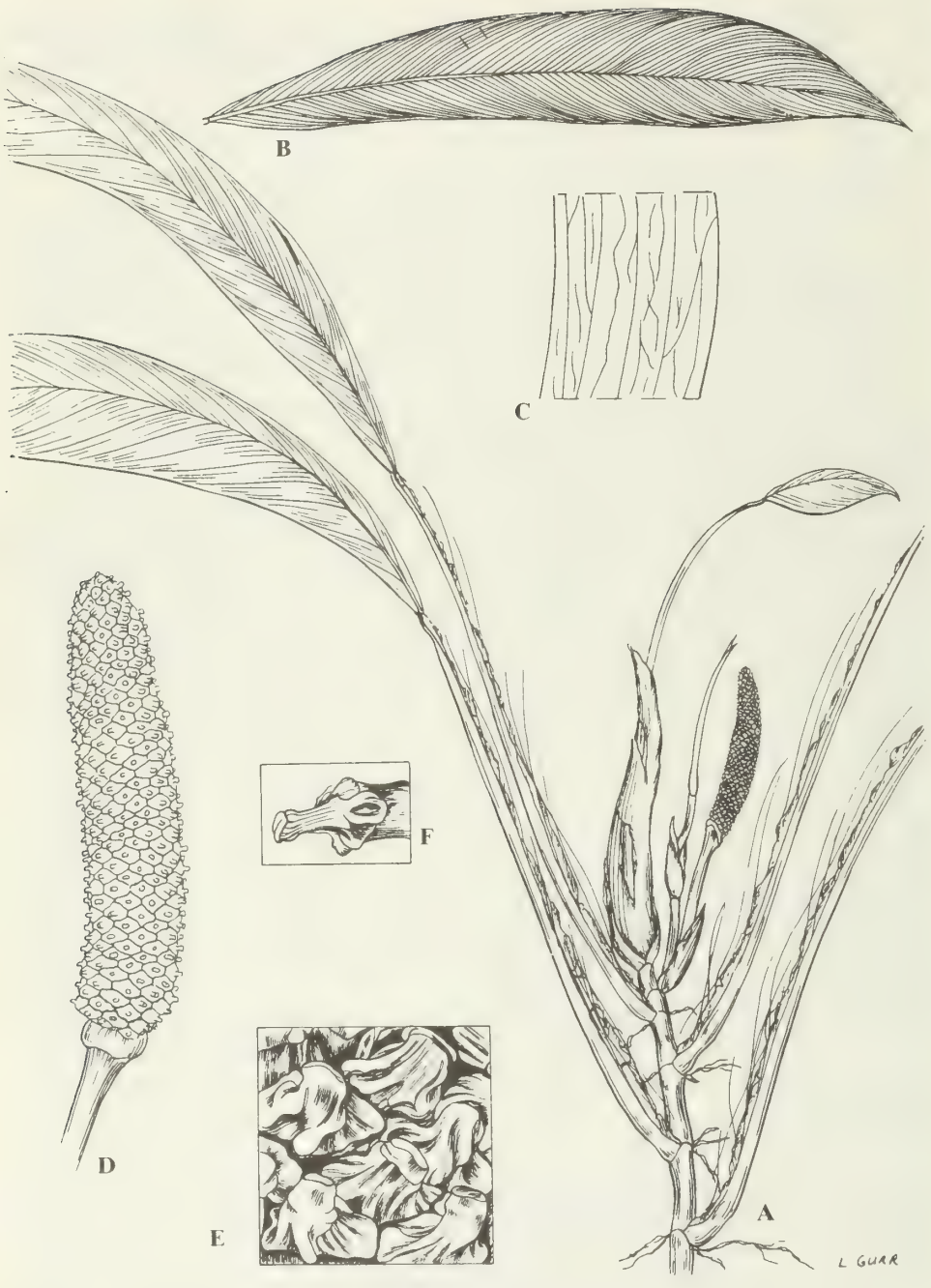

Figure 1. Rhaphidophora australasica F.M. Bailey
A. flowering shoot x $^1/_2$; B. leaf lamina x $^1/_3$; C. venation detail x 4; D. inflorescence, spathe fallen x $^1/_2$; E. spadix detail, post-male anthesis x 8; F. stylar region and stigma, side view x 8. A-C from *McKee 1877*; D-F from *Hollrung 746*.

Blake 19756 (K); c. 20 miles NNW of Daintree, *Boyland 399* (K); Along road from Atherton to Main Coastal Highway, along Palmerston Highway, Henrietta Falls, *Croat 52614* (MO); Wright Creek, Lake Eacham State Park, 20 km E of Atherton, *Croat 52575* (K, MO); S.F.R. 756, East Downey L.A., *Hyland 5608* (K, L); Wright Creek, c. 10 miles E of Atherton, *Melville 3693* (K, L, US); Lacey's Creek, Mission Beach area, *Smith 10189* (K).

Notes. 1. Almost all New Guinea specimens previously identified as *R. australasica* (incl. *R. hollrungii*) belong to either *R. spathacea* or to one of several new species described elsewhere in this paper. The combination of solitary inflorescences arising on clinging shoots, fibrous cataphyll remains and conical style is diagnostic for *R. australasica*.

2. The two widely separated New Guinea localities suggest a species that is widespread but uncommon in New Guinea.

2. Rhaphidophora brevispathacea Engl. & K. Krause

Rhaphidophora brevispathacea Engl. & K. Krause, Bot. Jahrb. Syst. 54 (1916) 79; K. Krause & Alderw., Nova Guinea 14 (1924) 212. — Type: Indonesian Papua, Mimika/Digul Prov. boundary, Lorentz River, near Kloofbivak, 31 Oct. 1912, *Pulle 254* (B, holo; BO, K, L, iso).

Figure 2

Moderate, somewhat slender, leptocaul, homeophyllous (?) liane of unknown ultimate height; *seedling* and *pre-adult plants* not observed; *adult shoot architecture* not completely known, but observed to be comprised of greatly elongated, spreading to strongly pendent, physiognomically unbranched, leafy, non-flowering stems giving rise to extremely short, free, sympodial, (foliage) leafless, flowering stems; *stems* smooth, climbing stems not observed, free stems weakly rectangular to ± terete in cross-section, dull yellow brown, internodes to 5 x 0.7 cm, flowering shoots extremely abbreviated, arising from axils of leaves and, where stems pendent then twisting to present inflorescences upwards, stems all but obscured by netted petiolar sheath and cataphyll fibre; *flagellate foraging stems* not observed; *clasping roots* arising singly from the nodes and internodes, slightly pubescent, later glabrescent; *feeding roots* not observed; *leaves* weakly spiralled, scattered; *cataphylls* and *prophylls* membranous, very quickly degrading leaving semi-persistent netted remains; *petiole* grooved adaxially, 7—9.5 x 0.2—0.3 cm, smooth, with a weakly defined apical and slightly prominent basal geniculum; *petiolar sheath* slightly prominent, extending beyond the apical geniculum by two ligules, caducous leaving a slight continuous scar from the petiole base, around the top of the apical

geniculum and back to the base; *lamina* entire, elliptic to elliptic- or lanceolate-elliptic, 6.2—20 x 2.5—8.75 cm, coriaceous, upper surfaces very slightly glossy, drying strongly bicolorous, adaxially dark brown, abaxially bright orange-brown with copious, minute tannin cells, base subovate, very briefly decurrent, apex acute to briefly acuminate, with a minute apiculate tubule; *midrib* slightly raised abaxially, sunken adaxially; *primary venation* pinnate, slightly raised abaxially, prominent (darker veins against pale lamina) in dried material; *interprimaries* parallel to, but much less distinctive than, primaries, very slightly raised abaxially; *secondary* and *tertiary venation* ± invisible in dried specimens, very weakly reticulate; *inflorescence* solitary, subtended by several reduced leaves (lamina absent) with rapidly degrading petiolar sheaths and netted cataphylls, the whole obscuring the peduncle; *peduncle* terete, 3—4 x 0.25—0.3 cm; *spathe* ovoid-cylindric, stoutly very short-beaked, 3—4 x 2—2.3 cm, thinly coriaceous, marcescent to fruiting, then abcissing basally and pushed off by developing fruits, leaving a slight scar; *spadix* slender cylindrical, stipitate, inserted more or less level on stipe, 2.9—3.4 x 1.7—1.9 cm; *stipe* slender terete, c. 3 x 1.5 mm; *stylar region* rhombohexagonal, 1.7—2.1 x c. 2 mm, depressed centrally; *stigma* punctiform, c. 0.4 mm diam., prominent in dried material; *anthers* exserted at male anthesis; *infructescence* not observed.

Distribution: Indonesian Papua (Mimika/Digul Prov. boundary). Known only from the type.

Habitat: Not recorded. 100 m altitude.

Note: Distinctive by the long pendent stems with much abbreviated, netting-sheathed flowering shoots and a small, marcescent spathe. *Rhaphidophora stolleana* shares the habit of long pendent stems with abbreviated of inflorescence-bearing shoots arising in the leaf axils, but is readily distinguished by a much longer spathe (c. 10.2 cm long) and spadix (c. 8 cm long). To date *R. brevispathacea* is known only from Mimika/Digul Prov. and *R. stolleana* only from East Sepik. In the small, marcescent spathe, *R. brevispathacea* resembles *R. neoguineensis*, although the latter has a quite different growth habit and inflorescence presentation.

3. Rhaphidophora conica Engl.

Rhaphidophora conica Engl., Bot. Jahrb. Syst. 1 (1881) 181. — Type: Indonesian Papua, Kepala Burung Prov., Ramoi, Feb. 1875, *Beccari PP 409* (FI, holo).

Figure 2. Rhaphidophora brevispathacea Engl. & K. Krause
A. adult shoot with flowering branches x $^1/_5$; B. leaf lamina x $^1/_5$; C. venation detail x 2; D. inflorescence, spathe fallen x $1^1/_5$; E. spadix detail, post-male anthesis x 8; F. stylar region and stigma, side view x 8. All from *Pulle 254*.

Rhaphidophora pallidivenia Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 339, **synon. nov.** — Type: Indonesian Papua, Mimika Province, Varen (Lorentz) River, 15 June 1907, *Djibda s.n.*, ex cult. Bogor B.G. Y.40, April 1921, *Alderwerelt* s.n. (BO, holo).

Figure 3

Moderately robust, semi-leptocaul, homeophyllous (?) liane to 5 m; *seedling* and *pre-adult plants* not observed; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and elongated, free, leafy, flowering stems; *stems* smooth, flexuous, stems ± terete in cross-section, without prophyll, cataphyll fibre, internodes 5—10 x 0.5—1 cm, separated by weak straight leaf scars, older stems woody; *flagellate foraging stems* not observed; *clasping roots* arising singly from nodes; *feeding roots* solitary from nodes; *leaves* weakly spiro-distichous, moderately densely arranged; *cataphylls* and *prophylls* membranous, caducous; *petiole* grooved adaxially, 7—30 x 0.6—1 cm, smooth, with a prominent apical and basal geniculum; *petiolar sheath* prominent, extending to base or top of apical geniculum, soon drying chartaceous, then degrading very slightly to weak fibres before falling leaving a feeble scar; *lamina* entire, elliptic to elliptic-lanceolate, 10—40 x 5—12 cm, thinly coriaceous, base cuneate to acute, apex acute-acuminate, with a minute tubule; *midrib* raised abaxially, slightly sunken adaxially, drying conspicuously lighter than surrounding lamina; *primary venation* pinnate, slightly raised on both surfaces in dried material, drying lighter; *interprimaries* sub-parallel to primaries and only slightly less conspicuous; *secondary venation* reticulate, fine but conspicuous; *inflorescence* solitary, subtended by a fully developed foliage leaf; *peduncle* slightly compressed-terete, 2.5—10 x 0.2—0.35 cm; *spathe* broadly cone-shaped to ellipsoid, truncate basally at insertion on petiole, apex briefly to rather long-beaked, 5—12 x 2—4 cm, thinly fleshy, greenish yellow, caducous, drying pale brown, falling leaving a thin scar; *spadix* cylindrical, sessile, inserted level on peduncle, 2—7 x 0.7—1.2 cm, obtuse, white to yellow; *stylar region* rounded-rhombohexagonal, 0.9—1.1 x 0.9—1.1 mm, slightly blunt-conical; *stigma* punctiform, c. 0.3 mm diam., rather prominent in dried material; *anthers* slightly exserted at male anthesis; *infructescence* not observed.

Distribution: Indonesian Papua (Kepala Burung and Mimika Prov.), Papua New Guinea (Muyua, New Britain).

Habitat: Rain forests, sometimes on coralline limestone. No altitudes recorded.

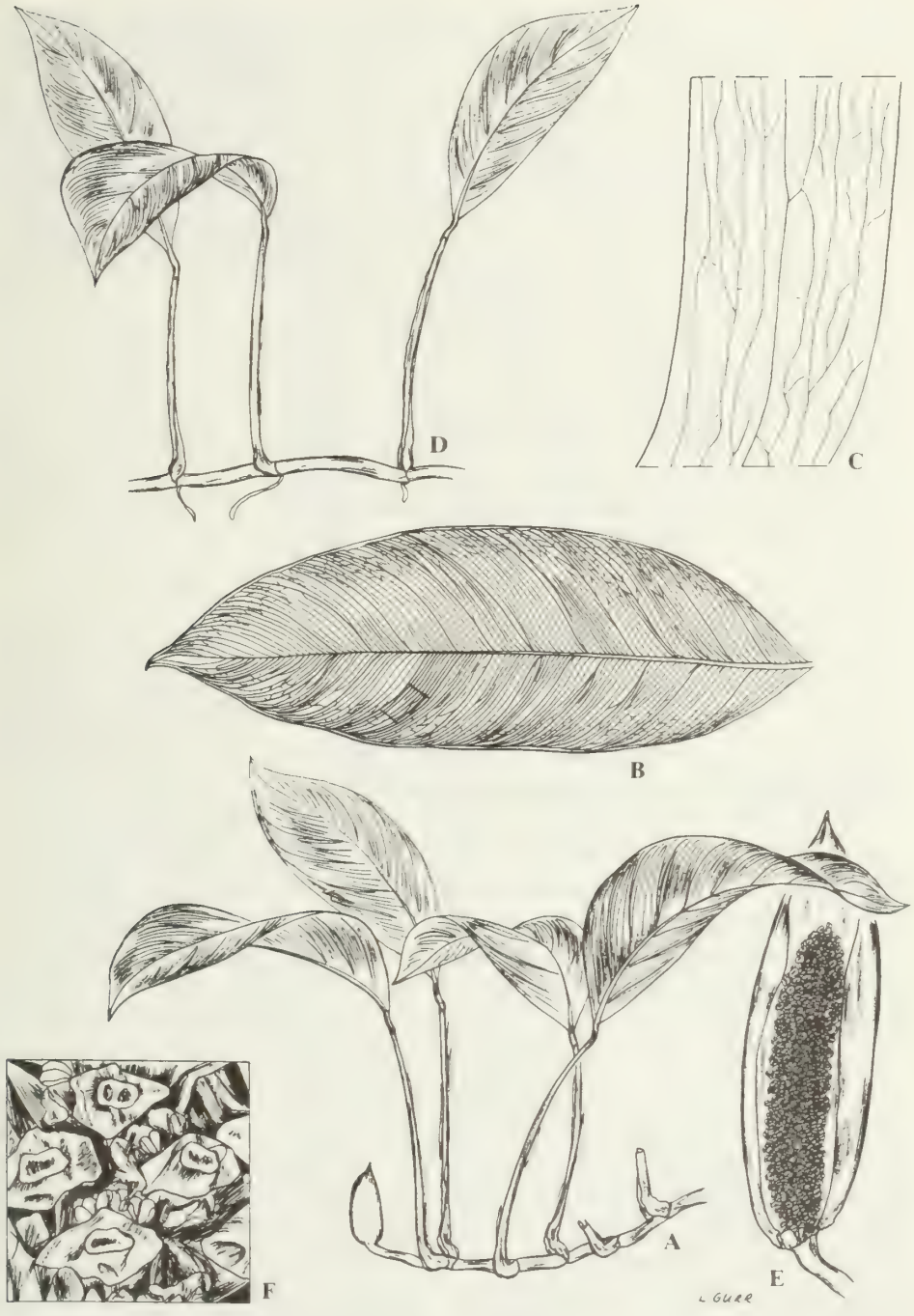

Figure 3. Rhaphidophora conica Engl.
A. flowering shoot x ½; B. leaf lamina x ¼; C. venation detail x 3; D. portion of creeping adult stem x ½; E. inflorescence x ½; F. spadix detail, pre-anthesis x 8. All from *Furtado s.n.*

Notes: 1. *Brass 28608*, while much smaller than the other collections, is morphologically identical.

Other specimens seen: INDONESIAN PAPUA. Mimika Prov.: Varen (Lorentz) River, Cult. Bogor, Y40, *Furtado s.n.* (SING), *Nicolson 926* (US). PAPUA NEW GUINEA. Woodlark (Muyua) Island: Kulumadu, *Brass 28608* (GH, L); West New Britain Prov.: 2 miles northeast of Kandrian, *Nicolson 1552* (K, L, US).

4. Rhaphidophora cravenschoddeana P.C. Boyce, *sp. nov.*

Rhaphidophora cravenschoddeana facile cum *R. intonsa* confunditur (species etiam cum inflorescentiis grandibus et apicibus surculorum fibrosis) sed fibris simplicibus neque reticulatis, lamina foliae textu tenuiore, costa abaxialiter prominenti, venis lateralibus primariis eis interprimariis magis diversis, antheris longe exsertis seorsa. — TYPUS: Papua New Guinea, North Solomons Prov., Bougainville, near Koniguru No.1, c. 11 miles north of Buin, 18 July 1963, *Craven & Schodde 14* (CANB, holo; GH, K, iso).

Figure 4

Large, robust, pachycaul (?), homeophyllous liane to unknown ultimate height; *seedling stage* not observed; *pre-adult plants* consisting of sparse terrestrial colonies; *adult shoot* comprised of elongated, clinging, physiognomically unbranched, non-flowering stems and free lateral, leafy flowering stems; *stems* with cataphylls and prophylls degrading to long sparse ragged fibres and weak sheets of tissue, internodes 0.5—3 x 0.5—2 cm, separated by prominent to very large unevenly oblique corky leaf scars; *flagellate foraging stem* and *clasping roots* not observed; *feeding roots* stout, arising singly from the node, densely velvety-hairy; *leaves* spirodistichous; *cataphylls* and *prophylls* quickly degrading to long sparse ragged fibres and weak sheets of tissue; *petiole* canaliculate, 6—46.5 x 1.3—1.5 cm, apical geniculum very large, prominent, basal geniculum very weakly defined; *petiolar sheath* very prominent, extending to apical geniculum, swiftly degrading to long ragged fibres and weak sheets of tissue, later falling leaving a jagged scar; *lamina* entire, ovate to oblong-elliptic or oblong-ovate, strongly oblique, 8—53 x 6—26 cm, submembranous, drying discolorous, adaxially dark brown, densely faint dark speckled, abaxially greenish brown, base oblique, one side rounded to almost truncate, other subacute, apex subacute to acuminate or briefly attenuate; *midrib* very prominently raised abaxially, slightly sunken adaxially; *primary venation* pinnate, prominently raised abaxially, very slightly raised adaxially, drying paler than lamina; *interprimaries* parallel to primaries, much less prominent, slightly raised abaxially, very slightly raised adaxially; *secondary venation*

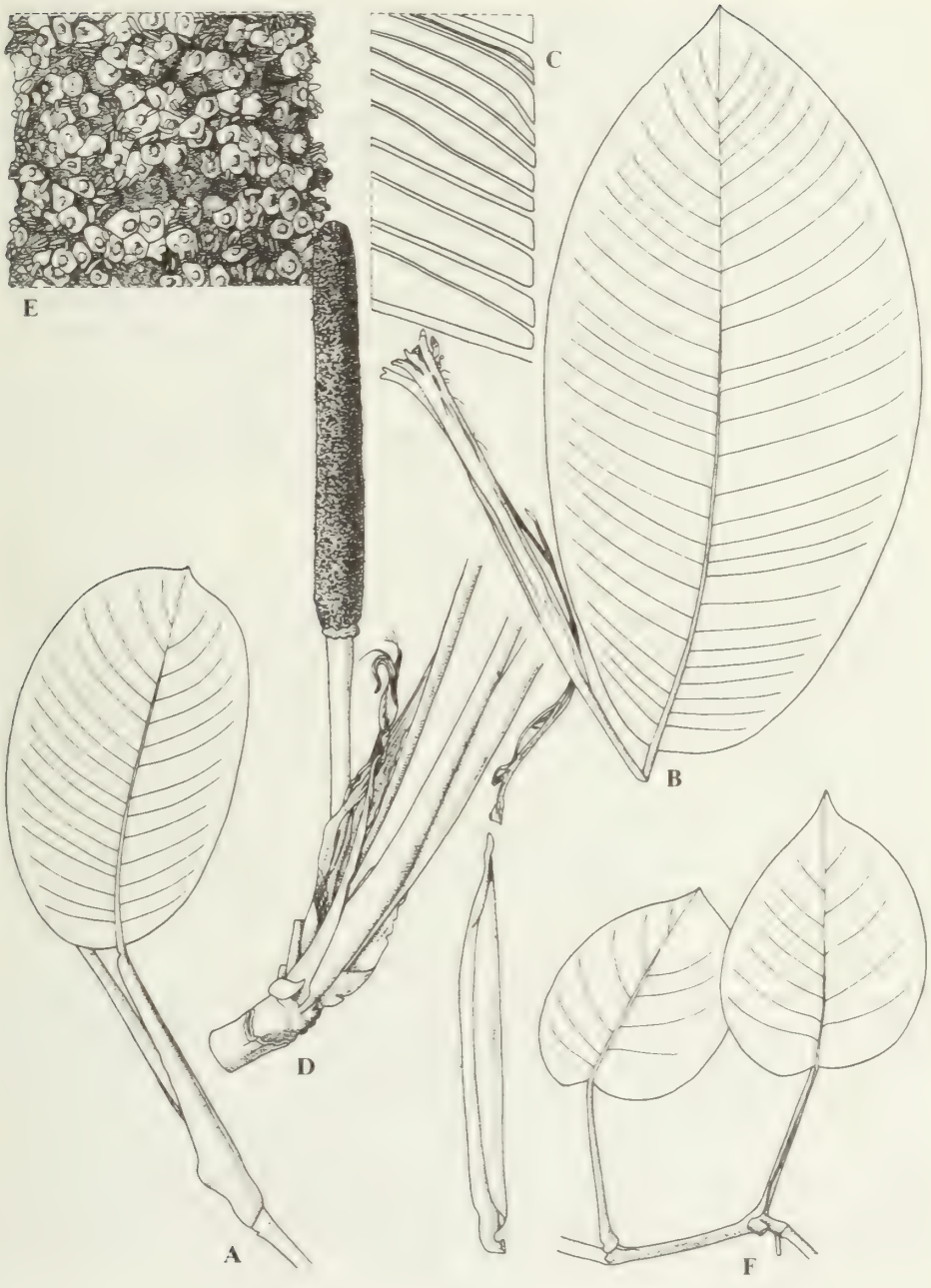

Figure 4. Rhaphidophora cravenschoddeana P.C. Boyce
A. part of flowering shoot x ⅛; B. leaf lamina x ⅛; C. venation detail x 2; D. entire inflorescence x ⅛; E. spadix detail, post-male anthesis x 2½; F. portion of creeping juvenile stem x ⅛; G. portion of pre-adult stem x ⅛. A-E from *Craven & Schodde 14*, F & G from *Croat 52760*.

parallel to interprimaries and only slightly less prominent, very slightly raised abaxially and adaxially; *tertiary venation* reticulate, weakly raised abaxially, invisible abaxially; *inflorescence* solitary, subtended by a ± fully developed foliage leaf and one or more degrading papery cataphylls; *peduncle* laterally compressed, stout, 13—15 x 0.7—1 cm; *spathe* slender canoe-shaped, 22 x 4 cm, stoutly long-beaked, caducous before male anthesis, falling leaving a large scar; *spadix* stoutly cylindrical, sessile, inserted more or less level on peduncle, 17—19 x 1.5—2 cm, yellow green; *stylar region* hexagonal, 1.5—2 x 1.2—1.5 mm, truncate; *stigma* punctiform to slightly ellipsoid, very slightly raised, 0.4 x 0.4—0.5 mm diam.; *anthers* long-exserted at male anthesis; *infructescence* not observed.

Distribution: Papua New Guinea (East Sepik and Morobe Prov.), Bougainville.

Habitat: Primary and secondary riverine rain forest. 100–1000 m altitude.

Notes: 1. Easily confused with *Rhaphidophora intonsa* (also with large inflorescences and fibrous shoot tips) but separated by the simple, not netted, fibres, thinner-textured leaf lamina with, on the abaxial surface, a conspicuously raised midrib and much more pronounced differentiation between the primary lateral and interprimary veins, and by the long-exserted anthers.

2. The specific epithet is for the collectors of the type, Lyndley Craven and Richard Schodde now at CANB, who made many collections in Papua New Guinea.

Other specimens seen: PAPUA NEW GUINEA. East Sepik Prov.: Vicinity of Wewak, along trail beyond Boys Town (Reform School operated by S.V.D. Missionaries), *Croat 52760* (MO), *Croat 52763A* (MO); Angoram, Upper Karawari River, *Domstreich 77* (L); Morobe Prov.: Sattelberg, *Clemens 8064* (B), *2066* (B); Along road to Sankewap, 1 km in from Sankewap River, beginning 2.7 km south of Lutheran School, *Croat 52818* (MO); Along Busu River, 22.6 km by road SE of Lae via road past PNG University of Technology and Igam road past Army Base, beginning 3.8 km from asphalt road at Army Base, *Croat 52842* (MO); North Solomons Prov.: Bougainville: Maide River gorge, lower south slopes of Lake Lolow crater, c. 15 miles north of Buin, *Craven & Schodde 286* (CANB, GH); Near Barilo village, c. 6 miles north of Buin, *Craven & Schodde 375* (CANB, GH, K).

5. Rhaphidophora cryptantha P.C. Boyce & C.M. Allen, *sp. nov.*

Architectura surculi *R. cryptanthae* eam *R. hayi* ob inflorescentias in apicibus surculorum abbreviatorum facile depulsorum ex axillis surculorum scindulantium exorientium feruntur arctissime revocat. *R. cryptantha* inflorescentias post folia ferenti, forma atque colore folii laminae, spatha minore marcescenti, spadice ellipsoidali atque stylo stigmatico longo nihilominus differt. Inflorescentiis in surculis post folia appressa scindulantia vectis orientibus ac aperientibus *R. cryptantha* distincta est ab omnibus speciebus ceteris neotenicus (*R. hayi*, *R. pachyphylla* et *R. parviflora*) in quibus inflorescentiae in surculis a foliis porrectis portatae sunt, atque in genere unica est. — TYPUS: Cultivated Fairchild Tropical Garden (acc. no. 74407), ex Papua New Guinea, Botanic Garden, Lae, 24 Sept. 2000, *Boyce 1447* (FTG, holo; K, M, MO, SING, iso).

Figures 5 & 6

Moderate-sized, slender to somewhat robust, semi-leptocaul, homeophyllous neotenic liane to 3 m; *seedling stage* unknown; *pre-adult plants* shingling, hardly or not forming terrestrial colonies; *adult shoot* architecture comprised of clinging, physiognomically unbranched, densely leafy, sterile stems and very abbreviated, free, flowering stems arising from the axils and remaining concealed behind the leaves of the main stem; *stems* rectangular in cross-section, widest side slightly convex, smooth, dark green, without prophyll and cataphyll fibre but with newest parts very thin, adherent, petiolar sheath tissue, internodes 1—5 x 0.2—0.5 cm, separated by ± straight scars; *flagellate foraging stems* rather weakly developed, usually at least partially leafy; *clasping roots* arising from the internodes, prominently pubescent, spreading but usually not extending much beyond the leaf span; *feeding roots* not observed (absent?); *leaves* distichous, shingling and ascending on adherent shoots, densely arranged and slightly spreading on free shoots, on flagella shoots leaves scattered with internodes between carrying a prominent cataphyll of short duration; *cataphylls* and *prophylls* membranous, caducous; *petiole* very shallowly grooved, 0.75—1.5 x 0.3—0.4 cm, smooth, apical and basal geniculа barely visible; *petiolar sheath* prominent, membranous, long-ligulate, margins of ligule fused, the ligule extending up to 3.5 cm above base of lamina and enclosing shoot apex, caducous but adhering to stem; *lamina* broadly ovate, coriaceous, base cordate, apex rounded with a tiny tubule; *midrib* barely visible abaxially and adaxially; *primary venation* reticulate, barely visible abaxially, slightly raised and silver-grey adaxially; *interprimaries* more-or-less absent; *secondary venation* reticulate, flush abaxially, very weakly raised adaxially, silver-grey; *inflorescence* sequentially produced from a shoot arising from

Figure 5. Rhaphidophora cryptantha P.C. Boyce & C. Allen
A. abaxial view of adult stem with two flowering branches, x $^{2}/_{3}$; B. entire flowering branch with inflorescence, spathe cut away to show spadix x 2. All from *Boyce 1447*.

Figure 6. Rhaphidophora cryptantha P.C. Boyce & C. Allen
A. adaxial view of adult stem. x ½; B. adaxial view of juvenile stem. x ½; C. flagellate stem x ½.
All from *Boyce 1447*.

behind the leaf, each subtended by a very small membranous, caducous prophyll and one or more very reduced leaves; *peduncle* terete, 0.75—1 x 0.2—0.3 cm; *spathe* ellipsoid, weakly beaked, 3.5—4 x 1.2—1.5 cm, spongy-fleshy, yellow, inflated and gaping at female anthesis and then closing and drying onto developing infructescence; *spadix* ellipsoid, stipitate, inserted ± level on stipe, 2.1—2.2 x 0.7—0.8 cm, creamy white; *stipe* 5—6 x 2—2 mm, white; *stylar* region irregularly rhombohexagonal, 2—2.2 x 2.1—2.3 mm, weakly conical; *stigma* very prominently raised on a c. 1 mm stipe, punctiform to globose, c. 0.5 mm diam.; *anthers* exserted at male anthesis; *infructescence* not seen.

Distribution: Not known with certainty. The specimen used to make the type was introduced into cultivation from Lae Botanic Garden and it seems quite possible that it originated in Papua New Guinea. The plant in cultivation at Kew was received from Ted Green, also ex Papua New Guinea.

Habitat: Unknown. In cultivation the plant is very intolerant of cool conditions, suggesting that it originates from low elevations.

Notes: 1. A species of extraordinary appearance, both in flowering in a neotenic state (otherwise known from *R. hayi*, *R. parvifolia* (Maluku) and *R. pachyphylla*) and especially by the inflorescences arising and opening on shoots carried *behind* the appressed shingling leaves. Often the mature inflorescences are completely obscured by the leaves, although occasionally the tip of the spathe is visible. In this flowering mode *R. cryptantha* is distinct from the neotenic species listed above (in which the inflorescences are carried on shoots held clear of the leaves), and unique in the genus.

The shoot architecture of *R. cryptantha* most closely recalls that of *R. hayi* in that the inflorescences are borne on the tips of easily dislodged abbreviated shoots arising from the axils of shingling shoots. However, *R. cryptantha* differs in bearing the inflorescences behind the foliage, in the shape and coloration of the leaf lamina, the smaller, marcescent spathe, ellipsoid spadix and long style.

2. In cultivation *R. cryptantha* has been confused with *Monstera dubia*, a species with a similar shingling juvenile stage and variegated leaves. The two are readily separable by the orientation of the leaves, those of *R. cryptantha* are ascending, those of *M. dubia* descending. Dissection of the ovary of *R. cryptantha* reveals two intrusive parietal placentae and numerous ovules, assigning it to *Rhaphidophora*.

3. Despite the as yet unconfirmed origin of this plant, we have no hesitation in publishing it as a new species as it is of such distinctive appearance.

4. The specific epithet alludes to the inflorescences that open hidden or barely emerging from behind the shingling, substrate-clasping leaves.

Other specimens seen: CULTIVATED. Ex Papua New Guinea, Cult. Kew acc. no. 1983-4495, *Green s.n.* (K).

6. Rhaphidophora discolor Engl. & K. Krause

Rhaphidophora discolor Engl. & K. Krause, Bot. Jahrb. Syst. 54 (1916) 80. — Type: Papua New Guinea, East Sepik Prov., April River, 7 Sept. 1912, *Ledermann 8569* (B & B spirit, holo).

Rhaphidophora oreophila Engl. & K. Krause, Bot. Jahrb. Syst. 54 (1916) 80. **synon. nov.** — Type: Papua New Guinea, Morobe Prov., Erap (Erappenberg), 31 Oct. 1912, *Ledermann 9590* (B & B spirit, holo).

Figure 7

Medium-sized, robust, pachycaul, homeophyllous (?) liane to 25 m; *seedling stage* and *pre-adult plants* not observed; *adult shoot architecture* not fully observed but apparently comprised of elongated, clinging, physiognomically unbranched, non-flowering stems and free, sympodial, leafy flowering stems; *stems* smooth, cataphylls and prophylls caducous, internodes 1—3 x 0.5—1 cm, separated by wide but not especially prominent slightly oblique corky leaf scars; *flagellate foraging stem*, *clasping roots* and *feeding roots* not observed; *leaves* distichous to very weakly spiro-distichous; *cataphylls* and *prophylls* caducous; *petiole* deeply canaliculate, 17—37 x 0.4—1 cm, apical geniculum prominent, basal geniculum large but weakly defined; *petiolar sheath* prominent, extending to apical geniculum, slowly degrading to chartaceous strips and a very few simple fibres, then falling leaving a pale scar; *lamina* entire, ovate to oblong-lanceolate or oblong-elliptic or oblanceolate, slightly oblique, 18—47 x 9—16 cm, coriaceous, base rounded to oblique and very weakly cordate on one side and slightly decurrent on the other, apex acute to briefly acuminate, drying adaxially dull olive-green and abaxially dark brown in the one known collection; *midrib* prominently raised abaxially, sunken adaxially; *primary venation* pinnate, raised abaxially and adaxially; *interprimaries* sub-parallel to primaries, only slightly less prominent, slightly raised abaxially and adaxially; *secondary venation* reticulate, slightly raised abaxially and adaxially in dry specimens;

inflorescence solitary, subtended by a fully developed foliage leaf; *peduncle* stout, terete, 9—10 x 1.7—2 cm; *spathe* canoe-shaped, stoutly acuminate, 20—23 x 2.5—2.5 cm, stiffly very fleshy, marcescent, eventually falling leaving a very large (c. 1.5 cm wide) scar; *spadix* cylindrical to slightly cigar-shaped, slightly curved, long-stipitate, inserted more or less level on stipe, 13.5—19 x 2.2—4 cm; *stipe* slender-terete, 1.5—3 x 0.4—1.5 cm; *stylar region* rhombohexagonal, 1.75—2.5 x 1.5—3 mm, truncate with a raised rim; *stigma* punctiform, flat, c. 0.4 mm diam.; *anthers* not exserted at male anthesis; *infructescence* cylindrical, c. 17 x 2 cm (known from fragments).

Distribution: Indonesian Papua (Yapen), Papua New Guinea (East anf West Sepik, Milne Bay and Morobe Provinces).

Habitat: Lowland swamp forest to upper hill *Araucaria* forest, 20–900 m altitude.

Notes: 1. A remarkable and readily identifiable species with a large, very long-stipitate spadix. Confusion with *Rhaphidophora stenophylla* (also flowering on free shoots and with long-stipitate spadix) is possible, although the latter is readily identifiable by the much narrower leaf laminas, persistent petiolar sheath not degrading to strips and fibre, smaller (6—9 x 1.5—2.2 cm) spadix and long, pointed style

2. While *Nicolson 1475* seems clearly to belong here on morphology, it occurs in very different habitat (upper hill *Araucaria* forest) from that of the type (lowland swamp).

3. *Rhaphidophora oreophila* Engl. & K. Krause is a smaller manifestation of this species.

Other specimens seen: INDONESIAN PAPUA. Pulau Yapen, Kamuda, near Serui, *Aet & Idjan s.n.* (L). PAPUA NEW GUINEA. West Sepik Prov.: Telefomin, Sandaun, Hak Valley, contour transect on south bank of Nenem river, opposite community school, *Frodin & Morren 3209* (K); East Sepik Prov.: Angoram, Latoma village, Wogupmeri river, *Leach NGF 34337* (L); Morobe Prov.: *Araucaria* forest plantation 2 miles west of Wau, *Nicolson 1475* (B, L, K, US); Milne Bay Prov.: Raba Raba, Mayu River, near Mayu Island, *Streimann NGF 28712* (L, US).

7. Rhaphidophora fortis P.C. Boyce, *sp. nov.*

Rhaphidophora fortis in Nova Guinea singularis est characteribus sequentibus concatenatis: folia breviter petiolata, surculi florentes

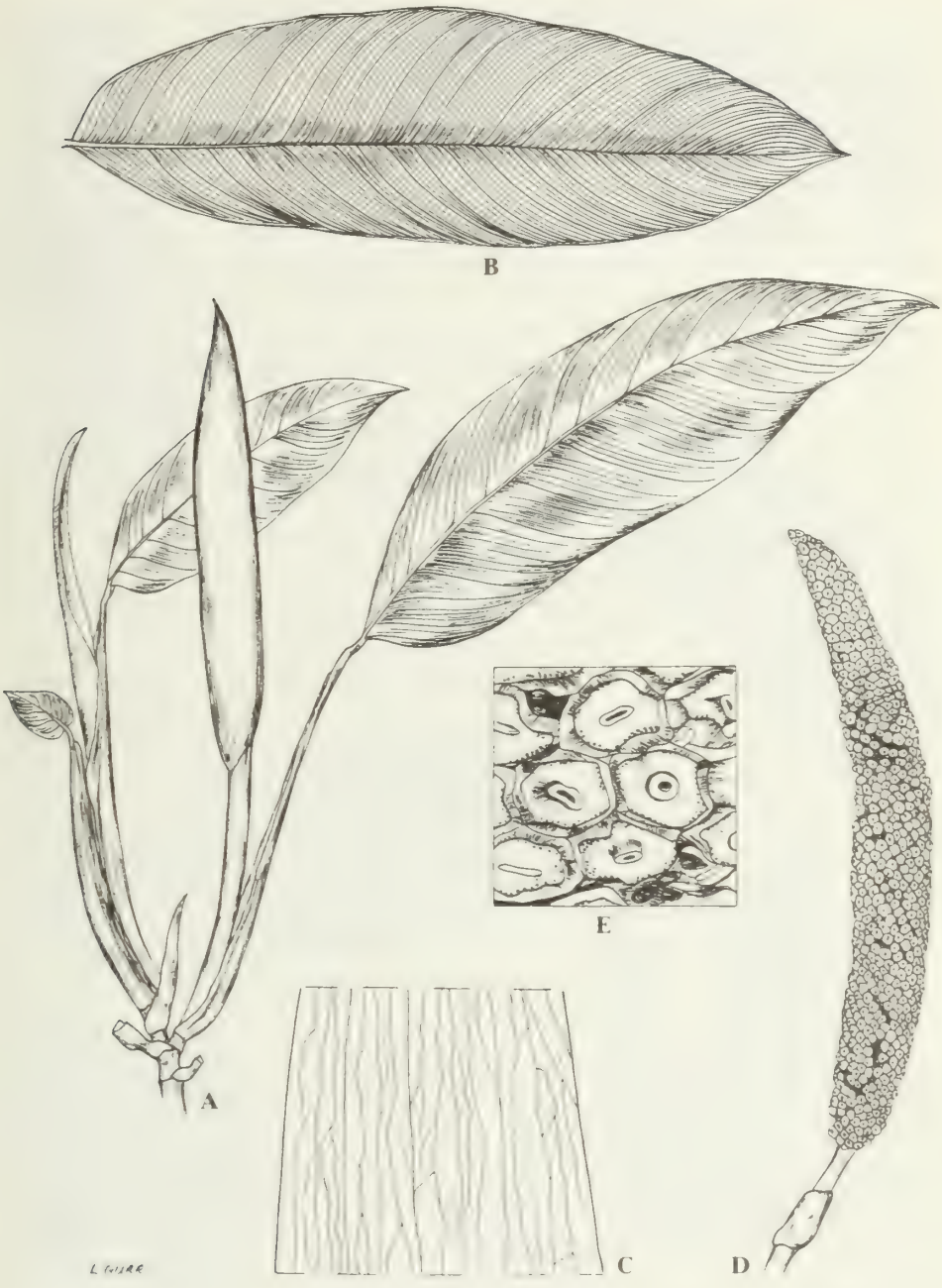

Figure 7. Rhaphidophora discolor Engl. & K. Krause
A. flowering shoot x ⅛; B. leaf lamina x ⅛; C. venation detail x 4; D. inflorescence, early stages of fruiting, spathe fallen x ⅓; E. lower spadix detail, early fruiting x 6; F. upper spadix detail, early fruiting x 3. All from *Streimann & Kairo NGF 39190.*

adhaerentes valde robusti, inflorescentiae ex axilliis foliorum enascentes ut videtur. — TYPUS: Papua New Guinea, West Sepik Prov., Vanimo SubProv., Ossima, 27 Jan. 1969, *Streimann & Kairo NGF 39190* (K, holo; L, LAE, CANB, US, iso).

Figure 8

Robust, pachycaul (?), homeophyllous (?) liane to unknown ultimate height; *seedling stage* and *pre-adult plants* not observed; *adult shoot* architecture not fully observed but apparently comprised of elongated, clinging, physiognomically unbranched, flowering stems; *stems* with epidermis drying smooth and yellowish, with cataphylls and prophylls degrading to weak netted fibres and sheets of chartaceous tissue at the stem tips, internodes 1—2.5 x 1.5—2 cm, separated by weakly defined leaf scars; *flagellate foraging stem* and *feeding roots* not observed; *clasping roots* arising from nodes and internodes, smooth with dark chartaceous epidermis; *leaves* distichous; *cataphylls* and *prophylls* very conspicuous, extending almost to apical geniculum of newly emerging leaves, quickly degrading to netted fibres and strips of chartaceous tissue; *petiole* stout, broadly and shallowly canaliculate, 14—16 x 0.8—1 cm, apical geniculum prominent, basal geniculum weakly defined and obscured by cataphyll remains; *petiolar sheath* very prominent, extending to apical geniculum, but very swiftly degrading to netted fibres, later falling leaving a smooth, scar; *lamina* entire, elliptic to oblong-elliptic or lanceolate elliptic, slightly to markedly oblique, 24—31 x 8—12 cm, subcoriaceous, base rounded to subacute, apex acute to briefly acuminate, falcate; *midrib* raised abaxially, sunken adaxially; *primary venation* pinnate, slightly raised abaxially and adaxially; *interprimaries* parallel to primaries, less prominent, slightly raised abaxially and adaxially; *secondary venation* tessellate-reticulate, slightly raised abaxially and adaxially in dry specimens; *inflorescences* not known but apparently arising two or more sequentially between foliage leaves, subtended by netted fibre and copious sheet-like tissue; *infructscences* with *peduncle* laterally compressed, c. 5 x 0.6 cm, more or less obscured by cataphyll remains; *spathe* not observed; *spadix* massively ovoid-cylindrical, sessile, inserted more or less level on peduncle, 8—9 x c. 3 cm; *stylar region* rounded-rhombohexagonal, c. 2.3 x 2.7, truncate; *stigma* punctiform, slightly raised, c. 0.6 mm diam.; *anthers* not observed.

Distribution: Papua New Guinea (West Sepik Prov.). Known only from the type.

Habitat: Lowland forest, 25 m altitude.

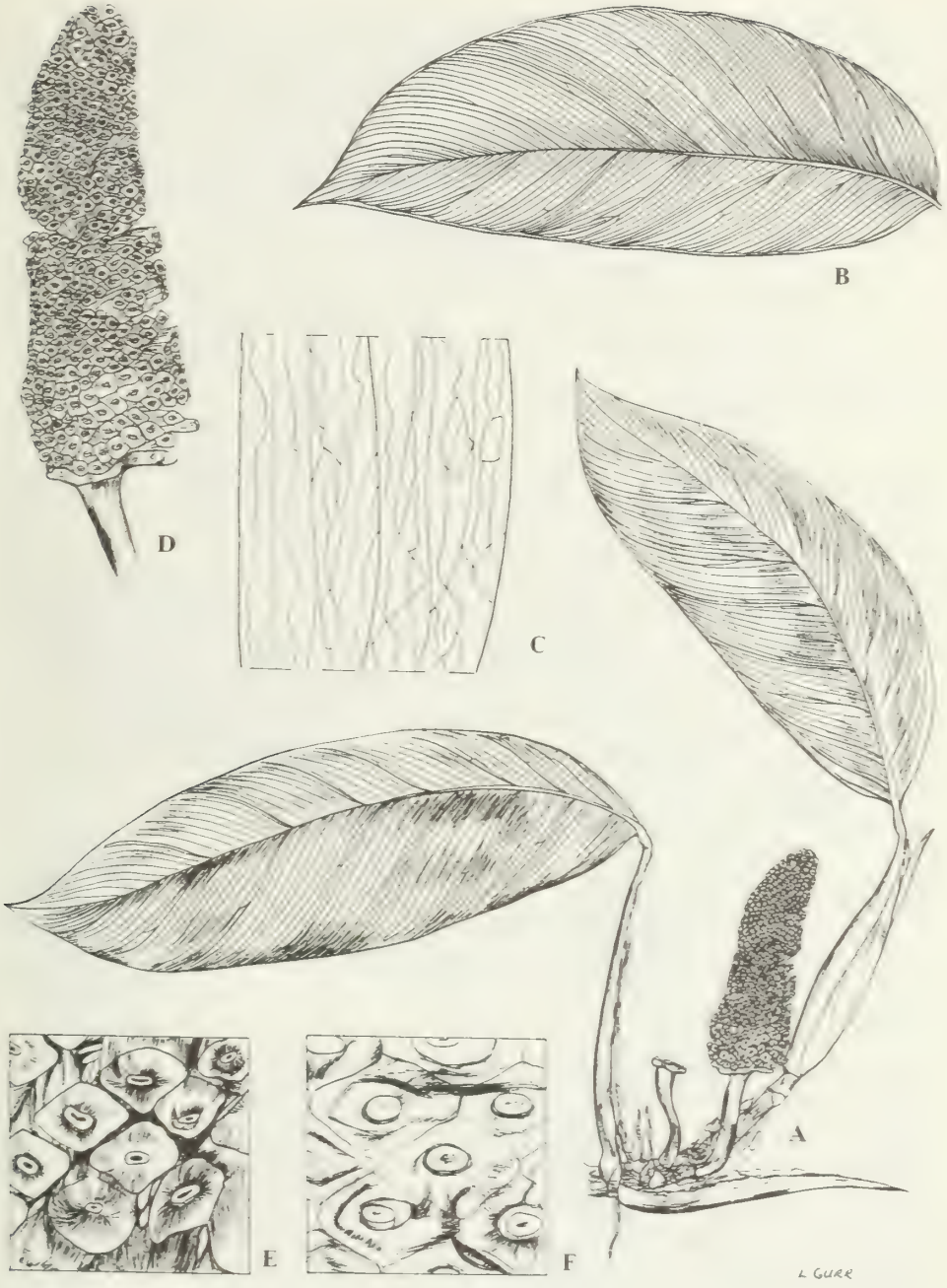

Figure 8. Rhaphidophora fortis P.C. Boyce
A. flowering shoot x 1/5; B. leaf lamina x 1/5; C. venation detail x 3; D. inflorescence, spathe fallen x 1/2; E. spadix detail, post-male anthesis x 4. F. spadix detail, early fruiting x 4. All from *Nicolson 1475*.

Notes: 1. An extraordinary species with extremely stout, clinging flowering shoots and short-petioled leaves, the whole shoot resembling a plant of Bornean *Scindapsus beccarii* Engl.. Inflorescences are borne in the leaf axils. It is not clear from the material available whether the inflorescence terminates the main axis which then reiterates, displacing the inflorescence, or whether the inflorescence is borne on a much abbreviated shoot arising from the axil.

2. The specific epithet comes from the Latin, *fortis*, strong or stout, in allusion to the plant's relatively massive form.

8. Rhaphidophora geniculata Engl.

Rhaphidophora geniculata Engl., Bot. Jahrb. Syst. 25 (1898) 7; K. Schum. & Lauterbach, Fl. Schutzgeb. Südsee (1900) 211; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 25, Fig. 7; Engl. & K. Krause, Nova Guinea 8 (1910) 249. — Type: Papua New Guinea, Madang Prov. (?), Bismarck Range, 9 Sept. 1896, *Lauterbach 827* (B, neo; designated here). In describing *R. geniculata*, Engler cited three syntypes [Papua New Guinea ('Kaiser Wilhelmsland'), Morobe Prov., Sattelberg, July 1890, *Lauterbach 616a* (B†); Papua New Guinea ('Kaiser Wilhelmsland'), Madang Prov., Gogol river, Nov. 1890, *Lauterbach 976* (B†) & *1058a* (B†)]. The specimen chosen here as the neotype was determined as *R. geniculata* by Engler and matches the protologue well.

Rhaphidophora wentii Engl. & K. Krause, Nova Guinea 8 (1910) 248 & Nova Guinea 8 (1912) 805, **synon. nov.** — Type: Indonesian Papua, Noordfluss, 2 June 1907, *Versteeg 1191* (B, holo; BO, L, K, iso).

Figure 9

Rather small, slender, semi-pachycaul homeophyllous liane to 3 m; *seedling stage* and *pre-adult plants* not observed; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, leafy, sterile stems and very short, adherent (always?) flowering stems arising from the axils of the leaves; *stems* smooth, terete in cross-section, drying deeply longitudinally sulcate; with very sparse to copious netted prophyll, cataphyll and petiolar sheath fibre, internodes 1—4 x 0.5—1.2 cm, separated by large, oblique, slightly corky leaf scars; *flagellate foraging stems* absent; *clasping roots* arising from the nodes and internodes, pubescent; *feeding roots* not observed; *leaves* distichous; *cataphylls* and *prophylls* membranous, quickly drying and degrading into netted fibres, these later falling; *petiole* shallowly grooved, 1.4—27 x 0.2—0.7 cm, apical geniculum long but not

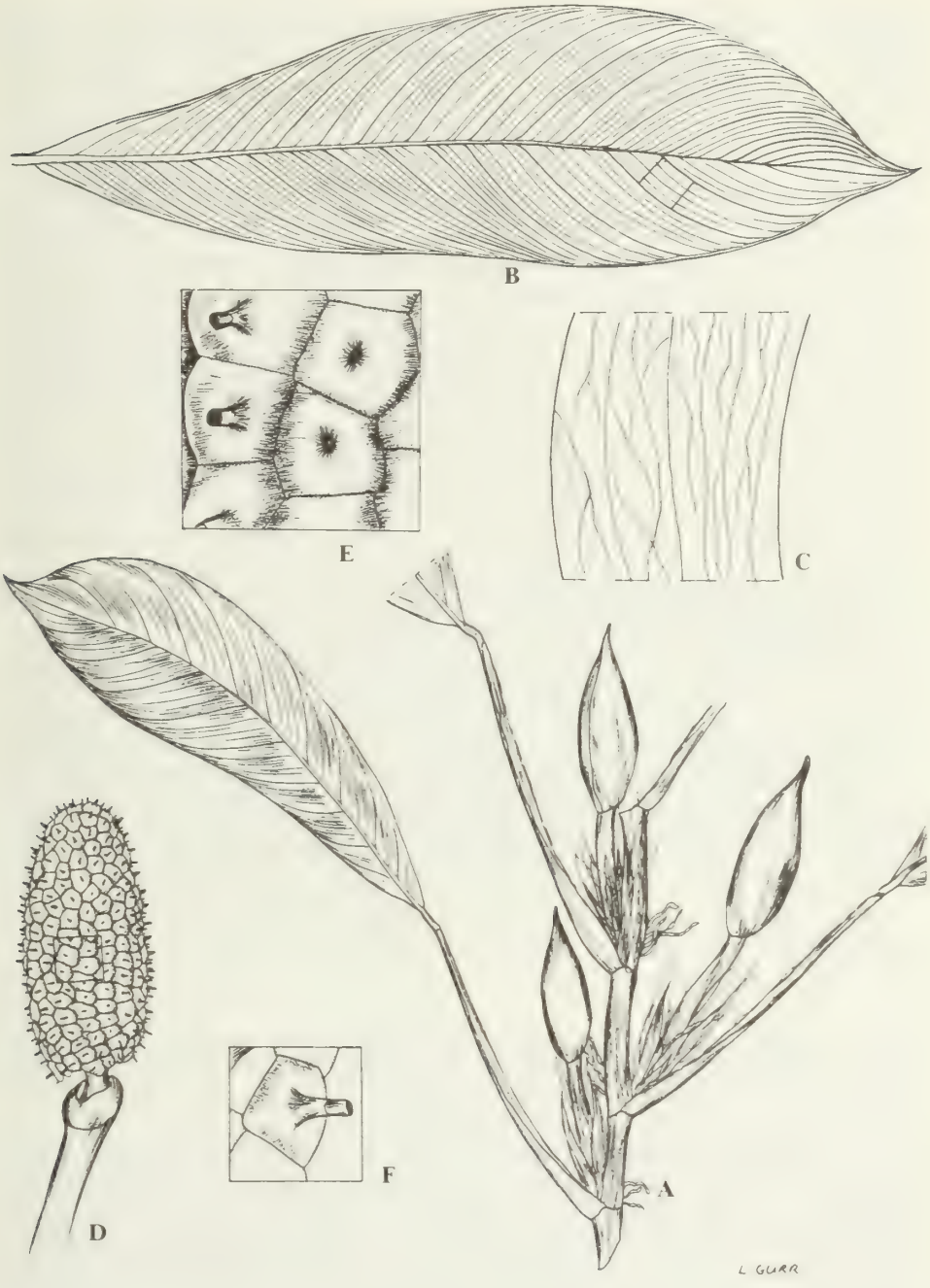

Figure 9. Rhaphidophora geniculata Engl.
A. flowering shoot x ½; B. leaf lamina x ⅛; C. venation detail x 3; D. inflorescence, spathe removed x 1; E. spadix detail, pre-anthesis x 6; F. stylar region and stigma, side view x 6. All from *Johns 9870*.

especially prominent, basal geniculum barely visible to rather large (dependent on age), moderately prominent; *petiolar sheath* extending to just below the apical geniculum degrading into semi-persistent netted fibres, eventually falling; *lamina* entire, oblanceolate or oblong-elliptic, slightly to markedly oblique, oblique, 1.8—35 x 3—7 cm, thinly coriaceous to weakly chartaceous, usually drying conspicuously discolorous, adaxially dark olive-brown, abaxially pale olive-green to reddish brown, base decurrent, apex acute, falcate-acute, acuminate or rounded-acuminate; *midrib* prominently raised and usually darker abaxially, ± flush adaxially; *primary venation* arching-pinnate, slightly raised abaxially, almost flush adaxially; *interprimaries* sub-parallel to primaries, slightly to much less prominent, slightly raised; *secondary venation* weakly reticulate, slightly raised; *tertiary venation* reticulate-striate, barely visible; *inflorescence* solitary, terminating a short shoot arising in the axils of leaves, occasionally arising from axils of fallen leaves, and usually inflorescences arising from several adjacent leaves, and thus sections of stems carrying several inflorescences in diffuse clusters, each inflorescence subtended by a prophyll and several degraded, netted cataphylls; *peduncle* strongly compressed-terete, 5—9 x 0.3—0.6 cm; *spathe* ovoid-ellipsoid, base decurrent and oblique, apex rounded, slender-acuminate, 3.5—6.5 x 1.5—2.5 cm, white, marcescent falling at fruit maturation leaving a large oblique scar; *spadix* ovoid-ellipsoid, stipitate, inserted obliquely on stipe, 2.5—3.5 x 1.3—1.7 cm; stipe 2—8 x 1—2 mm; *stylar region* mostly hexagonal, 1.5—2 x 2.1—2 mm, prominently conical; *stigma* punctiform on a long (c. 2 mm) stipe, c. 0.2—0.35 diam.; *anthers* not exserted at male anthesis. *Infructescence* stout ellipsoid-cylindrical, c. 4 x 2 cm.

Distribution: New Guinea. Widespread but, in view of the rather few collections, perhaps uncommon.

Habitat: Primary and slightly disturbed lowland to upper hill forest and lower montane forest, 150–790 m altitude.

Notes: 1. In flowering on clinging shoots and by the conical style *Rhaphidophora geniculata* resembles *R. australasica* from which it may be distinguished by the ovoid-ellipsoid, stipitate spadix (cylindrical and sessile in *R. australasica*) and the lack of fibrous petiolar sheath remains. It also differs from that species by the inflorescences borne on short shoots arising from the leaf axils. In this respect it is reminiscent of *R. brevispathacea* and *R. stolleana*, although in these the stems are pendent and not clinging.

2. The protologue of *R. wentii* states the spadix to be sessile; examination

of the fertile types (B, BO, L) shows this to be incorrect; all are stipitate. The illustration accompanying the protologue of *R. geniculata* is a good match for the B holotype and L isotype of *R. wentii*.

Other specimen seen: INDONESIAN PAPUA. Digul Prov.: Merauke, *Branderhorst 324* (L); Mimika Prov.: Freeport Concession Area, Golf Course surrounds, *Johns 9970* (BO, K, MAN); Kali Kopi, between Kali Kopi levee and the Kopi River, *Utteridge 79* (BO, K, MAN). PAPUA NEW GUINEA. West Sepik Prov.: Vanimo, Vanimo hinterland, *Streimann LAE 52964* (LAE, US); Southern Highlands Prov.: Mt Bosavi, northern side, 2—4 km west of Ludesa mission station, *Jacobs 9331* (L); Wasu, NE slope of Mt Bosavi, *Moi et al. 196* (BFC, L, LAE); Morobe Prov.: vicinity of Kajabit Mission, *Clemens 10662* (GH); Vicinity of Lae, along logging road to Busu River, from 3.8 km E of Igam road and Military Base to c. 6 km up the road junction, *Croat 52787* (MO), *Croat 52788* (MO); Left off of Igam road past Military Reserve, *Croat 52803* (MO).

9. Rhaphidophora gorokensis P.C. Boyce, *sp. nov.*

Rhaphidophora gorokensis R. kokodensi R. okapensi, R. pilodi atque *R. wariae* similis, species omnes monticolae foliis parvis rigide coriaceis sunt. A *R. waria* atque *R. okapensi* in surculis liberis lateralibus florenti et spadice sessili prompte distinguibilis est; porro a *R. waria* vaginis petiolaribus plus minusve omnio cadentibus neque in fibris fatiscentibus, atque a *R. okapensi* forma laminae foliae (anguste lanceolate vel elliptics, basi acuta, apice longe acuminata tubulo minuto instructa, neque ovata, basi ovata, apice longe acuminata tubulo manifeste) distinguitur. *A R. pilode* atque *R. kokodensi* (ambo in surculis liberis lateralibus florentes) *R. gorokensis* fibra vaginae petiolaris carenti distinguitur. — TYPUS: Papua New Guinea, Eastern Highlands Prov., Goroka, Marafunga logging area, Upper Asaro Valley, 6 Sept. 1961, *Womersley & Sleumer NGF 13971* (GH, holo; L, LAE, iso).

Figure 10

Small, homeophyllous (?) liane to 12 m; *seedling stage* and *pre-adult plants* not observed; *adult shoot architecture* not fully observed but presumably comprised of elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and (observed), free, little branching, sympodial, densely leafy flowering stems; *stems* terete in cross-section, without cataphyll, prophyll and petiolar sheath fibre, internodes to 1—4 x 0.5—0.8 cm, separated by slightly oblique, corky leaf scars; *flagellate foraging stems, clasping roots* and *feeding roots* unknown; *leaves* spiro-distichous on free shoots; *cataphylls* and *prophylls* chartaceous, caducous; *petiole* deeply canaliculate, 6.5—11 x 0.15—0.25 cm, smooth, genicula weak; *petiolar sheath* prominent, chartaceous, extending to apical geniculum, briefly persistent,

then partially caducous, later falling leaving an irregular, corky scar; *lamina* entire, narrowly lanceolate to elliptic, oblique, falcate, 7—16 x 2—5 cm, stiffly coriaceous, base acute, oblique, apex long-acuminate with a minute tubule; *midrib* raised abaxially, flush to slightly sunken adaxially; *primary venation* densely pinnate, raised abaxially and adaxially; *interprimaries* subparallel to primaries, indistinguishable from them; *secondary* and *tertiary venation* conspicuously parallel-reticulate; *inflorescence* solitary, subtended by an under-developed foliage leaf; *peduncle* compressed-terete, 5—7 x 0.2—0.2.5 cm; *spathe* narrowly canoe-shaped, stout-acuminate, 6—6.5 x c. 1.5 cm, marcescent(?); *spadix* cylindrical, sessile, 3.3—3.5 x c. 0.7 cm; *stylar region* rhombohexagonal, c. 0.9—1 x 0.8—1.1 mm, truncate; *stigma* punctiform, flush with a raised rim, c. 0.5 mm diam.; *anthers* not exserted at male anthesis; *infructescence* not observed.

Distribution: Papua New Guinea (Eastern Highlands Prov. - Goroka and Mendi).

Habitat: Lower montane rain forest, Fagaceae and Nothofagaceae forest on limestone. 1600–2440 m altitude.

Note: Similar to *Rhaphidophora kokodensis*, *R. okapensis*, *R. pilosa* and *R. waria* in being a montane species with small, stiffly coriaceous leaves. It is readily distinguishable from *R. okapensis* and *R. waria* by flowering on free lateral shoots and by the sessile spadix. It can be further distinguished from *R. waria* by the petiolar sheaths falling more or less entire and not degrading into fibres, and from *R. okapensis* by the shape of the leaf lamina (narrowly lanceolate to elliptic, base acute, apex long-acuminate with a minute tubule v. ovate, base cordate, apex long acuminate with a pronounced tubule). From *R. kokodensis* and *R. pilosa* (both flowering on free lateral shoots) *R. gorokensis* is distinguished in lacking petiolar sheath fibre.

Other specimens seen: PAPUA NEW GUINEA. Southern Highlands Prov.: Mendi, Det Mission, 16 km SSW of Mendi, *Vinas 151* (GH, K); Eastern Highlands Prov.: Goroka, Collins Mill, Omahaiga River valley, Mt Otto area, *Robbins 870* (L).

10. Rhaphidophora guamensis P.C. Boyce, *sp. nov.*

Dum *Rhaphidophoram spathaceum* simulans, *R. guamensis* inflorescentia solitaria apicem surculi liberi lateralis ferenti neque e mole prophyllorum chartaceorum cataphyllorumque exorienti, etiam specice robuste stipitato statim distinguibilis est. Praeterea, stipes stigmaticus egregie longus insignis

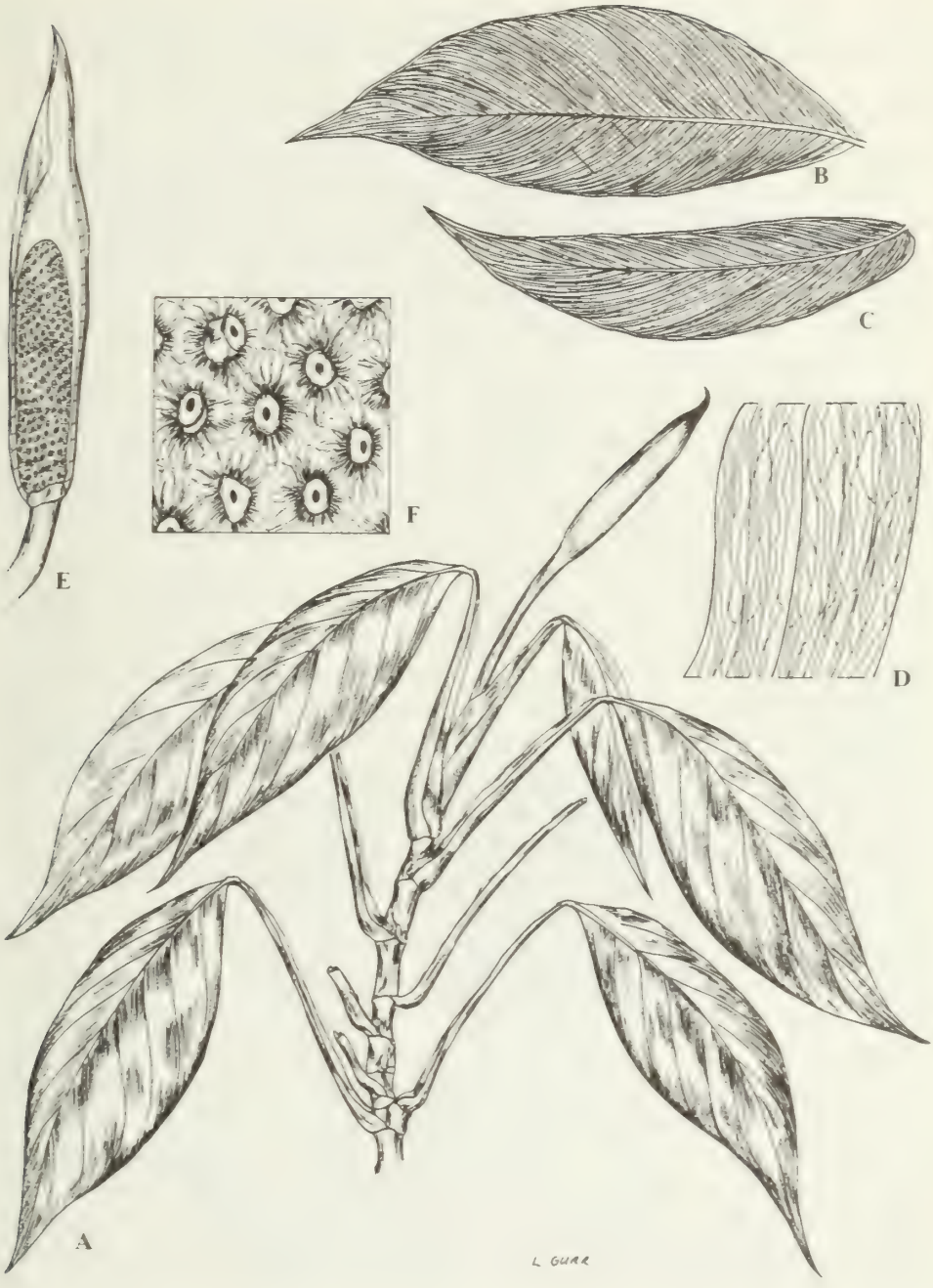

Figure 10. Rhaphidophora gorokensis P.C. Boyce
A. flowering shoot x ½; B. leaf lamina x ¼; C. leaf lamina x ¼; D. venation detail x 4; E. inflorescence x 1; F. spadix detail, pre-anthesis x 8. A & B. D-F from *Womersley & Sleumer NGF 13971*; C from *Robbins 870*.

est. — TYPUS: Guam, slopes of Mt Almagosa, Naval Magazine, near Fena Dam, 28 April 1962, *B.C. Stone 4101* (L, holo; GUAM, US, iso).

Figure 11

Moderately robust, medium-sized semi-leptocaul, heterophyllous(?) liane to unknown ultimate height; *seedling stage* not observed; *pre-adult plants* forming scattered terrestrial colonies; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, scattered-leafy, non-flowering stems and free, sympodial, leafy flowering stems; *stems* smooth, mid-green, cataphylls and prophylls briefly persistent then falling leaving bare stems, internodes 0.5—3 x 0.3—1 cm, separated by prominent straight leaf scars; *flagellate foraging stem* not observed; *clasping roots* solitary to somewhat densely produced arising from the nodes and internodes adjacent to nodes; *feeding roots* not observed; *leaves* more-or-less distichous; *cataphylls* and *prophylls* drying chartaceous, briefly persistent; *petiole* deeply canaliculate, 9—15 x 0.2—0.4 cm, smooth, apical geniculum large but not especially prominent, basal geniculum almost invisible; *petiolar sheath* extending to base of apical geniculum, broad, chartaceous, short-persistent, degrading to very sparse papery strips, then falling; *lamina* entire, oblong-elliptic to oblong-lanceolate or oblanceolate, slightly oblique to markedly oblique, 15—32 x 4—8.5 cm, submembranous to coriaceous, base rounded to acute, apex acute to weakly acuminate; *midrib* raised abaxially, ± flush adaxially to weakly raised abaxially; *primary venation* pinnate, slightly raised abaxially, flush adaxially, drying darker than lamina; *interprimaries* sub-parallel to primaries, much less prominent, slightly raised abaxially, barely visible adaxially; *secondary venation* reticulate, raised, especially notable in dry material; *inflorescence* solitary, subtended by a fully to partially developed foliage leaf and one to several degraded and soon-falling chartaceous cataphylls; *peduncle* rather stout, terete, 6—8 x 0.3—0.5 cm; *spathe* broadly canoe-shaped, briefly stout-beaked, 10—12 x 2—7 cm, spongy-fleshy, very thick-walled, pale yellow, caducous, falling leaving a very prominent oblique scar; *stipe* stoutly terete, 1—1.5 x 0.4—0.5 cm; *spadix* slender to somewhat stout-cylindrical, stipitate, cochleate at insertion on stipe, 7—9 x 1—1.5 cm, white at male anthesis; *stylar region* strongly conical, mostly hexagonal in top view, 0.9—1.2 x 1—1.1 mm; *stigma* punctiform on the tip of a long (c. 2 mm) stipe, 0.5—0.2 x c. 0.3 mm, glossy and black in dried material; *anthers* not exserted at male anthesis; *infructescence* not observed.

Distribution: Guam.

Habitat: Mixed forest, coconut plantation, on limestone, c. 400 m altitude.

Figure 11. Rhaphidophora guamensis P.C. Boyce
A. flowering shoot x ½; B. leaf x ⅛; C. pre-adult creeping shoot x ⅛; D. spadix detail at post male anthesis x 6. All from *Stone 4101*.

Note: While resembling *Rhaphidophora spathacea*, *R. guamensis* is immediately distinguishable by the solitary inflorescence carried on the tip of a free lateral shoot, and which does not emerge from a mass of chartaceous prophyll and cataphylls, and also by the robustly stipitate spadix. In addition, the remarkably long stigmatic stipe is notable.

Other specimens seen: GUAM. Mt Lamlam summit, near lighthouse, *Anderson 147* (GUAM, US); Almagosa Springs area, Naval Magazine, *Rinehart 15568* (GUAM, US).

11. Rhaphidophora hayi P.C. Boyce & Bogner

Rhaphidophora hayi P.C. Boyce & Bogner, Gard. Bull. Singapore 52 (2000) 91, fig.1. — Type: Australia, Queensland, Cooroo Lands, north Johnstone River, near Innisfail, Nov. 1965, *Webb & Tracey* 7066 (BRI, holo).

Figure 12

Moderate-sized, slender to somewhat robust, semi-leptocaul, homeophyllous neotenic liane to 5 m; *seedling stage* a non-skototropic shingling juvenile shoot; *pre-adult plants* forming small terrestrial colonies; *adult shoot architecture* comprised of clinging, physiognomically unbranched, mostly densely leafy, sterile stems and abbreviated, free, flowering stems; *stems* rectangular to terete in cross-section, widest side prominently convex, smooth, dark green, without prophyll and cataphyll fibre but with very thin, adherent, petiolar sheath tissue, internodes to 8 x 1 cm, separated by slight ± straight scars, older stems sub-woody; *flagellate foraging stems* weakly developed, usually at least partially leafy and mostly replaced by short, readily disarticulating free side shoots functioning as vegetative propagation units; *clasping roots* arising from the internodes, prominently pubescent; *feeding roots* c. 3 mm diam., brown, minutely pubescent, sparsely lenticellate; *leaves* distichous, shingling and ascending on adherent shoots, densely arranged or slightly scattered on free shoots, scattered leaves with internodes between carrying a prominent cataphyll of short duration; *cataphylls* and *prophylls* membranous, caducous; *petiole* deeply grooved, 1—2 x 0.2—0.3 cm, smooth, apical and basal genicula barely visible; *petiolar sheath* prominent, caducous but adhering to stem, membranous, ligulate, margins of ligule fused, the ligule extending up to 3 cm above base of lamina and enclosing shoot apex; *lamina* broadly to narrowly ovate-elliptic, coriaceous, base truncate to cuneate or cordate (the last not on flowering shoots), and briefly decurrent, apex acute with a tiny tubule; *midrib* prominently raised abaxially, slightly raised adaxially; *primary venation* densely pinnate, slightly raised abaxially, somewhat impressed adaxially;

Figure 12. Rhaphidophora hayi P.C. Boyce & Bogner
A. adult shoot with flowering branch x 1/6; B. leaf lamina x 1/6; C. venation detail x 3; D. pre-adult climbing shoot x 1/4; E. disarticulating side shoot x 1/6; F. inflorescence x 1; G. spadix detail at female anthesis x 10; H. spadix detail at post-male anthesis x 10. A-C from *Backer 11199*; D-H from *Sands et al. 2384*.

interprimaries sub-parallel to primaries, slightly raised on both leaf surfaces; *secondary venation* reticulate, slightly raised abaxially, ± flush adaxially; *inflorescence* solitary, subtended by a membranous, caducous prophyll and one or more similar cataphylls; *peduncle* slightly laterally compressed, 2—3 x 0.6—1 cm; *spathe* canoe-shaped, stoutly beaked, 5.5—8 x 2—4 cm, stiffly fleshy, yellow, gaping wide at female anthesis and then slowly falling leaving a large scar at the base of the spadix; *spadix* stoutly cigar-shaped, shortly stipitate, inserted ± level on stipe, 3.5—6 x 1—1.2 cm, yellow; *stipe* 4—6 x 3—3.5 mm; *stylar* region weakly developed, mostly irregularly rhombohexagonal, 1.1—1.3 x 1—1.1 mm, truncate; *stigma* prominently raised, elongated, longitudinally orientated, c. 0.3—0.5 x 0.2—0.4 mm; *anthers* not exserted at male anthesis; *infructescence* not seen.

Distribution: Indonesian Papua, Papua New Guinea (including New Britain, New Ireland, Bougainville and Muyua (Woodlark) Island), and Australia (eastern tropical Queensland).

Habitat: Primary and secondary monsoon or rain forest on coralline limestone and basalt. 20–600 m altitude.

Notes: 1. While resembling *Rhaphidophora pachyphylla*, *R. hayi* is immediately distinguishable by the flowering shoots with broader, truncate-based leaf laminas, the raised, larger, elongated, longitudinally orientated stigmatic region, the occasional foraging shoot, and by the presence of free, disarticulating side shoots functioning as vegetative propagation units. This last character occurs also in *R. cryptantha* (*q.v.*).

2. Very similar to *R. parvifolia* Alderw. (Maluku: Pulau Ternate) but differing by the stipitate spadix. From available material it is not possible to tell if *R. parvifolia* has the disarticulating side shoots typical of *R. hayi*.

3. There are many collections of *R. hayi* originating from Australia (mostly in BRI and QRS) but all except those cited here are sterile.

Other specimens seen: INDONESIAN PAPUA. Kepala Burung Prov.: 2 km N of Manokwari, *Nicolson 1577* (B, K, L, US). PAPUA NEW GUINEA.Woodlark (Muyua) Island: Kulumadau, *Brass 28831* (GH, L); Central Prov.: Sogeri Plateau, 5 - 7 miles beyond Kokoda Trail Monument, 30 miles east of Port Moresby, *Nicolson 1431* (L, US); Milne Bay Prov.: Esa'ala , Normanby Island, Sewa Bay, 21 Oct. 1971, *Lelean & Streimann LAE 52541* (L, LAE, US); North Solomons Prov.: Bougainville, Arawa, McKillup's Plantation, 6 m west of Kieta, *Nicolson 1512* (B, K, US); West New Britain Prov.: Kandrian, along road from airport, *Nicolson 1540* (L, US); New Ireland, Namatanai, Hans Meyer Range, above Mandih river, near Mandih Lake, c. 6 km WNW of Taron, 30 Oct. 1975, *Sands et al. 2384* (K, K

(living collection acc. no. 1975-5026, K spirit no. 639388). AUSTRALIA. Queensland: Cape Tribulation, *Rijkers 1484* (BRI).

12. Rhaphidophora intonsa P.C. Boyce, *sp. nov.*

Rhaphidophora intonsa apicibus surculorum reticulo fibroso denso inclusis distinguitur, porro inflorescentiae grandes in surculis liberis diagnostici sunt. Cum *R. spuria* eam confundere potest, sed haec basi laminae truncata vel leniter cordata atque apicibus surculorum multo minus fibrosis facile distinguitur. Cum *R. australasica* eam etiam confundere potest, sed ab illa *R. intonsa* in surculis liberis florenti et inflorescentias multo maiores (spatha 17—20 cm nec 5—9.5 cm, spadice 10.5—18.5 cm nec 3.75—8 cm) procreanti differt; praetera, apex regionis stylaris truncata est, neque manifeste conica. — TYPUS: Papua New Guinea, Central Prov., Boridi, 30 Sept. 1935, *Carr 14313* (SING, holo; BM, L, iso).

Figure 13

Medium to large, robust, pachycaul (?), homeophyllous (?) liane to 12 m; *seedling stage* and *pre-adult plants* not observed; *adult shoot architecture* not fully observed but apparently comprised of elongated, clinging, physiognomically unbranched, non-flowering stems and free lateral, leafy flowering stems; *stems* with cataphylls and prophylls degrading to dense ragged fibres and sheets of tissue and forming dense matting at the stem tips, internodes 1—3 x 0.5—1.4 cm, separated by prominent slightly oblique corky leaf scars; *flagellate foraging stem*, *clasping roots* and *feeding roots* not observed; *leaves* spiro-distichous; *cataphylls* and *prophylls* quickly degrading to dense ragged fibres and sheets of tissue; *petiole* shallowly canaliculate, 12—43 x 0.4—0.9 cm, apical geniculum prominent, basal geniculum weakly defined and obscured by fibre; *petiolar sheath* very prominent, extending to apical geniculum, swiftly degrading to copious netted fibres, later falling leaving a smooth, corky scar; *lamina* entire, ovate to oblong-elliptic, slightly oblique, 17—47 x 9—20 cm, subcoriaceous, base subacute to slightly decurrent, apex acute to briefly acuminate; *midrib* prominently raised abaxially, very slightly raised adaxially; *primary venation* pinnate, slightly raised abaxially and adaxially; *interprimaries* parallel to primaries, slightly less prominent, raised abaxially, slightly impressed adaxially; *secondary venation* reticulate, slightly raised abaxially and adaxially in dry specimens; *inflorescence* solitary, mostly subtended by a ± fully developed foliage leaf and copious netted fibre and sheet-like tissue; *peduncle* laterally compressed to terete, 9—13 x 0.9—2 cm; *spathe* canoe-shaped, 17—20 x 1.5—2.5 cm, stoutly long-beaked, stiffly fleshy, caducous leaving a large scar at the base of the spadix; *spadix* cylindrical, slightly

curved, sessile, inserted more or less level on peduncle, 10.5—18.5 x 1.7—2.3 cm, cream; *stylar region* rhombohexagonal, 1—2 x 1—1.5 mm, truncate; *stigma* punctiform, raised at male anthesis flattened in dry material, c. 0.3 mm diam.; *anthers* not exserted at male anthesis; *infructescence* curved-cylindrical, c. 17 x 2 cm.

Distribution: Papua New Guinea (Central & Morobe Prov.).

Habitat: Montane forest. 1290–1800 m altitude.

Notes: 1. The densely netted fibre-encased shoot tips and large inflorescences are diagnostic. *Nicolson 1473* is smaller and less robust than the type but otherwise matches very well.

2. Confusion with *R. spuria* is possible although the latter is readily distinguished by the truncate to weakly cordate lamina base and in having very much less fibre at the shoot tips. Confusion with *R. australasica* is possible. *Rhaphidophora intonsa* differs by flowering on free shoots and in producing much larger inflorescences (spathe 17—20 cm/spadix 10.5—18.5 cm *vs.* spathe 5—9.5 cm/spadix 3.75—8 cm in *R. australasica*). Additionally, the stylar region is truncate-topped in *R. intonsa* and prominently conical in *R. australasica*.

3. The specific epithet comes from the Latin *intonsa*, unshaven, in allusion to the dense, untidy prophyll and cataphyll fibre clothing the stem tips.

Other specimens seen: PAPUA NEW GUINEA. Morobe Prov.: Ogeramnang to Malang, *Clemens 4637* (GH); Sambangan, *Clemens 7779* (B); Edie Creek road, above Wau, *Nicolson 1473* (B, K, L, P, US).

13. Rhaphidophora intrusa P.C. Boyce, *sp. nov.*

Dum *Rhaphidophoram schlechteri* simulans, *R. intrusa* apice spathae longe extenso (usque ad tertiam partem longitudinis spathae toto) atque ligulis vaginae petiolaris valde elongatis secundum costam abaxialem usque ad dimidiam longitudinis laminae extensis et secum adnatis statim cognoscibilis. Hic character etiam, in spatione minore, in *R. hayi* repertus est, a qua *R. intrusa* habitu non scindulanti, petiolis longioribus, lamina foliorum tenuiore atque longiore differt. — TYPUS: Indonesian Papua, Kepala Burung Prov., Kabupaten Manokwari, Kecamatan Manokwari, Arfak Plains, close to road from SP & to Sg. Wariori crossing, 22 April 1994, *Sands 6276* (K, holo; BO, MAN, iso).

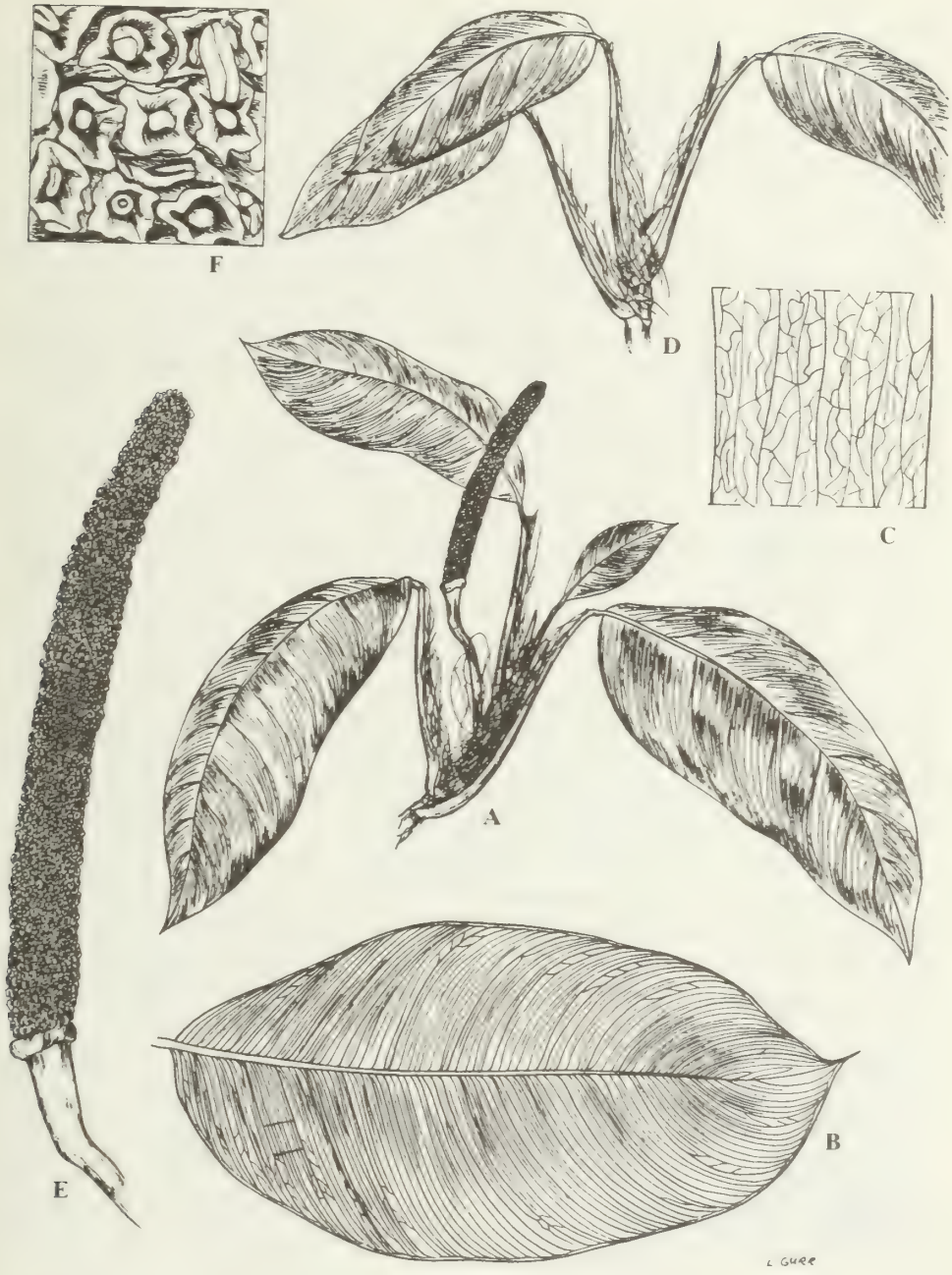

Figure 13. Rhaphidophora intonsa P.C. Boyce
A. flowering shoot x 1/8; B. leaf lamina x 1/4; C. venation detail x 2; D. portion of clinging adult stem x 1/4; E. inflorescence, spathe fallen x 1/4; F. spadix detail, male anthesis x 6; F, A-C, E & F from *Carr 14313*; D from *Nicolson 1473*.

Figure 14

Slender, leptocaul, homeophyllous liane to 5 m; *seedling* and *pre-adult plants* not observed; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and somewhat lengthened mostly unbranched, free, sympodial, spreading to pendent, rarely ascending, leafy, flowering stems; *stems* smooth, flexuous, climbing stems ± terete, free stems somewhat longitudinally flattened, without prophyll, cataphyll and petiolar sheath fibre, internodes 1—6 x 0.6 cm on clinging shoots, those on free shoots much more slender, separated by weak straight to slightly oblique leaf scars, older stems woody; *flagellate foraging stems* not observed; *clasping roots* arising sparsely from nodes of clinging stems, slightly pubescent; *feeding roots* not observed; *leaves* distichous, somewhat scattered; *cataphylls* and *prophylls* not observed; *petiole* shallowly to rather deeply grooved adaxially, 2.5—5 x 0.1—0.2 cm, smooth, with very slight apical and basal geniculum; *petiolar sheath* prominent, chartaceous, extending beyond the apical geniculum by two ligules adaxially and by ligules fused along the abaxial midrib for up to half the leaf lamina length, sheath eventually falling leaving a continuous scar from the petiole base, around the top of the apical geniculum and back to the base and remnants along the abaxial midrib; *lamina* entire, oblong-elliptic, 6—16.5 x 3.5—6 cm, submembranous, base subovate, apex weakly acuminate, with a minute tubule; *midrib* raised abaxially, slightly sunken adaxially in fresh material, slightly sunken abaxially and adaxially in dry material; *primary venation* pinnate, slightly raised on both surfaces in dried material; *interprimaries* sub-parallel to, but much less distinctive than, primaries; *secondary venation* very feebly reticulate, almost invisible; *inflorescence* solitary, subtended by a fully developed foliage leaf; *peduncle* slender-terete, 3.5—4 x 0.15 cm; *spathe* cigar-shaped, cuneate basally at insertion on petiole, apex truncate and extending into a very long slender beak up to $^1/_3$ length of entire spathe, 7—8 x 1.3—1.5 cm, thick fleshy, marcescent(?), later pushed off by developing infructescence(?) leaving a large scar; *spadix* cigar-shaped, stipitate, inserted level on stipe, 4.5—5.5 x 0.9—1.2 cm, obtuse; stipe slender terete, c. 1 x 0.2 cm; *stylar region* dorso-ventrally compressed-rhombohexagonal, 0.9—1.5 x 0.85—1.2 mm, truncate; *stigma* punctiform, c. 0.45 mm diam., prominent in dried material; *anthers* not exserted at male anthesis; *infructescence* stoutly cigar-shaped, c. 5 x 1.5 cm.

Distribution: Indonesian Papua (Kepala Burung Prov.). Known only from the type.

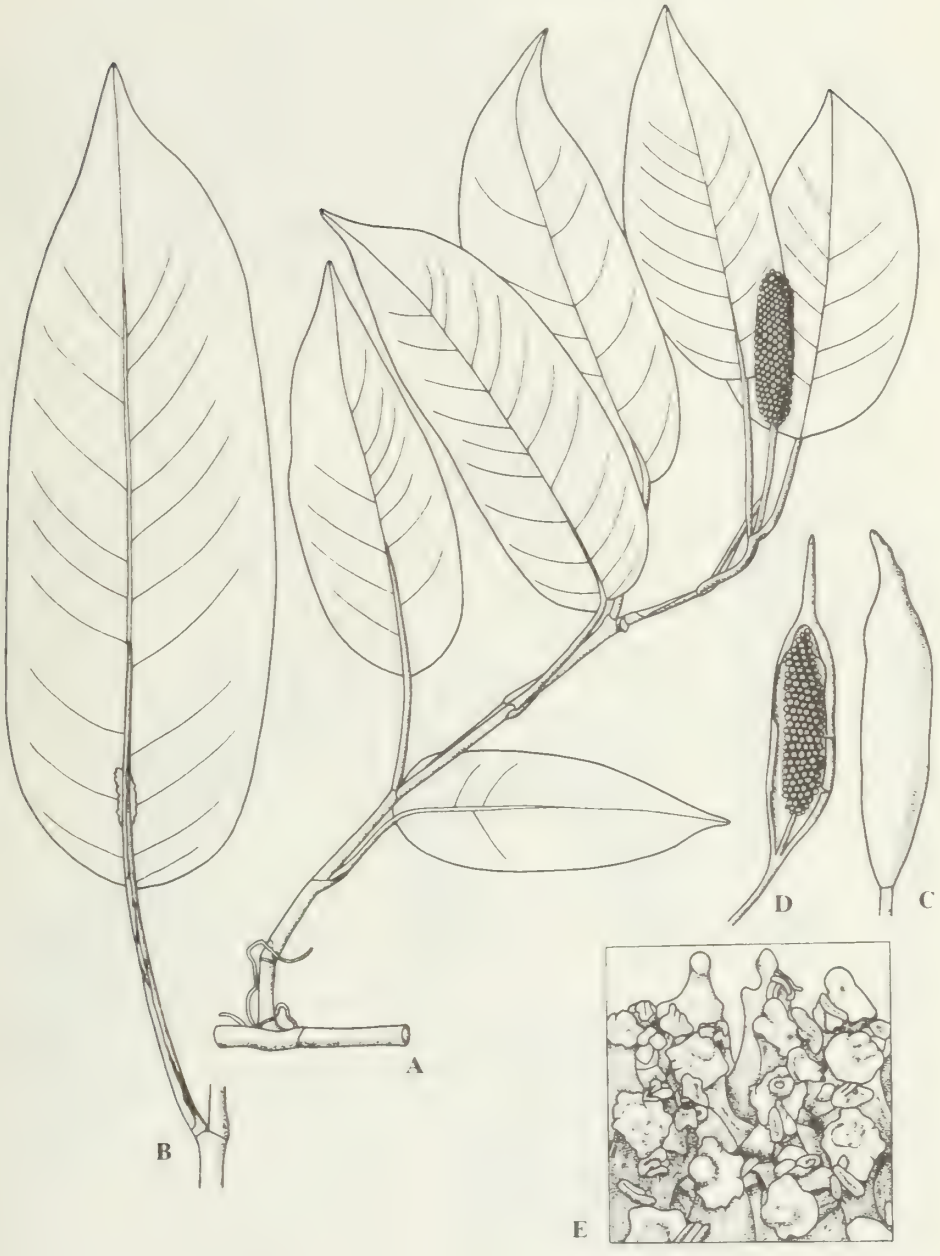

Figure 14. Rhaphidophora intrusa P.C. Boyce
A. flowering shoot x ; B. leaf lamina x ; C. inflorescence x ; D. inflorescence, spathe partly removed to show spadix x . E. spadix detail, male anthesis x 6. All from *Sands 6276*.

Habitat: Partially disturbed lowland rain forest. Sea level to 20 m altitude.

Notes: 1. While resembling *Rhaphidophora schlechteri*, *R. intrusa* is immediately recognizable by the long extended spathe apex (up to $^1/_3$ the length of the entire spathe) and by the greatly elongated petiolar sheath ligules that extend fused along the abaxial midrib for up to half the leaf lamina length. The latter character is also found, to a much lesser extent, in *R. hayi*, from which *R. intrusa* differs in the non-shingling habit, longer petioles and thinner, longer leaf lamina.

2. The specific epithet comes from the Latin, *intrusus*, to intrude, in allusion to the extraordinary ligules described above.

14. Rhaphidophora jubata P.C. Boyce, *sp. nov.*

Rhaphidophora jubata species valde distincta est magnitudini grandi, pedunculo longo, apicibus stylaribus parvis stigmatibus prominentibus atque seminibus cristatis reniformibus notabilis (his adhuc *Rhaphidophorae* non perscriptis). Cum *R. spuria* eam confundere potest, sed haec stylares maiores (1.6—2.4 x c. 2 mm diametro) atque stigmata punctiforma vel leviter ellipsoidea non manifeste elevata neque siccitate nigra seminaque ellipsoidea ecristata habet. — TYPUS: Papua New Guinea, North Solomons Prov., Bougainville, path from Arawa to Korpei, 10 miles southwest of Kieta, 1 Nov. 1964, *Nicolson 1529* (L, holo; B, K, P, US, iso).

Figure 15

Very robust, pachycaul, homeophyllous liane to 10 m; *seedling stage* not observed; *pre-adult plants* forming extensive terrestrial populations; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, densely leafy, flowering; *stems* smooth, with cataphylls and prophylls degrading into weak slightly fibrous patches and then falling, internodes to 4—13 x 1—3.5 cm; *flagellate foraging stem* not observed; *clasping roots* not observed; *feeding roots* arising singly from nodes, robust; *leaves* spiro-distichous; *cataphylls* and *prophylls* subcoriaceous, degrading to weakly fibrous patches, then falling; *petiole* deeply canaliculate, (6—) 40—85 x 0.35—0.5 cm, smooth, apical and basal genicula very large though not especially prominent; *petiolar sheath* very prominent, extending from between $^2/_3$ petiole length up to the apical geniculum, short-persistent, falling leaving thin scar; *lamina* entire, ovate to oblong-ovate, slightly oblique, 21.5—90 x 10.5—35 cm, thinly coriaceous to submembranous, drying pale yellow-brown to brown, base oblique, broadly rounded to

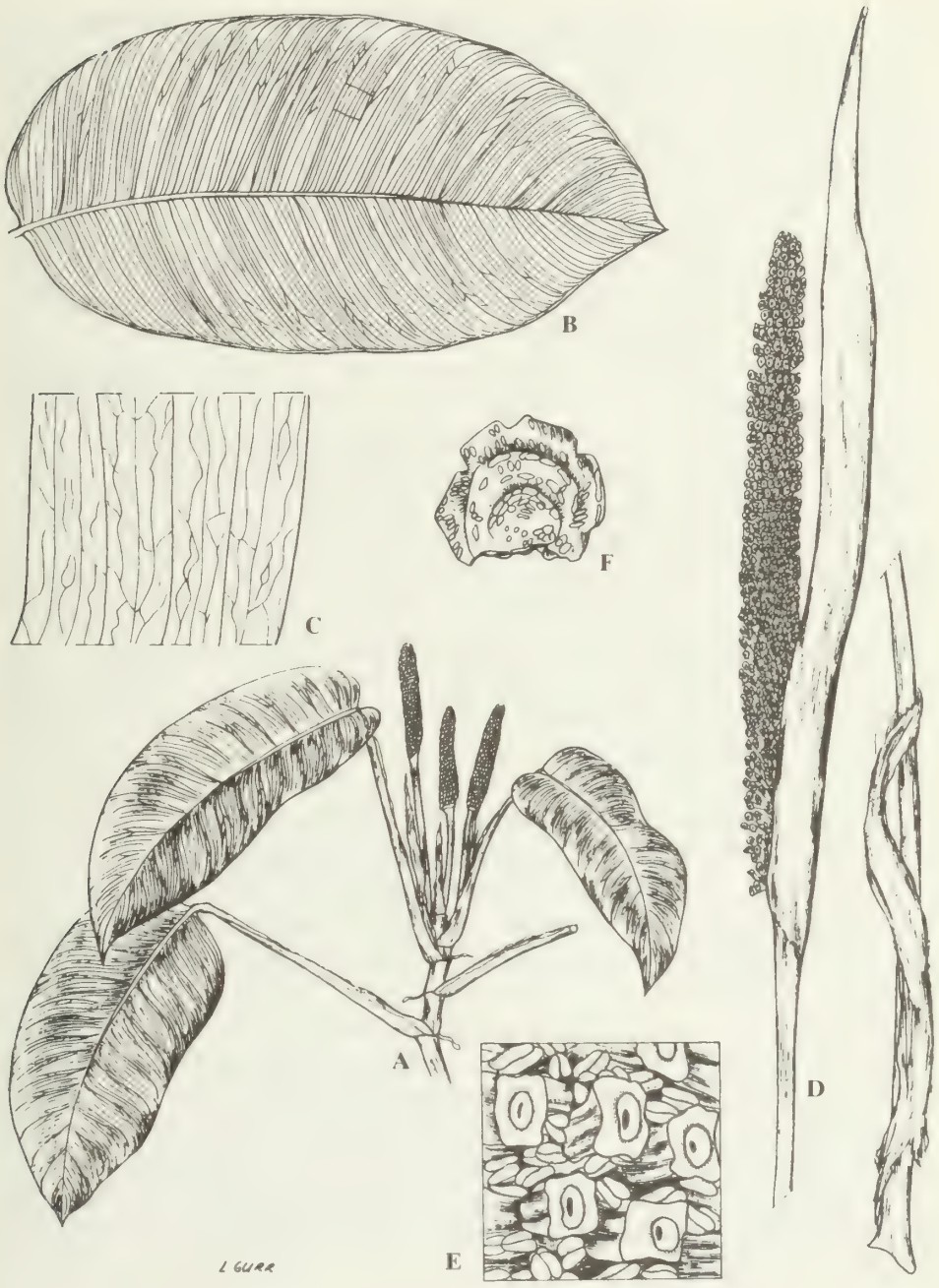

Figure 15. Rhaphidophora jubata P.C. Boyce
A. flowering shoot x 1/15; B. leaf lamina x 1/5; C. venation detail x 2; D. inflorescence, plus lower peduncle x 1/3; E. spadix detail, pre-anthesis x 6; F. mature seed, side view x 20. A from *Nicolson 1496*; B-C from *Nicolson 1530*; D-F from *Nicolson 1529*.

shallowly and minutely cordate, more rarely subacute, apex rounded-acuminate with a small apical tubule; *midrib* very prominently raised and abaxially, ± impressed adaxially; *primary venation* pinnate, raised abaxially and adaxially; *interprimaries* parallel to primaries, much less prominent; *secondary venation* reticulate, hardly visible; *inflorescence* several together, each subtended by a prophyll and one or more chartaceous cataphylls, these soon degrading; *peduncle* terete, 11—25 x 0.3—2 cm; *spathe* slender canoe-shaped, stoutly attenuate-beaked, 16—24 x 2.5—3 cm, stiffly thin-fleshy, caducous, yellow; *spadix* slender cylindrical, sessile but long decurrent (to 2 cm) on peduncle/spathe insertion, 13—21 x 1—3 cm; *stylar region*, weakly rhombohexagonal to trapezoid, 1—1.2 x 1—1.3 mm, truncate; *stigma* punctiform, prominently raised, c. 0.25 mm diam., drying glossy black; *anthers* not exserted at male anthesis; *infructescence* slender cylindrical, 14.5—17.5 x 2.5 cm; *seed* reniform, laterally compressed, conspicuously crested along dorsal side (i.e., the side opposed to the insertion of the funicle), c. 1.2 x 2.5 mm at maturity, c. 8—12 per fruit arranged on two parietal placentae.

Distribution: Papua New Guinea (New Britain and Bougainville).

Habitat: Primary and secondary lowland to upper hill forest, along streams and paths. 90–980 m altitude.

Notes: 1. A very distinct species notable for its overall large size, long peduncle and small stylar tops with prominently raised stigmas. Confusion with *Rhaphidophora spuria* is possible although the latter has larger stylar tops (1.6—2.4 x c. 2 mm diam.) and punctiform to slightly ellipsoid stigmas that are not prominently raised and do not dry glossy black, and ellipsoid seeds lacking a crest.

2. The specific epithet is derived from the Latin, *jubatus*, crested, in allusion to the crested reniform seeds of this species, a form of seed not hitherto recorded for *Rhaphidophora*. This seed form is common in *Epipremnum* Schott, which differs from *Rhaphidophora* by having 4 (– 6) seeds at base of a single intrusive parietal placenta. Furthermore, the testa in *Rhaphidophora* (including *R. jubata*) is brittle, while that of *Epipremnum* is tough and bony.

Other specimen seen: PAPUA NEW GUINEA. North Solomons Prov.: Bougainville, path up Dakao Creek near Korpei, 11 miles southwest of Kieta, *Nicolson 1530* (B, K, L, P, US); Pavairi, *Ridsdale & Lavarack NGF 30628* (LAE, US); Kapikavi, *Ridsdale & Lavarack NGF 31600* (LAE, US); East New Britain Prov.: Kareeba road, 2 miles west of Kerevat, *Nicolson 1496* (US).

15. Rhaphidophora kokodensis P.C. Boyce, *sp. nov.*

Rhaphidophora kokodensis R. australasicae similis videtur sed in surculis liberis lateralibus florenti, stylis apice planis, et foliis minoribus angustoribus magis coriaceis prompte sejuncta. Porro species montana est igitur altitudinaliter sejuncta. Cum *R. pilode* (etiam in surculis liberis lateralibus florenti) eam confundere potest, quamquam *R. kokodensis* non fibras aspectu coacto proprio ut in *R. pilode* habet. — TYPUS: Papua New Guinea, Central Prov., Kokoda , eastern side of Lake Myola no. 1, 23 July 1974, *Croft et al. LAE 61974* (GH, holo; BRI, CANB, L, LAE, iso).

Figure 16

Small, homeophyllous (?) liane to unknown ultimate height; *seedling stage* and *pre-adult plants* not observed; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and long, moderately elaborated, free, sympodial, densely leafy flowering stems; *stems* terete in cross-section, internodes to 1—4 x 0.5—0.8 cm, separated by slightly oblique, prominent leaf scars; *flagellate foraging stems*, *clasping roots*, and *feeding roots* unknown; *leaves* spiro-distichous on free shoots; *cataphylls* and *prophylls* chartaceous but very soon degrading into long tough fibres; *petiole* deeply canaliculate, 5—16 x 0.2—0.25 cm, smooth, apical geniculum quite well defined, basal geniculum weak; *petiolar sheath* prominent, chartaceous, extending to apical geniculum, very swiftly degrading to fibres; *lamina* entire, narrowly lanceolate to narrowly lanceolate-elliptic, occasionally slightly falcate, 13—25 x 1.75—6 cm, stiffly coriaceous, base acute, apex acuminate to long-acuminate with a minute tubule; *midrib* slightly raised abaxially, slightly sunken adaxially; *primary venation* densely pinnate, slightly raised abaxially and adaxially; *interprimaries* parallel to primaries indistinguishable from them; *secondary* and *tertiary venation* very faintly reticulate; *inflorescence* solitary, subtended by an underdeveloped foliage leaf and much degraded cataphyll fibre; *peduncle* compressed-terete, 7—12 x 0.2—0.3 cm; *spathe* narrowly cigar-shaped, long stout-acuminate, (4—)8—9 x c. 1.3 cm, marcescent(?); *spadix* cylindrical, sessile, 2—6 x 0.8—1 cm; *stylar region* rhombohexagonal, c. 0.9—1 x 0.8—1.1 mm, truncate; *stigma* punctiform, very slightly raised, c. 0.4 mm diam.; *anthers* not exserted at male anthesis; *infructescence* cylindrical, c. 11 x 1.3 cm.

Distribution: Papua New Guinea (Central Prov. - Kokoda and Port Moresby).

Habitat: Submontane rain forest on dark brown loam. 1500–2000 m altitude.

Note: Superficially similar to *Rhaphidophora australasica* but readily separated by its flowering on free lateral shoots, by the flat-topped styles and the smaller, narrower, much more coriaceous leaves. In addition, being a montane species, *R. kokodensis* is separated altitudinally. Confusion with *R. pilosa* (also flowering on free lateral shoots) is possible, although *R. kokodensis* has petiole and shoot fibres without the distinctive felted appearance of those of *R. pilosa*.

Other specimens seen: PAPUA NEW GUINEA. Central Prov.: Port Moresby, Boridi, *Carr 13237* (BM, K, L, SING), *Carr s.n.* (BM); East slope of Lake Myola No. 2, *Croft & Lelean NGF 34561* (GH, K, L).

16. Rhaphidophora korthalsii Schott

Rhaphidophora korthalsii Schott, Ann. Mus. Bot. Lugd.-Bat. 1 (1863) 129; Engl. in A. & C. DC., Monogr. Phan. 2 (1879) 246; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 49—51, Fig. 21; Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 341; Hay, Aroids of Papua New Guinea, pl. XV, a—c. — Type: Indonesia, Java, *P.W. Korthals s.n.* (L, holo; L, P, iso).

Pothos celatocaulis N.E. Br., Gard. Chron. 13 (1880) 200. — *Rhaphidophora celatocaulis* (N.E. Br.) Alderw., Bull. Jard. Bot. Buitenzorg III, 1 (1920) 382 & Bull. Jard. Bot. Buitenzorg III, 4 (1922) 198. — Type: Malaysia, Sabah, *Burbidge s.n., Hort. Veitch no. 215* (K, holo; K, iso).

Rhaphidophora maxima Engl., Bull. Soc. Tosc. Ortic. 4 (1879) 269; Beccari, Malesia 1 (1882) 271, Tab. xx 1—5; K. Schum. & Lauterbach, Fl. Schutzgeb. Südsee (1900) 211; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 48—49; K. Krause & Alderw., Nova Guinea 14 (1924) 214. — Type: Sarawak, G. Gading, July 1866, *Beccari PB 2314* (FI, lecto, selected by Boyce, 1999).

Rhaphidophora tenuis Engl., Bot. Jahrb. Syst. 1 (1881) 181; Beccari, Malesia 1 (1882) 271—272; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 53. — Types: Malaysia, Sarawak, *Beccari PB 1977* (FI lecto; B isolecto; selected by Boyce, 1999).

Rhaphidophora korthalsii var. angustiloba Ridl. ex Engl. & K. Krause in Engler, Pflanzenr. 37 (IV.23B) (1908) 49. — Type: Malaysia, Sarawak, Matang, July 1903, *Ridley s.n.* (SING, lecto; selected by Boyce, 1999).

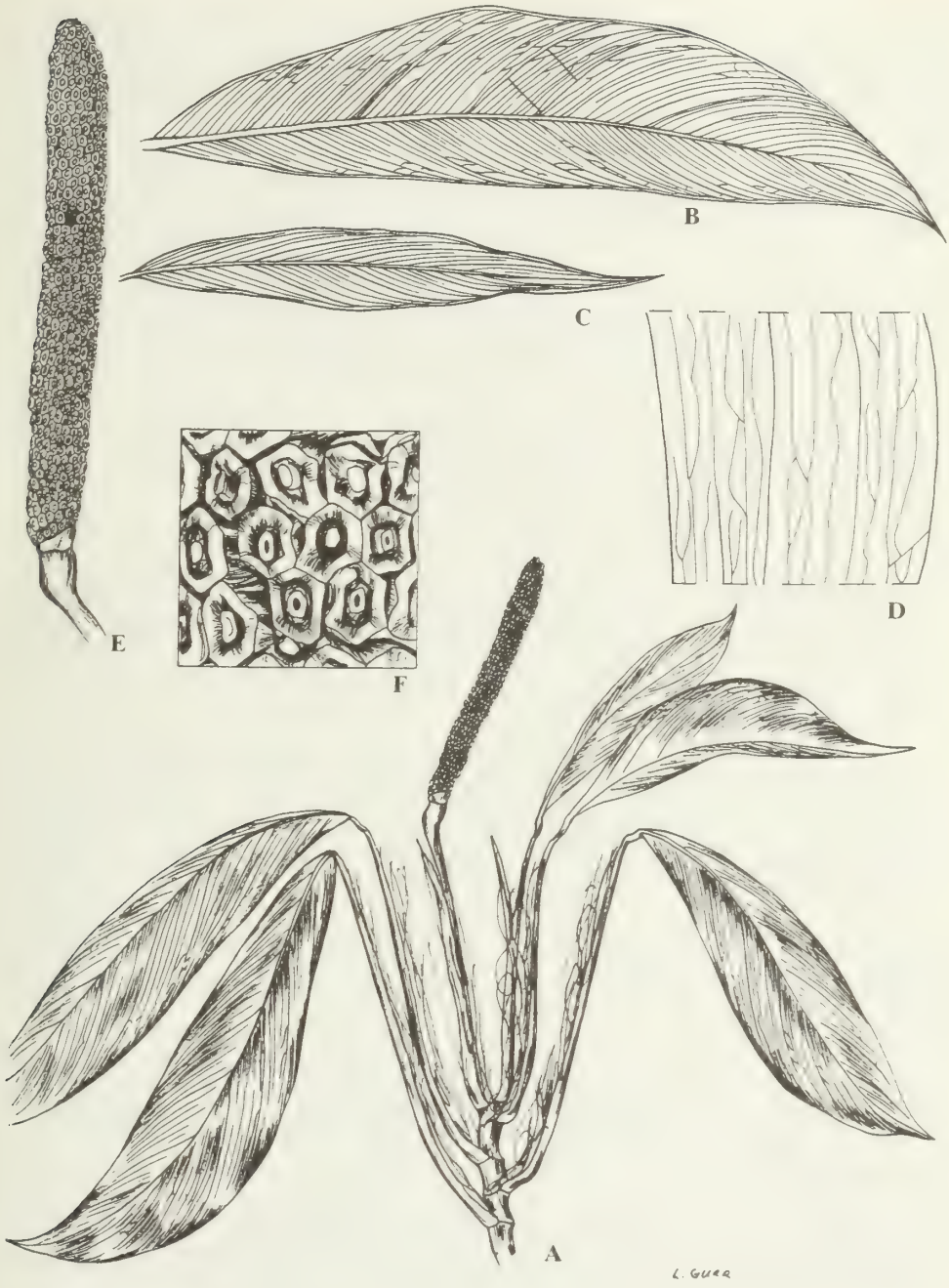

Figure 16. Rhaphidophora kokodensis P.C. Boyce
A. flowering shoot x 1/5; B. leaf lamina x 1/5; C. leaf lamina x 1/5; D. venation detail x 3; E. inflorescence, spathe fallen x 2/5; F. spadix detail, post-male anthesis x 4. A & D from *Croft et al. LAE 61974*; B-C, E-F from *Carr 13237*.

Rhaphidophora copelandii Engl., Bot. Jahrb. Syst. 37 (1905) 115; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 49. — Type: Philippines, Mindanao, Davao, Mt Apo, April 1904, *Copeland 1193* (B holo; PNH iso†).

Monstera latevaginata Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 11. — Type: Cult. Bot. Gard. Berlin, *Engler & Krause s.n.* (B, holo).

Rhaphidophora grandifolia K. Krause, Bot. Jahrb. 44, Beibl. 101 (1910) 11. — Type: Philippines, Negros, Negros Orientale, Dumaguete (Cuernos Mts), March 1908, *Elmer 9464* (B, holo; E, K, L, LE, MO, PNH† iso).

Rhaphidophora trinervia Elmer, Leafl. Philipp. Bot. 8 (1919) 3073. — Type: Philippines, Laguna, Los Baños (Mt Maquiling), June—July 1917, *Elmer 18057* (PNH, holo†; FI, K, L, MO, P, iso).

Rhaphidophora ridleyi Merr., J. Str. Br. Roy. As. Soc. Special Edition (Enum. Pl. Borneo) (1921) 90. — *Rhaphidophora grandis* Ridl., J. Straits Branch Roy. Asiat. Soc. 49 (1907) 51, *nom. illeg., non* Schott 1858 [India = *R. decursiva* (Roxb.) Schott]. — Type: Malaysia, Sarawak, Tambusan, Sept. 1905, *Ridley 12414* (SING, holo).

Rhaphidophora latifolia Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 341; K. Krause & Alderw., Nova Guinea 14 (1924) 213. —Type: Indonesian Papua, Bonggo Range, Mamberamo, Pionierbivak, 23 July 1920, *Lam 711* (BO, holo; L, iso).

Rhaphidophora palawanensis Merr., Philipp. J. Sci. 26 (1925) 451. — Type: Philippines, Palawan, Malampaya Bay, Oct. 1922, *Merrill BoS 11570* (PNH, holo†; B, K, P, iso)

Rhaphidophora trukensis Hosok., J. Jap. Bot. 13 (1937) 195. — Type: Federated States of Micronesia, Chuuk (Truk) Island, near Orrip, 29 July 1939, *Hosokawa 8334* (TI , holo).

[*Epipremnum multicephalum* Elmer, Leafl. Philipp. Bot. 10 (1938) 3624, *nom. inval., descr. Angl.* — Based on: Philippines, Luzon, Sorsogon, Irosin (Mt Bulusan), May 1916, *Elmer 16061* (FI, K, L, MO, P, PNH†)].

Figures 17 & 18

Very large, occasionally enormous, slender to rather robust, pachycaul, heterophyllous liane to 20 m; *seedling stage* a non-skototropic shingling juvenile shoot; *pre-adult plants* never forming terrestrial colonies; *adult shoot architecture* comprised of greatly elongated, clinging, physiognomically unbranched, densely leafy flowering stems; *stems* smooth, bright green, with sparse to copious prophyll, cataphyll and petiolar sheath fibre, especially at the stem tips, internodes to 15 x 3.5 cm, separated by prominent oblique leaf scars, older stems subwoody; *flagellate foraging stems* absent; *clasping roots* densely arising from the nodes and internodes, prominently pubescent; *feeding roots* abundant, adherent and free, very robust, densely ramentose-scaly; *leaves* distichous; *cataphylls* and *prophylls* membranous, soon drying degrading to intricately reticulate fibres, these only very slowly falling; *petiole* shallowly grooved, upper part ± terete, (1—) 9—65 x 0.2—1.5 cm, smooth, apical and basal genicula prominent; *petiolar sheath* prominent, membranous, strongly to slightly unequal on one side, extending almost to or reaching the apical geniculum, of ± short-duration, soon degrading into persistent netted fibres, these eventually falling leaving a prominent, slightly corky scar; *shingling lamina* entire, falcate-lanceolate, 5—11 x 3.5—6 cm, base slightly cordate, *pre-adult* and *adult lamina* spreading, entire, pinnatipartite, pinnatisect or pinnatifid, 10—44 x 14—94 cm, broadly oblong-elliptic to oblong lanceolate, slightly oblique, membranous to chartaceous or subcoriaceous, base truncate and very briefly decurrent, apex acute to acuminate, individual pinnae 1—10 cm wide, frequently perforated basally adjacent to the midrib, thus appearing stilted; *midrib* very prominently raised abaxially, slightly sunken adaxially; *primary venation* pinnate, raised abaxially, somewhat impressed adaxially, 2—4 primary veins per pinna; *interprimaries* sub-parallel to primaries, slightly raised abaxially, slightly impressed adaxially; *secondary venation* strongly reticulate, slightly raised; *tertiary venation* invisible; *inflorescence* solitary to several together, first inflorescence subtended by a membranous prophyll and one or more cataphylls, these swiftly degrading to netted fibres, subsequent inflorescences subtended by one or more swiftly degrading cataphylls, the whole forming a mass of developing and open inflorescences and developing infructescences partially concealed by persistent netted cataphyll and prophyll remains; *peduncle* slightly laterally compressed to terete, 6—26 x 1—1.5 cm; *spathe* narrowly canoe-shaped, stoutly beaked, 10—30 x 3—5 cm, stiffly fleshy, greenish to dull yellow, gaping wide at female anthesis and then caducous leaving a large straight scar at the base of the spadix; *spadix* cylindrical, sessile, inserted ± level on peduncle, 9—26 x 1.5—2 cm, dull green to dirty white; *stylar region* rather well developed,

mostly rhombohexagonal, 1.5—2 x c. 2 mm, slightly conical; *stigma* punctiform to slightly elliptic, if the latter then mostly longitudinally orientated, c. 0.3—0.5 x 0.2—0.4 mm; *anthers* barely exserted at male anthesis; *infructescence* 14—27 x 3—3.5 cm, dark green ripening to dull orange, stylar tissue abscissing to reveal orange ovary cavity pulp.

Distribution: Widespread in south tropical Asia from Sumatera and southern Thailand to Borneo and the Philippines eastwards through the tropical western Pacific.

Habitat: Disturbed lowland, lower and upper hill forest primary, riverine or secondary forest, on basalt, granite, clay and coralline limestone. 10–800 m altitude.

Notes: 1. *Rhaphidophora korthalsii* is a very widespread and variable species, with an extensive synonymy. However, as with *Epipremnum pinnatum* (L.) Engl. (Boyce, 1998) there are several geographical elements that, given more intensive study, might warrant formal taxonomic recognition. Unfortunately, current herbarium material is inadequate to confirm these plants' status and more field observations are needed.

2. Sterile herbarium material lacking the pre-adult stage may prove difficult to distinguish from the *Epipremnum pinnatum*. Mature leaves of 'typical' *E. pinnatum* never have more than one primary lateral vein per pinna and the stems of *R. korthalsii* lack the prominent irregular whitish longitudinal crests and older stems the distinctive matt to sublustrous pale brown papery epidermis typical of *E. pinnatum*. The feeding roots of *R. korthalsii* are prominently scaly while those of *E. pinnatum* are lenticellate-corky. The pre-adult stage of *R. korthalsii* is a shingle climber with oblong-elliptic to ovate slightly falcate upwards pointing leaves overlapping in the manner of roof tiles and with c. 3 prominent veins per side, running from near the base of the leaf to the upper margin or tip and crossing over the minor venation,.

3. Fertile material of *R. korthalsii* and *E. pinnatum* is readily separated by the shape of the style apex (round v. trapezoid) and the shape and orientation of the stigma (± punctiform and circumferential v. strongly linear and longitudinal) and, if fruits are mature, by seed characters. The fruits of *R. korthalsii* each contains many small ellipsoid seeds with a brittle, smooth testa whereas *E. pinnatum* has fruits with two large, strongly curved seeds with a bony and ornamented testa.

Figure 17. Rhaphidophora korthalsii Schott
A. pre-adult shoot x $\frac{1}{4}$; B. pre-adult shingling shoot x $\frac{1}{4}$. A from *Boyce 679*; B from *Nicolson 1712*.

4. Confusion is possible between *R. korthalsii* and *Amydrium zippelianum* (Schott) Nicolson although there is a suite of characters that distinguish them. The leaflet tips of the *Amydrium* species are acute to acuminate, those of *R. korthalsii* are truncate, the petiolar sheath in *R. korthalsii* extends to the apical geniculum while in *Amydrium* the sheath only reaches to the top of the basal geniculum, the remainder of the petiole being terete with two sharply defined low keels running its length to merge with the base of the leaf lamina. The feeding roots of *R. korthalsii* are prominently scaly while those of *A. zippelianum* are smooth. Fruiting material of *R. korthalsii* has the stylar region abcissing to reveal a pulp cavity with numerous, small, ellipsoid seeds whereas *A. zippelianum* has one or two large reniform to ovoid seeds in each indehiscent fruits.

Other specimens seen: INDONESIAN PAPUA. Kepala Burung Prov.: surroundings of Ayawasi, *Ave 4330* (BO, L); Manokwari Prov.: Pengunungan Maoke (Nassua Mts), *Docters van Leeuwen 10750* (BO); Wariori River, river valley west of camp between Wariori and Mangopi rivers, c. 11 km inland, *Johns 8197* (BO, K, MAN); Fanindi, 1 km west of Manokwari, *Nicolson 1573* (B, K, L, P, US); Arfak Mountains, Mupi Dessa, trail from Mupi village to G. Humibou, near S. Mupi, c. 3 km from Kali Umera, between Kali Ureda and the confluence of Kali Ngwes and S. Mupi, *Sands 6846* (K); Mimika Prov.: Freeport Concession Area, along road from bridge to Kuala Kenchana, along track near left turn by river, *Barker 145* (BO, K, MAN); Kali Kopi, between Kali Kopi levee and the Kopi River, *Johns 9796* (BO, K, MAN); Lorentz River, near Bivak Island *Pulle 66* (L); Beaufort (Van der Sande) River *Pulle 353* (K, L); Biak Island, hill northeast of Mokmer airport, *Nicolson 1567* (B, K, L, US). PAPUA NEW GUINEA. East Sepik Prov.: vicinity of Wewak, along trail beyond Boys Town (Reform School operated by S.V.D. Missionaries), *Croat 52763* (MO); Lordberg, *Ledermann 10319* (B spirit); Malu, *Ledermann 10826* (B spirit); Central Prov.: Port Moresby, northeast of Manumu village, *Isles & Vinas NGF 33829* (US), *Isles & Vinas NGF 34488* (L); Manus Prov.: Manus, 1 km SW of Kabuli village on south coast in western Manus, *Sands 2779* (K); Western Prov., Kiunga, *Streimann & Womersley LAE 51847* (L, US); Morobe Prov.: vicinity of Lae, along logging road to Busu River, from 3.8 km E of Igam road and Military Base to c. 6 km up the road junction, *Croat 52792* (MO), *Croat 52793* (MO); c. 20 km SE of Lae, along logging road to Busu River (left off Igam road past Military Reserve), *Croat 52800* (MO); Along Busu River, 22.6 km by road SE of Lae (via road past PNG University of Technology and Igam road past Army Base), beginning 3.8 km from asphalt at Army Base, *Croat 52840* (MO); Lae B.G. *Croat 52849* (MO); Bumbu logging area, 7 miles north of Lae, *Nicolson 1385* (L, US); Oomsis Creek, 20 miles from Lae on Bulolo road, *Nicolson 1483* (B, K, L, P, US); Madang Prov.: no further data, *Ledermann 6641* (B spirit); Lower Ramu-Atitau area, SE of Aiome Patrol Post, along Apenam track, east side of Tiganants River (Ioka Creek), *Pullen 949* (CANB, L); North Solomons Prov.: Bougainville, McKillip's Arawa Plantation, 6 miles west of Kieta, *Nicolson 1520* (B, K, L, US); West New Britain Prov.: Kandrian, along road to airport, *Nicolson 1542* (B, K, L, US); East New Britain Prov.: Kareeba road, 2 miles west of Kerevat, *Nicolson 1498*, (B, K, L, P, US). FEDERATED STATES OF MICRONESIA. Chuuk (Truk), Toi Island, Suiyota, *Takamatsu 40* (K, L); Winipwoot, *C.C.Y. Wong 278* (GH, US). SOLOMON ISLANDS. Rennell Island: *Dissing 2776* (K); Kolombangara: 2 miles NNW of Kuzi village, *Hunt RSS 2398* (K, US); San Cristobal: Ridge between Warahito and Pegato river, *Whitmore 6204* (K, L, US). VANUATU. Erromango: Poututu, *Bourdy 228* (P);

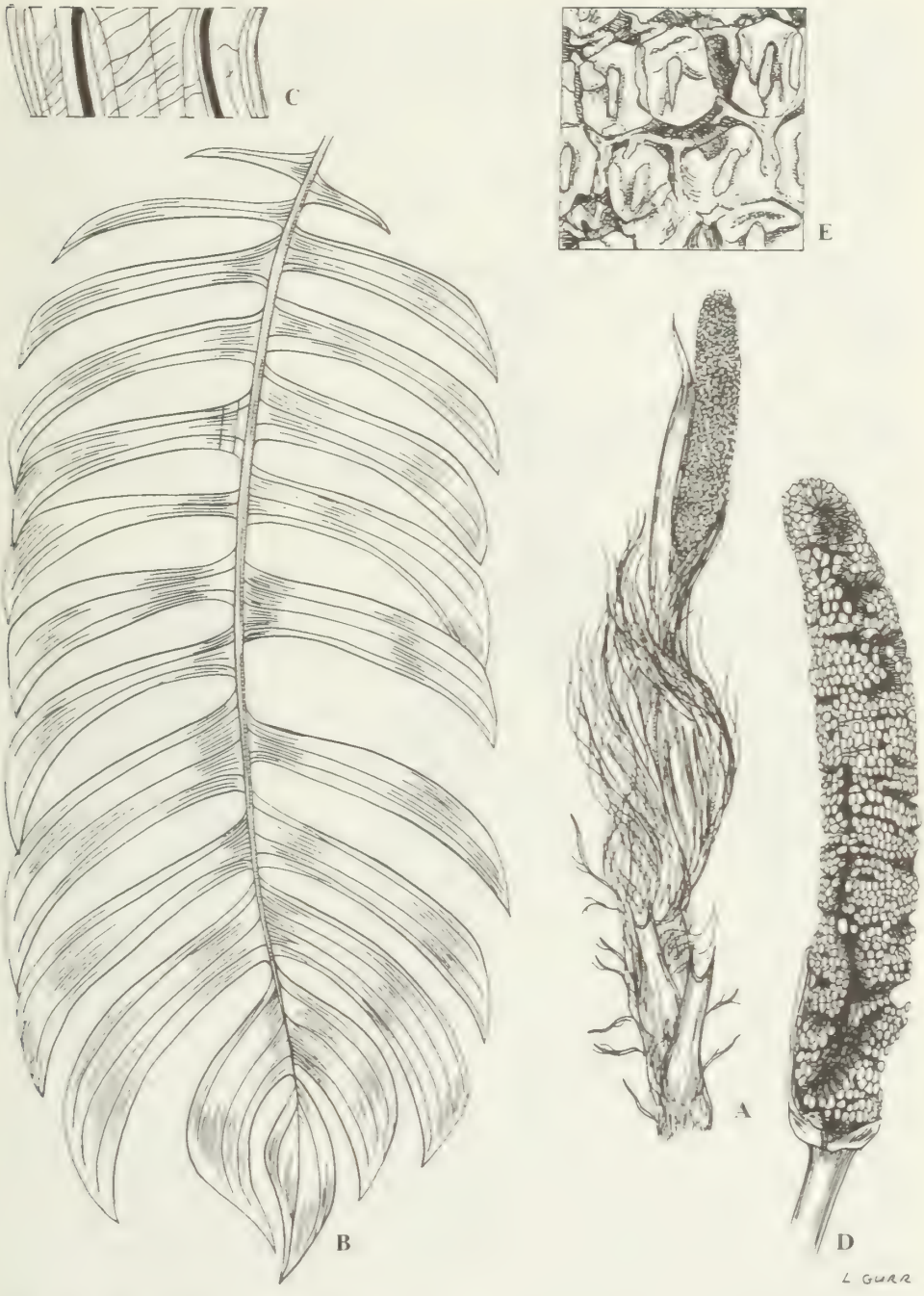

Figure 18. Rhaphidophora korthalsii Schott
A. flowering shoot, leaves removed x 1/4; B. leaf lamina x 1/4; C. venation detail x 2; D. inflorescence, spathe removed x 1; E. spadix detail, post floral x 8. All from *Kerr 15051*.

Ipota, *Bourdy 244* (K, P); Portnarvin, Rautop, *Cabalion 2370* (P); vicinity of Nouankao Camp, *Green RSNH 1267* (K); Forestry route, km 16.5, *Raynal RSNH 16222* (K); Espiritu Santo: Bank of Achone River, opposite side from Casevaia village, *Curry 939* (K); Kuvutant, *Ludvigson 20* (L); Anatom (Aneityum): Anelgauhat Bay, *Kajewski 830* (K, P), *Morrison s.n.* (K).

17. Rhaphidophora microspadix K. Krause

Rhaphidophora microspadix K. Krause, Bot. Jahrb. Syst. 49 (1912) 92. — Type: Papua New Guinea ('Kaiser Wilhelmsland'), Madang Prov., Bismarck Range, 11 Nov. 1908, *Schlechter 18678* (B, holo).

Rhaphidophora nutans Ridl., Trans. Linn. Soc. Lond. 9 (1916) 239, **synon. nov.** — Type: Indonesian Papua, Mimika Prov., Puncak Jaya (Mt. Carstensz), Camp 6a, 16 Jan. 1913, *Boden Kloss s.n.* (BM, holo; K iso).

Figure 19

Small, very slender, leptocaul, homeophyllous (?) liane to unknown ultimate height; *seedling* and *pre-adult plants* not observed; *adult shoots* comprised of greatly elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and long, free, sympodial, leafy flowering stems; *stems* smooth, somewhat flexuous, stems terete in cross-section, branching little, growing to considerable lengths and pendent with flowering tips upturned, without prophyll, cataphyll and petiolar sheath fibre, internodes to 4 x c. 0.2 cm, separated by weak slightly oblique leaf scars, older stems woody; *flagellate foraging stems* absent; *clasping roots* arising singly from each node; *feeding roots* not observed; *leaves* weakly distichous and sparsely arranged; *cataphylls* and *prophylls* membranous, caducous; *petiole* deeply grooved adaxially, 2—5 x 0.15—0.25 cm, smooth, with a slight apical and basal geniculum; *petiolar sheath* slightly prominent, extending to the apical geniculum, caducous in strips leaving a slender scar; *lamina* entire, narrowly lanceolate to lanceolate falcate, 4—19 x 1—3 cm, thinly coriaceous, drying adaxially dull mid-brown, abaxially paler brown with dense, well-defined to somewhat obscure tannin cells, base cuneate, apex long-acuminate with a slender prominent tubule; *midrib* slightly raised abaxially and adaxially; *primary venation* pinnate, very slightly raised on both surfaces; *interprimaries* sub-parallel to, but much less distinctive than, primaries, sometimes degrading into weakly reticulate venation, very slightly raised abaxially; *secondary venation* ± invisible in dried specimens, parallel-reticulate; *inflorescence* solitary, subtended by a fully developed foliage leaf and a caducous cataphyll; *peduncle* compressed-terete, 3—7.3 x 0.2—0.25 cm; *spathe* ovoid-ellipsoid, stoutly long-beaked and tipped with a fine tubule,

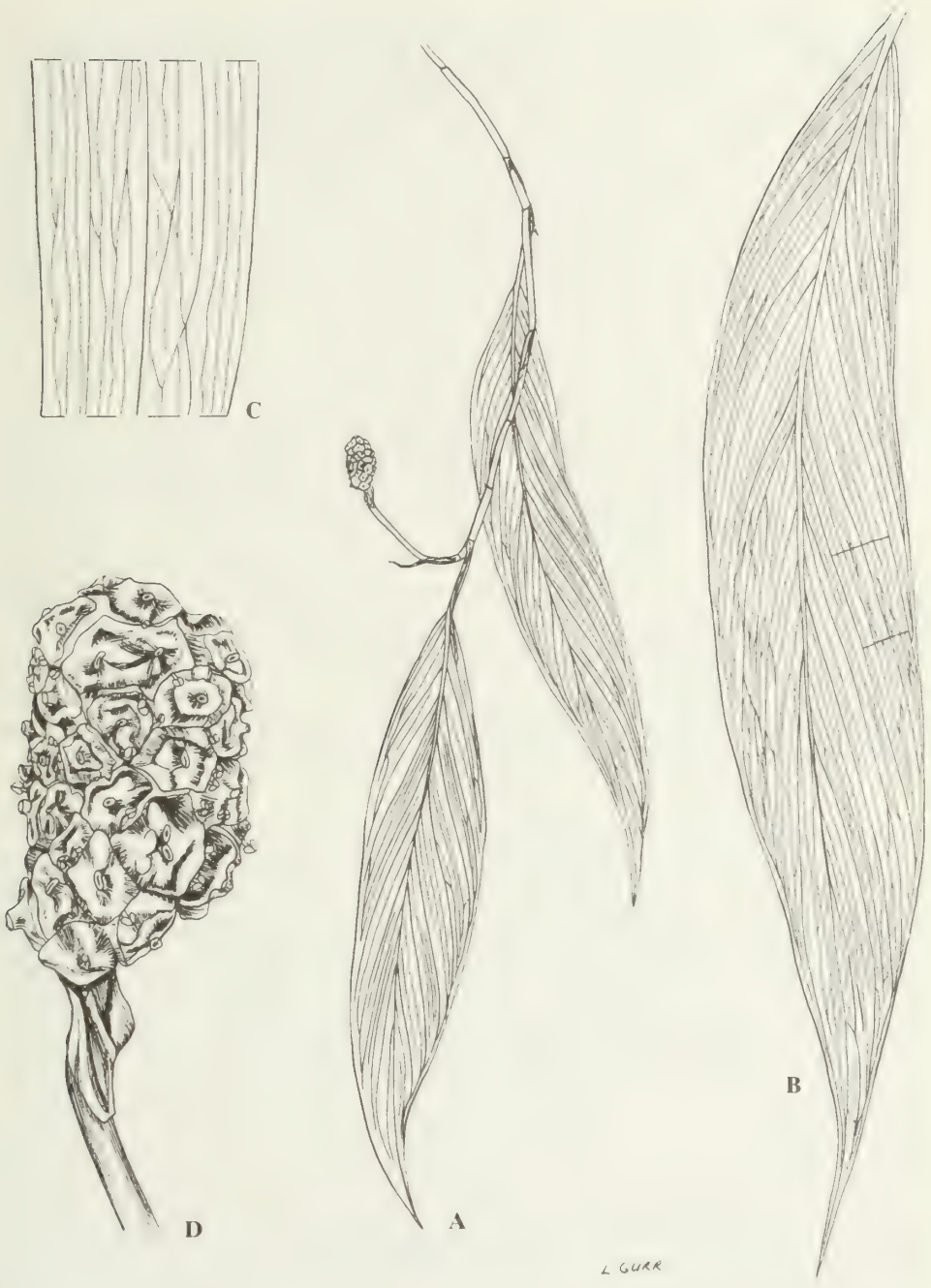

Figure 19. Rhaphidophora microspadix K. Krause
A. flowering shoot x 1/5; B. leaf lamina x 1 1/5; C. venation detail x 6; D. inflorescence, spathe fallen x 4. All from *Boden Kloss s.n.*

2.5—3 x 0.7—0.9 cm, marcescent until early fruiting, then falling leaving a large, oblique scar; *spadix* ovoid-globose to ovoid-cylindrical, sessile, inserted slightly obliquely on peduncle, 1—1.5 x 0.5—0.6 cm; *stylar region* rhombohexagonal, 1.4—2 x c. 2 mm, truncate; *stigma* punctiform, c. 0.4 mm diam., prominent in dried material; *anthers* well-exserted at male anthesis; *infructescence* ovoid-globose, c. 1.2—2.5 x 1—1.5 cm.

Distribution: Indonesian Papua (Mimika Prov.), Papua New Guinea (Madang and Morobe Provinces).

Habitat: Lower montane forest. 945–1700 m altitude.

Notes: 1. The type specimen of *Rhaphidophora microspadix* has the abaxial leaf lamina with dense conspicuous tannin cells visible to the naked eye. These cells are also present on the type of *R. nutans*, but much less clearly visible (x10 lens is required).

2. *Rhaphidophora microspadix* appears to be allied to *R. neoguineense*, differing in the much narrower leaf lamina with a long acuminate tip and in flowering habitually on long, pendent shoots.

Other specimens seen: PAPUA NEW GUINEA. Morobe Prov.: Matap, *Clemens 11151, 41197* (GH); Gumi Divide, 25 km west of Bulolo, *Kairo 757* (L, LAE).

18. Rhaphidophora mima P.C. Boyce, *sp. nov.*

Rhaphidophora mima multum cum *R. neoguineensi* (non in Insulas Solomonenses inventa) persimili confusa est, quamquam ab ea spatha fusiformi caduca atque spadice cylindrica (spatha globosa marcescensque et spadix globoso-ellipsoideus in *R. neoguineensi)* prompte distinguitur. — TYPUS: Solomon Islands, Guadalcanal, Wanderer Bay area, 23 Oct. 1968, *Mauriasi et al. BSIP 12268* (SING, holo; BSIP, K, iso).

Figure 20

Slender, leptocaul, homeophyllous liane to 4 m; *seedling* and *pre-adult plants* not observed; *adult shoot architecture* not fully observed but seemingly comprised of elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and slightly lengthened mostly unbranched, free, leafy, flowering stems; *stems* smooth, flexuous, climbing stems ± terete, occasionally weakly angled, free stems terete, to similarly sulcate, without prophyll, cataphyll and petiolar sheath fibre, internodes 0.3—5 x 0.2—0.3 cm on free shoots, flowering shoots with shorter internodes, separated by

weak straight leaf scars, older stems woody; *flagellate foraging stems* not observed; *clasping roots* and *feeding roots* not observed; *leaves* spirodistichous, slightly scattered; *cataphylls* and *prophylls* membranous, caducous; *petiole* grooved adaxially, 1.5—5 x 0.1—0.18 cm, smooth, with a slight apical and basal geniculum; *petiolar sheath* slightly prominent, extending beyond the apical geniculum by two ligules, caducous leaving a continuous scar from the petiole base, around the top of the apical geniculum and back to the base; *lamina* entire, elliptic to elliptic-lanceolate or oblanceolate, slightly falcate, 5—16 x 2.2—7 cm, thinly coriaceous, base cuneate subovate or minutely cordate, apex acute to briefly acuminate, with a small tubule; *midrib* raised abaxially, sunken adaxially; *primary venation* pinnate, slightly raised on both surfaces in dried material; *interprimaries* reticulate to sub-parallel to, but much less distinctive than, primaries, degrading into weakly reticulate venation, very slightly raised abaxially; *secondary* and *tertiary venation* reticulate; *inflorescence* solitary, subtended by a fully developed foliage leaf and a caducous cataphyll; *peduncle* slightly compressed-terete, 1—3 x 0.2—0.3 cm; *spathe* cigar-shaped, apex beaked, 1—4.5 x 0.7—1.2 cm, fleshy, yellow-green to yellow-cream, caducous leaving a large scar; *spadix* cylindrical, sessile, inserted level on peduncle, 1.5—2.5 x 0.5—0.8 cm, obtuse, white; *stylar region* rounded-rhombohexagonal, 0.9—1 x 0.85—1.1 mm, truncate; *stigma* punctiform, c. 0.3 mm diam., slightly prominent in dried material; *anthers* not exserted at male anthesis; *infructescence* not observed.

Distribution: Papua New Guinea (Bougainville, Manus), Solomon Islands (Fauore, Guadalcanal, Kolombangara, Malaita, San Jorge, Small Malaita).

Habitat: Well-drained primary and secondary forest on flat and hilly terrain, occasionally in lowland swamp forest, 3–1000 m altitude.

Notes: 1. In herbaria *Rhaphidophora mima* is much confused with the very similar *R. neoguineensis* (absent from the Solomon Islands) although it is readily distinguished by a caducous, cigar-shaped spathe and cylindrical spadix (spathe globose and marcescent, spadix globose-ellipsoid in *R. neoguineensis*).

2. The specific epithet is the adjectival form of *mimus*, from the Greek, *mimos*, actor, in allusion to the confusing similarity of this species to *Rhaphidophora neoguineensis*.

3. The Manus collection (*Foreman & Katik LAE 59291A*), while outside the main geographical range of the species, is undoubtedly *R. mima*.

Other specimens seen: PAPUA NEW GUINEA. Manus Prov.: Manus, near Pelikawa, *Foreman & Katik LAE 59291A* (L, US); North Solomons Prov.: Bougainville, Sulka wide bay, *Bateson 89, 91, 92, 93* (K); Buin, Kugumaru, *Kajewski 1891* (BM, GH, K, SING); Koniguri, *Kajewski 2162* (GH, P); Pavairi, *Lavarack & Lavarack NGF 31091* (K, L, US); McKillup's Arawa Plantation, 6 miles west of Kieta, *Nicolson 1516* (US), *Nicolson 1522* (B, K, L, US); vicinity of Aku village, c. 10 miles west of Buin, *Schodde 4070* (BRI, CANB, GH, K, L, LAE, US); Siwai, *Waterhouse 207* (GH, K), *Waterhouse 778* (K). SOLOMON ISLANDS. Malaita: SW Malaita, Wairokai River area, *Gafui et al. BSIP 10215* (BSIP, K, SING); Su'u area, *Mauriasi et al. BSIP 13632* (BSIP, L, SING); Tantalau - Kwalo trail, near Kwalo, *Stone 2366* (BISH, K, US); Small Malaita: Palasu'u, east of Rota School, *Gafui BSIP 17296* (BSIP, K, SING); San Jorge: Talise village, *Hunt RSS 2722* (K, US); Kolombangara: Ridge west of Vila river, *Mauriasi et al. BSIP 8429* (BSIP, K, SING); Fauore: Halluma River, *Mauriasi et al. BSIP 13977* (BSIP, K, L, SING).

19. Rhaphidophora neoguineensis Engl.

Rhaphidophora neoguineensis Engl. in K. Schum. & Hollrung, Fl. Kais. Wilh. Land (1889) 19 (`*neo-guineensis*`); K. Schum. & Lauterbach, Fl. Schutzgeb. Südsee (1900) 211; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 20—21, Fig. 3 (`*novo-guineensis*`); Engl. & K. Krause, Nova Guinea 8 (1912) 805; Alderw., Bull. Jard. Bot. Buitenzorg III, 1 (1920) 386 (`*novo-guineensis*`); Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 337—338 (`*novo-guineensis*`); K. Krause & Alderw., Nova Guinea 14 (1924) 212 (`*novo-guineensis*`). — Type: Papua New Guinea (`Kaiser Wilhelmsland`), Madang Prov., Adelbert Range, near Hatzfeldthafen, Oct. 1886, *Hollrung 372* (B, holo).

Figure 21

Slender, leptocaul, homeophyllous liane to 5 m; *seedling* not observed; *pre-adult plants* forming small terrestrial colonies; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and very short to somewhat lengthened mostly unbranched, free, sympodial, leafy, flowering stems; *stems* smooth, flexuous, climbing stems ± terete, occasionally weakly sulcate on two opposing sides, free stems terete, to similarly sulcate, without prophyll, cataphyll and petiolar sheath fibre, internodes 1—9 x 0.2—0.6 cm on clinging and free shoots, flowering shoots with shorter internodes, separated by weak straight leaf scars, occasionally disarticulating into 2—4 internode lengths and these later rooting and forming independent plants, older stems woody; *flagellate foraging stems* frequent, terete in cross-section with reduced leaves basally, terminal portion with caducous cataphylls; *clasping roots* arising sparsely from the clinging stems, very slightly pubescent; *feeding roots* solitary from

Figure 20. Rhaphidophora mima P.C. Boyce
A. flowering branch, spathe intact x 1/6; B. flowering branch, spathe fallen x 1/6; C. inflorescence, spathe fallen, x 2; D. spadix detail, post-anthesis x 4. A from *Kajewski 1891*; B from *Foreman & Katik LAE 59291A*; C-D from *Nicolson 1522*.

nodes, clinging to climbing surface; *leaves* weakly spiro-distichous, moderately densely arranged; *cataphylls* and *prophylls* membranous, caducous; *petiole* grooved adaxially, 3—12 x 0.1—0.2 cm, smooth, with a slight apical and basal geniculum, although older leaves often with genicula enlarged and cracking-corky; *petiolar sheath* slightly prominent, extending beyond the apical geniculum by two ligules, caducous leaving a continuous scar from the petiole base, around the top of the apical geniculum and back to the base; *lamina* entire, elliptic to elliptic-lanceolate or oblanceolate, 6—25 x 2—9 cm, thinly coriaceous to submembranous, base cuneate to acute or subovate, apex acute to weakly acuminate, with a minute tubule; *midrib* raised abaxially, slightly sunken adaxially in fresh material, slightly sunken abaxially and adaxially in dry material; *primary venation* pinnate, slightly raised on both surfaces in dried material; *interprimaries* reticulate to sub-parallel to, but much less distinctive than, primaries, degrading into weakly reticulate venation, very slightly raised abaxially; *secondary* and *tertiary venation* reticulate; *inflorescence* solitary, subtended by a fully developed foliage leaf and a caducous cataphyll; *peduncle* slightly compressed-terete, 1.3—2.5 x 0.15—0.3 cm; *spathe* globose to ovoid-ellipsoid, truncate basally at insertion on petiole, apex briefly beaked, 1—2 x 1—2.5 cm, thick fleshy, dark yellow, marcescent, drying brown, later pushed off by developing infructescence leaving a large scar; *spadix* globose to ellipsoid-cylindrical, sessile, inserted level on peduncle, 1—1.5 x 0.7—1 cm, obtuse, yellow-white; *stylar region* rounded-rhombohexagonal, 0.9—1.5 x 0.85—1.2 mm, truncate; *stigma* punctiform to very slightly elliptic, c. 0.45 x 0.3 mm diam., prominent in dried material; *anthers* well-exserted at male anthesis; *infructescence* not observed.

Distribution: New Guinea. Widespread but, by the exclusion of many collections here recognized as new species, not as common as was once thought.

Habitat: Primary to disturbed secondary lowland, gallery and hill monsoon and rain forest on various substrates including coralline limestone, 3–700 m altitude.

Note: *Rhaphidophora neoguineensis* is characterized by a small (1—2 x 1—2.5 cm), marcescent, globose spathe and ellipsoid-cylindrical spadix. In herbaria it is much confused with *R. mima* but which is readily separated by the cigar-shaped, caducous spathe and cylindrical spadix. Confusion with *R. schlechteri* is also possible, although this has a larger spathe (4—6 x c. 2.4 cm) and a stipitate spadix.

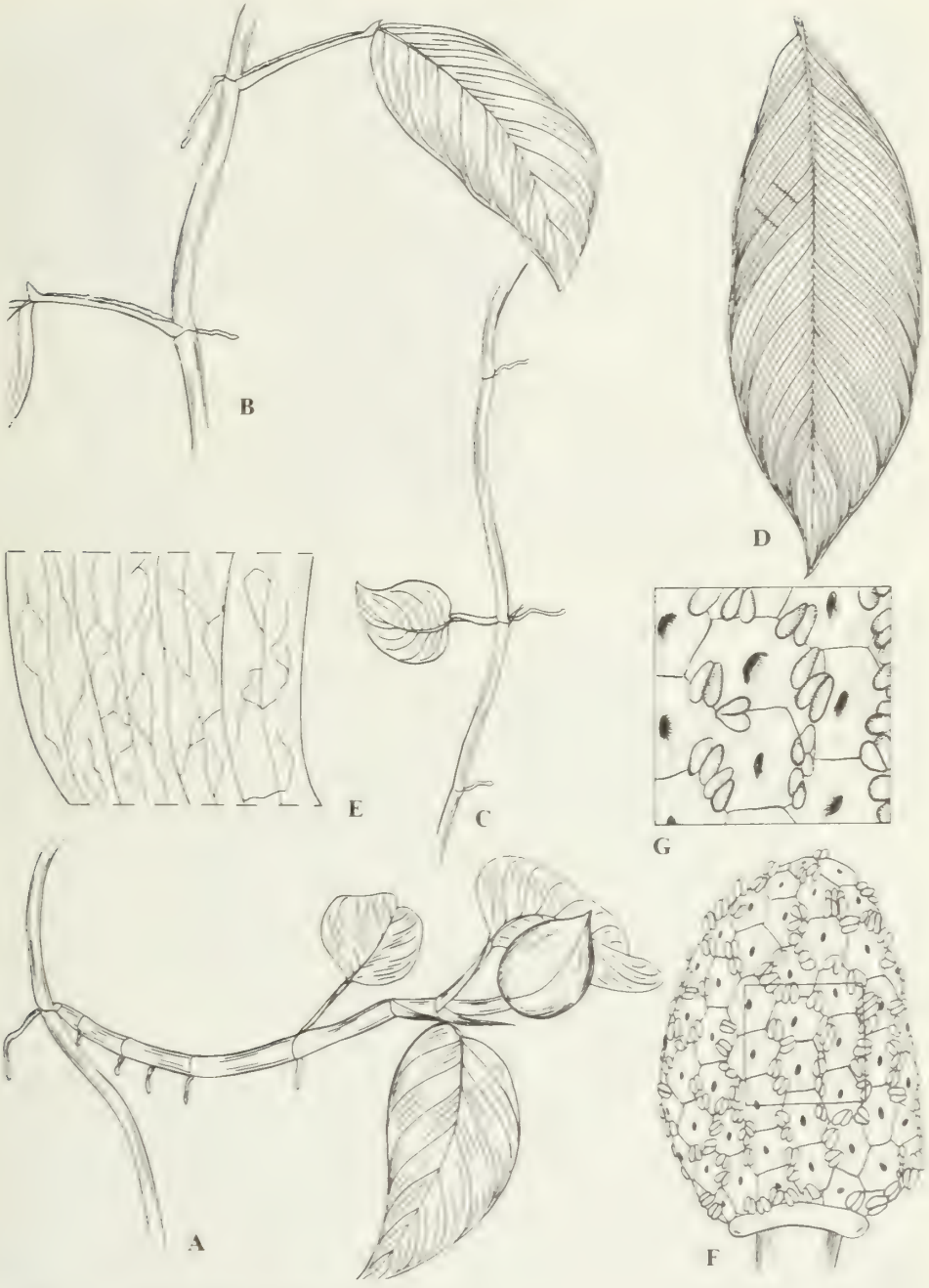

Figure 21. Rhaphidophora neoguineensis Engl.
A. adult shoot with flowering branch x 1/6; B. adult clinging shoot x 1/4; C. flagellate shoot x 1/3; D. leaf lamina x 1/4; E. venation detail x 3; F. inflorescence, spathe removed x 4; G. spadix detail, male anthesis x 6. A-C, F-G from *Hay K2* [cult. Kew (Acc. no. 1982-5010) & K spirit no. 58061] x 1/3; D-E from *Nicolson 1402*.

Other specimens seen: INDONESIAN PAPUA. Bonggo Range, Mamberamo, Pionierbivak, *Lam 763* (L). Jayapura Prov.: Taritatau (Idenburgh) River, Bernhard Bivak, *Meyer Drees 279* (L); Biak, hill northeast end of Mokmer airport, *Nicolson 1565* (L, US). PAPUA NEW GUINEA. East Sepik Prov.: Wewak, 2 miles west of But village, *Essig & Martin LAE 55124* (L, LAE); West Sepik Prov.: Vanimo, Wutung, on Papua New Guinea/Indonesian Papua border, *Streimann LAE 52789* (LAE, US); Sepik Prov.: Sepik River, *Gjellerup 330* (L); Kelel, *Schlechter 16329* (P); Keneyia, *Schlechter 18298* (P); Western Highlands Prov.: Mt Hagan, near Ruti E.L.G., *Henty & Streimann NGF 38835* (US); Morobe Prov.: Lae, Markham Bridge, *Kairo & Streimann NGF 30715* (GH, K, L, SING, US); Lae B.G., *Millar NGF 9938* (GH, K, L), *Nicolson 1402* (B, BM, K, L, P, SING, US); Near Markham River, 9 miles southwest of Lae on Bulolo road, *Nicolson 1480* (US); Central Prov.: Port Moresby, Brown River F.R., 20-25 miles northwest of Port Moresby, *Nicolson 1427* (US).

20. Rhaphidophora okapensis P.C. Boyce & Bogner

Rhaphidophora okapensis P.C. Boyce & Bogner, Gard. Bull. Singapore 52 (2000) 94, fig.2. — Type: Papua New Guinea, Eastern Highlands, 5 miles NE of Okapa, 24 Sept. 1964, *Hartley* TGH 13098 (CANB, holo; GH, K, L, iso).

Figure 22

Moderate, slightly robust, semi-leptocaul, homeophyllous neotenic liane to unknown ultimate height; *seedling stage* and *pre-adult plants* not observed; *adult shoot architecture* comprised of clinging, physiognomically unbranched, densely leafy, sterile stems, and clinging, leafy flowering stems; *stems* terete in cross-section, smooth, without prophyll, cataphyll and petiolar sheath remains, internodes to 5 x 0.75 cm, separated by slightly swollen nodes with ± sloping scars, older stems sub-woody; *flagellate foraging stems* not observed; *clasping roots* arising sparsely from the internodes, smooth to very slightly pubescent; *feeding roots* not observed; *leaves* distichous, those on adherent shoots weakly shingling to slightly scattered, those on free shoots pendent to slightly spreading; *cataphylls* and *prophylls* membranous, caducous; *petiole* shallowly and broadly grooved, 1—4 x 0.1—0.2 cm, smooth, apical and basal geniculа quite prominent; *petiolar sheath* prominent, membranous, ligulate, ligule extending c. 1.5 cm beyond apical geniculum, soon drying and adhering to stem, later disintegrating and falling; *lamina* ovate, adaxially mid-green, abaxially paler, very stiffly coriaceous, 2.5—8.5 x 0.9—4 cm, base cordate to rounded and slightly notched, apex long acuminate with a pronounced tubule; *midrib* proximally raised abaxially, slightly impressed adaxially; *primary venation* pinnate, slightly raised on both leaf surfaces; *interprimaries* sub-parallel to and barely distinguishable from primaries, slightly raised on both leaf surfaces; *secondary venation* reticulate, slightly raised abaxially and adaxially;

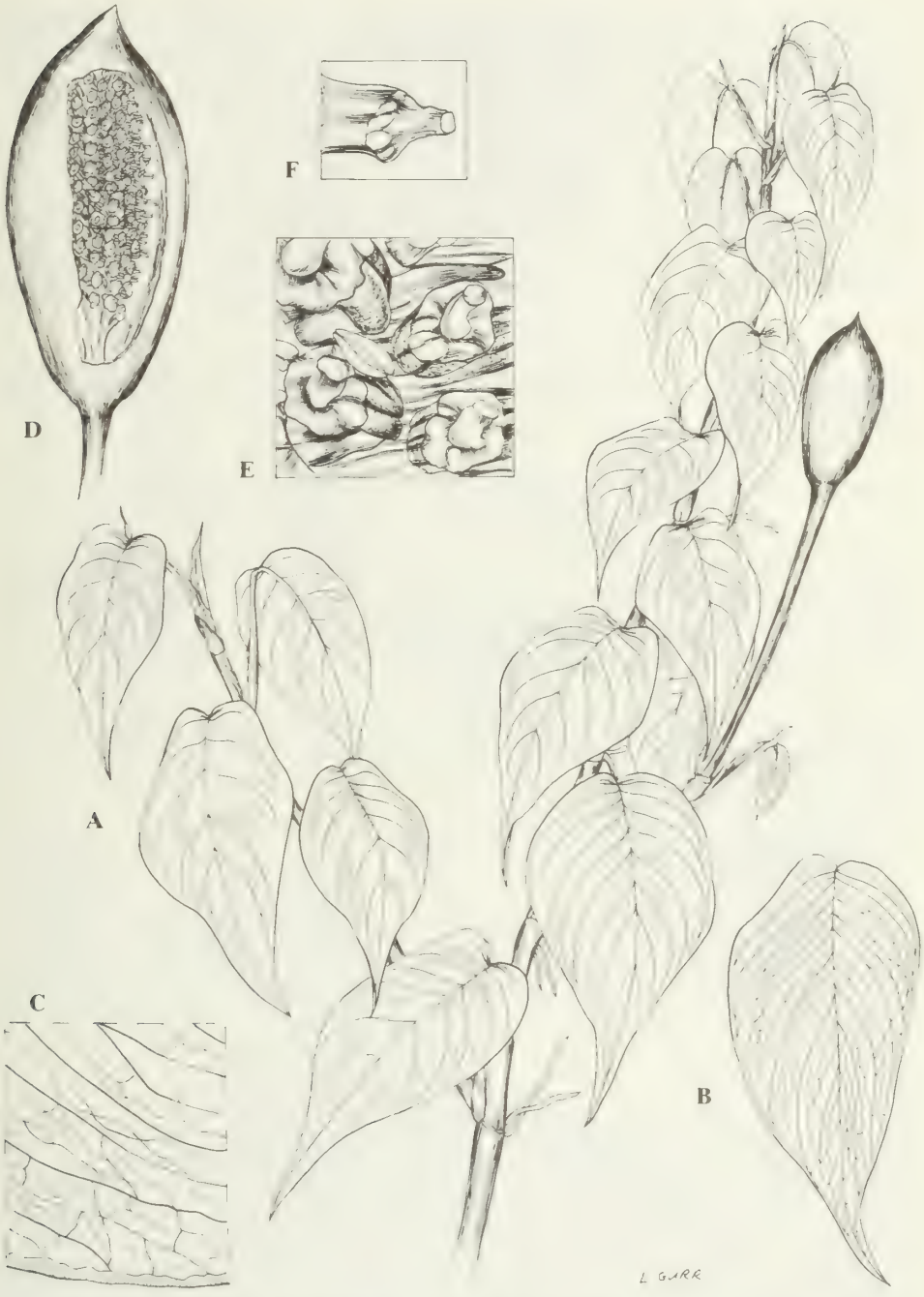

Figure 22. Rhaphidophora okapensis P.C. Boyce & J. Bogner
A. adult shoot with flowering branch x ⅛; B. leaf lamina x 1; C. venation detail x 4; D. inflorescence x 1½; E. spadix detail at male anthesis x 10; F. pistil, side view x 10. All from *Hartley 13098*.

inflorescence solitary on short leafy shoots, subtended by a fully developed or reduced foliage leaf, and a soon-degrading, membranous, long-ligulate prophyll; *peduncle* terete, 4—6 x 0.15—0.2 cm; *spathe* broadly canoe-shaped, rounded, minutely apiculate, 3—3.5 x 1.2—1.5 cm, stiffly fleshy, yellow, turning purple, (early marcescent?) leaving a large scar at the base of the spadix; *spadix* stout, cigar-shaped, stipitate, inserted level on stipe, 1.9—2.2 x 0.75—1 cm; *stipe* 4—4.5 x 1—1.2 mm; *stylar* region conical, regularly rhombohexagonal in plan view, 0.8—1 x c. 1 mm; *stigma* slightly raised, punctiform, c. 0.4 mm diam.; *anthers* exserted at male anthesis; *infructescence* not seen.

Distribution: Papua New Guinea (Eastern Highlands and Central Provinces).

Habitat: Disturbed mixed forest on slope. 1200–1600 m altitude.

Note: A very distinctive species notable for the stiffly erect, densely leafy stems, the thickly coriaceous, ovate-cordate leaves with a long acuminate tip, the relatively large inflorescences turning purple at maturity, the long-stipitate spadix, and the conical stigmatic region.

Other specimens seen: PAPUA NEW GUINEA. Central Prov.: Boridi, *Carr 14863* (BM, L, SING); Eastern Highlands Prov.: Kainantu, Arau-Andandara road, *Streiman NGF 23963* (US).

21. Rhaphidophora pachyphylla K. Krause

Rhaphidophora pachyphylla K. Krause, Bot. Jahrb. Syst. 49 (1912) 92; P.C. Boyce & Bogner, Gard. Bull. Singapore 52 (2000) 94, fig.2. — Type: Papua New Guinea, Madang Prov., near Wabbe, 29 Aug. 1907, *Schlechter* 16463 (B, holo; P, iso).

Figure 23

Moderate to rather large, somewhat robust, semi-leptocaul, homeophyllous neotenic liane to 5 m; *seedling stage* a non-skototropic shingling juvenile shoot; *pre-adult plants* forming small terrestrial colonies; *adult shoot architecture* comprised of clinging, physiognomically unbranched, mostly densely leafy, sterile stems and free, leafy flowering stems; *stems* rectangular-terete in cross-section, widest side prominently convex, smooth, mid-green, without prophyll, cataphyll and petiolar sheath fibre although flowering shoots occasionally with parchment-like remains, internodes to 3 x 1 cm,

Figure 23. Rhaphidophora pachyphylla K. Krause
A, adult shoot with flowering branch x ; B, section of adult climbing shoot x : leaf lamina x : C, juvenile climbing shoot x ; D, pre-adult climbing shoot x ; E, leaf lamina x ; F, venation detail x 4; G, infloresecence, spathe fallen x 1 ; H, spadix detail, post-male anthesis x 10. A, E – F from *Krause 108*; B from *Kalkman 3389*; C–D from *Nicolson 1416*; G–H from *Schlechter 16436*.

separated by rather prominent ± straight scars, older stems sub-woody; *flagellate foraging stems* absent; *clasping roots* arising sparsely from the internodes, pubescent; *feeding roots* not observed; *leaves* distichous, those on adherent shoots shingling, those on free shoots slightly spreading, all densely arranged; *cataphylls* and *prophylls* membranous, caducous; *petiole* deeply grooved, 1.5—4 x 0.15—0.2 cm, smooth, apical and basal genicula quite prominent; *petiolar sheath* prominent, membranous, ligulate, slightly unequal on one side, of short-duration, degrading to very weak fibres and soon falling; *lamina* narrowly ovate-elliptic, stiffly coriaceous, base acute to cuneate, apex acute with a short tubule; *midrib* prominently raised abaxially, slightly impressed adaxially; *primary venation* pinnate, slightly raised abaxially, somewhat impressed adaxially; *interprimaries* sub-parallel to primaries, slightly raised on both leaf surfaces; *secondary venation* weakly reticulate, slightly raised abaxially, ± flush adaxially; *inflorescence* solitary on short to somewhat elongated leafy shoots, subtended by a fully developed foliage leaf, and soon-degrading membranous prophyll; *peduncle* terete, 4—7 x 0.2—0.25 cm; *spathe* broadly canoe-shaped, obtuse to slightly pointed, 5—6.5 x 1.5—2.2 cm, stiffly fleshy, yellow, gaping at female anthesis and then caducous leaving a large scar at the base of the spadix; *spadix* narrowly cigar-shaped, long stipitate, inserted obliquely on stipe, 4—5.5 x 1.2—1.6 cm, yellow; *stipe* 6—10 x 2—2.4 mm; *stylar* region weakly developed, mostly irregularly rhombohexagonal, 1—1.2 x1—1.4 mm, truncate; *stigma* slightly raised, punctiform, c. 0.2—0.3 x 0.3—0.35 mm; *anthers* slightly exserted at male anthesis; *infructescence* not seen.

Distribution: Indonesian Papua, Papua New Guinea. The scattered localities and few collections suggest a widespread but uncommon species.

Habitat: Lowland monsoon or rain forest at 10–30 m altitude.

Notes: 1. Long confused with *Rhaphidophora hayi*, *R. pachyphylla* differs in leaf shape, and form of the stigma. Additionally, *R. pachyphylla* lacks the disarticulating shoots unique to *R. hayi*, and never has foraging shoots.

2. It is still not fully clear whether *R. pachyphylla* as here defined is a single taxon. *Hoogland & Schodde 6943* (Western Highlands Prov., Wabag, near Poio village, west slopes of lower Yaki valley, 6 July 1960, in montane *Nothofagus* forest, 2380 m (BM, GH, L), while vegetatively matching typical *R. pachyphylla*, has a markedly rounded spathe apex, a shorter stipe (c. 3 mm long) and also represents an enormous altitudinal increase on the other specimens seen. More specimens of '*R. pachyphylla*' from higher altitude are required to resolve this plant's status.

Other specimens seen: INDONESIAN PAPUA. Tamimonding, *Kalkman* s.n. (L); Digul Prov.: Merauke, Bis, Agats, *Widjaja* 6344 (BO, K, L). PAPUA NEW GUINEA. Central Prov.: Brown River F.R., 20 - 25 miles northwest of Port Moresby, *Nicolson* 1416 (K, L, US).

22. Rhaphidophora petrieana A. Hay

Rhaphidophora petrieana A. Hay, Telopea 5 (1993) 295, fig. 1. — Type: Australia, Queensland, National Park Reserve 904, Palmerston Highway, 30 Nov. 1982, *B. Gray 2862* (QRS, holo).

Rhaphidophora sp. *aff. australasica* (Qld) in Jones & Gray, Climbing Pl. Australia (1988) 316, unnumbered plate p. 322.

Figure 24

Medium to large, moderately robust, semi-leptocaul homeophyllous liane to 20 m; *seedling* and *pre-adult plants* not observed; *adult shoot architecture* comprised of greatly elongated, clinging, physiognomically unbranched, sparsely leafy, non-flowering stems and long, moderately elaborated, free, sympodial, densely leafy, flowering stems; *stems* smooth, climbing and free stems terete in cross-section, green, later mid-brown, without prophyll, cataphyll and petiolar sheath fibre, internodes to 2.5—5 x 0.5—1 cm on clinging shoots, usually less stout on free shoots, separated by well defined, slightly oblique, corky leaf scars, older stems subwoody; *flagellate foraging stems* absent; *clasping roots* sparse, arising from the nodes of clinging stems, minutely pubescent; *feeding roots* not observed; *leaves* spiro-distichous on clinging shoots, disticho-secund on free shoots; *cataphylls* and *prophylls* membranous, very quickly drying and falling; *petiole* grooved adaxially, 4.5—8 x 0.15—0.3 cm, smooth, apical and basal genicula weakly defined; *petiolar sheath* very prominent, extending to just below apical geniculum, swiftly drying and eventually falling more-or-less entire leaving a conspicuous scar; *lamina* entire, narrowly ovate to lanceolate, somewhat falcate, slightly oblique, 4.5—22.5 x 1—4.5 cm, thinly coriaceous, base acute, apex acuminate, with a tiny tubule; *midrib* raised abaxially, slightly sunken adaxially; *primary venation* pinnate, slightly raised abaxially and adaxially; *interprimaries* parallel to primaries and barely less prominent, very slightly raised abaxially and adaxially; *secondary venation* ± obscure in fresh material, visible as a faint reticulum in dried specimens; *inflorescence* solitary, subtended by a partially developed foliage leaf and a membranous cataphyll; *peduncle* compressed-terete, 3—10 x 0.15—0.8 cm; *spathe* canoe-shaped, stoutly short- to rather long-beaked, 6—8 x 1—3 cm (8 cm wide flattened out), thickly stiff-fleshy, creamy yellow, caducous at female

Figure 24. Rhaphidophora petrieana A. Hay
A. flowering shoot x ⅓; B. inflorescence, longitudinal section x ⅔; C. spadix detail, male anthesis x 6. All from *Hyland 9162*.

anthesis: *spadix* bluntly tapering-cylindric, stipitate, inserted ± level on stipe, 3—6 x 1—2.5 cm; *stipe* terete, c. 1 x 0.6 cm; *stylar region* mostly rounded-hexagonal, c. 2 x 1.8—2 mm, conical; *stigma* punctiform and prominently raised, c. 0.25—0.3 mm diam.; *anthers* exserted at male anthesis; *infructescence* not observed.

Distribution: Australia (wet tropical regions of eastern Queensland).

Habitat: Lowland to lower montane rain forest. Sea level to 800 m altitude.

Note: Long confused in herbaria and literature with *Rhaphidophora australasica* but readily distinguished by flowering on free lateral shoots and by the stipitate spadix. Further, in *R. petrieana* the petiolar sheaths fall more-or-less intact and do not degrade into semi-persistent fibres as they do in *R. australasica*.

Other specimens seen: AUSTRALIA. Queensland: Foot of Mt Demi, *Flecker 9005* (QRS); Timber Reserve 55, Whyanbeel, *Gray 202* (QRS); State Forest Reserve 310, Upper Goldsborough Logging Area, *Gray 1055* (QRS); Cooper Creek, *Hind 246* (NSW); State Forest Reserve 755, Barong Logging Area, *Hyland 9162* (BRI, L, NSW, QRS).

23. Rhaphidophora pilosa P.C. Boyce, *sp. nov.*

Rhaphidophora pilosa R. gorokensi R. kokodensique simillima est, ab illa apices surculorum fibrosos (fibram in *R. gorokensi* deest) habenti atque ad hac natura coacta (non simpliciter fibrosa) reliquiarum apicum surculorum differens. Cum *R. waria* eam confundere potest, quamquam illa species magis major est in surculis adhaerentibus non liberis florens. — TYPUS: Indonesian Papua, Kepala Burung Prov., Arfak Mts, Minjambau, 20 May 1962, *C. Versteegh BW 12647* (L, holo; MAN, iso).

Figure 25

Small, homeophyllous (?) liane to unknown ultimate height; *seedling stage* and *pre-adult plants* not observed; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, leafy(?), non-flowering stems and short, free, sympodial, flowering stems; *stems* terete in cross-section, internodes to at least 5 x 0.5 cm, separated by straight oblique, weak leaf scars; *flagellate foraging stems*, unknown; *clasping roots* solitary, stout, arising from nodes; *feeding roots* not observed; *leaves* weakly spiro-distichous on free shoots; *cataphylls* and *prophylls* chartaceous, very soon degrading into weak fibres and patches of soft felt-like debris; *petiole* weakly canaliculate, 4.5—9 x 0.2—0.25 cm, smooth, apical and basal geniculum

Figure 25. Rhaphidophora pilosa P.C. Boyce
A. flowering branch, spathe intact x 1/5; B. flowering branch, spathe fallen x 1/5; C. spadix detail, post-anthesis x 5. All from *Versteegh BW12647*.

well defined *petiolar sheath* prominent, chartaceous, extending to apical geniculum, very swiftly degrading to weak fibres and strips of soft felt-like debris; *lamina* entire, narrowly lanceolate to narrowly lanceolate-elliptic, occasionally very slightly falcate, 6—18 x 2—3.5 cm, stiffly coriaceous, base rounded to acute, apex long-acuminate with a prominent apicule; *midrib* raised abaxially, slightly flush to very slightly sunken adaxially; *primary venation* densely pinnate, very slightly raised abaxially and adaxially; *interprimaries* parallel to primaries, slightly less pronounced; *secondary venation* very faintly open-reticulate; *inflorescence* solitary, subtended by a foliage leaf and felted debris; *peduncle* stout, compressed-terete, 8—11 x 0.3—0.5 cm; *spathe* canoe-shaped, very long stout-acuminate, 9.5 x c. 1.8 cm, marcescent; *spadix* cigar-shaped, sessile, 5.5 x 1 cm; *stylar region* rhombohexagonal, c. 0.9—1 x 1.2—1.5 mm, truncate; *stigma* punctiform, flush, c. 0.4 mm diam.; *anthers* not exserted at male anthesis; *infructescence* cylindrical, c. 8 x 1.8 cm.

Distribution: Indonesian Papua (Kepala Burung Prov.). Known only from the type.

Habitat: Secondary submontane forest, 1250 m altitude.

Notes: 1. *Rhaphidophora pilosa* is one of several montane species with stiffly coriaceous leaves (Okapensis Group). It is most similar to *R. gorokensis* and *R. kokodensis*, differing from the former in possessing fibrous shoot tips (*R. gorokensis* lacks fibre) and from the latter in the felted (not simply fibrous) nature of the shoot tip debris. Confusion with *R. waria* is possible although this is a much larger species flowering on clinging, not free, shoots.

2. The specific epithet is from the Greek 'pilosa', felt-like, in allusion to the unique manner in which the cataphylls, prophylls and petiolar sheath degrade into felted fibres.

24. Rhaphidophora schlechteri K. Krause

Rhaphidophora schlechteri K. Krause, Bot. Jahrb. Syst. 49 (1912) 94. — Type: Papua New Guinea, Eastern Highlands Prov., Tanqueti camp, 27 Nov. 1908, *Schlechter 18888* (B, holo).

Rhaphidophora conferta K. Krause, Bot. Jahrb. Syst. 49 (1912) 95, **synon. nov.** — Type: Papua New Guinea, Keneyia Camp, 2 Oct. 1908, *Schlechter 18308* (B, holo; P, iso).

Rhaphidophora peekelii Engl. & K. Krause, Bot. Jahrb. Syst. 54 (1916) 78; Peekel ex Henty, Fl. Bismarck Archipelago (1984) 66—67 fig. 110, **synon. nov.** — Type: Papua New Guinea, New Ireland, Namatanai, *Peekel 296* (B, holo).

Rhaphidophora buergersii Engl. & K. Krause, Bot. Jahrb. Syst. 54 (1916) 78 (*'bürgersii'*), **synon. nov.** — Type: Papua New Guinea, Sepik Prov., Lordberg, 9 Dec. 1912, *Ledermann 10241* (B, holo).

Rhaphidophora drepanophylla Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 340; K. Krause & Alderw., Nova Guinea 14 (1924) 213, **synon. nov.** — Type: Indonesian Papua, Bonggo Range, Mamberamo, near Prauwen Bivak, 1 Sept. 1920, *Lam 1014* (BO, holo; L, iso).

Rhaphidophora obliquata Alderw., Bull. Jard. Bot. Buitenzorg III, 4 (1922) 340; K. Krause & Alderw., Nova Guinea 14 (1924) 212, **synon. nov.** — Type: Indonesian Papua, Bonggo Range, Mamberamo, near Pionier Bivak, 30 June 1920, *Lam 483* (BO, holo).

Figures 26 & 27

Slender to moderately robust, leptocaul, homeophyllous (?) liane to 20 m; *seedling* and *pre-adult plants* not observed; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and very short to somewhat lengthened, unbranched, free, sympodial, leafy, flowering stems; *stems* smooth, flexuous, terete, without prophyll, cataphyll and petiolar sheath fibre, internodes 1—9 x 0.5—1.5 cm, separated by thin, slightly oblique, leaf scars, older stems woody; *flagellate foraging stems* absent; *clasping roots* arising singly from the node; *feeding roots* not observed; *leaves* spiro-distichous, scattered; *cataphylls* and *prophylls* membranous, caducous; *petiole* grooved adaxially, 7—14 x 0.2—0.3 cm, smooth, with a very slight apical and prominent basal geniculum; *petiolar sheath* very prominent on newest leaves, very broad basally, narrowing c. + way along petiole and extending beyond the apical geniculum by two tiny ligules, caducous leaving a continuous scar from the petiole base, around the top of the apical geniculum and back to the base; *lamina* entire, lanceolate to oblong-lanceolate, slightly to prominently oblique, 10—34 x 4—9.5 cm, thinly coriaceous, base obtuse-cuneate to rounded and minutely cordate, apex falcate, acute to long-acuminate, with a tiny tubule; *midrib* slightly raised abaxially, flush to very slightly sunken adaxially; *primary venation* pinnate, slightly raised on both surfaces; *interprimaries* sub-parallel and barely less distinctive than primaries; *secondary* and *tertiary venation* reticulate, conspicuous in dry material; *inflorescence* solitary, subtended by

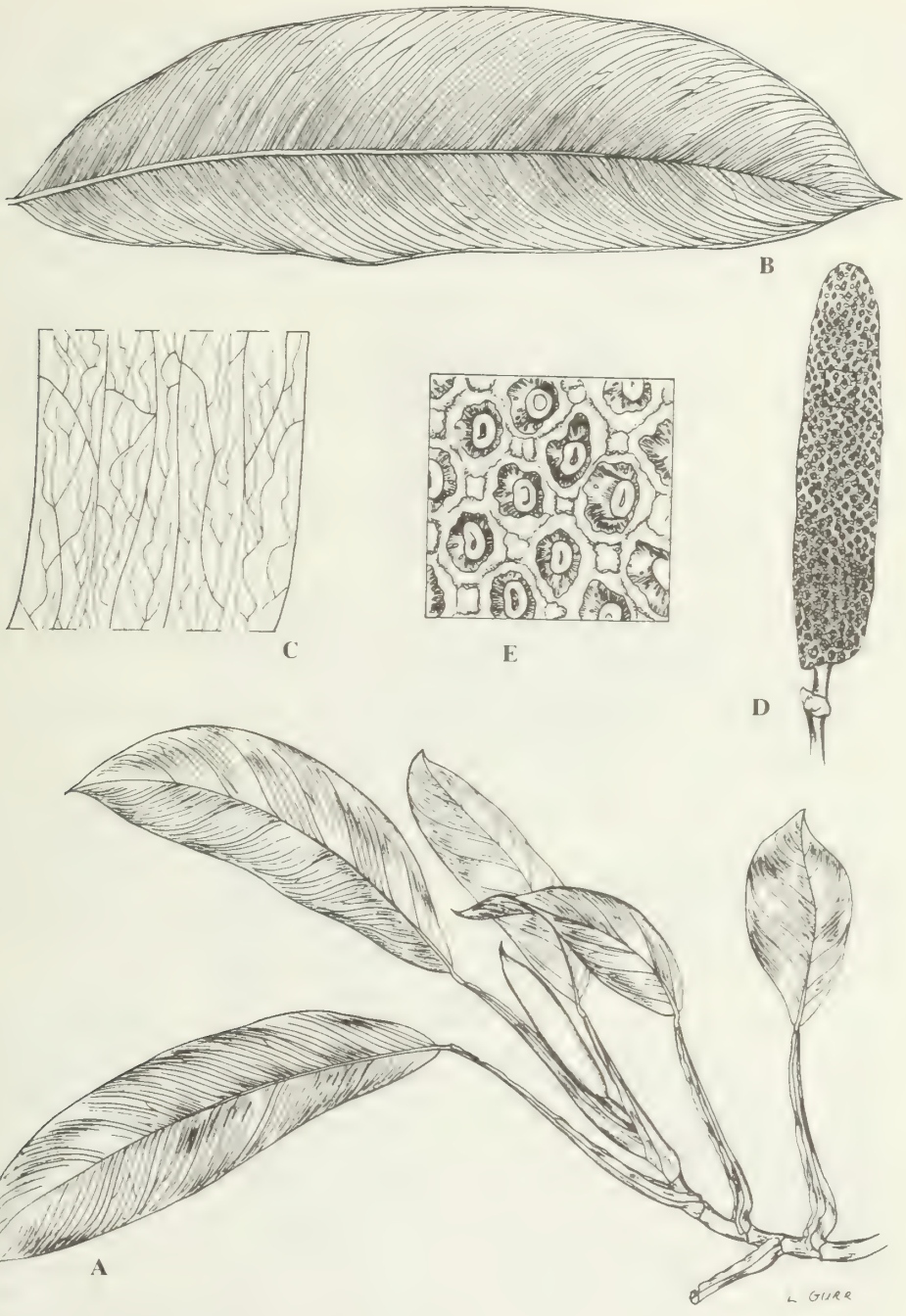

Figure 26. Rhaphidophora schlechteri K. Krause
A. flowering shoot x $^1/_3$; B. leaf lamina x $^1/_2$; C. venation detail x 4; D. inflorescence, spathe fallen x 1; E. spadix detail, pre-anthesis x 8. A & C from *Schlechter 18888*; B, D-E from *Boraule et al. BSIP 9141*.

a incompletely developed foliage leaf and one or more prominent caducous cataphylls; *peduncle* slightly compressed-terete, 5—9 x c 0.5—1 cm; *spathe* cigar-shaped, apex stoutly beaked, 4—11 x c. 3.5 cm (flattened out), thick, marcescent, falling as fruits ripen, green at male anthesis; *spadix* cylindrical, stipitate, inserted slightly obliquely on stipe, 6—8.5 x 1.5—2 cm, creamy white; *stipe* terete, 0.5—1 cm long; *stylar region* depressed-rhombohexagonal, c. 1.2 x 1.3 mm, truncate; *stigma* punctiform, c. 0.3 mm diam., raised at male anthesis but barely prominent in dried material; *anthers* strongly exserted at male anthesis; *infructescence* stoutly cylindrical, c. 8 x 3 cm, with dry spathe persisting.

Distribution: Widespread from Papua New Guinea (including Bismarck Archipelago) to the Solomon Islands.

Habitat: Primary to disturbed secondary broadleaf and coniferous (*Araucaria*) forest on humus, alluvium and lava. Sea level to 1500 m altitude

Notes: 1. As defined here *Rhaphidophora schlechteri* is a variable and widespread species. The broad species concept adopted is based on examining all the numerous duplicates of the Nicolson collections cited here that exhibit wide variation, which supports the merging of elements recognized as separate species by earlier workers.

2. In most of its medium to large manifestations *R. schlechteri* is similar in overall appearance to *R. mima*, but is distinguishable by the marcescent spathe and stipitate spadix. Small forms of *R. schlechteri* maybe confused with *R. neoguineensis*, although the globose spathe and sessile ellipsoid spadix readily distinguish the latter.

Other specimens seen: PAPUA NEW GUINEA. West Sepik Prov.: Telefomin, Sanduan, track on leaf bank of Mai (Yuwa) river, to 0.5 km south of Fiak airstrip, *Frodin et al. 2553* (K); Central Prov.: Sogeri Plateau, Rouna Waterfall, 20 miles east of Port Moresby, *Nicolson 1432* (B, BM, K, L, P, SING, US); Morobe Prov.: Wau, road half way to Yamap, *Kairo NGF 44078* (L, NGF, US); 10 miles north of Bulolo, *Nicolson 1477* (B, K, L, P, US); Madang Prov., southern slopes of Finisterre Range, near Budemu, *Pullen 5996* (BM, L, LAE); Saidor, Matafuma village, vicinity of Pukie Primary School, *Vandenberg & Katik NGF 42372* (GH, K, L, US); North Solomons Prov.: Bougainville, vicinity of Barilo village, c. 6 miles north of Buin Station, *Schodde 3935* (GH, L); New Ireland: Mussau, *Koie & Olsen 1377* (L); Namatanai, coastal region, near Tamul River, c. 0.5km NW of Taron, east coast, *Sands et al. 2044* (GH, K, L, US); SOLOMON ISLANDS. Guadalcanal: West Guadalcanal, Wanderer Bay, Vuragoba area, *Boraale et al. BSIP 9141* (BSIP, K, SING); North central Guadalcanal, Tina River, *Nakisi & Babala BSIP 8222* (BSIP, K, SING); San Cristobal: Puepue River, *Brass, 2794* (BO, GH, L); South Ridge west of Tetere village, *Gafui et al. BSIP 1 2575* (BSIP, K, SING); Fauore ('Fauo') Island: *Guppy 196* (K); Ulawa: Moli, *Teona BSIP 6303* (BSIP, K, L, SING).

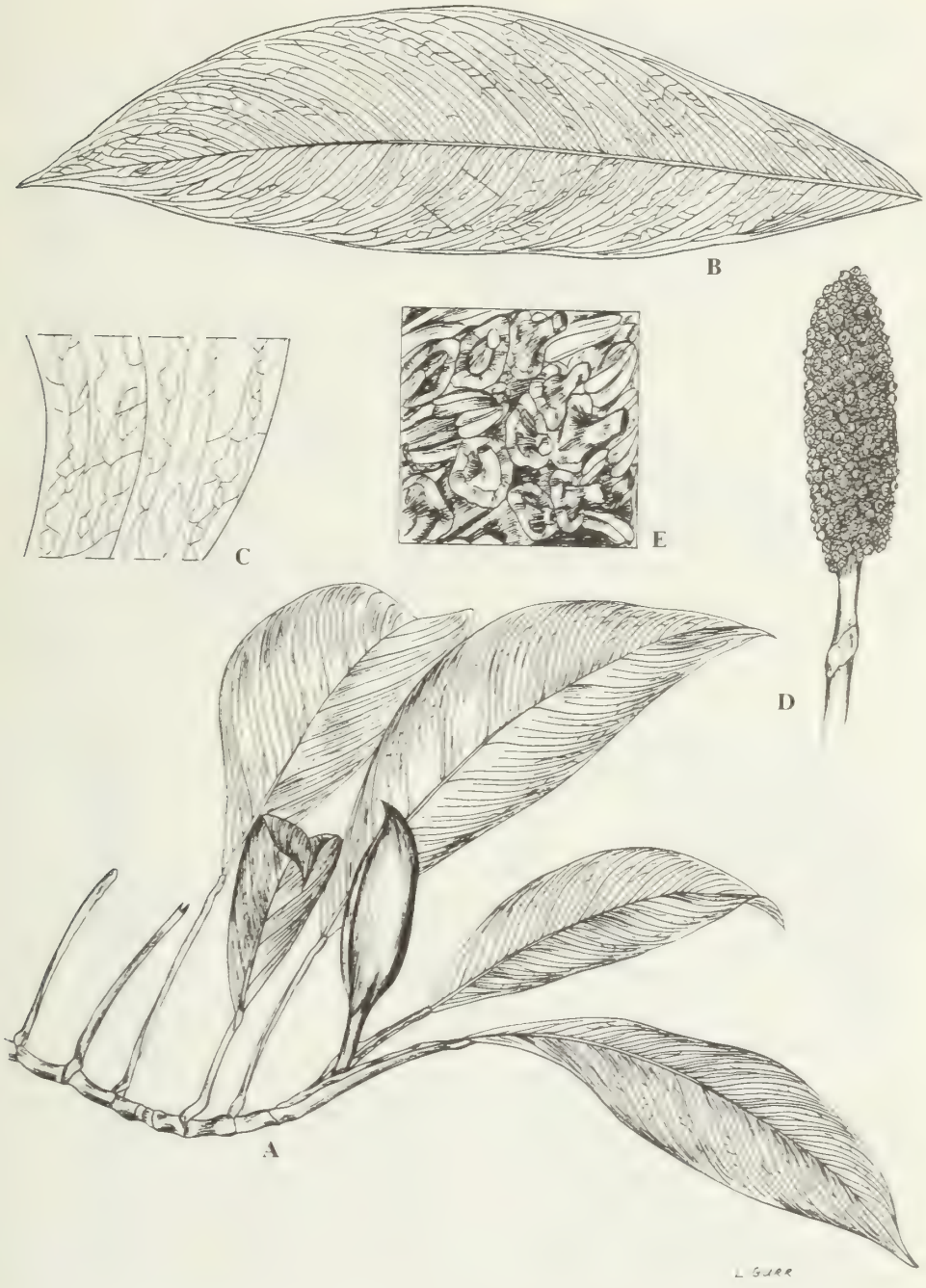

Figure 27. Rhaphidophora schlechteri K. Krause
A. flowering shoot x ⅛; B. leaf lamina x ⅛; C. venation detail x 2; D. inflorescence, spathe fallen x 1; E. spadix detail, post-male anthesis x 6. All from *Ledermann 10241*.

25. Rhaphidophora spathacea Schott

Rhaphidophora spathacea Schott, Ann. Mus. Bot. Lugd.-Bat. 1 (1863) 129. — Type: 'New Guinea', *Zippelius s.n.* (L, holo).

Rhaphidophora apiculata K. Krause, Bot. Jahrb. Syst. 49 (1912) 93, **synon. nov.** — Type: Papua New Guinea ('Kaiser Wilhelmsland'), Madang Prov., Finisterre Range, 2 Sept. 1908, *Schlechter 18152* (B, holo; P, iso).

Rhaphidophora palauensis Koidz., Bot. Mag. Tokyo 30 (1916) 400, **synon. nov.** — Type: Palau, Angaur Island, *Kayima 154* (TI, holo).

Rhaphidophora forbesii Rendle, J. Bot. 61, Suppl. (1923) 58, **synon. nov.** — Type: Papua New Guinea, Sogeri Prov., 1885-1886, *Forbes 323* (BM, holo).

Rhaphidophora engleri Kanehira, Fl. Micrones. (1933) 409. — *Rhaphidophora palauensis* Engl. & K. Krause, Bot. Jahrb. Syst. 56 (1921) 433, *nom. illeg., non* Koidz. (1916), **synon. nov.** — Type: Palau, Babelthuap ('Babelthaob'), Dorfe Ngarsul, 21 Feb. 1914, *Ledermann 14336* (B, holo).

Rhaphidophora kanehirae Hatusima, J. Japanese Bot. 15 (1939) 19, fig. 1, g—j, **synon. nov.** — Type: Federated States of Micronesia, Yap, *Kanehira 1188* (TI, holo).

Figures 28 & 29

Moderately robust, medium-sized pachycaul, homeophyllous liane to 15 m; *seedling stage* not observed; *pre-adult plants* forming scattered terrestrial colonies; *adult shoot architecture* comprised of clinging, physiognomically unbranched, densely leafy flowering stems; *stems* smooth, mid-green, with cataphylls and prophylls persistent and drying dark yellow, then degrading into fibres and parchment-like remains, internodes 1—6 x 0.4—1.5 cm, separated by prominent slightly oblique leaf scars; *flagellate foraging stem* absent; *clasping roots* densely arising from the nodes and internodes, smooth and drying with parchment-like epidermis; *feeding roots* not observed; *leaves* spiro-distichous to distichous; *cataphylls* and *prophylls* chartaceous, later degrading into strips of tissue and fibres, especially at tips of flowering shoots; *petiole* deeply canaliculate, 8—53 x 0.4—0.8 cm, smooth with faint to rather prominent dark dense speckling, apical geniculum prominent, basal geniculum slightly less so; *petiolar sheath* extending to apical geniculum, broad, chartaceous, short-persistent, degrading to sparse fibres and papery strips, then falling; *lamina* entire, ovate-elliptic to oblong-

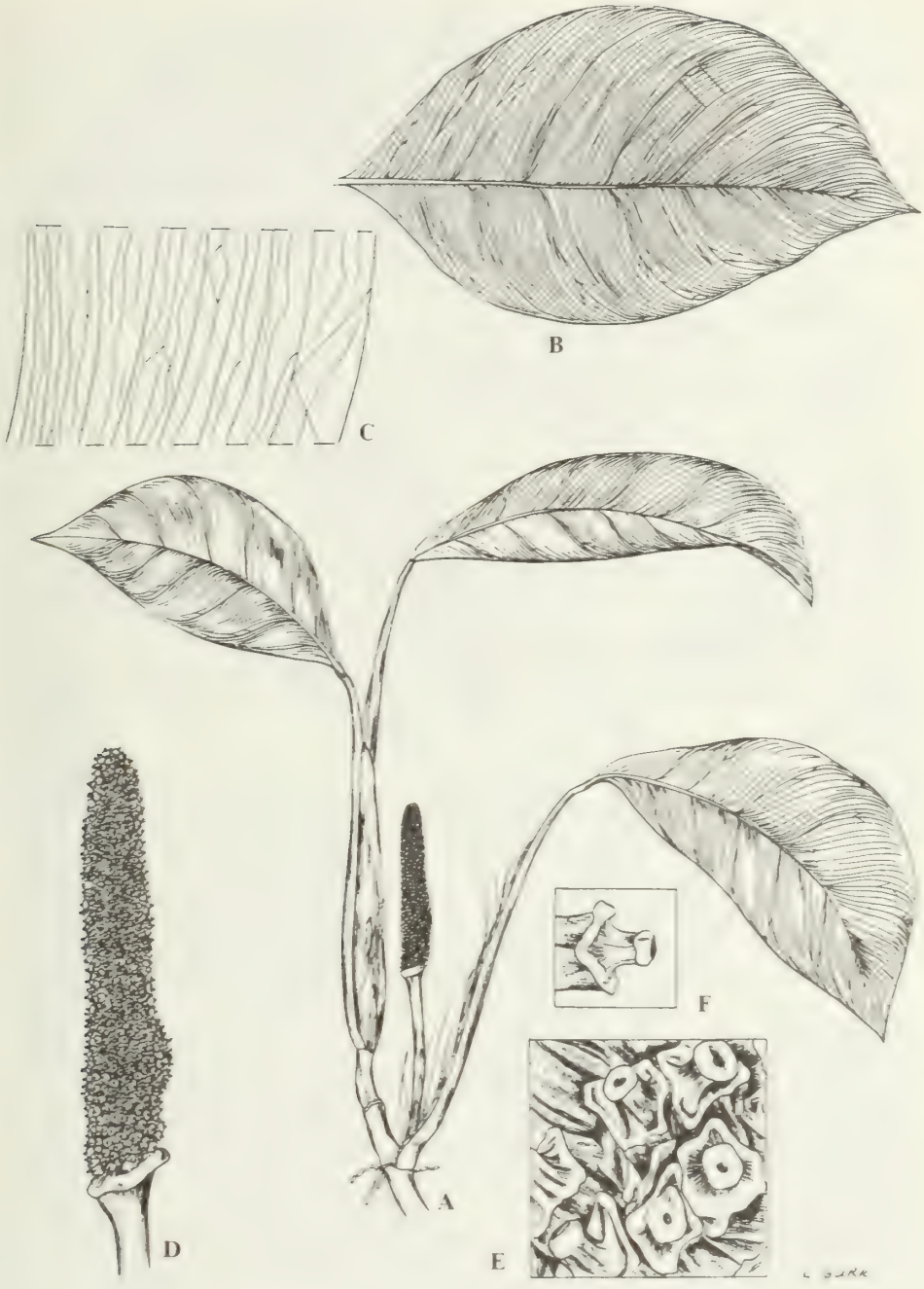

Figure 28. Rhaphidophora spathacea Schott
A. flowering shoot x ⅛; B. leaf lamina x ½; C. venation detail x 3; D. inflorescence, spathe removed x ⅛; E. spadix detail, post-male anthesis x 8; F. stylar region and stigma, side view x 6. All from *Forbes 323*.

lanceolate or oblong-elliptic, slightly oblique, 11—35 x 2.5—18 cm, chartaceous to coriaceous, base rounded to acute, apex acute to acuminate; *midrib* prominently raised abaxially, ± flush adaxially; *primary venation* pinnate, raised abaxially, less so adaxially; *interprimaries* sub-parallel to primaries, slightly to much less prominent than the primaries, slightly raised abaxially, barely visible adaxially; *secondary venation* reticulate, raised, especially conspicuous in dry material; *tertiary venation* minutely reticulate, hardly visible; *inflorescences* two, three or more together, each subtended by a prominent chartaceous prophyll and one or more chartaceous cataphylls, the entire synflorescence emerging from a mass of dried, chartaceous cataphyll remains; *peduncle* slender to stout, terete, partially to completely obscured by cataphylls, 4—12 x 0.2—0.8 cm; *spathe* slender canoe-shaped, hardly to stoutly beaked, 5—13.5 x 2—2.5 cm, stiff-fleshy, lower 0.7—1 cm with connate margins (*fide Nicolson 1580*, but not observed elsewhere), yellow to yellow green, marcescent to early fruiting, eventually falling leaving a prominent scar; *spadix* stoutly cylindrical, sessile, inserted almost level on peduncle, 3—16.5 x 1—1.5 cm, white at male anthesis; *stylar region* conical, mostly hexagonal in top view, 0.9—1.2 x 1—1.1 mm; *stigma* punctiform, very prominently raised, those at the tip of the spadix even more raised, 0.1—0.2 x c. 0.3 mm, glossy and almost black in dried material; *anthers* exserted at male anthesis; *infructescence* stoutly oblong-cylindrical, 6—9 x 1.4—2 cm.

Distribution: Palau, Indonesian Papua, Papua New Guinea (including Woodlark (Muyua) Island), Federated States of Micronesia (Yap).

Habitat: Lowland to lower montane primary to disturbed secondary forest on a variety of substrates including granite, coralline limestone, volcanically-derived soils. Sea-level to 1500 m altitude.

Notes: 1. Most similar to *Rhaphidophora versteegii* but readily separated by the non-shingling juvenile phase and on drying the strongly discolorous leaf laminas of which the abaxial surface is bright orange-brown with copious, minute tannin cells. Further, *R. spathacea* never has perforated leaf laminas.

2. In publishing *R. spathacea*, Schott stated that it was from Java, although both type sheets in L are labelled '*Nov. Guinea*.' The types of *R. spathacea* match very well collections from New Guinea made under the various synonyms proposed above.

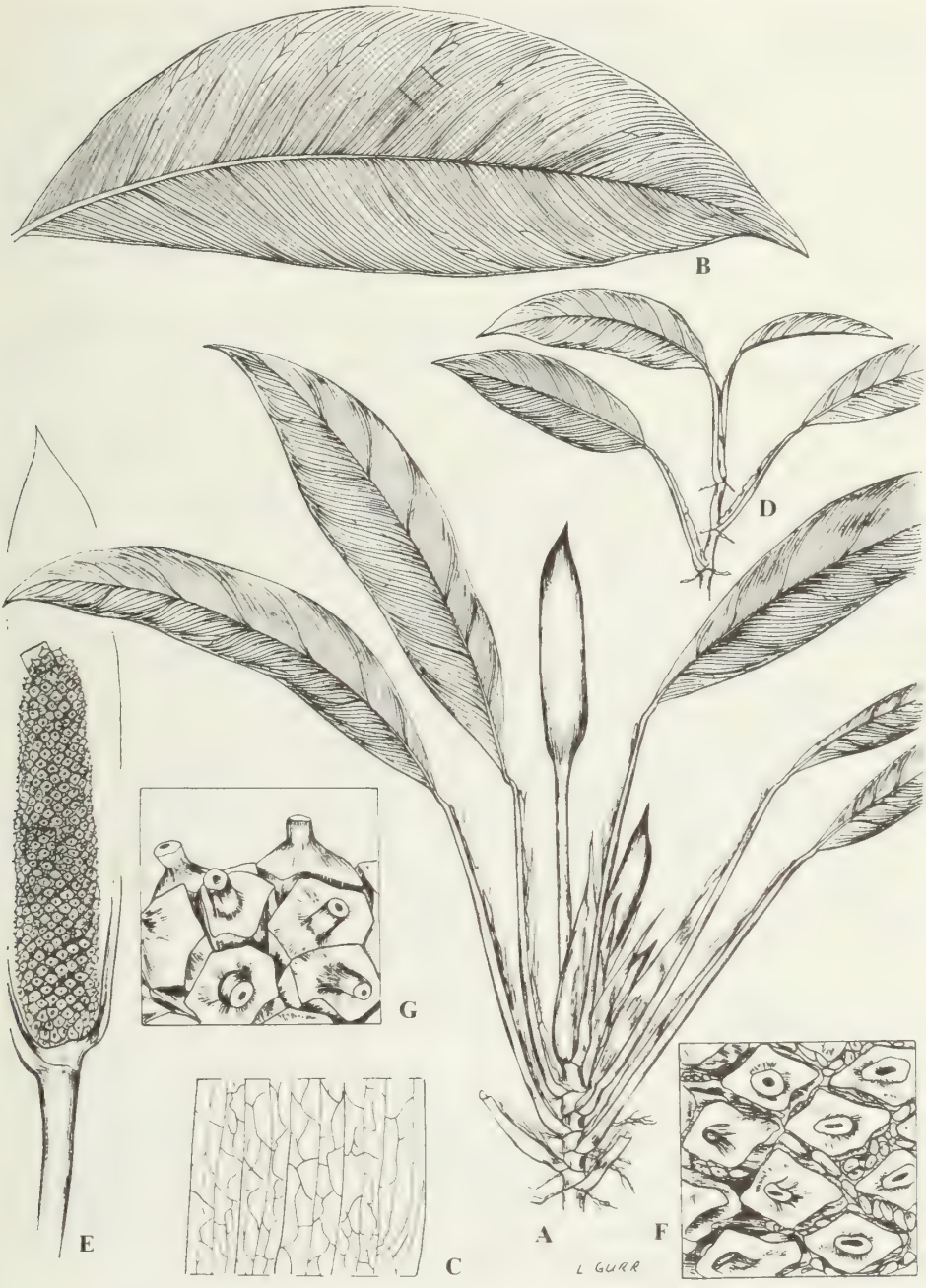

Figure 29. Rhaphidophora spathacea Schott
A. flowering shoot x 1/3; B. leaf lamina x 1/3; C. venation detail x 2; D. pre-adult clinging shoot x 1/3; E. inflorescence, spathe sectioned x 1; F. spadix detail, post male anthesis x 8; G. stylar regions and stigmas at spadix tip x 8. All from *Brass 23847*.

3. The type of *R. engleri* has rather narrow leaves, although other collections from Palau match collections of *R. spathacea* from New Guinea.

4. The holotype of *R. apiculata* K. Krause is notable for the ovate-elliptic leaf laminas with primary and interprimary veins almost indistinguishable. However, the isotype (P) is of a much longer, narrower leaf, which is much closer in appearance to the type of, for example, *R. versteegii* and *R. spathacea*.

5. The type of *R. forbesii* is very incomplete. Nonetheless, the leaf lamina shape and spadix match the type of *R. apiculata* almost exactly.

Other specimens seen: PALAU: Babelthuap: trail along Japanese pipeline between Ngardmau and waterfront, *Bowden-Kerby 5983* (US); Lake Ngardok *Fosberg 32572* (US); Aulupse'el, Dii'ebachal Beach, *Evans 581* (US); Yap: Talgo n Bibau village agroforest, *Falanrum & Faimaw 6795* (US); Angaur: East coast, *Fosberg 31986* (US); Angaur, *Koidzumi s.n.* (TI). INDONESIAN PAPUA. Kepala Burung Prov.: Surroundings of Ayawasi, *Ave 4736* (BO, L); Triton Bay, *Le Guillou 'Triton 48'* (P); 2 km north of Manokwari, west end of Tafelberg F.R., *Nicolson 1580* (B, K, L, P, US); Mimika Prov.: Freeport Concession Area, path east at Mile 50 on road to Tembagapura, *Coode 8037* (BO, K, MAN); Golf Course surrounds, *Johns 9967* (BO, K, MAN); Freeport Concession Area, *Johns 10393* (BO, K, MAN); Golf Course surrounds, *Johns 10431* (BO, K, MAN). PAPUA NEW GUINEA. East Sepik Prov.: vicinity of Malu and April river, *Ledermann 7384* (B spirit); Western Prov., Palmer River, 2 miles below junction of Black River, *Brass 7100* (GH), *Brass 7380* (GH); Central Prov.: Port Moresby, above Boridi village, *Foreman & Vinas LAE 60099* (BRI, L, LAE, US); Morobe Prov.: Along road to Sankwep SE of Lae, c. 10 km beyond Sankwep, *Croat 52808* (MO); North slopes of Mt Missim (Misson), *Croat 52952* (K, MO); Bumbu Logging Area, 7 miles north of Lae, *Nicolson 1386* (B, P, SING, US), *Nicolson 1409* (SING, US); Lae, Sankwep, 10 miles east of Lae, *Streimann NGF 47654* (US); Milne Bay Prov.: Bibiguni Camp, Gwariu River, *Brass 23847* (GH, L, US); Alotau, Kulumadau Island, *Kairo 237* (GH, L); Woodlark (Muyua) Island: Kulumadau, *Brass 28618* (L).

26. Rhaphidophora spuria (Schott) Nicolson

Rhaphidophora spuria (Schott) Nicolson, Allertonia 1 (1978) 348. — *Cuscuaria spuria* Seem. ex Schott, Bonplandia 9: 260, *nom. nud.*; Schott, Bonplandia 9 (1861) 367; Seeman, Viti (1862) 444 & Fl. Vit. (1868) 287; Engl., DC. Monogr. Phan. 2 (1879) 251, *in syn. pro Cuscuaria marantifolia* Schott; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 68, *in syn. pro Scindapsus cuscuaria* (Aubl.) Presl. — Type: Fiji, Viti Levu, 1860, *Seeman 655* (K, holo).

Rhaphidophora storckiana Schott, Bonplandia 10 (1862) 346; Seeman, Fl. Vit. (1868) 287; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908)

43: Parham, Pl. Fiji Isl. (1964) 267; ed.2 (1972) 363. — *Rhaphidophora peepla* var. *storckiana* (Schott) Engl., DC. Monogr. Phan. 2 (1879) 243; Drake, Ill. Fl. Ins. Mar. Pac. (1892) 326. — Type: Fiji, Ovalau, 1862, *Storck 911* (K, holo; BM, iso).

Rhaphidophora reineckei Engl., Bot. Jahrb. Syst. 25 (1898) 9; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 41, **synon. nov.** — Type: Western Samoa, Savai'i, 1894, *Reinecke 594* (B, holo).

Rhaphidophora graeffei Engl., Bot. Jahrb. Syst. 25 (1898) 9; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 40, **synon. nov.** — Type: Western Samoa, Upolu, *Graeff 73* (B, holo).

Figure 30

Moderate to large, robust, semi-pachycaul homeophyllous liane to 15 m; *seedling stage* not observed; *pre-adult plants* forming small terrestrial colonies; *adult shoot architecture* comprised of elongated, clinging, physiognomically unbranched, leafy, non-flowering stems and short, usually unbranched, free, sympodial, densely leafy, flowering stems; *stems* smooth, terete in cross-section, with sparse prophyll, cataphyll and petiolar sheath fibre, this soon falling, internodes 0.5—8 x 0.5—2 cm on clinging shoots, usually shorter and stouter on free shoots, separated by large, straight, corky leaf scars, older stems woody; *flagellate foraging stems* absent; *clasping roots* densely arising from the nodes and internodes of clinging stems, notably pubescent; *feeding roots* not observed; *leaves* weakly spiro-distichous on clinging and free shoots; *cataphylls* and *prophylls* membranous, quickly drying and degrading into sparse fibres, these soon falling; *petiole* deeply canaliculate, 14—66 x 0.3—0.1.5 cm, apical and basal geniculum moderately prominent; *petiolar sheath* prominent, extending to the apical geniculum, swiftly drying and degrading into sparse, soon-falling fibres; *lamina* entire, ovate-oblong to oblong-lanceolate or oblong-elliptic, sometimes slightly oblique, occasionally falcate, 5.7—76 x 2.5—32 cm, thinly to quite coriaceous (larger laminas tending to be thinner textured), often drying strongly discolorous, adaxially mid-brown, abaxially pale brown, base unequal, cuneate to rounded, subtruncate or weakly cordate, where present basal 'lobes' more developed on one side, apex acute to obtuse, acuminate with a prominent, short tubule; *midrib* prominently raised abaxially, ± sunken adaxially; *primary venation* pinnate, raised abaxially and adaxially; *interprimaries* sub-parallel to primaries, hardly less prominent, slightly raised abaxially and adaxially; *secondary venation* reticulate, slightly raised; *inflorescence* solitary to several together, strongly sweet-fragrant, if solitary

then subtended by a partially to fully developed foliage leaf, if more then one than subsequent inflorescences each subtended by a soon-degrading membranous prophyll and cataphyll; *peduncle* compressed-terete, often with a deep longitudinal sulcus on the shoot side, 5—19 x 0.25—1 cm; *spathe* broadly canoe-shaped, stoutly beaked, 9.5—16 x 2.5—5.5 cm (up to c. 7 cm wide when flattened out), stiff-fleshy, cream at male anthesis, caducous leaving a large, straight scar; *spadix* cylindrical, inserted ± level to somewhat obliquely on peduncle, 6.2—15.5 x 1.2—1.5 cm, creamy white at male anthesis; *stylar region* mostly hexagonal, 1.6—2.4 x c. 2 mm diam., truncate, area around stigma sunken; *stigma* punctiform to slightly ellipsoid, c. 0.5—0.7 mm x 0.5 mm; *anthers* exserted at male anthesis; *infructescence* stoutly oblong to tapering-cylindrical, 10—12 x 1.1—2.5 cm.

Distribution: Papua New Guinea (Western Prov.), Solomon Islands (Guadalcanal, New Georgia, San Cristobal and the Santa Cruz Group), Fiji, Western and American Samoa.

Habitat: Well-drained primary and secondary lowland to upper hill forest, on rocky, red soils. 30– 1000 m altitude.

Notes: 1. *Rhaphidophora spuria* is the only entire-leaved *Rhaphidophora* indigenous to Fiji and Samoa. Examination of the types of *R. spuria*, *R. graeffei* and *R. reineckei* reveals no characters separating these species hitherto recognized as endemic for Fiji (*R. spuria*) and the Samoan islands (*R. graeffei* and *R. reineckei*). The earliest name, *R. spuria*, is adopted here.

2. *Rhaphidophora spuria* is most similar to *R. intonsa* from Papua New Guinea (Morobe and Central Prov.) but may be readily distinguished by the truncate to weakly cordate lamina base and in having very much less fibre at the shoot tips.

3. Despite the geographical disjunction, the single collection from mainland Papua New Guinea is of this species, matching the Pacific plants in vegetative and floral characters.

Other specimens seen: PAPUA NEW GUINEA. Western Prov.: Fly River, Madiri Plantation, *Womersley & Simmonds 5047* (GH). SOLOMON ISLANDS. New Georgia: Hovoro, *Cowmeadow's collectors BSIP 3791* (BSIP, K, SING); San Cristobal: Ridge west of Warahito, *Hunt RSS 2297* (BSIP, K, L); Santa Cruz Group: Vanikolo (Vanikoro) Island, *Kajewski 584* (GH, K); Guadalcanal: adjacent to Tina River, 12 miles inland from coast, *Womersley & Whitmore BSIP 1110* (BSIP, K, L, SING). FIJI. No further data, *Capt. Wilkes Exped. s.n.* (US); Viti Levu: Nausori Highlands, 16 km from Bukika Sawmill, *Melville & Melville*

Figure 30. Rhaphidophora spuria (Schott) Nicolson
A. flowering shoot x ⅛; B. leaf x ⅛; C. spadix detail, male anthesis x 10. A from *Kajewski 584*; B from *Teraoka & Kennedy 64*; C from *Smith 8653*.

71.998 (K); Naitasiri, Colo-I-Suva, *Parham 11246* (K); MBA, vicinity of Nalotawa, eastern base of Mt Evans Range, *Smith 4443* (US); Namosi, northern base of Korombasambasanga Range, in drainage of Wainavindrau Creek, *Smith 8653* (K, L, P, US); Namosi, hills east of Wainikoroiluva River, near Namuamua, *Smith 8947* (K, L, P, US). Kadavu (Kandavu), Namalata Isthmus region, *Smith 29* (K, P, US); WESTERN SAMOA. Upolu: Lake Lanuto'o, *Christophersen 402* (BISH, K); Above Vaipouli, *Christophersen & Hume 1902* (BISH, K, P, US); Tapatapa, *Cox 34* (K); Near Lotofaga, Lafulemu Ranch (property of Fay Ala'ilima), west of Fagatola River, c. 0.5 km NW of the bridge, *Teraoka & Kennedy 64* (US); Near Mt Leou'e, *Whistler 743* (B, US); Savai'i: Salailua,*Christophersen 2956* (BISH, K, P); La Vai, above Salailua *Christophersen 3004* (BISH, US); Above Asau, Block 28, *Whistler 1036* (B, US). AMERICAN SAMOA. Pago Pago, *Meebold 8209* (K).

27. Rhaphidophora stenophylla K. Krause

Rhaphidophora stenophylla K. Krause, Bot. Jahrb. Syst. 49 (1912) 94. — Type: Papua New Guinea ('Kaiser Wilhelmsland'), East Sepik Prov., Djamu, 22 April 1908, *Schlechter 17581* (B, holo†; P, iso).

Figure 31

Large, rather robust, semi-leptocaul, homeophyllous liane to unknown ultimate height; *seedling stage* very slender terrestrial to climbing, leaves arranged in two ranks; *pre-adult plants* clinging, slender, with very narrow leaves; *adult shoot* comprised of elongated, clinging, physiognomically unbranched, non-flowering stems and free lateral, leafy flowering stems; *stems* terete to strongly compressed, but not rectangular in cross-section, without cataphyll, prophyll and petiolar sheath fibre, internodes 1—3 x 0.2—2 cm, separated by prominent almost straight, slightly corky leaf scars; *flagellate foraging stem* absent; *clasping roots* arising from nodes and internodes; *feeding roots* not observed; *leaves* spiro-distichous in mature plants; *cataphylls* and *prophylls* caducous; *petiole* deeply canaliculate, 2—16 x 0.2—1 cm, apical geniculum small and very obscure, basal geniculum weakly defined; *petiolar sheath* very prominent, broadly winged and extending to apical geniculum, persistent almost through to leaf fall; *lamina* entire, linear-lanceolate to narrowly lanceolate or narrowly oblong-lanceolate, slightly falcate, 9—38 x 1.5—4 cm, subcoriaceous, base subacute to slightly decurrent, apex acute to briefly acuminate with a prominent tubule; *midrib* raised abaxially, sunken adaxially; *primary venation* pinnate, slightly raised abaxially, almost flush adaxially; *interprimaries* reticulate-parallel to primaries, almost indistinguishable from them, slightly raised abaxially, almost flush adaxially; *secondary venation* reticulate, hardly visible; *inflorescence* solitary, subtended by a ± fully developed foliage leaf; *peduncle* slightly laterally compressed to terete, 6—10 x c. 1 cm; *spathe* broadly canoe-shaped, stoutly long-beaked, 11—13 x 1.5—2.5 cm, stiffly

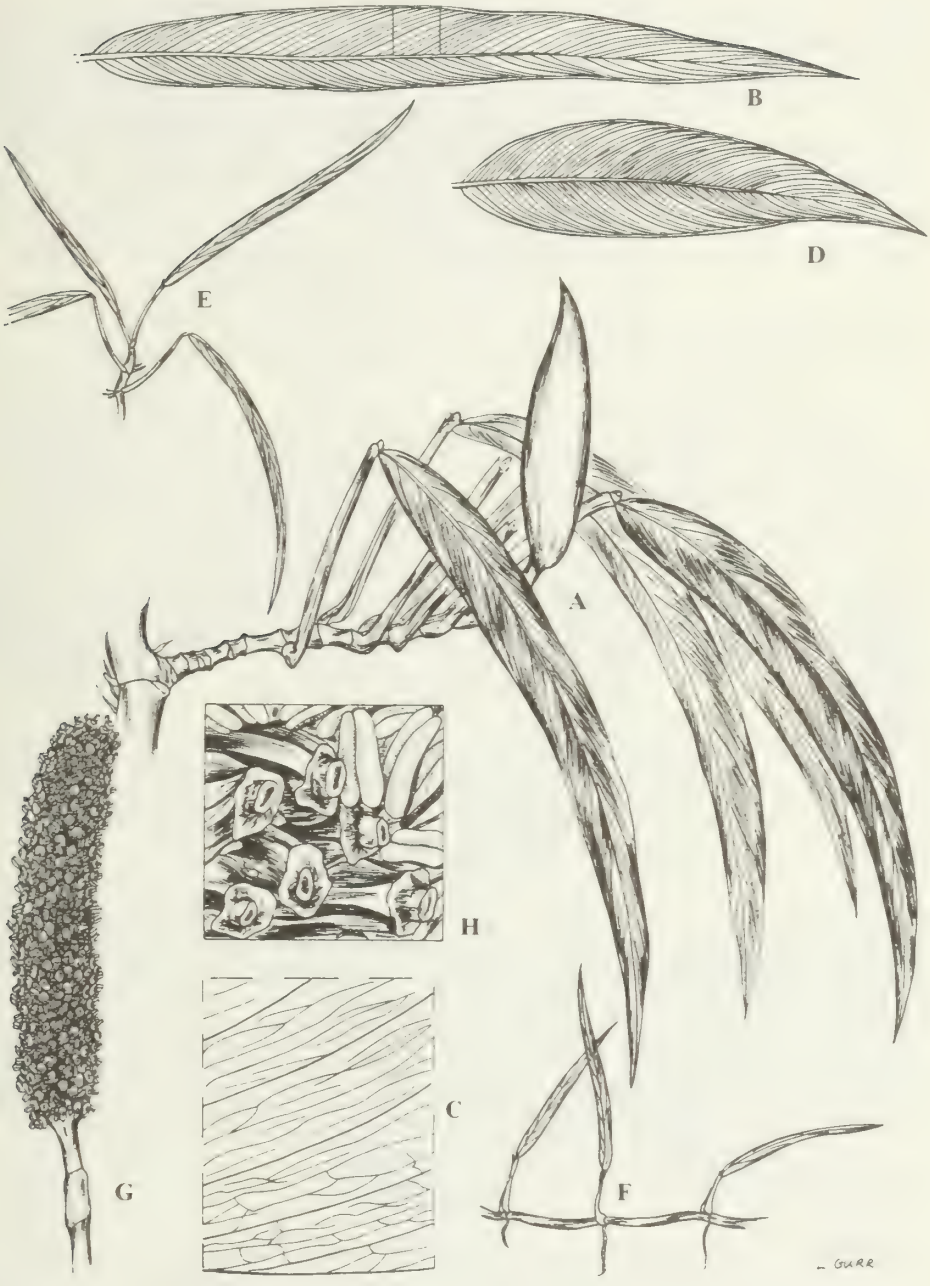

Figure 31. Rhaphidophora stenophylla K. Krause
A. adult shoot with flowering branch x [illegible]; B. leaf lamina x [illegible]; C. venation detail x 3; D. leaf lamina x [illegible]; E. pre-adult clinging shoot x [illegible]; F. pre-adult creeping shoot x [illegible]; G. inflorescence, spathe fallen x 1; H. spadix detail, male anthesis x 6. A-C, E & F from *Nicolson 1430*; D, G-H from *Streimann NGF 44247*.

fleshy, yellow, caducous leaving a large scar at the base of the spadix; *spadix* cylindrical, slightly curved, long stipitate, 6—9 x 1.5—2.2 cm, inserted level to almost truncate on stipe, white; *stipe* slender to stoutly terete, 2.5—3 x 3—0.4 cm; *stylar region* rhombohexagonal, 1—2 x 1—1.5 mm, conical; *stigma* punctiform, prominently raised, c. 0.3 mm diam.; *anthers* strongly exserted at male anthesis; *infructescence* not observed.

Distribution: Papua New Guinea (including the Louisiade Archipelago).

Habitat: Monsoon lower montane forest to submontane primary forest on moderate to steep slopes, sometimes on limestone. 20–940 m altitude.

Notes: 1. Unmistakable by the long, narrow leaves, persistent winged petiolar sheath, long stipitate spadix and prominently raised stigma. There exist plants with broader laminas than typical (*Brass 27691* & *28311* are of this broad-leaf type) that may be confused with *Rhaphidophora discolor* (also flowering on free shoots and with long-stipitate spadix), although the latter is readily distinguished by the broader leaf laminas, petiolar sheath degrading to strips and fibres, larger (13.5—19 x 2.2—4 cm) spadix and flat stigmas.

2. *Scindapsus schlechteri* K. Krause is superficially similar in its narrow leaf lamina and persistent-winged petioles but differs, aside from a single ovule per ovary (and thus one-seeded fruits), by the sessile spadix and thicker leaf lamina with almost no visible venation.

Other specimens seen: PAPUA NEW GUINEA. West Sepik Prov.: Telefomin, Sandaun, Hak Valley, Gentry transect on slope above Nenem, SE of Mianmin Airstrip, *Frodin & Morren 3155* (K); East Sepik Prov.: vicinity of Malu & April river, *Ledermann 8614* (B spirit); Central Prov.: Port Moresby, Koitaki (c. 30 km WNW of Port Moresby), *Carr 12218* (BM, SING); Sogeri Plateau, 5-7 miles beyond Kokoda Trail Monument, 30 miles east of Port Moresby, *Nicolson 1430* (K, L, P, SING, US); Milne Bay Prov.: Louisiade Archipelago, Rossel and Misima Island, Narian, *Brass 27691* (GH, L); Abaleti, *Brass 28311* (L); Morobe Prov.: Wau, Bulolo, Middle L.A., *Streimann NGF 44247* (GH, K, LAE, SING, US).

28. Rhaphidophora stolleana Engl. & K. Krause

Rhaphidophora stolleana Engl. & K. Krause, Bot. Jahrb. Syst. 54 (1916) 79. — Type: Papua New Guinea, East Sepik Prov., April River, 24 May 1912, *Ledermann 7382* (B, holo).

Figure 32

Moderate, somewhat robust, semi-leptocaul, homeophyllous (?) liane

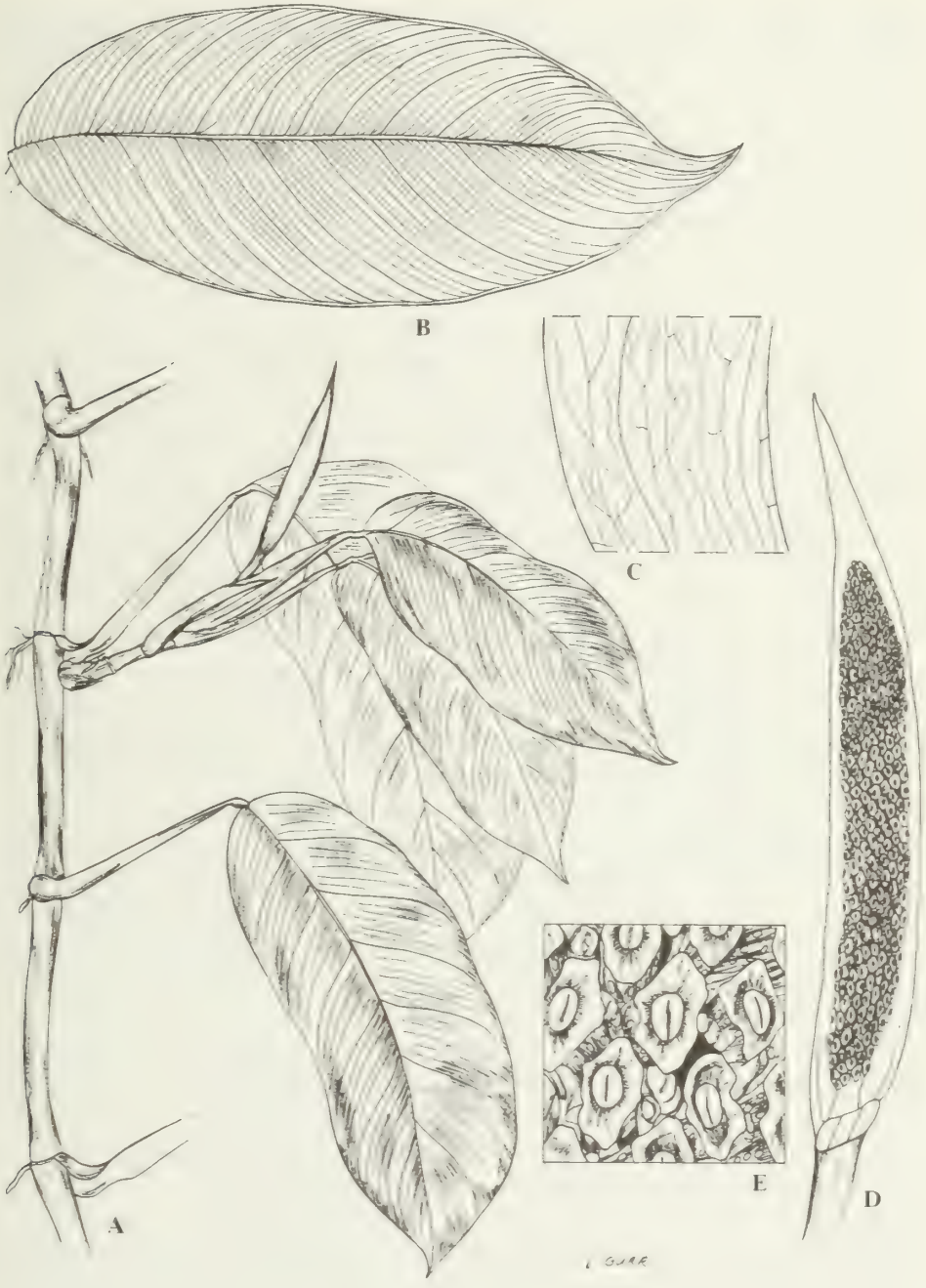

Figure 32. Rhaphidophora stolleana Engl. & K. Krause
A. adult shoot with flowering branch x ⅛; B. leaf lamina x ⅛; C. venation detail x 3; D. inflorescence, spathe sectioned x 1½; E. spadix detail, post-male anthesis x 8. All from *Ledermann 7382*.

unknown ultimate height; *seedling* and *pre-adult plants* not observed; *adult shoot architecture* not completely known, but observed to comprise of greatly elongated, strongly pendent, physiognomically unbranched, leafy, non-flowering stems giving rise to abbreviated short, free, sympodial, flowering stems; *stems* smooth, climbing stems not observed, free stems weakly four angled to ± terete in cross-section, occasionally with two close longitudinal keels along one side, dull pale yellow brown, without prophyll, cataphyll and petiolar sheath fibres, internodes to 13.5 x 1 cm, flowering shoots abbreviated, arising from just above the axils of leaves and twisting to present inflorescences upwards; *flagellate foraging stems* not observed; *clasping roots* arising singly from the nodes and internodes, slightly pubescent; *feeding roots* not observed; *leaves* very weakly spiralled, scattered; *cataphylls* and *prophylls* membranous, caducous; *petiole* shallowly canaliculate, 13—14 x 0.35—0.7 cm, smooth, with a well defined apical and large, slightly prominent basal geniculum; *petiolar sheath* very prominent, extending to apical geniculum, swiftly caducous leaving a slight scar; *lamina* entire, elliptic to oblong-elliptic, 20—29 x 8—13 cm, membranous, drying discolorous, adaxially mid-brown, abaxially pale orange-brown, base subovate, very briefly decurrent, apex acute to briefly acuminate, slightly falcate with a minute apiculate tubule; *midrib* slightly raised abaxially, sunken adaxially; *primary venation* pinnate, slightly raised abaxially; *interprimaries* parallel to primaries, occasionally slightly reticulated, slightly raised abaxially; *secondary* and *tertiary venation* reticulate, prominent abaxially in dried specimens; *inflorescence* solitary, subtended by a foliage leaf; *peduncle* terete, c. 6 x 0.3 cm; *spathe* elongate-cylindric, stoutly short-beaked, c. 10.2 x 1.7 cm, thinly stiff-coriaceous, duration unknown; *spadix* slender cylindrical, sessile, inserted very obliquely on to the peduncle, c. 8 x 1.1 cm; *stylar region* rhombohexagonal, 1—1.2 x c. 1 mm, truncate; *stigma* slightly longitudinally elongate to punctiform, c. 0.4 x 0.25 mm; *anthers* exsertion not observed; *infructescence* not observed.

Distribution: Papua New Guinea (East Sepik Prov.). Known only from the type.

Habitat: Lowland riverine forest. 20–50 m altitude.

Note: In its growth form, with long pendent stems with abbreviated flowering shoots arising in the leaf axils, *Rhaphidophora stolleana* resembles *R. brevispathacea*. The inflorescences are, however, quite different, with the spathe ovoid-cylindrical, 3—4 cm long, spadix slender cylindrical, 2.9—3.4 cm long in *R. brevispathacea* v. the spathe c. 10.2 cm long, spadix c. 8 cm

long in *R. stolleana*. To date, *R. stolleana* is known only from East Sepik and *R. brevispathacea* only from Mimika/Digul Province.

29. Rhaphidophora versteegii Engl. & K. Krause

Rhaphidophora versteegii Engl. & K. Krause, Nova Guinea 8 (1910) 248, Nova Guinea 8 (1912) 805; K. Krause & Alderw., Nova Guinea 14 (1924) 213. — Type: Indonesian Papua, Mimika/Digul border, near Sabang, 25 June 1907, *Versteeg 1308* (B, holo; BO, L, K, iso).

Rhaphidophora ledermannii Engl. & K. Krause, Bot. Jahrb. Syst. 54 (1916) 81; Hay, Aroids of Papua New Guinea (1990) Pl. XIV, b, **synon. nov.** — Type: Papua New Guinea, West Sepik Prov. (Felsspitz), 7 Aug. 1913, *Ledermann 12684* (B, lecto; selected here). Engler & Krause cited two syntypes, the other, Papua New Guinea, West Sepik (Felsspitz), Aug. 1913, *Ledermann 12722*, is missing from Berlin and presumed destroyed.

Figures 33 & 34

Robust, large, pachycaul, heterophyllous liane to 20 m; *seedling stage* not observed; *pre-adult plants* shingling; *adult shoot architecture* comprised of clinging, physiognomically unbranched, densely leafy flowering stems; *stems* smooth, mid-green, with cataphylls and prophylls persistent and drying dark yellow, degrading into parchment-like remains, internodes 1—4 x 0.4—2.5 cm, separated by very prominent slightly oblique leaf scars; *flagellate foraging stem* absent; *clasping roots* densely arising from the nodes and internodes, smooth and drying with parchment-like epidermis; *feeding roots* not observed; *leaves* distichous; *cataphylls* and *prophylls* chartaceous, degrading into strips of tissue and weak fibres at tips of flowering shoots; *petiole* deeply canaliculate, 8—48 x 0.4—0.8 cm, smooth, with faint to rather prominent dark dense speckling, apical geniculum prominent, basal geniculum very large but not prominent; *petiolar sheath* extending to apical geniculum, broad, chartaceous, short-persistent, degrading to papery strips and sparse fibres, then falling; *shingling lamina* entire, cordiform, 2.5—7.5 x 3—6.5, chartaceous, base cordate, posterior lobes overlapping, apex obtuse and minutely apiculate; *adult lamina* entire to slightly or extensively perforated, perforations elliptic to rhombic, extending from c. + to entire width of lamina on each side of the midrib, lamina ovate-elliptic to oblong-lanceolate or oblong-elliptic, slightly oblique, 33—57 x 9.5—27 cm, submembranous, drying pale grey-green to bright green, base rounded to acute, apex acute to acuminate; *midrib* prominently raised abaxially, ± flush adaxially; *primary venation* pinnate, prominently raised abaxially, weakly

so adaxially; *interprimaries* sub-parallel to primaries, less prominent than interprimaries, slightly raised abaxially and adaxially; *secondary venation* feebly reticulate to subtesselate; *inflorescence* very rarely solitary, usually several together, each subtended by a prominent chartaceous prophyll and one or more chartaceous cataphylls, the entire synflorescence emerging from a mass of dried, chartaceous cataphyll remains; *peduncle* slender to stout, terete, partially to completely obscured by cataphylls, 4—12 x 0.2—0.8 cm; *spathe* slender canoe-shaped, hardly to stoutly beaked, 5—10.5 x 1—2 cm, stiff-fleshy, very thick-walled (up to 1 cm at tip), yellow to yellow green, marcescent to early fruiting, eventually falling leaving a prominent scar; *spadix* stoutly cylindrical, sessile, inserted almost level on peduncle, 3—9.5 x 1—1.5 cm, white at male anthesis; *stylar region* conical, mostly hexagonal in top view, 0.9—1.2 x 1—1.1 mm; *stigma* punctiform, very prominently raised, those at the tip of the spadix even more raised, 0.1—0.2 x c. 0.3 mm, glossy, almost black in dried material; *anthers* exserted at male anthesis; *infructescence* stoutly oblong-cylindrical, 6—9 x 1.4—2 cm.

Distribution: Indonesian Papua, Papua New Guinea (including New Ireland). Seemingly widespread but, based on known collections, perhaps not common.

Habitat: Lowland to lower montane primary to secondary rain forest on clays and silts. Sea level to 1500 m altitude.

Notes: 1. *Rhaphidophora versteegii* is most similar to *R. spathacea* in having clusters of inflorescences subtended and interspersed by chartaceous prophylls and cataphylls. It is readily identifiable, and distinguished from *R. spathacea*, by the distinctive pale grey-green colour of dried material and the form of the juvenile growth phase. Further, leaf lamina perforations occur in most (but not all) individuals of *R. versteegii*; laminas of *R. spathacea* are never perforated. The arrangement and shape of the juvenile shingling leaves of *R. versteegii* are unique in the genus although known from only one collection (*Croat 5252*).

2. The type of *R. ledermannii* differs primarily in the perforation of the leaf lamina (*R. ledermannii* has profoundly perforated laminas) and as such appears to represent distinct species. However, the occurrence of perforated and unperforated laminas in different plants of the same species is not rare, e.g. *R. puberula* Engl., *R. megasperma* Engl. (see Boyce 1999, 2001) and its occurrence in *R. ledermannii* is not sufficient to warrant segregating the two species. Furthermore, a suite of characters – clustered inflorescences arising on clinging stems and subtended by chartaceous, later weakly fibrous

Figure 33. Rhaphidophora versteegii Engl. & K. Krause
A. flowering shoot x 1/6; B. leaf lamina x 1/4; C. venation detail x 3; D. juvenile shingling stage, adaxial view x 1/3; E. juvenile shingling stage, abaxial view x 1/3; F. inflorescence, spathe removed x 1; G. spadix detail, post-male anthesis x 8; H. spadix detail, early fruiting x 8; J. stylar region and stigma, side view x 4. All from *Croat 52752*.

prophylls and cataphylls, stoutly cigar-shaped spathes, prominently raised and, compared with style diameter, large, glossy black stigmas and petioles with small speckles (tannin cells?) - leaves little doubt that one species is involved.

3. Perforated leaf laminas occur in a number of otherwise unrelated *Rhaphidophora* species (e.g., *R. foraminifera* (Engl.) Engl., *R. puberula*, *R. versteegii*, *R. pertusa* (Roxb.) Schott) suggesting that while a useful diagnostic tool, lamina perforation cannot be used to circumscribe taxonomically meaningful groups within *Rhaphidophora*.

Other specimens seen: INDONESIAN PAPUA. No locality, *Docters van Leeuwen III74* (L); Mimika/Digul Prov. boundary: Lorentz River, near Bivakeiland, *Pulle 44* (B spirit, L, K), *Pulle 67* (L, K). PAPUA NEW GUINEA. East Sepik Prov.: vicinity of Wewak, along trail beyond Boys Town (reform school operated by S.V.D. Missionaries), *Croat 52752* (MO); Southern Highlands Prov.: Aria, near Veta, *Aet 375* (L); Gulf Prov.: Baimuru, Vailala River, 70 km at 110 from Baimuru, 50 km at 318 from Kerema, *Croft et al. LAE 61251* (L, LAE); New Ireland: Lamet, NW Lavongai (New Hanover), 5km S of Lai Bay, *Croft & Lelean LAE 65461* (E, GH, K, L, LAE, M).

30. Rhaphidophora waria P.C. Boyce, *sp. nov.*

Vicinitate in donatione inflorescentiae condita, *Rhaphidophora waria R. spathaceae* proxima est, sed foliorum laminis minoribus angustioribus magis rigidioribus venis lateralibus primatiis eis interprimariis clare inter se diversis, spadice stiptato, stigatibus profunde excavatis differt. — TYPUS: Papua New Guinea, East Sepik Prov., Ambunti, along Yapa (Hunstein) River, 1 Aug. 1966, *Hoogland & Craven* 10796 (L, holo; GH, K, L, LAE, CANB, iso).

Figure 35

Small but robust pachycaul, homeophyllous (?) liane to unknown ultimate height; *seedling stage* not observed; *pre-adult plants* climbing with leaves arranged in two ranks and distinctive by the conspicuous yellow chartaceous petiolar sheaths; *adult shoot architecture* comprised of clinging, physiognomically unbranched, densely leafy flowering stems; *stems* with conspicuous smooth papery epidermis and cataphylls and prophylls persistent and drying dark yellow, then degrading into parchment-like remains and fibres, internodes 1—2.5 x 0.3—0.9 cm, separated by almost straight leaf scars; *flagellate foraging stem* absent; *clasping roots* densely arising from the nodes and internodes, minutely pubescent; *feeding roots* not observed; *leaves* distichous; *cataphylls* and *prophylls* thinly but stiffly chartaceous, eventually degrading into strips of tissue and fibres, particularly

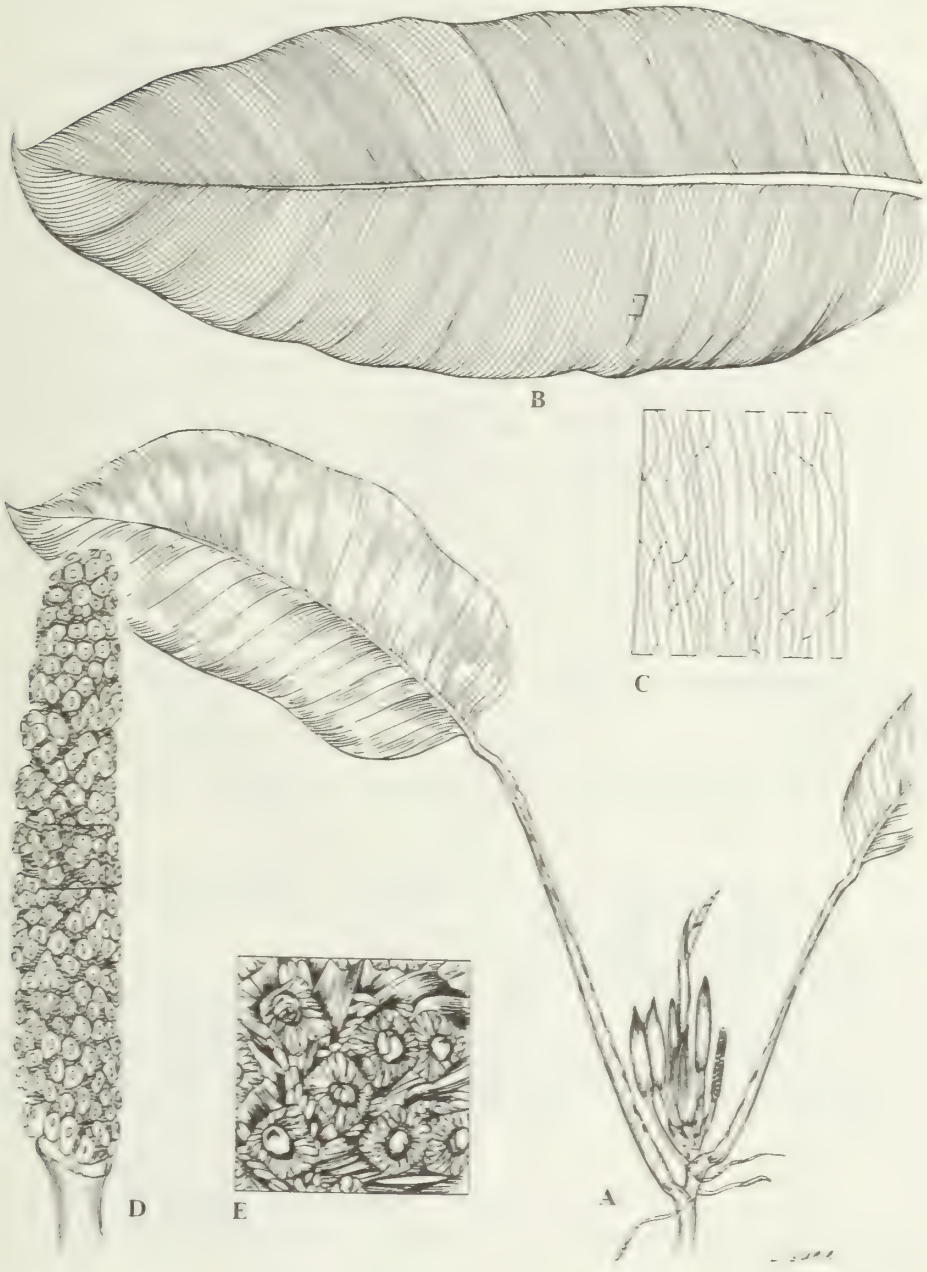

Figure 34. Rhaphidophora versteegii Engl. & K. Krause
A. flowering shoot x ½; B. leaf lamina x ¼; C. venation detail x 4; D. inflorescence, spathe removed x 2; E. spadix detail, pre-anthesis x 8. A from *Versteeg 1308*; B-E from *Croft & Lelean LAE 65461*.

at tips of flowering shoots; *petiole* deeply canaliculate, 3—15 x 0.2—0.4 cm, smooth, apical geniculum weakly prominent, basal geniculum slightly less so and mostly obscured by cataphyll remains; *petiolar sheath* extending to apical geniculum, persistent, eventually degrading in strips leaving fibres; *lamina* entire, lanceolate to elliptic, falcate, 6—23 x 1.5—5 cm, stiffly coriaceous, apex acute, briefly acuminate; *midrib* raised abaxially, sunken adaxially; *primary venation* pinnate, raised abaxially, slightly less raised adaxially; *interprimaries* sub-parallel to primaries and less conspicuous; *secondary venation* tessellate-reticulate, raised abaxially, nearly flush abaxially; *tertiary venation* similar to secondary venation although more or less invisible; *inflorescences* several together, each subtended by a prominent chartaceous prophyll and one or more chartaceous cataphylls, the entire synflorescence emerging from a mass of cataphyll remains; *peduncle* stout, terete to laterally compressed, obscured by cataphylls, 2—4 x 0.3—0.35 cm; *spathe* canoe-shaped, slightly stoutly beaked, 4—5.5 x 1.5—2 cm, stiff-fleshy, duration unknown; *spadix* cylindrical, stipitate, c. 3.2 x 0.9 cm, cream; *stipe* 2—3 mm; *stylar region* rounded-conical, almost circular in plan view, 0.25—0.4 mm diam.; *stigma* deeply excavated, c. 0.2 mm diam.; *anthers* not exserted at male anthesis; *infructescence* not observed.

Distribution: Indonesian Papua (Mimika Prov.) and Papua New Guinea (East Sepik Prov.).

Habitat: Stunted forest and mixed heath forest on steep slopes. 200–580 m altitude.

Notes: 1. Based on inflorescence presentation, *Rhaphidophora waria* is close to *R. spathacea* but differs in the smaller, narrower, much stiffer leaf laminas with the primary lateral and interprimary veins clearly differentiated from one another, the stipitate spadix and the deeply excavated stigmas.

2. The specific epithet is taken from the Wasuk name 'waria' for the plant, which is recorded on the type specimen label. It does not refer to the Waria valley.

Other specimen seen: INDONESIAN PAPUA. Mimika Prov.: Freeport Concession Area, *Garcinia* site on road, *Johns 10418* (BO, K, MAN).

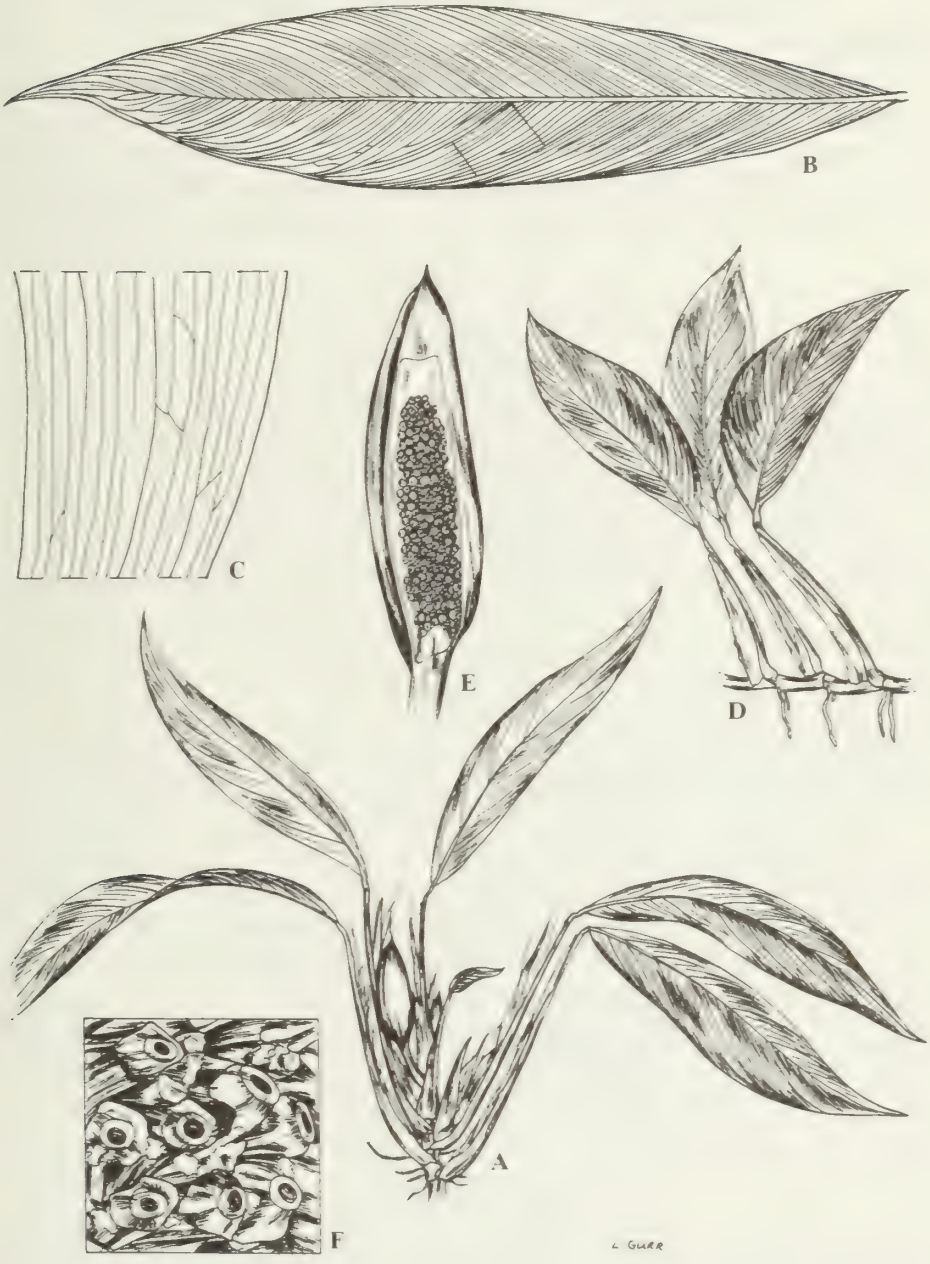

Figure 35. Rhaphidophora waria P.C. Boyce
A. flowering shoot x ⅛; B. leaf lamina x ⅛; C. venation detail x 3; D. juvenile creeping stage x ⅛; E. inflorescence, spathe sectioned x 1; F. spadix detail, post-male anthesis x 8. All from *Hoogland & Craven 10796*.

Insufficiently known species

Rhaphidophora dahlii Engl.

Rhaphidophora dahlii Engl., Bot. Jahrb. Syst. 25 (1898) 8; K. Schum. & Lauterbach, Fl. Schutzgeb. Südsee (1900) 211; Engl. & K. Krause in Engl., Pflanzenr. 37 (IV.23B) (1908) 33. — Type: Papua New Guinea, East New Britain, Gazelle Peninsula, Ralum, Jan. 1897, *Dahl s.n.* (B†, holo).

With no extant type, no spirit material in B (where the rich spirit collection is occasionally a source of type material in the absence of a dried type specimen), no specimens annotated by Engler or Krause (who presumably would have been familiar with, and have annotated, authentic material), and an ambiguous protologue, it is impossible to unequivocally ascribe the name *R. dahlii* to any known species.

On the face of it, attempts to match Engler's protologue to known *Rhaphidophora* in the Bismarck Archipelago should be straightforward. There are only five *Rhaphidophora* species present on New Britain (*R. conica*, *R. hayi*, *R. jubata*, *R. korthalsii* and *R. mima*) and two (*R. hayi* and *R. schlechteri*) on nearby New Ireland. Of these, *R. korthalsii* and *R. hayi* may be immediately discounted since neither is remotely similar to the vegetative characters described for *R. dahlii*. Of the remaining four species, *R. schlechteri* can be ruled out because of its stipitate spadix (that of *R. dahlii* is described as sessile), and *R. jubata* because it is far too large (petiole to 85 cm long, lamina to 90 cm long, spathe 16—24 cm, spadix 13—21 v. petiole to 14 cm, lamina to 24 cm, spathe c. 4 cm, spadix to 3 cm in *R. dahlii*). The remaining species, *R. conica* and *R. mima*, are both possible candidates, but there remain several problems, not least of which is that while in description rather similar to *R. dahlii*, *R. conica* and *R. mima* are clearly distinguishable from one another on characters such as spathe persistence and shape of the stylar region, characters that are either not or only scantily recorded by Engler for *R. dahlii*. Thus it is impossible to be certain if either or neither is attributable to *R. dahlii*.

Excluded species

Rhaphidophora amplissima Schott = **Epipremnum amplissimum** (Schott) Engl.
Rhaphidophora carolinensis (Volk.) Fosberg = **Epipremnum carolinense** Volk.
Rhaphidophora cunninghamii Schott = **Epipremnum pinnatum** (L.) Engl.

Rhaphidophora koidzumii Kanehira = **Epipremnum carolinense**
Rhaphidophora lovellae F.M. Bailey = **Epipremnum pinnatum**
Rhaphidophora neocaledonica Guillaumin = **Epipremnum pinnatum**
Rhaphidophora pinnata (L.) Schott = **Epipremnum pinnatum**
Rhaphidophora pertusa var. *vitiensis* (Schott) Engl. = **Epipremnum pinnatum**
Rhaphidophora vitiensis Schott = **Epipremnum pinnatum**
Rhaphidophora zippeliana Schott = **Amydrium zippelianum** (Schott) Nicolson

Acknowledgements

Thanks are due to Linda Gurr, Pat Davis and Emmanuel Papadopoulos for skillfully executing the illustrations that accompany this article, and to Dr Alan Radcliffe-Smith for the Latin translations of the diagnoses. Thanks also to Dr Alistair Hay (NSW) who critically reviewed the manuscript and offered much useful advice and to Dr Dan Nicolson (US) for advice on nomenclature.

References

Boyce, P.C. 1998. The genus *Epipremnum* Schott (Araceae—Monsteroideae—Monstereae) in west and central Malesia. *Blumea*. **43**: 183—213.

Boyce, P.C. 1999. The genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae-Monstereae) in Peninsular Malaysia, and Singapore. *Gardens' Bulletin Singapore*. **51**: 183—256.

Boyce, P.C. 2000a. The genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae-Monstereae) in the Southern and Western Indonesian Archipelago. *Gardens' Bulletin Singapore*. **52**: 101—183.

Boyce, P.C. 2000b. The genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae-Monstereae) in the Philippines. *Gardens' Bulletin Singapore*. **53**: 213—256.

Boyce, P.C. 2001. The genus *Rhaphidophora* Hassk. (Araceae-Monsteroideae-Monstereae) in Borneo. *Gardens' Bulletin Singapore*. **53**: 19—74.

Boyce, P.C. & J. Bogner. 2000. An account of neotenic species of

Rhaphidophora Hassk. (Araceae-Monsteroideae-Monstereae) in New Guinea and Australia. *Gardens' Bulletin Singapore*. **52**: 89—100

Engler, A. & K. Krause 1908. Araceae-Monsteroideae. In A. Engler (ed.), *Das Pflanzenreich* 37 (IV.23B) 4—139. Engelman, Leipzig.

Mayo, S.J., J. Bogner & P.C. Boyce. 1997. *Genera of Araceae*. Royal Botanic Gardens, Kew, U.K.

Schimper, A.F.W. 1903. *Guilds in Plant-geography upon a Physiological Basis*. Pt 2, ch. 2: 192—206. (English translation by W.R. Fisher, revised and edited by P. Groom & I.B. Balfour.) Clarendon Press, Oxford, U.K.

Stearn, W.T. 1992. *Botanical Latin*, 4th Ed. David & Charles, Newton Abbot & London, U.K.

Strong, D.R. & Ray, T.S. 1975. Host tree location behavior of a tropical vine (*Monstera gigantea*) by skototropism. *Science*. **190**: 804—806.

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Gardens' Bulletin Singapore **53** *(2001) 185–189.*

Cytology of Two New Species of *Musa* (*Musaceae*) and Their Sectional Relationship

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Abstract

Cytological observations were made on two recently described new Bornean species of *Musa* L., *M. monticola* and *M. suratii*. Both have 2n = 20. Taxonomic and biogeographic implications are discussed.

Introduction

Two new Bornean species of *Musa* (*Musaceae*) were recently described by Argent (2000), *M. suratii* Argent and *M. monticola* [Hotta ex] Argent, both from Sabah, Malaysia.

Their sectional placement, however, was unconfirmed. As cytological information has historically been of major value in helping to determine the sections and relationships in *Musa* taxonomy (Simmonds, 1962), chromosome preparations of these two species were made.

Materials and Methods

Seeds collected in the field were germinated in garden compost under glass at 28°C. Young seedlings were potted up for growing on. Root tips were pre-treated in alpha-bromonaphthalene for 22 h at 4.5°C or in paradichlorobenzene for 4 h at room temperature (c. 20°C), fixed in 3:1 ethanol:glacial acetic acid and stored in this fixative until required. After hydrolysis in 5M HCl at room temperature for 30 min, the roots were transferred to the Feulgen Reagent (prepared according to Fox, 1969) for 2 h. After washing with tap water, roots were placed in an 1:1 enzyme mixture of 2% pectinase and 2% cellulase for 60 min. Squashing was done in 45% acetic acid or in 0.4% aceto-carmine. Permanent slides were prepared according to a modified freezing method outlined in Jong (1997).

Cytological Observations and Discussion

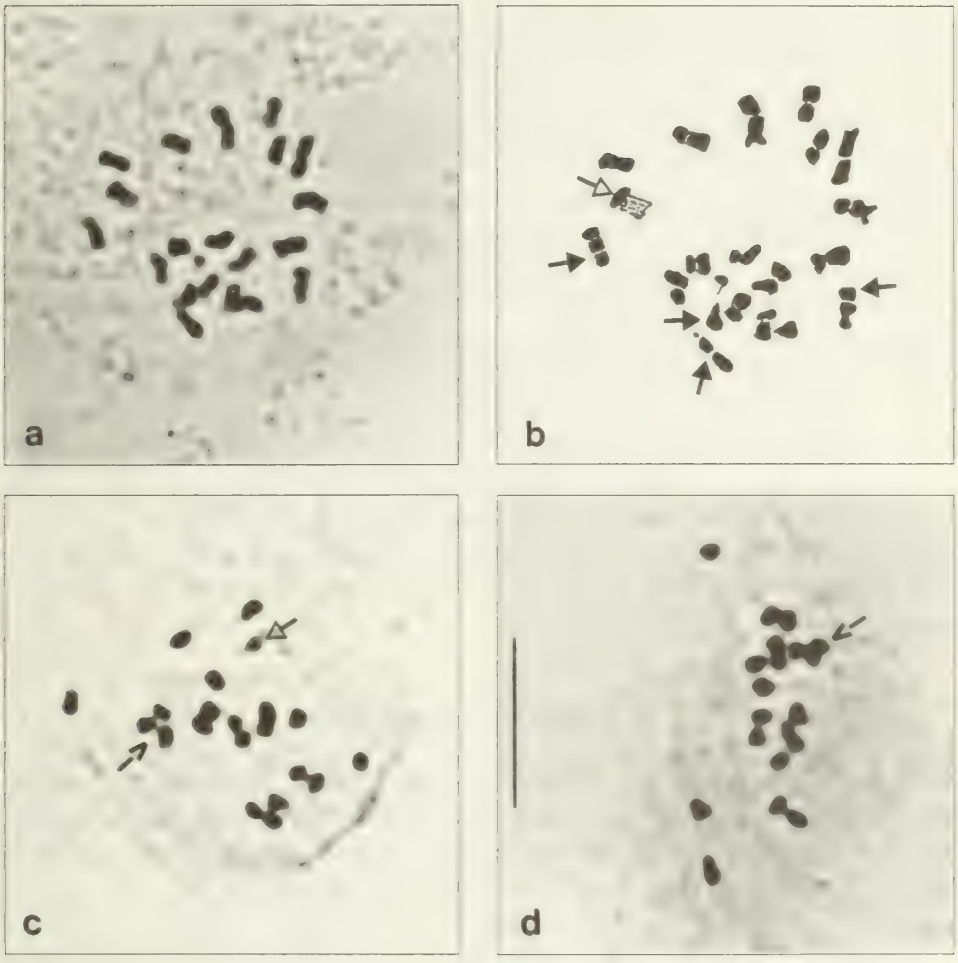
Musa has a range of basic chromosome numbers that is associated with the traditional sections (Stover and Simmonds 1987) as follows:

Section	Basic Number
Musa (formerly *Eumusa*) Baker	x = 11
Rhodochlamys Sagot	x = 11
Australimusa Cheesman	x = 10
Callimusa Cheesman	x = 10
[*Musa beccarii*] *Incertae Sedis* Simmonds	x = 9
Ingentimusa Argent	x = 7

One section, *Ingentimusa* is represented only by a single species, *M. ingens* Simmonds. The genus *Ensete* Horan has a basic number of 9, the same as *Musa beccarii* N.W. Simmonds, although there is no question that that species belongs with *Ensete*, its position within *Musa* is still problematic since molecular and morphological data (Jarret & Gawel 1995) appear to be in conflict. In fact, there has been a progressive tendency to amalgamate sections *Musa* and *Rhodochlamys* (Simmonds 1962, Jarret and Gawel 1995, Shepherd 1999). Further, Jarret and Gawel (1995) imply that *Musa coccinea* Andr. is sufficiently different from the other *Musa* species to be placed in a section of its own. The only basic number missing from this dysploid series of x = 7 to 11 is x = 8.

The somatic chromosome number of both *M. suratii* and *M. monticola* is 2n = 20 (Fig. 1a–1d). There are, however, certain cytological differences between the two species that are worth noting. The chromosomes of *M. suratii* are larger than those of *M. monticola*, and at least two pairs of chromosomes bear satellites. There is also a gradual gradation of chromosome size not obvious in *M. monticola*, where only one satellited chromosome pair is visible. Interphase nuclei are finely granulose, with no distinctively stained chromocentres, in contrast to those of *M. monticola*, where chromocentres are obvious and numerous. Unlike *M suratii*, there is a characteristic tendency for chromosomes in *M. monticola* to associate in twos, often so closely together that they might be mistaken as single chromosomes; quite frequently there is one association of three as illustrated in Fig 1c and 1d.

In terms of chromosome number, both new species fall within either sect. *Callimusa* or sect. *Australimusa* whose basic chromosome number is x = 10. At present we have insufficient evidence to say whether the difference in the chromosome morphology and behaviour noted above are consistent



Figures 1a and 1b *Musa suratii*, metaphase, 2n = 20. 1b is a drawing of 1a, solid arrowheads indicating satellited chromosomes. Open arrow points to chromosome partially out-of-focus. **Figures 1c and 1d** *Musa monticola*, metaphase, 2n = 20 from different roots. Note marked close association of certain chromosomes in twos, and one in a group of three. Open arrow points to out-of-focus chromosome. Scale bar = 10 μm

or taxonomically significant between these two sections.

Section *Callimusa* has distinctive seed morphology with elongated, barrel-shaped seeds that have a large oil store, which is represented in old seed by an air space. Most of the species also have well-developed corrugated, scarious auricles at the apex of the leaf sheath ('shoulder' as defined by Argent 1976). *Australimusa* seeds by contrast are variable from globose to highly angled, the leaves have variable 'shoulders' on the leaf

sheaths, which may occasionally be loosely corrugated but are never expanded into auricles. On these morphological grounds, both species are clearly associated with sect. *Australimusa* rather than sect. *Callimusa*.

Hotta (1987) clearly realised the relationship between *Musa monticola* and the local form of *M. textilis Née* in Sabah and the seed, although slightly larger and more distinctly mammilose, is very similar to that of cultivars of *M. textilis*. *Musa suratii* has the smallest seed recorded in the genus but the morphology is even closer to that of *M. textilis*, which is the type species of sect. *Australimusa*. However, *Musa suratii* has extraordinary morphology with green flowers, orange bracts, a very slender habit and copious wax. All of these characters considerably expand the concept of sect. *Australimusa*. The description of two more species in sect. *Australimusa* from Borneo moves the emphasis of the distribution a little more to the west as previously five of the six known species occurred in New Guinea and the Solomon Islands. Now with the uncertain status of *M. muluensis* Hotta and *M. tuberculata* Hotta, it is looking as if Borneo may actually encompass more variation in this section than is found in New Guinea.

Acknowledgements

We wish to thank all the horticultural staff who have looked after the living banana collections, in particular Mr D. Mitchell and Mr P. Smith who have them in their overall charge. Mary Mendum has provided important technical assistance for which we are most grateful.

References

Argent, G.C.G. 1976. The wild bananas of Papua New Guinea. *Notes from the Royal Botanic Garden Edinburgh*. **35**: 77-114.

Argent, G. 2000. Two interesting wild *Musa* species (*Musaceae*) from Sabah, Malaysia. *Gardens' Bulletin Singapore*. **52**: 203-210.

Fox, D. 1969. Some characteristics of the cold hydrolysis technique for staining plant tissues by the Feulgen reaction. *Journal Histochemistry and Cytochemistry*. **17**: 226-232.

Hotta, M. 1987. Distribution of the genus *Musa* in Malaysia. *Acta Phytotaxonomica et Geobotanica*. **38**: 292-302.

Jarret, R.L. and N. Gawel. 1995. Molecular markers, genetic diversity and

systematics in *Musa*. In: Gowen, S. (ed.). *Bananas and Plantains*. Chapman & Hall, U.K. Chapter 3.

Jong, K. 1997. *Laboratory Manual of Plant Cytological Techniques*. Royal Botanic Garden Edinburgh, Edinburgh, U.K. vi+96 pp.

Shepherd, K. 1999. *Cytogenetics of the Genus Musa*. International Network for the Improvement of Banana and Plantain, Montpellier, France.

Simmonds, N.W. 1962. *The Evolution of the Bananas*. Longmans, U.K..

Stover, R.H. and N.W. Simmonds.1987. *Bananas*. 3rd ed. Longmans Scientific & Technical, U.K.

Gardens' Bulletin Singapore **53** *(2001) 191–239.*

The Genus *Etlingera* (Zingiberaceae) in Peninsular Malaysia Including a New Species

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Abstract

Etlingera pieeae Khaw from the Temenggor Forest Reserve in Perak, Peninsular Malaysia, is described as a new species. Including this new species, there are 12 *Etlingera* species in Peninsular Malaysia for which a key and descriptions are provided.

Introduction

Etlingera species are recognized by the presence of an involucre of large, sterile bracts, elongate and tubular bracteoles (Fig. 1), flowers with a distinct tube formed by the bases of the labellum and the filament above the attachment of the corolla lobes (Fig. 2), and the labellum inrolling as the flower withers (Burtt and Smith, 1986).

The first comprehensive systematic account of Peninsular Malaysian species now included in *Etlingera* was given in the classic monograph of Holttum (1950). His detailed account included four *Phaeomeria* species and six *Achasma* species, now all considered as species of *Etlingera* (Table 1).

Holttum (1950) credited Valeton for recognizing that *Phaeomeria* is closely related to *Achasma*. The two major characters that Holttum (1950) used to distinguish between these two genera were the peduncle (long and erect in *Phaeomeria*, short and usually subterranean in *Achasma*) and the labellum (short in *Phaeomeria* and elongate in *Achasma*).

Subsequently, Burtt and Smith (1986) united the two genera *Achasma* and *Nicolaia* Horan., which replaced *Phaeomeria*, an invalid name (Burtt and Smith, 1986) with a third, *Geanthus* Valeton, to form a composite genus, *Etlingera* Giseke. (*Geanthus* is not found in Peninsular Malaysia). In uniting the three into a single composite genus, Burtt and Smith (1986) maintained that the two characters conventionally used to divide *Achasma*, *Geanthus* and *Phaeomeria* into distinct genera were inadequate. In addition, they observed that the anther is held at an angle to the filament in *Achasma*, whereas it is erect in *Geanthus* and *Phaeomeria*.

Table 1. *Etlingera* species in Peninsular Malaysia, including the names used by Holttum.

Etlingera species	Name in Holttum (1950)
E. elatior	*Phaeomeria speciosa*
E. maingayi	*P. maingayi*
E. fulgens	*P. fulgens*
E. venusta	*P. venusta*
E. pauciflora	*Achasma pauciflorum*
E. punicea	*A. macrocheilos*
E. subterranea	*A. subterraneum*
E. metriocheilos	*A. sphaerocephalum*
E. triorgyalis	*A. triorgyale*
E. littoralis	*A. megalocheilos*
E. corneri	
E. pieeae	

Further to Holttum's enumeration of the species, while making an inventory of gingers of the Temenggor Forest Reserve, Perak, Peninsular Malaysia, in 1994 and 1995, two unnamed species of *Etlingera* were collected (Khaw, 2000). One, *E. corneri* J. Mood & H. Ibrahim, was recently described (Mood & Ibrahim 2000); the other, *E. pieeae* Khaw, is described here.

The new species, *E. pieeae*, is particularly interesting as it is in some respects intermediate between Holttum's *Phaeomeria* and *Achasma*. In Peninsular Malaysia, the two are easily recognized based on inflorescence characters (the flower head of the *Phaeomeria* group being either cup-shaped on a long, aerial stalk or in the *Achasma* group sub-cylindric on a short, subterranean stalk). However, the inflorescences of *E. pieeae* do not have the typical appearance of either group. Instead, because its sterile bracts are not broad but oblanceolate, spreading slightly and loosely imbricating at the bases, a wide cup-like or a narrow sub-cylinder of sterile bracts is not obvious. In this aspect, its inflorescence resembles that of *E. pauciflora* (formerly a species of *Achasma*), which has the typical subterranean inflorescence. In addition, *E. pieeae* is intermediate between the two groups in the flower head having a relatively long peduncle. The result is that the distal part of its peduncle together with the flower head are aerial, a character of the *Phaeomeria* group. These features, coupled with flowers with a long labellum, (a character of *Achasma*) make it distinct from other *Eltingera* species in Peninsular Malaysia. The fact that it is intermediate between the two groups adds support for uniting *Phaeomeria*

and *Achasma* into a single genus.

Illustrated accounts of Peninsular Malaysian *Etlingera* were given by Weber (1995), Larsen *et al.* (1999) and Lim (2000).

The attractive and colourful inflorescences and infructescences of *Etlingera* species are of horticultural potential. In Peninsular Malaysia, only *kantan*, *E. elatior* (Jack) R.M. Smith, is grown as an ornamental and commercially for culinary purposes. The rest are not widely cultivated horticulturally or for the cut-flower trade, although they are gaining popularity in subtropical Australia and U.S.A..

Materials and Methods

This account is based on the examination of the living specimens. Field observations on the morphology of the living plants and the development of the inflorescence and infructescence were made for all the *Etlingera* species, except for *E. subterranea* and the fruits of *E. littoralis*, for which material was not available. In addition, observations were made of plants cultivated from rhizomes and seed collected from the field. Material fixed in Copenhagen mixture, colour photographs, as well as dried specimens were prepared for study. Observations of fresh materials, unless otherwise stated, form the basis of the characters used in the key and the descriptions of the species. Drawings of dissected *Etlingera* flowers follow the style of Burtt and Smith (1986). Herbarium material from the *Etlingera* collections at KEP, KLU and SING were examined. Types not seen are indicated (*s.v.*). Photographs of the type specimen of *E. venusta* at K were made by Dr Saw Leng Guan.

Compared with Holttum's account, several additional characters have proved useful in identifying the species, such as the production of stilt roots, number of flowers, the aspect of the flower head in lateral view, shape of the basal lobes of the labellum, the form of the epigynous glands and the scent of the crushed leaf sheaths. Examination of the minute epigynous glands that Holttum (1950) called stylodes (nectary glands) reveals that there are two main types in *Etlingera* (Fig. 3), the one with a rounded or irregular apex is found in the *Phaeomeria* group of species, the other type with a narrowed apex with the sole exception of *E. metriocheilos* is found in the *Achasma* group.

The description of the fruit of *E. metriocheilos* in the present work differs from that of Holttum. He described the fruit as smooth based on the examination of a single specimen (*Ridley s.n.* Maxwell's Hill, June 1893), whereas examination of living material shows the fruits to be ridged longitudinally, each ridge with a shoulder-like apical mound, covered with

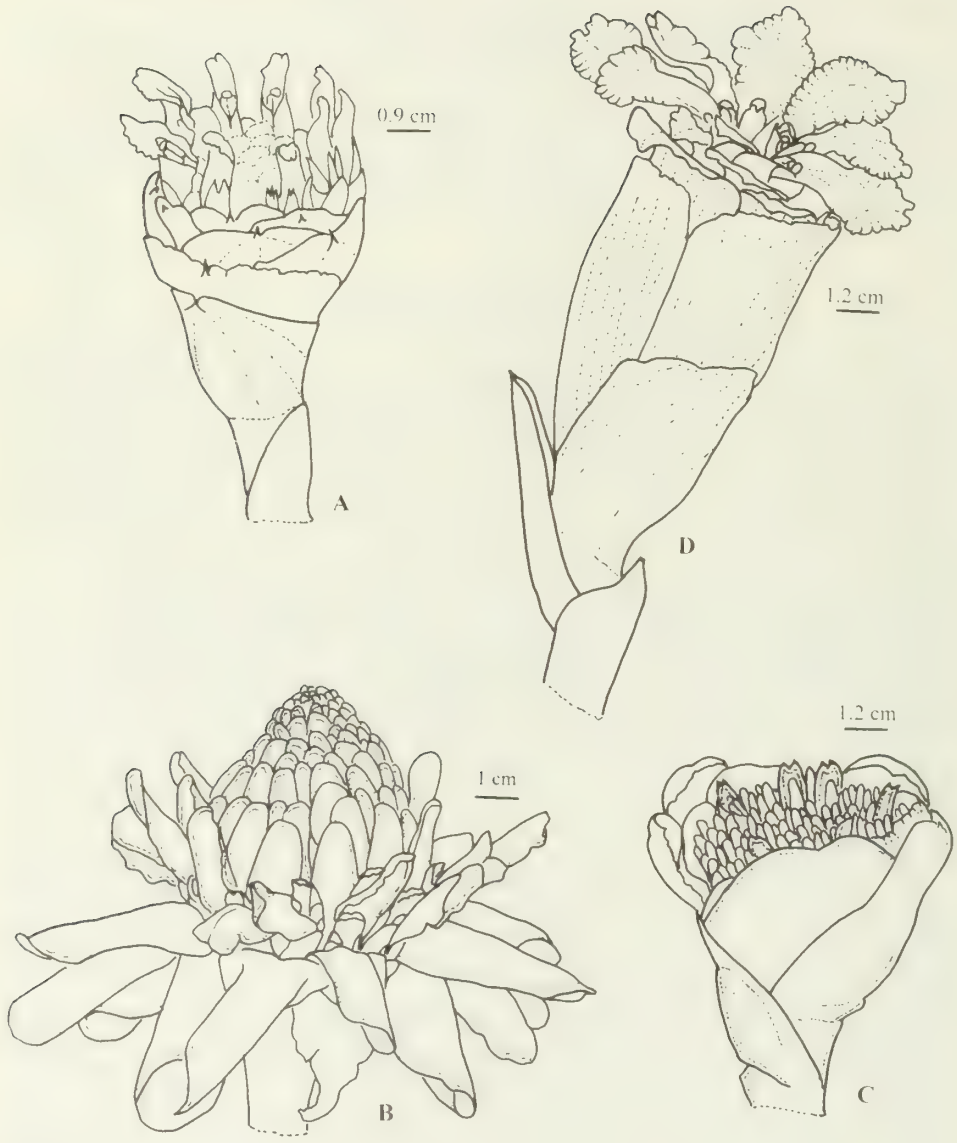
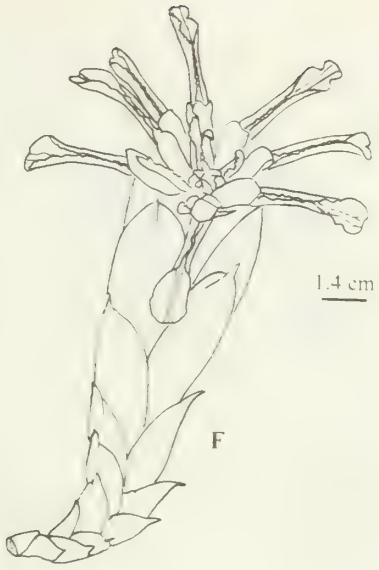


Figure 1. Inflorescence types in *Etlingera*. A, *E. maingayi*; B, *E. elatior*; C, *E. fulgens*; D, *E. triorgyalis*; E, *E. pauciflora*; F, *E. punicea*; G, *E. metriocheilos*; H, *E. littoralis*; (from living material).


1.3 cm
E


1.4 cm
F


1.2 cm
G


1.2 cm
H
KSH 2000

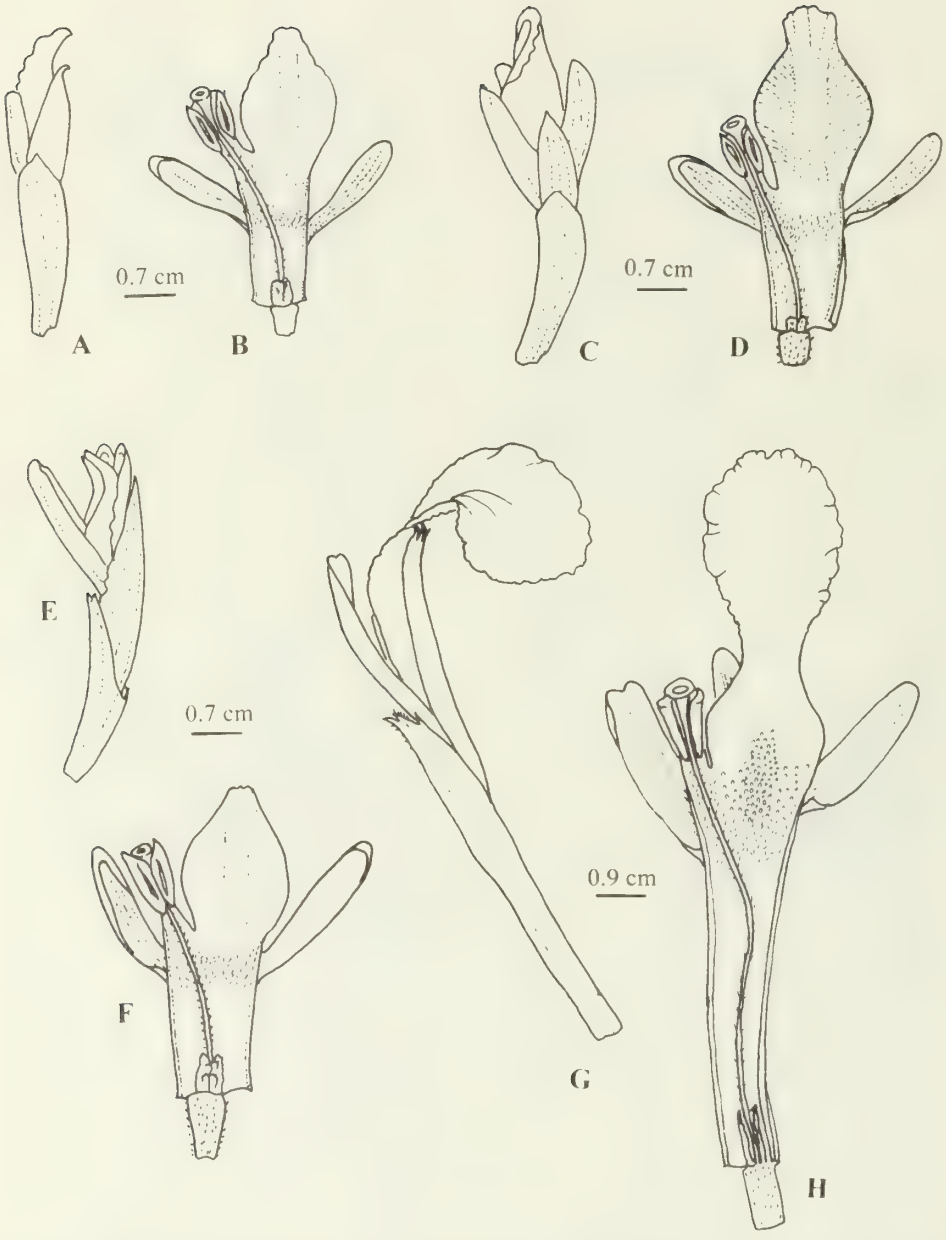
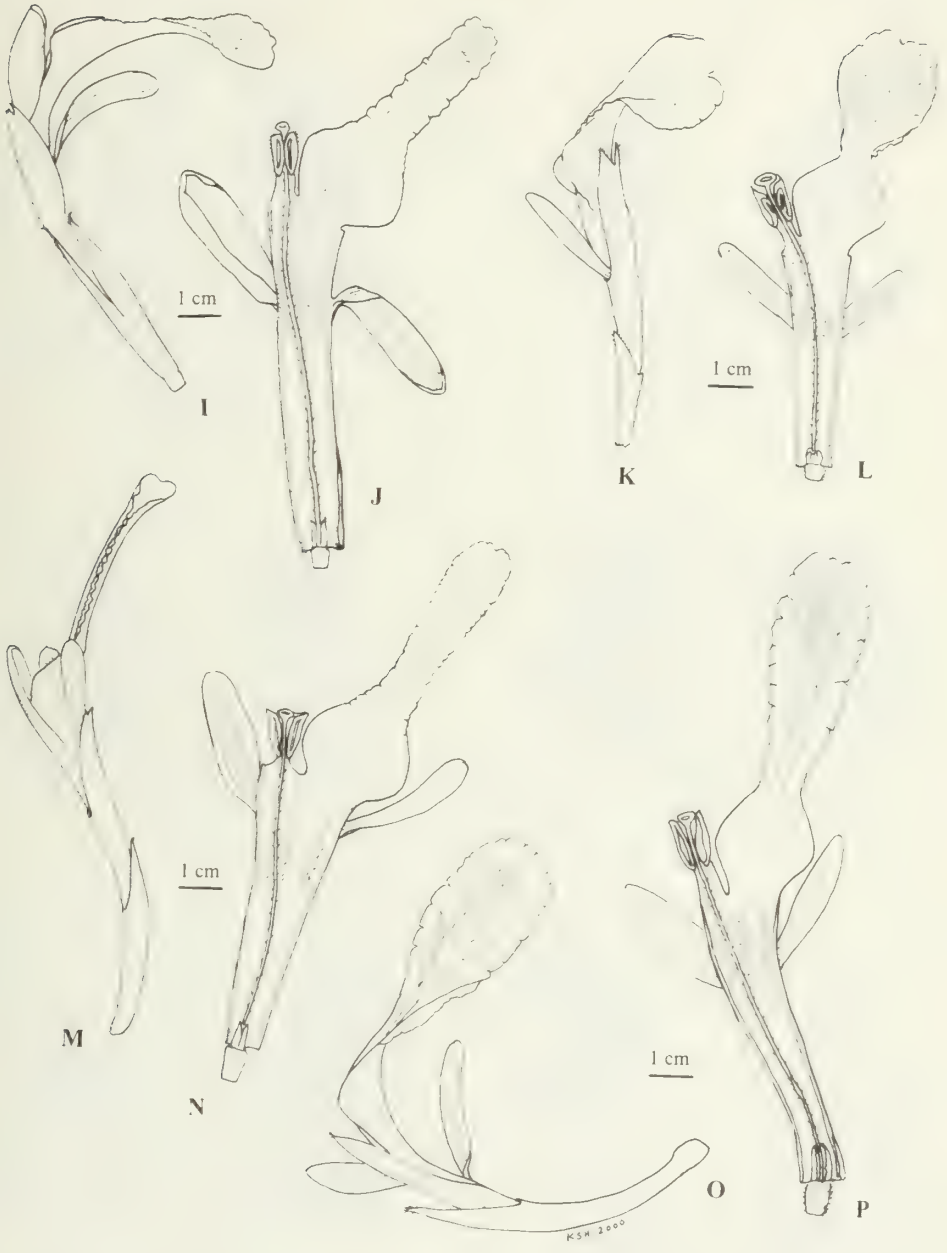


Figure 2. Flower and labellum types in *Etlingera*. A, B, *E. maingayi*; C, D, *E. elatior*; E, F, *E. fulgens*; G, H, *E. triorgyalis*; I, J, *E. pauciflora*; K, L, *E. metriocheilos*; M, N, *E. punicea*; O, P, *E. littoralis*; (left, flower in lateral view; right, dissected flower; from spirit material).


1 cm
I
J
K
1 cm
L
M
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N
O
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P
KSH 2000

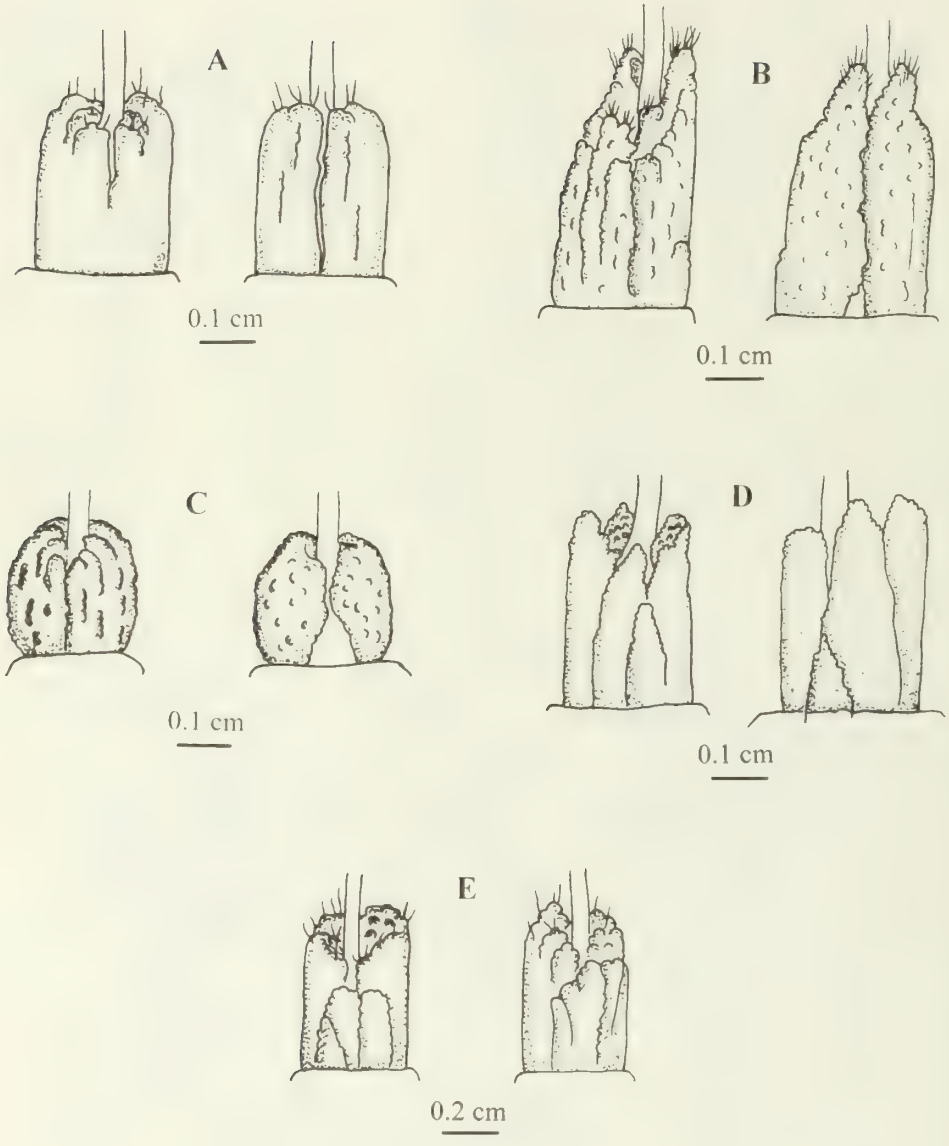
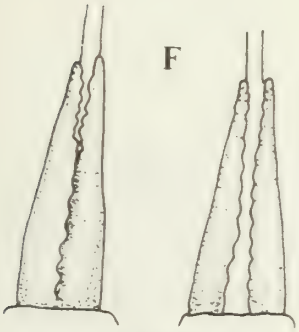
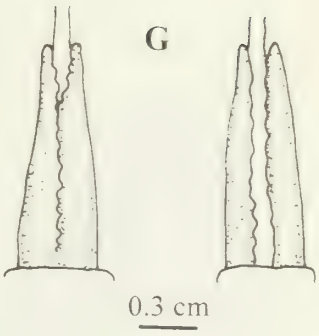
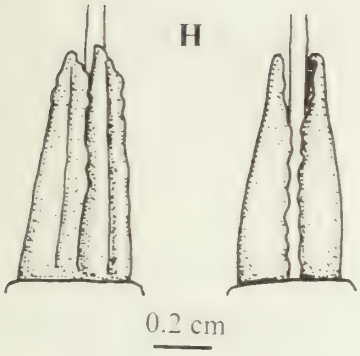
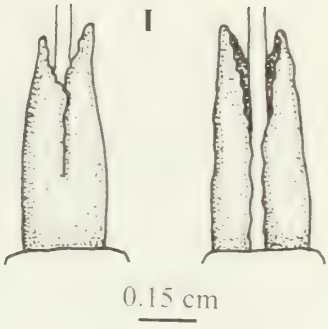


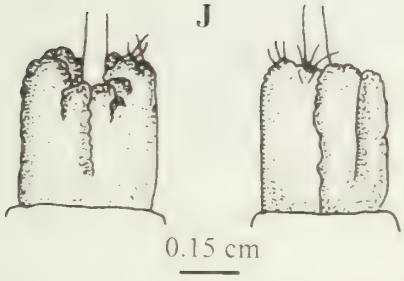
Figure 3. Epigynous glands in *Etlingera*. A, *E. maingayi*; B, *E. fulgens*; C, *E. elatior*; D, *E. corneri*; E, *E. venusta*; F, *E. pieeae*; G, *E. triorgyalis*; H, *E. pauciflora*; I, *E. punicea*; J, *E. metriocheilos*; K, *E. littoralis*; (A–K, left, adaxial view; right, abaxial; from spirit material).


F
0.15 cm


G
0.3 cm


H
0.2 cm


I
0.15 cm


J
0.15 cm

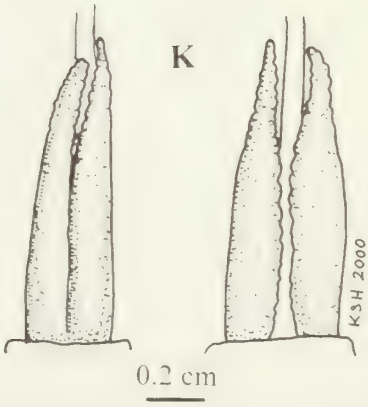
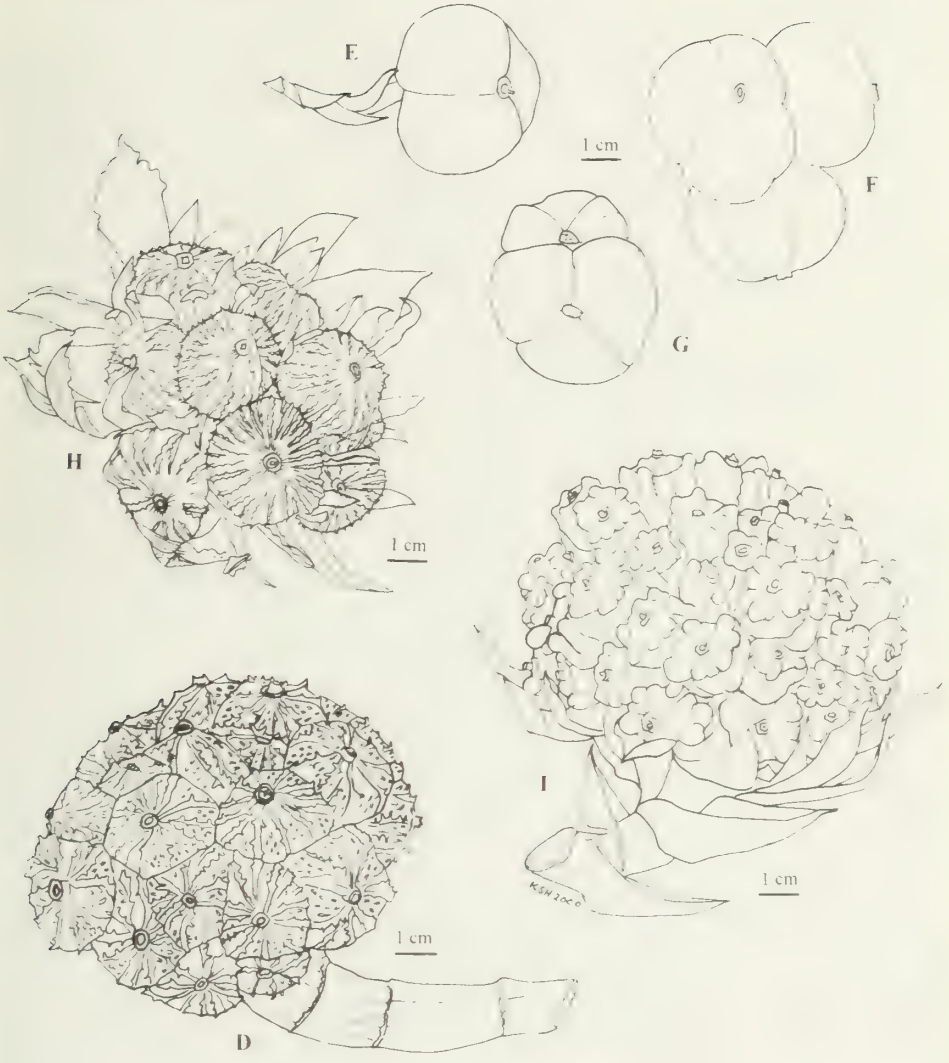

K
KSH 2000
0.2 cm

Figure 4. Infructescence types in *Etlingera*. A, *E. maingayi*; B, *E. elatior*; C, *E. fulgens*; D, *E. triorgyalis*; E, F, G, *E. pauciflora*; H, *E. punicea*; I, *E. metriocheilos*; (from spirit material).


E
1 cm
F
G
H
1 cm
I
1 cm
1 cm
D

prominent warts (Fig. 4I). In addition, infructescences of three species (*E. triorgyalis*, *E. pauciflora* and *E. punicea*) stated as unknown by Holttum, are described and illustrated here (Fig. 4D, E–G, H).

Description of the Genus *Etlingera* in Peninsular Malaysia

Rhizomes at, just below, or deeper in the ground (*E. pauciflora*, *E. punicea* and *E. littoralis)*; elements long and slender between the leafy shoots in the smaller species (*E. maingayi* and *E. pauciflora*) or stout in the larger species; with stilt-roots above the soil, leaf-litter or swampy ground (*E. maingayi* and *E. corneri)*. *Leafy shoots* tall, to 6 m in the larger species, often with swollen, bulbous bases; close together forming clumps or widely spaced to about 1 m apart; sheaths ribbed longitudinally with cross-bars covered by tufts of short, white hairs (often clearer on young sheaths); *scent* of crushed sheaths either a pleasant sour scent (all species in the *Phaeomeria* group and including *E. corneri*) or strong and peppery (in *E. triorgyalis* and *E. pieeae*) or without a distinct odour; *ligule* bilobed or entire; *petiole* usually present or lamina subsessile (*E. venusta*); *laminas* many, large, to about 1 m long, often when young pink or with brownish-pink broad bars or deep purple-red beneath (*E. fulgens* and *E. metriocheilos*). *Inflorescence* on a separate leafless shoot, arising from the base of the leafy shoot. *Peduncle* covered by bladeless sheaths in two ranks, widely spaced and not overlapping (the *Phaeomeria* group) or overlapping (the *Achasma* group); long, slender with a short horizontal subterranean axis, which turns upwards, forming a much longer, erect, aerial stalk (Fig. 5A) with the flower head raised well above the ground (in the *Phaeomeria* group and *E. corneri*) or with the horizontal subterranean part of the peduncle relatively longer (Fig. 4D), the erect part only a few cm long with the flower head just below ground level, so that only the opened flowers are displayed on the soil surface (the *Achasma* group) or the peduncle is at first horizontal and subterranean but then erect and producing a flower head well above the ground level (*E. pieeae*, Fig. 7A, B). *The flower head* enclosed by broad sterile bracts; usually tightly imbricating and forming either a capitate, wide cup-like structure (the *Phaeomeria* group, Fig. 1A–C, 5B, 6B) or a narrower, sub-cylindric structure (the *Achasma* group, Fig. 1D, F–H). In both cases, in side view the sterile bracts hide a portion of the flower-head proper except in *E. pauciflora*, *E. subterranea* and *E. pieeae* where the narrow lanceolate sterile bracts are loosely imbricating at the bases only, so do not form a sub-cylindric structure (Fig. 1E, 7B), their inflorescence heads proper thus in side view are visible between the bracts. *Receptacle of inflorescence* with apex inflated, rounded

or flat, usually elongating only a few cm but up to 17 cm in *E. elatior*; with numerous (55—200 or more) flowers per flower head in the *Phaeomeria* group, 30—60 in the *Achasma* group, 20—35 in *E. pieeae* and 1—3 flowers in *E. pauciflora* and *E. subterranea*. *Sterile and fertile bracts*: the outermost sterile bracts show a transition from the uppermost sheath of the peduncle, bracts usually not persisting until fruit maturity, coloured or whitish, erect or spreading, much broader than the fertile bracts; outermost fertile bracts show a transition from the sterile bracts, decreasing in size towards the centre of the flower-head; each fertile bract producing one flower. *Bracteole* tubular, two-lobed, deeply slit down the opposite side. *Calyx* tubular, 3-lobed, deeply slit down the opposite side. *Corolla* tubular, often densely hairy at entrance to tube; with three erect lobes (petals), the dorsal lobe slightly wider than the lateral ones. *Labellum* with a short or elongated blade, broadening at the base to form distinct basal lobes (Fig. 2, 7H) or without basal lobes (*E. venusta* and *E. corneri*, Fig. 5H, 6J); the lowest part of the labellum joined to the base of the stamen to form a short, fleshy staminal tube above the bases of the corolla-lobes; usually with the basal lobes erect on either side of the anther or folded together, partially or entirely covering the anther; after flowering, the lower part of the blade inrolling while the distal part withers; with the blade erect or spreading horizontally and the apex slightly reflexed; the apex entire or bilobed. *Staminodes* lacking. *Filament* short or in *E. venusta* and *E. corneri* almost sessile. *Anther* erect or bent forward towards the labellum. *Epigynous glands* as two fleshy, rounded mounds surrounding the base of the style, each mound irregularly lobed at the apex in the *Phaeomeria* group (Fig. 3A–E) and *E. metriocheilos* (Fig. 3J) or as two fleshy, compressed blades, not encircling the base of the style, each blade not further lobed, apex shortly pointed in most species of the *Achasma* group (Fig. 3F–I, K). *Ovary* glabrous or hairy, stigma rather large. *Infructescence* large, usually globular but elongate in *E. elatior*; *fruits* close together, pericarp smooth and each with a long persistant calyx in the *Phaeomeria* group (Fig. 4A–C, 5I, 6M) or ridged longitudinally and with warts in the *Achasma* group (Fig. 4D, H, I) or in *E. pauciflora* (Fig. 4E–G) and *E. littoralis* (Holttum, 1950) smooth; indehiscent, fleshy or dry; maturing within about two months. *Seeds* irregularly angular and truncate, each surrounded by thin, whitish, translucent pulp.

Key to *Etlingera* species in Peninsular Malaysia

1a. Inflorescence raised well above the ground on peduncles 40–200 cm; sterile bracts showy, aerial, tightly imbricating, with their upper half spreading horizontally, forming a very shallow or deep, wide, cup (with diameter exceeding or nearly the same as the height); lip with a very short blade 2

1b. Inflorescence almost entirely subterranean on peduncles 5–20 cm or rarely (only in *E. pieeae*) raised above the ground on peduncles to 48 cm long; sterile bracts not showy, usually embedded in the ground except for their distal parts, usually tightly imbricating, then forming a long narrow sub-cylinder (with diameter always less than the height) or loosely imbricating at the bases only, thus not forming a sub-cylinder; lip with elongated blade. 6

2a. Sterile bracts tightly imbricating at the bases only, forming a very shallow, inconspicuous cup, with the upper half of the bracts spreading horizontally; receptacle of inflorescence elongating markedly during flowering forming a cone-shaped flower head within the involucral cup ..... **1. *E. elatior***

2b. Sterile bracts tightly imbricating, forming a firm cup; receptacle of inflorescence hardly elongating during flowering forming a flat or bowl-like flower head at side view. 3

3a Involucral cup up to *c.* 3 cm high and *c.* 4 cm wide, in side view the cup hiding a third of the flower-head; sterile bracts densely appressed white-hairy all over surface. ..... **2. *E. maingayi***

3b. Involucral cup up to *c.* 9 cm high and *c.* 7.5 cm wide, in side view the cup hiding almost entirely the flower-head; sterile bracts glabrous or only sparsely white-hairy. 4

4a. Leaves with upper surfaces glossy, dark green, lower surfaces conspicuously purple-red when young; lamina smooth, not prominently ribbed, margin markedly crisped; sterile bracts subrotund, strongly incurved at apex; lip with blade widening at base to form distinct basal lobes, red with yellow margin; fruits pale green, densely appressed short-hairy ..... **3. *E. fulgens***

4b. Leaves entirely green on both surfaces even when young; lamina prominently ribbed, margin not markedly crisped; sterile bracts oblong-elliptic, recurved at apex; lip with blade narrowed to base, not widening to form distinct basal lobes, white with red median band; fruits bright red and glabrous 5

5a. Stilt-roots absent; petiole always inconspicuous (leaf subsessile); leaf base always cuneate; sterile and fertile bracts with acute apices, purple-pink, pale green at the base; the involucral cup completely decayed before fruit maturity. ..... **4. *E. venusta***

5b. Stilt-roots 10–25 cm long; petiole 1.5–4 cm long; leaf base mostly rounded (sometimes cuneate); sterile and fertile bracts with subtruncate apices, bright red, white at the base; involucral cup persisting to fruit maturity. ..... **5. *E. corneri***

6a. Peduncles to 30 cm; fertile part of inflorescence with all sterile bracts raised well above the ground; bracts loosely imbricating at the bases only, not forming a sub-cylinder, in side view the flower head visible between the bracts. ..... **6. *E. pieeae***

6b. Peduncles 3–15 cm; fertile part of inflorescence always subterranean except for distal parts of sterile bracts; bracts tightly imbricating, forming a long, narrow sub-cylinder, in side view hiding one to two thirds of the flower-head 7

7a. Flowers 1–3 per inflorescence. 8

7b. Flowers 30–60 per inflorescence. 9

8a. Corolla lobes 1–2 cm longer than calyx, dorsal lobe 3–4 x *c.* 1.5 cm; lip yellow at centre with red margins. ..... **7. *E. pauciflora***

8b. Corolla lobes almost same length as calyx, dorsal lobe 1–1.5 x *c.* 0.5 cm; lip crimson with white margins. ..... **8. *E. subterranea***

9a. Corolla *c.* 2 cm longer than calyx; dorsal corolla lobe hiding the entire anther; stigma hidden under dorsal corolla lobe; lip with yellow median band and red margins. ..... **9. *E. punicea***

9b. Corolla about the same length as calyx; dorsal corolla lobe hiding only the basal part of anther; stigma clearly visible; lip entirely red or with yellow, orangey-red or white margins, always without a yellow median band. 10

10a. Leaf sheaths purple-red; lower surface of young leaves purple-red; sterile bracts deep-red; lip purple-red with white margin; stigma purple-red, almost black. ..... **10. *E. metriocheilos***

10b. Leaf sheaths green; lower surface of young leaves entirely green or green flushed pale-pink; sterile bracts white or pale green with pink apices; lip entirely red or with a yellow margin; stigma pale-pink or bright red. 11

11a. Outer sterile bracts with apices recurved; lip entirely pink-red; stigma pale-pink; crushed leaf sheaths with a distinct peppery scent; inner surface of staminal tube densely hairy and conspicuously warty; fruits with longitudinally ridged pericarp. ..... **11. *E. triorgyalis***

11b. Outer sterile bracts with apices not recurved; lip entirely red or with a yellow or orange-red margin; stigma bright red; crushed leaf sheaths without any distinct scent; only inner surface of staminal tube densely hairy, not warty; fruits with smooth pericarp. ..... **12. *E. littoralis***

Description of the Species

1. Etlingera elatior (Jack) R.M. Sm., Notes Roy. Bot. Gard. Edinb. 43 (1986) 244; Lim, Folia malaysiana 1 (2000) 4. Syn.: *Alpinia elatior* Jack, Misc. mal. 3, 7 (1822) 2 (*s.v.*); *Elettaria speciosa* Blume, Enum. Pl. Javae (1827) 51; *Alpinia magnifica* Roscoe, Monandr. Pl. (1828) t. 75 (*s.v.*); *Phaeomeria imperialis* Lindl., Nat. Syst. Ed. 2 (1836) 446 (s.v.); Ridl., Fl. Malay Penins. 4 (1924) 272; *Nicolaia imperialis* Horan., Prodr. Monogr. Scitam. (1862) 32, t. 1. (*s.v.*); *Nicolaia speciosa* Horan., Monogr. Scitam. (1862) 32 (*s.v.*); Valeton, Bull. Jard. Bot. Buitenz. 3rd Ser. 3 (1921) 138; *Hornstedtia imperialis* Ridl., in J. Str. Br. Roy. Asiat. Soc. 32 (1899) 148; Mat. Fl. Malay. Penins. (1907) 40; *Phaeomeria magnifica* (Roscoe) K. Schum., Pflanzenr. Zingib. (1904) 262; *Phaeomeria speciosa* (Blume) Merr., Enum. Philip. Pl. 1 (1922) 241; Holttum, Gard. Bull. Sing. 13 (1950) 181; Henderson, Malayan Wild Flowers, Monocots. (1954) 153. Type: Sumatra, *Jack s.n.*, (*s.v.*) – specimen lost?

Figures 1B, 2C & D, 3C, 4B

Rhizomes just below ground; stout, 3–4 cm diam.; scale-leaves overlapping, green. *Leafy shoots* 5–6 m tall; 10–18 cm apart, forming clumps; young sheaths longitudinally ribbed, with cross-bars not covered by tufts of short, white hairs; crushed sheaths with a pleasant, sour fragrance; *ligule c.* 2 cm long, apex broad, entire or slightly bilobed, margin with short brown hairs; *petiole* 2.5–3.5 cm long, surface longitudinally ribbed. *Laminas c.* 17 pairs; (topmost) *c.* 33 x 4.5 cm, (middle) 66–81 x 15–18 cm, (basal) *c.* 36 x 14 cm; upper surface with slightly raised lateral veins; entirely green on both surfaces, (sometimes flushed pink in young leaves); lower surface glabrous; base variable, mostly broadly rounded or cordate, sometimes cuneate or unequal. *Peduncle* to 100–200 cm; shortly horizontal, then erect, aerial, close to base of leafy shoot; sheaths *c.* 13, shortest at base 5–20 cm long, apex rounded with subapical tooth 0.1 cm long, pale green at apex, dark green towards base; not overlapping, widely spaced. *Inflorescence* raised

well above the ground. *Fertile apical part of inflorescence* with well developed sterile bracts tightly imbricating at the bases only, forming a very shallow inconspicuous cup-like structure c. 2.5 cm high, 6 cm wide and with the upper half of the bracts reflexed; in side view the cup hiding *c.* 1/3 or less of the conical inflorescence head proper; the cup not persistent until fruit maturity. *Receptacle of inflorescence* 4–9 cm long, lengthening to 17 cm (usually shorter); apex inflated and rounded; bearing up to 200 or more flowers; 11–13 flowers open simultaneously; flower (from base of ovary to apex of labellum) *c.* 4.5 cm long. *Sterile bracts c.* 13; 5.5–10 x 1.5–3.5 cm; soft (not rigid), spreading outwards from a loosely imbricating base; oblong-elliptic, strongly recurved; apex rounded, with subapical tooth *c.* 0.5 cm long; glabrous; pink with white margins. *Outer floral bracts* resembling the sterile bracts, *c.* 7.5 x 1–2 cm; *inner floral bracts* smaller *c.* 4 x 0.7 cm. *Bracteole* 2–2.5 x *c.* 1.5 cm (when flattened); unequally 2-lobed, apex of lobe acute with *c.*1 cm slit on opposite side; glabrous, translucent with a pink median band. *Calyx* 2.5–3 x *c.* 1.5 cm (when flattened); 3-lobed, each lobe with an apical tuft of short, brown hairs; tube with *c.*1.5 cm slit on opposite side; glabrous; white, deep pink at apex. *Corolla tube* 1–1.5 cm long; inner surface densely covered with long hairs at entrance to tube; *lobes (petals)* longer than calyx, 2–2.5 cm long, apices rounded, slightly hooded, white with pink tips; dorsal lobe not hiding the anther and stigma, *c.* 0.7 cm wide, lateral lobes narrower, *c.* 0.4 cm. *Labellum* held erect; blade 1.8–2 cm long, *c.* 0.8 cm wide; deep red with a yellow margin except at basal lobes; margin of blade plain; apex rounded and retuse. *Staminal tube* 0.5–1 cm long above the base of the corolla-lobes; inner surface of tube sparsely covered with long hairs, more hairy below anther, (not warty). *Filament* short, *c.* 0.5 x 0.3 cm wide, adaxially hairy. *Anther* c. 0.7 x 0.3 cm; dark red, with white hairs on pollen sacs. *Epigynous glands* 0.2–0.4 x 0.2–0.3 cm; comprising 2 rounded mounds, surrounding base of style, each mound deeply and irregularly lobed, apices glabrous, surface conspicuously warty. *Ovary* 0.4–0.6 x 0.3–0.5 cm; densely covered with appressed, white, short hairs; *style* white, hairy; *stigma* dark red, 0.3 cm across. *Infructescence* elongate, up to *c.* 19 cm but usually shorter x 10 cm in diam.; surmounted by withered flowers; withered, sterile bracts persistent until fruit maturity at base of fruit head; floral bracts persistent with fruits at their axils; number of fruits per head 15–25 (or more). *Fruits* obovoid; *c.* 2.5 x *c.* 3 cm wide at the top; densely covered with appressed short hairs; apex with remnant of calyx *c.* 3 cm long; pericarp smooth, not ridged longitudinally; pericarp 0.2–0.3 cm thick; buff or pale green at maturity. *Seeds* irregularly angular, truncate; *c.* 0.4 x 0.3 cm wide.

Distribution: This species is widely cultivated and has been collected from several places in the Peninsula. Ridley (1924) reported the species wild in forests in Rawang, Selangor and in Tambun near Ipoh and the Taiping Hills in Perak. The species is described as native to the Peninsula, Java and Sumatra (Ridley, 1899).

Notes: Locally known as *kantan*, this is commonly cultivated as a flavouring, the young inflorescences and fruits being used in curries. The newly opened inflorescence is beautiful but the bracts quickly turn black and rot, rendering it unsuitable for the cut-flower trade.

One of the most conspicuous features of this species is the lengthening of the receptacle of the inflorescence during flowering, the spike thus forming an elongating cone within the involucral cup.

Ridley (1899 p: 148 & 149) described the lip as white edged in *Hornstedtia imperialis* var. *imperialis* and the margins as yellow in var. *speciosa*. Ibrahim (1986) reported a form with white bracts and yellow flowers from Pulau Tioman.

Specimens seen: PERAK: Tanjong Malim, *Burkill & Haniff 14002* (SING); Ipoh, Ampang limestone cliffs, *Burkill & Haniff 13934* (SING); Taiping, Batu Tegoh, *Henderson 10139, 10143, 10312* (SING); Larut Hills, *King's Collector 3075* (SING); Telok Anson, Durian Sebatang, *Haniff 15293* (SING); Taiping Waterfall, *Ridley s.n.* (SING); Bubu F.R., Jalong, *Symington SFN 39556* (KEP). SELANGOR: Rawang, *Ridley 7811* (SING); Kanching, Bukit Takun, *Stone 8787* (SING). JOHOR: Kota Tinggi, *Ridley s.n.* (SING). PAHANG: Pelangai or Manchis, *Burkill & Haniff 16793* (SING); Ulu Tembeling, Sg. Sat, *Henderson 22068* (SING). TERENGGANU: Ulu Brang, *Moysey & Kiah SFN 33873* (SING); Kuala Terengganu, Bukit Berangan, *Sinclair & Kiah SFN 40891* (SING).

2. Etlingera maingayi (Baker) R.M. Sm., Notes Roy. Bot. Gard. Edinb. 43 (1986) 247; Lim, Folia malaysiana 1 (2000) 5. Syn.: *Amomum maingayi* Baker, in Hook. *f.*, Fl. Brit. India 6 (1892) 235; *Hornstedtia maingayi* (Baker) Ridl., in J. Str. Br. Roy. Asiat. Soc. 32 (1899) 150; Mat. Fl. Malay. Penins. 1 (1907) 41; *Phaeomeria maingayi* (Baker) K. Schum., Pflanzenr. Zingib. 20 (1904) 266; Ridl., Fl. Malay Penins. 4 (1924) 272; Holttum, Gard. Bull. Sing. 13 (1950) 180; Henderson, Malayan Wild Flowers, Monocots. (1954) 155; *Nicolaia maingayi* (Baker) K. Larsen, Nat. Hist. Bull. Siam Soc. 23: 574 (1970). Type: Malacca, *Maingay 1586, s.v.* (K).

Figures 1A, 2A & B, 3A, 4A

Rhizomes long, slender, creeping, *c.* 2.5 cm diam.; supported by stilt-roots 10–30 cm long; scale-leaves overlapping; green flushed orange-pink. *Leafy shoots* 3–4 m tall; 10–20 cm apart, forming clumps; young sheaths slightly longitudinally ribbed, with cross-bars covered by tufts of very short, white

hairs; crushed sheaths with a pleasant, sour fragrance; *ligule* to 1.5 cm, apex entire or slightly bilobed, margin and surface with short, light-brown hairs; *petiole* to 0.5 cm, surface longitudinally ribbed. *Laminas c.* 17 pairs, (topmost) 25–62 x 3–5 cm, (middle) *c.* 66 x 10–12 cm, (basal) 20–43 x 5.5–8.5 cm; upper surface smooth, entirely green (young leaves sometimes brownish-pink all over on both surfaces or with brownish-pink bars on green lamina), lower surface glabrous, base cuneate, unequal. *Peduncle* up to *c.* 100 cm long, shortly horizontal, then erect, close to base of leafy shoot; sheaths *c.* 9, shortest at base 2–7 cm long, apex rounded, with subapical tooth *c.* 0.2 cm long, pink or purplish-red at apex, green towards base, not overlapping, widely spaced. *Inflorescence* raised well above the ground. *Fertile apical part of inflorescence* with well developed sterile bracts tightly imbricating, forming a firm, cup-like structure, 2–3 x *c.* 4 cm; in side view the cup hiding *c.* 1/3 of the inflorescence head proper, the cup persistent until fruit maturity. *Receptacle of inflorescence* 1.5–2 cm long; apex inflated and conical; bearing *c.* 70 flowers; *c.* 9 flowers open simultaneously; flower (from base of ovary to apex of labellum) *c.* 4.5 cm long. *Sterile bracts c.* 8; 3–4 x 4.5–5 cm; rigid, erect, subrotund, the whole concave towards the inside; apex broadly rounded, retuse, with a subapical tooth 0.2–0.5 cm long; outer surface with densely appressed, white hairs, red. *Outer floral bracts* like sterile bracts; *c.* 3.5 x 1.5–3 cm; *inner floral bracts* smaller, 3–3.5 x 0.5–1.5 cm. *Bracteole c.* 2 x 1 cm (when flattened); apex 2-lobed and rounded with 0.5 cm slit on opposite side; densely, tawny hairy on entire surface. *Calyx* 2.5–3 x *c.*1 cm (when flattened); 3-lobed, each lobe with a glabrous, subapical tooth 0.2 cm long; tube with *c.*1 cm slit on opposite side; surface densely covered with appressed, tawny hairs; red. *Corolla tube c.* 1.5 cm long; inner surface densely covered with long hairs at entrance of tube; *lobes (petals)* shorter than calyx, *c.* 1.5 cm long, apices rounded, not hooded, red; dorsal lobe not hiding the anther and stigma, *c.* 0.5 cm wide, lateral lobes narrower, *c.* 0.2 cm. *Labellum* held erect; blade 1.5–2 cm long, 0.6–0.8 cm wide; blade and basal lobes pink with a red median band not reaching the apex, margins of base white; margins of blade crisped; apex rounded and bilobed. *Staminal tube c.* 1 cm long above the base of the corolla-lobes; inner surface of tube densely covered with long hairs, not warty. *Filament* very short, *c.* 0.1 x 0.2 cm, adaxially hairy. *Anther c.* 0.8 x 0.2 cm, red, hairy on pollen sacs. *Epigynous glands c.* 0.3 x 0.2 cm; comprising 2 rounded mounds, surrounding base of style, each mound minutely lobed, apices hairy, (not warty). *Ovary c.* 0.3 x 0.3 cm, glabrous; *style* red, hairy; *stigma* red, *c.* 0.2 cm wide. *Infructescence* spherical, small, 5–7 x 5.5–7 cm in diameter; surmounted by withered flowers; sterile bracts persisting until fruit maturity at base of fruit-head; floral bracts persistent with fruits at their axils; 12—15 fruits per head. *Fruits* obovoid, *c.* 2.5 x 2.5–

3.5 cm wide at the top; glabrous; apex with remnant of calyx *c.* 3 cm long; pericarp smooth, not ridged longitudinally; pericarp 0.4–0.8 cm thick; bright red, shiny. *Seeds* irregularly angular, truncate, *c.* 0.4 x 0.4 cm.

Distribution: In Peninsular Malaysia, this species had been collected from many localities in lowland forests. It is also found in Thailand (Smith, 1986).

Notes: This widely distributed species has involucral/sterile bracts of variable widths and apices. The inflorescence is recognizable from its red peduncle, small subglobose flower-heads and pink outer bracts entirely covered with appressed silvery-white hairs and rose-red flowers.

Lim (2000) published a new variety, var. *ovata* (type at KEP), which has much broader leaves, 18.5 cm wide, compared with *c.* 12 cm wide and sessile, (not petiolate) in var. *maingayi*. Unfortunately, vegetative characters are less reliable than those of the inflorescence in *Etlingera* taxonomy. Within the same species, some leafy shoots may produce both petiolate and sessile leaves, as in *E. pauciflora*. Lim did not give any measurements of the inflorescence or its organs for a comparative study although his photographs showed specimens in flower. A more complete study is required for a taxonomic decision on the status of this variety.

In the same publication, Lim (2000) rendered Holttum's var. *longibracteata* (type at SING) synonymous with var. *maingayi*. In his variety, Holttum (1950) described the involucral bracts as *c.* 3 x 1.5 cm (v. *c.* 3 x 2.5 cm in var. *maingayi*), with the apex narrowly rounded instead of broadly rounded. Without stating sound reasons, Lim declared that var. *longibracteata*, "may be an aberration, and has so far not been found again near the type location – where the usual form is not uncommon". However, not being able to relocate a taxon at the type-site (moreover, 'Tembeling' covers a large area) is insufficient grounds for eliminating Holttum's var. *longibracteata*. The variety should be maintained until detailed comparative studies with var. *maingayi* are made.

Specimens seen: PERLIS: Lubuk Sireh, Hutan Simpan Mata Ayer, *Wan Fadhilah HI 931* (KLU). KEDAH: Pass to Kroh from Baling, *Corner SFN 31569* (SING); Yan, G. Jerai, Batu Hampar, *Saw FRI 44640* (KEP). PERAK: Upper Perak, *Wray s.n.* (SING); Temengor, *Ridley 14419* (SING). SELANGOR: Dusun Tua, *Ridley 7801* (SING). JOHOR: Sedili River, below Mawai, *Corner SFN 36969* (2 sheets) (KEP, SING,); Batu Pahat, *Ridley s.n.* (SING); Ulu Kahang, *Holttum 10902* (SING); Kota Tinggi, G. Panti F.R., West, *Saw FRI 37746* (KEP). KELANTAN: Kuala Lebir, *Gimlette s.n.* (SING); Gua Musang, *Saw FRI 37403* (KEP). PAHANG: Kota Glanggi, *Furtado s.n.* (SING); Ulu Sg. Sat, *Mohd. Shah & Mohd. Noor MS 1772* (KEP, SING); Genting Highlands, Awana Trail, *Saw FRI 37406* (KEP); Taman Negara, Sg. Relau, *Chua, Mustapa & Apok FRI 40607* (KEP).

3. *Etlingera fulgens* (Ridl.) C.K. Lim, Folia malaysiana 1 (2000) 6. Syn.: *Hornstedtia fulgens* Ridl., J. Str. Br. Roy. Asiat. Soc. 32 (1899) 149; Mat. Fl. Malay. Penins. (1907) 40; *Phaeomeria fulgens* (Ridl.) K. Schum., Pflanzenr. Zingib. (1904) 262; Ridl., Fl. Malay Penins. 4 (1924) 272; Holttum, Gard. Bull. Sing. 13 (1950) 180; *Nicolaia fulgens* (Ridl.) K. Larsen, Nat. Hist. Bull. Siam Soc. 23 (1970) 574. Type: Perak, *Ridley s.n.* (SING, iso).

Figures 1C, 2E & F, 3B, 4C

Rhizomes just below ground; *c.* 3 cm diam.; scale-leaves overlapping, creamy-white. *Leafy shoots* 4–5 m tall; 10–14 cm apart, forming clumps; young sheaths faintly ribbed longitudinally, with cross-bars not covered by tufts of short, white hairs; crushed sheaths with a pleasant, sour fragrance; *ligule* 1.5–2 cm, apex broad, entire or slightly bilobed, margin with short, light brown hairs; *petiole* 1.5–2 cm, surface longitudinally ribbed. *Laminas c.* 15 pairs; (topmost) *c.* 31 x 4 cm, (middle) 64–96 x 14–19 cm, (basal) 12–28 x 4.5–8.5 cm; upper surface smooth, glossy, dark green; lower surface glabrous; young leaves with lower surface conspicuously dark purple-red, older leaves with only petiole and midrib purple-red; base variable, blunt or rounded, unequal. *Peduncle* up to *c.* 100 cm, shortly horizontal at first, then erect, aerial, close to base of leafy shoot; sheaths *c.* 12, shortest at base 2.5–12 cm long, apex rounded with subapical tooth 0.1 cm long, green, not overlapping, widely spaced. *Inflorescence* raised well above the ground. *Fertile apical part of inflorescence* with well developed sterile bracts tightly imbricating, forming a firm, broad cup-like structure *c.* 8.5 x *c.* 7.5 cm, in side view the cup almost entirely hiding the inflorescence head proper, the cup not persisting until fruit maturity. *Receptacle of inflorescence c.* 1.5 cm long, apex inflated and rounded; bearing *c.* 60 flowers; 3–6 flowers open simultaneously; flower (from base of ovary to apex of labellum) *c.* 5 cm long. *Sterile bracts c.* 7; 5–7 x 3.5–5.5 cm; rigid, erect, subrotund, strongly incurved at apex; apex broadly rounded, slightly retuse, with subapical tooth hardly 0.1 cm long; outer surface glabrous to sparsely hairy all over with white hairs, deep pink with green margins. *Outer floral bracts* resembling sterile bracts, 4–5 x 2–3.5 cm; *inner floral bracts* smaller, 3–4 x 0.5–1.5 cm. *Bracteole* 2.5 x *c.* 1 cm (when flattened); 2-lobed, apex of lobe acute with 1.5 cm slit on opposite side; glabrous, translucent, tinged red. *Calyx c.* 4 x 1 cm (when flattened); 3-lobed, each lobe with a glabrous subapical tooth less than 0.1 cm; tube with *c.* 2 cm slit on opposite side, glabrous, red. *Corolla-tube c.* 1.5–2 cm long, inner surface densely covered with long hairs at entrance into tube; *lobes (petals)* longer than calyx, 2 cm long, apices rounded, slightly hooded, red with white tips; dorsal lobe not hiding the anther and stigma, *c.* 0.5 cm wide, lateral lobes *c.* 0.3 cm. *Labellum*

held erect; blade 1.8–2 cm long, *c.* 0.8 cm wide; blade and basal lobes pink-red with a yellow margin except at basal lobes; margins of blade plain, apex rounded and retuse. *Staminal tube* *c.* 0.5 cm long above the base of the corolla-lobes; inner surface of tube sparsely covered with long hairs, more hairy below the anther, (not warty). *Filament* short, *c.* 0.3 x 0.2 cm, adaxially hairy. *Anther* *c.* 0.8 x 0.4 cm, pink-red, hairy on pollen sacs. *Epigynous glands* 0.5-0.6 x 0.2 cm; comprising 2 rounded mounds, surrounding base of style, each mound deeply and irregularly lobed, apices hairy, surface conspicuously warty. *Ovary* *c.* 0.6 x 0.3 cm; densely appressed hairy with white, short hairs; *style* red, hairy; *stigma* pink-red, *c.* 0.3 cm across. *Infructescence* globular, flat-topped, large; *c.*11 x 13 cm in diameter; not surmounted by withered flowers; sterile and floral bracts completely disintegrated at fruit maturity; 30—35 fruits per head. *Fruits* ovoid; *c.* 4–5 x 2.5–3.5 cm at the middle; densely covered by appressed short hairs; apex with remnant of calyx 3–4 cm long; pericarp smooth, (not ridged longitudinally); pericarp 0.2–0.4 cm thick; pale green at maturity. *Seeds* irregularly angular, truncate; *c.* 0.4 x 0.3 cm.

Distribution: In Peninsular Malaysia, this species is not common. Holttum (1950) reported it was in cultivation in Singapore. Larsen (1970) recorded it occurs in southern Thailand.

Notes: This species is recognized by its shiny leaves that are dark green above and when young are conspicuously purple-red beneath but turn green when old and have wavy margins, and by its inflorescences with rounded, sterile bracts, strongly incurved at the apex, rose-red with greenish white margins, forming a shallow, wide cup. The young plants sometimes produce short stilt-roots but these are not observed in adult plants.

Smith (1986) had combined this taxon with a Javan one as *Etlingera hemisphaerica* (Blume) R.M. Sm.. Lim (2000) rejected this decision and resurrected the epithet *fulgens* for the Peninsular Malaysian taxon. Among the arguments he presented were that Smith (1986), in making the combination *E. hemisphaerica*, did so without having viewed the types of either Ridley's Malayan *Hornstedtia fulgens* or Blume's Javan *Elettaria hemisphaerica*. However, Lim did not make clear whether he had actually seen the types of these two species himself nor did he give a critical assessment of the inflorescence characters of both the species. The arguments presented by Lim for his decision are therefore not conclusive. Since I have not seen Blume's type from East Java, and to avoid any unnecessary changes until the types of both species are examined, *E. fulgens*, is used in the present work for the taxon from Peninsular Malaysia.

Specimens seen: PERAK: Jor, Batang Padang, *Henderson 10854* (SING). PAHANG: Krau Wildlife Reserve, Hulu Sg. Lompat, *Chua FRI 41742* (KEP). TERENGGANU: Ulu Brang, *Moysey & Kiah SFN 33670* (SING).

4. *Etlingera venusta* (Ridl.) R.M. Sm., Notes Roy. Bot. Gard. Edinb. 43 (1986) 250. Syn.: *Hornstedtia venusta* Ridl., in J. Str. Br. Roy. Asiat. Soc. 32 (1899) 149; Mat. Fl. Malay Penins. (1907) 40; *Phaeomeria venusta* (Ridl.) K. Schum., Pflanzenr. Zingib. (1904) 264; Ridl., Fl. Malay Penins. 4 (1924) 272; Holttum, Gard. Bull. Sing. 13 (1950) 182; *Nicolaia venusta* (Ridl.) K. Larsen, Nat. Hist. Bull. Siam Soc. 23 (1970) 575. Type: Selangor, Genting Bidai, *Ridley 7810* (K, holo; SING, iso).

Figure 5

Rhizomes just below ground; 2.5–4.5 cm diam.; scale-leaves overlapping, green. *Leafy shoots* 2.5–4 m tall; 10–18 cm apart, forming clumps; young sheaths longitudinally ribbed, with cross-bars not covered by tufts of short, white hairs; crushed sheaths with a pleasant, sour fragrance; *ligule* 2–3 cm; apex deeply bilobed; margin and surface densely covered with short, brown hairs; thin, papery, upper portion breaking off easily; *petiole* inconspicuous, always subsessile. *Laminas* c. 10 pairs; (topmost) 51–64 x 9.5–13 cm, (middle) 66–80 x 14–20 cm, (basal) 45–54 x 13–14.5 cm; lamina prominently ribbed; entirely green on both surfaces; lower surface glabrous; base cuneate always. *Peduncle* to 60–80 cm; shortly horizontal, then erect, aerial, close to base of leafy shoot; sheaths c. 12, shortest at base 2–9 cm long, apex rounded with subapical tooth 0.2 cm long, flushed red at apex, green towards base, not overlapping, widely spaced. *Inflorescence* raised well above the ground. *Fertile apical part of inflorescence* with well developed sterile bracts, tightly imbricating, forming a firm, deep cup-like structure 8–9 x c. 7.5 cm; in side view the cup almost entirely hiding the inflorescence head proper; cup not persisting until fruit maturity. *Receptacle of inflorescence* 2–3 cm long; apex inflated and conical; bearing 60–70 flowers; 1–5 flowers open simultaneously; flower (from base of ovary to apex of labellum) 5–5.3 cm long. *Sterile bracts* c. 8; 7.5–12 x 4–5.5 cm; rigid, erect, oblong-elliptic, strongly recurved at apex; apex acute, with subapical tooth c. 0.5 cm; outer surface glabrous or sparsely covered with white hairs; bracts entirely purple-pink or with some white towards apex, pale green at base. *Outer floral bracts* resembling inner sterile bracts but narrower, 7.5–8 x 2.5–3.7 cm; inner floral bracts smaller, 2–6 x 0.5–1.5 cm. *Bracteole* c. 3 x 1.5 cm (when flattened); 2-lobed, apex of lobe acute; with c. 2 cm slit on opposite side; glabrous, translucent, pink towards apex. *Calyx* 4–4.3 x c. 1.5 cm (when flattened); 2- or 3-lobed, each lobe with a glabrous or hairy subapical tooth 0.1 cm; tube with 2–2.5 cm slit on opposite side; glabrous, with brown hairs

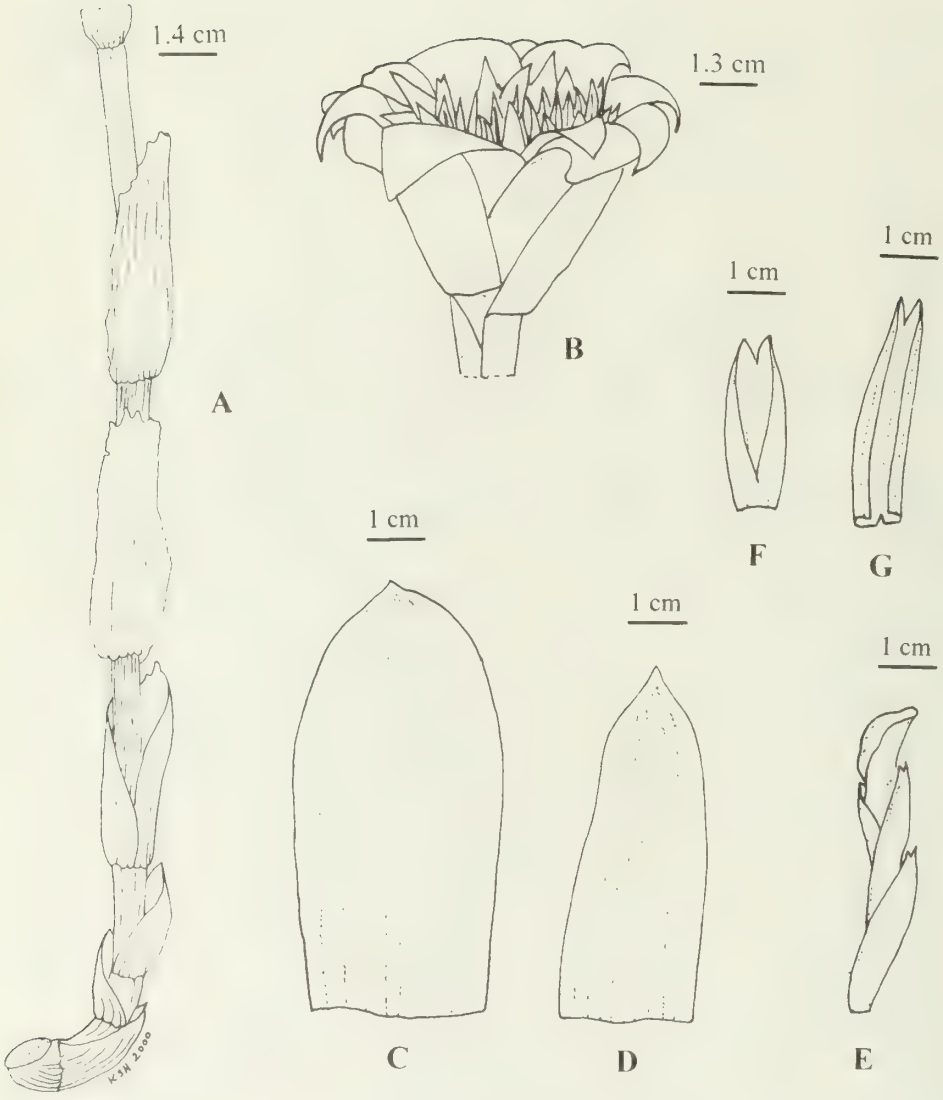
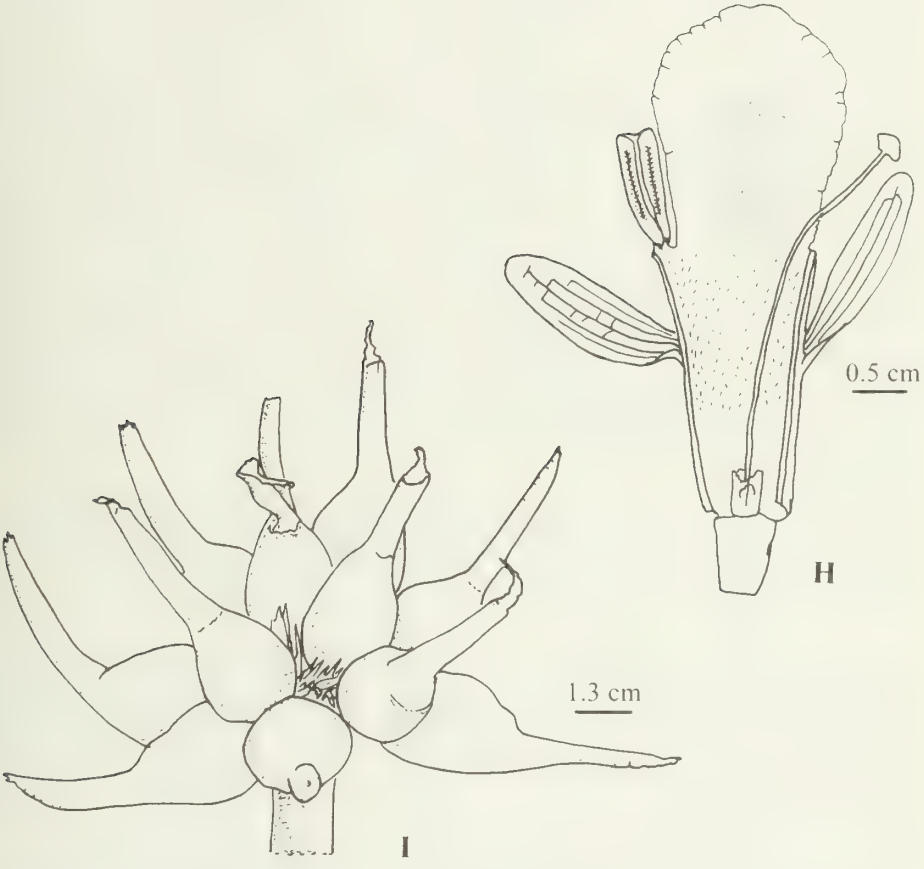


Figure 5. ***Etlingera venusta.*** A, base of peduncle; B, inflorescence; C, sterile bract; D, floral bract; E, flower with bracteole, side view; F, bracteole; G, calyx; H, flower dissected with style displaced; I, infructescence; (A from dry material, B–I from spirit material of *Khaw KSH 244*).


0.5 cm
H
1.3 cm
I

at apex only; white, deep purple-red towards apex. *Corolla-tube* 1–1.2 cm long, inner surface with long hairs at entrance into tube; *lobes (petals)* shorter than calyx, *c.* 1.5 cm long, apices rounded, slightly hooded, white with pink tips; the dorsal lobe not hiding the anther and stigma, 0.5–0.7 cm wide, lateral lobes 0.4–0.5 cm. *Labellum* held erect; blade narrowed to base without widening to form basal lobes; 2–2.2 x 1.2–1.3 cm; white with a red median band not reaching the apex, without red lines radiating from the red band towards the margin; margin slightly crisped or plain; apex rounded, (not retuse). *Staminal tube* 1.2–1.3 cm long above the base of the corolla-lobes; inner surface of tube with long hairs, (not warty). *Filament* very short, *c.* 0.1 x 0.2–0.3 cm wide, adaxially hairy. *Anther c.* 1 x 0.3 cm, pale yellow or white, with white hairs on pollen sacs. *Epigynous glands c.* 0.5 x 0.2 cm; comprising 2 rounded mounds, surrounding base of style, each mound deeply and irregularly lobed, apices hairy, surface warty towards the apices. *Ovary* 0.4–0.7 x 0.4–0.7 cm, glabrous; *style* white, hairy; *stigma* pale pink, 0.3 cm across. *Infructescence* globular; large, *c.* 9 x 13–15 cm diam.; not surmounted by withered flowers; sterile and floral bracts completely disintegrated at fruit maturity; 15—20 fruits per head. *Fruits* ovoid, *c.* 5 x c. 3.5 cm wide at the middle; glabrous, apex with remnant of calyx 3–4.5 cm long; pericarp smooth, not ridged longitudinally; pericarp 0.4–0.5 cm thick; bright red or pink, shiny. *Seeds* irregularly angular, truncate; *c.* 0.4 x 0.3–0.5 cm wide, widest at apex.

Distribution: In Peninsular Malaysia, this species is collected mainly from Perak, Selangor and Pahang. As it has not been recorded elsewhere, *P. venusta* is therefore endemic to Peninsular Malaysia.

Notes: This species is distinguished from *E. corneri* by the absence of stilt-roots, its subsessile, broader leaves with cuneate bases; its rose-pink inflorescences formed by bracts with acute apices and infructescences of red fruits not surrounded by bracts, which completely decay during fruit development.

Specimens seen: PERAK: Ulu Batang Padang, *Ridl. 13835* (SING); Tapah Hills, Sg. Woh, *Ng FRI 1330* (KEP, SING); Tapah Hills, S. Keteh, *Whitmore FRI 15668* (KEP); Hulu Perak, Temenggor F.R., Sg. Samlor, *Khaw KSH 378* (KEP). PAHANG: Genting Highlands, Awana Hotel Trail, *Saw FRI 36448* (KEP).

5. *Etlingera corneri* J. Mood & H. Ibrahim, Nord. J. Bot. 20 (24. 8. 2000) 278–283. Syn.: *Etlingera terengganuensis* C.K. Lim, Folia malaysiana 1 (2000) 9. Type: Thailand, Narathiwat Province, 1991, *Vitoon, Lyon 91.433, s.v.* (KLU, SING).

Figure 6

Rhizome above leaf-litter or just below soil level, 3–4.5 cm diam.; supported by pinkish-orange stilt-roots, 10–25 cm long; scale-leaves overlapping, green tinged dull red. *Leafy shoots* 2.5–4 m tall; close together, 6–14 cm apart, forming clumps; sheaths longitudinally ribbed, with cross-bars not covered by tufts of short, white hairs, when crushed emitting a pleasant, sour fragrance; *ligule* 1.5–2 cm, apex deeply bilobed, margin and surface densely covered with short hairs; *petiole* 1.5–4 cm, surface reticulate. *Laminas* 10–11 pairs; (topmost) 36–47 x 5.5–8 cm, (middle) 57–65 x 13–16 cm, (basal) 14–35 x 5–10 cm; apex shortly-pointed, *c.*1 cm long; base variable, mostly rounded, occasionally unequal, sometimes cuneate; entirely green on both surfaces when young; upper surface prominently ribbed; lower surface glabrous; margin red, crisped, with short white or light brown hairs. *Peduncle* *c.* 90 cm, shortly horizontal to *c.* 4 cm, then erect, close to base of leafy shoot; sheaths *c.* 12, shortest at base, 2.5–13 cm long, apex bilobed with subapical tooth to *c.* 0.5 cm long, surface with short hairs, red at apex, pale green towards base; not overlapping, widely spaced. *Inflorescence* raised well above the ground. *Fertile apical part of inflorescence* with well developed sterile bracts tightly imbricating, forming a firm, deep, cup-like structure 8–9 x *c.* 7.5 cm; the cup almost entirely hiding the inflorescence-head proper in side view; the cup persistent until fruit maturity. *Receptacle of inflorescence* 1–1.5 cm long; apex inflated, conical or rounded; bearing 50–60 flowers; 1–5 flowers open simultaneously; flower (from base of ovary to apex of labellum) 5.3–6 cm long. *Sterile bracts* 8–14; 6.5–8.5 x 2–5.5 cm; rigid, erect, oblong-elliptic, recurved at apex; apex subtruncate, retuse, with subapical tooth *c.* 0.5 cm long; outer surface of bract glabrous, densely covered with appressed white hairs at base only; bracts bright red, white or pale green at base. *Outer floral bracts* resembling the sterile bracts but smaller, 5.5–7.5 x 2–4 cm; *inner floral bracts* smaller still, 3.5–4 x 0.5–1.5 cm. *Bracteole* tubular at base; *c.* 3.5 x 1.5 cm when flattened; unequally 2-lobed, apex of lobe acute or rounded with *c.* 2 cm slit on opposite side; surface with white hairs; white with red apex. *Calyx* tubular at base; 4–4.4 x *c.* 1.5 cm when flattened; 3-lobed, each lobe with a glabrous or hairy subapical tooth *c.* 0.1 cm long; tube with *c.* 2.5 cm slit on opposite side; glabrous, with appressed white hairs at base only; white, red at apex. *Corolla-tube* 1.5–2 cm long, inner surface densely covered with long hairs at entrance into tube; *lobes (petals)* shorter than calyx, *c.* 2 cm long, apices rounded, not hooded, pink; dorsal lobe not hiding the anther and stigma, *c.* 0.5 cm wide, lateral lobes narrower, *c.* 0.4 cm wide. *Labellum* held erect, blade narrowed to base without widening to form basal lobes; *c.* 2 x 1.2–1.3 cm; white with a red median band not reaching the apex, with red lines

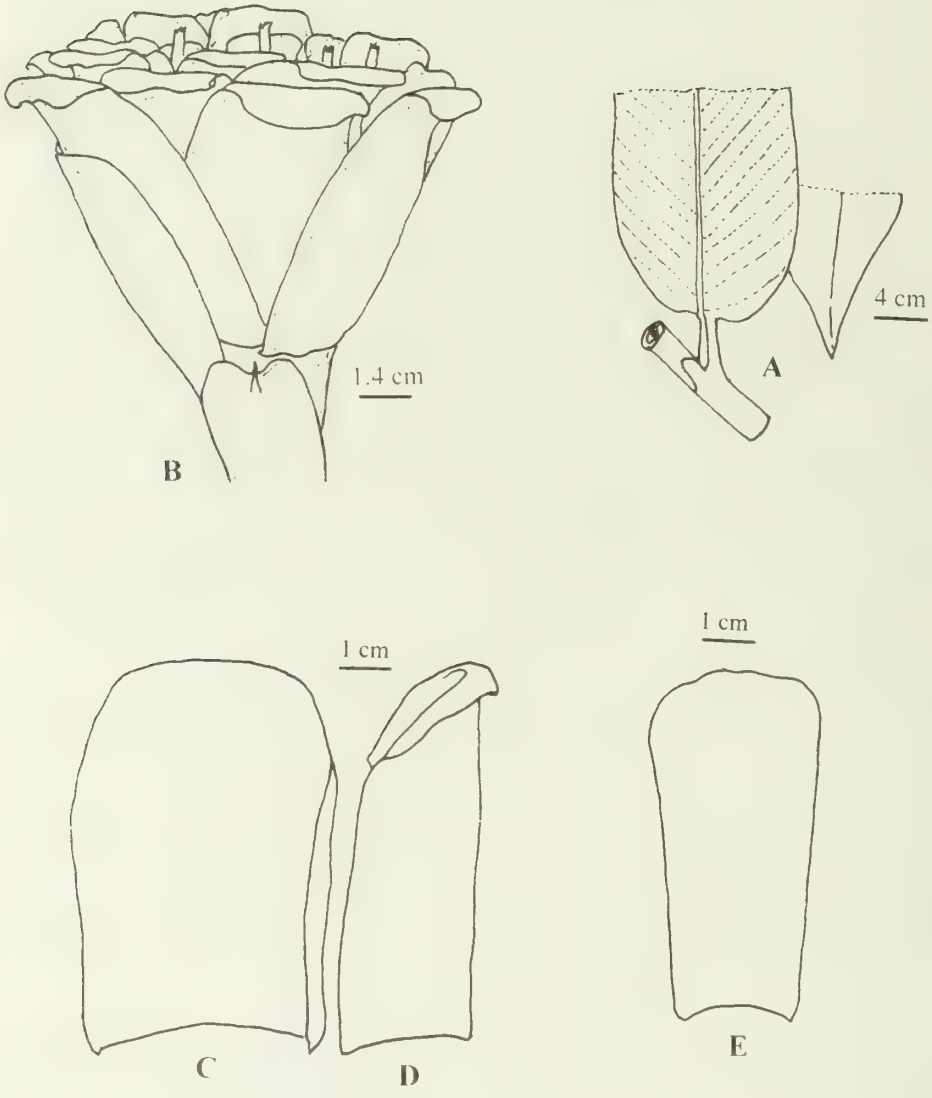
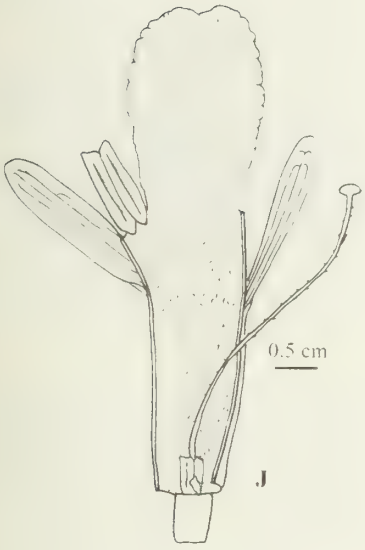
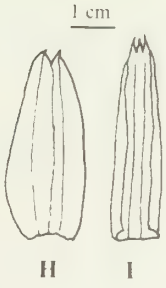


Figure 6. ***Etlingera corneri.*** A, leaf base and tip; B, inflorescence; C, sterile bract, adaxial view; D, sterile bract, lateral view; E, floral bract, adaxial view; F, flower with bracteole, lateral view; G, flower with bracteole, adaxial view; H, bracteole, flattened, adaxial view; I, calyx, flattened, adaxial view; J, flower dissected with style displaced; K, epigynous glands, adaxial view; L, epigynous glands, abaxial view; M, infructescence with persistent involucral and floral bracts displaced; (A, B from fresh material, C-L, spirit, M, dry; from *Khaw KSH 601*).


0.5 cm
J


1 cm
M
KSH 2000


1 cm
F
G


1 cm
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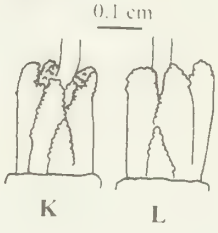
I


0.1 cm
K
L

radiating from the red band towards the margin; margin slightly crisped; apex rounded, slightly retuse. *Staminal tube* 0.9–1 cm long above the base of the corolla-lobes, inner surface of tube densely covered with long hairs, (not warty). *Filament* very short, *c.* 0.1 x 0.2–0.3 cm, adaxially hairy. *Anther* *c.* 1 x 0.3 cm, red at apex, white at base, with yellow hairs on pollen sacs. *Epigynous glands* *c.* 0.4 x 0.2 cm; comprising two rounded mounds, surrounding base of style, each mound deeply and irregularly lobed, apices glabrous, surface warty towards the apices. *Ovary* 0.4–0.6 x *c.* 0.4 cm, glabrous, white; *style* white, hairy; *stigma* pink, *c.* 0.2 cm across. *Infructescence* globular, large, *c.* 9 x 10–11 cm, not surmounted by withered flowers, sterile bracts surrounding fruits persisting to fruit maturity, 8—17 fruits per fruit head. *Fruit* ovoid; *c.* 4 x 2.5 cm at the middle; glabrous; apex with remnant of calyx 3–4.5 cm long; bright red or pink, shiny; pericarp smooth, not ridged longitudinally, 0.3–0.4 cm thick. *Seeds* 35–45 in each fruit; covered with a white, pulpy aril; dark brown; irregularly angular truncate; *c.* 0.4 x 0.3–0.5 cm, widest at apex.

Distribution: This attractive species of horticultural potential has been recorded in the Peninsula from the states of Kedah, Perak, Pahang and Terengganu. It is not common and there are few collections. It is also found in southern Thailand (Mood & Ibrahim, 2000).

Notes: The confusion over *Etlingera corneri* and *E. venusta* is discussed in detail by Mood & Ibrahim (2000). *E. corneri* is distinguished from *E. venusta* by its stilt roots, petiolate leaves usually with rounded bases, its bright red inflorescence in the form of a deep cup; the outer bracts that are strongly recurved and have subtruncate apices, and the infructescence of red fruits surrounded by persistent bracts.

The plants from northern Perak, on which the above description is based, have leaves that are entirely green on both surfaces, even when young. This character differs from that described by Mood & Ibrahim (2000): "dark green above, ... green (or purple) below ...". For two specimens from Johor, which were previously annotated as *Phaeomeria venusta* and which were cited by Mood & Ibrahim as being *E. corneri*, the field notes read: "leaves dark green, glossy with undulate edge, purple beneath, though old leaves may lose the purple" (*Corner SFN 32778*, KEP, SING) and "dark green above, purple beneath, glossy on both surfaces" (*Sinclair 10596*, SING). This leaf character is reminiscent of *E. fulgens*. As I am uncertain of the identity of *Corner SFN 32778* and *Sinclair SFN 10596*, I have excluded them from the list below of specimens seen. The field notes in *Corner SFN 32778* also mention "stilts 2–4" high", shorter than those described here. Until Mood and Ibrahim (2000) clarified the confusion over the identities

of *E. venusta* and *E. corneri*, these two species were often misidentified. The photographs in Weber (1995) showing the inflorescence and infructescences of *E. venusta* from Sekayu, Terengganu are actually those of *E. corneri*. This was noted by Mood and Ibrahim (2000). Similarly, photographs of *E. venusta* infructescences in Larsen *et al.* (1999) are in fact those of *E. corneri*, while the photograph showing "clusters of horn-like *Etlingera* fruits" are the fruits of *E. venusta*.

Specimens seen: KEDAH: Ulu Muda F.R., Baling, Waduk, *K.H. Lim, LKH 158* (KEP). PERAK: Hulu Perak,Temenggor F.R., Pos Chiong, Sg. Sara, *Khaw KSH 373* (KEP); Sg. Tiang, *Khaw KSH 586, 601, 606* (KEP). PAHANG: Kuantan, Sg. Pohoi, *Mohd. Shah, Sidek & Samsuri MS 3787* (KEP). TERENGGANU: Ulu Brang, *Movsey & Kiah SFN 33721* (KEP, SING); Hulu Terengganu F.R., Hutan Lipur Sekayu, *Anthonysamy SA 648* (KEP); Ulu Terengganu (Extension) F.R., Cpt. 43, *Saw FRI 39880* (KEP); Ulu Terengganu F.R., *C.K. Lim LIM 4229* (KEP).

6. *Etlingera pieeae* Khaw, *sp. nov.*

Etlingera triorgyali affinis sed inflorescentia supra terram elevata, pedunculo saltem duplo longiore, bracteis involucralibus tantum basin laxe imbricatis ergo cupulam involucralem conspicuam non formanti, inflorescentia inter bracteas a latere visibili, bracteis rigidis leviter expansis, oblanceolatis, longitudinaliter inflexis non recurvatis, pallide viridis marginibus et apicibus rubris et longitudinaliter rubro-striatis, apice inflato axis florifero conico, flore, bractea involucrale, bracteis, bracteolis et calycibus brevioribus et angustioribus, corolla calyce longiore loba dorsali antheram et stigma occultanti, tubo corollae multo breviore, labello erecto loba media breviore et angustiore, tubo staminali breviore, infructescentia minore vestigiis bractearum involucrarum persistentibus, fructibus paucis minoribus, pericarpio laeve non porcato recedit. ***Typus:*** Perak, Hulu Perak, Belum F.R., Sg. Beruar, *Khaw KSH 420* (*holotypus* KEP; *isotypus* KLU).

Figure 7

Rhizomes just below soil level; 3–4 cm diam.; scale-leaves overlapping, green. *Leafy shoots* to 4–5 m tall; 7–18 cm apart, forming clumps; sheaths conspicuously longitudinally ribbed with cross-bars covered by short, white hairs; when crushed with a strong, peppery scent; *ligule* 2–2.5 cm long, apex acute, margin and surface densely covered with short, brown hairs; *petiole* 2.5–4 cm long, surface reticulate. *Laminas* 13–14 pairs; (topmost) 68–73 x 7–9 cm, (middle) 87–93 x 16-21 cm, (basal) *c.* 55 x 13 cm; when young entirely green on both surfaces; upper surface prominently ribbed; lower surface and margin with soft, short hairs; base cuneate, unequal;

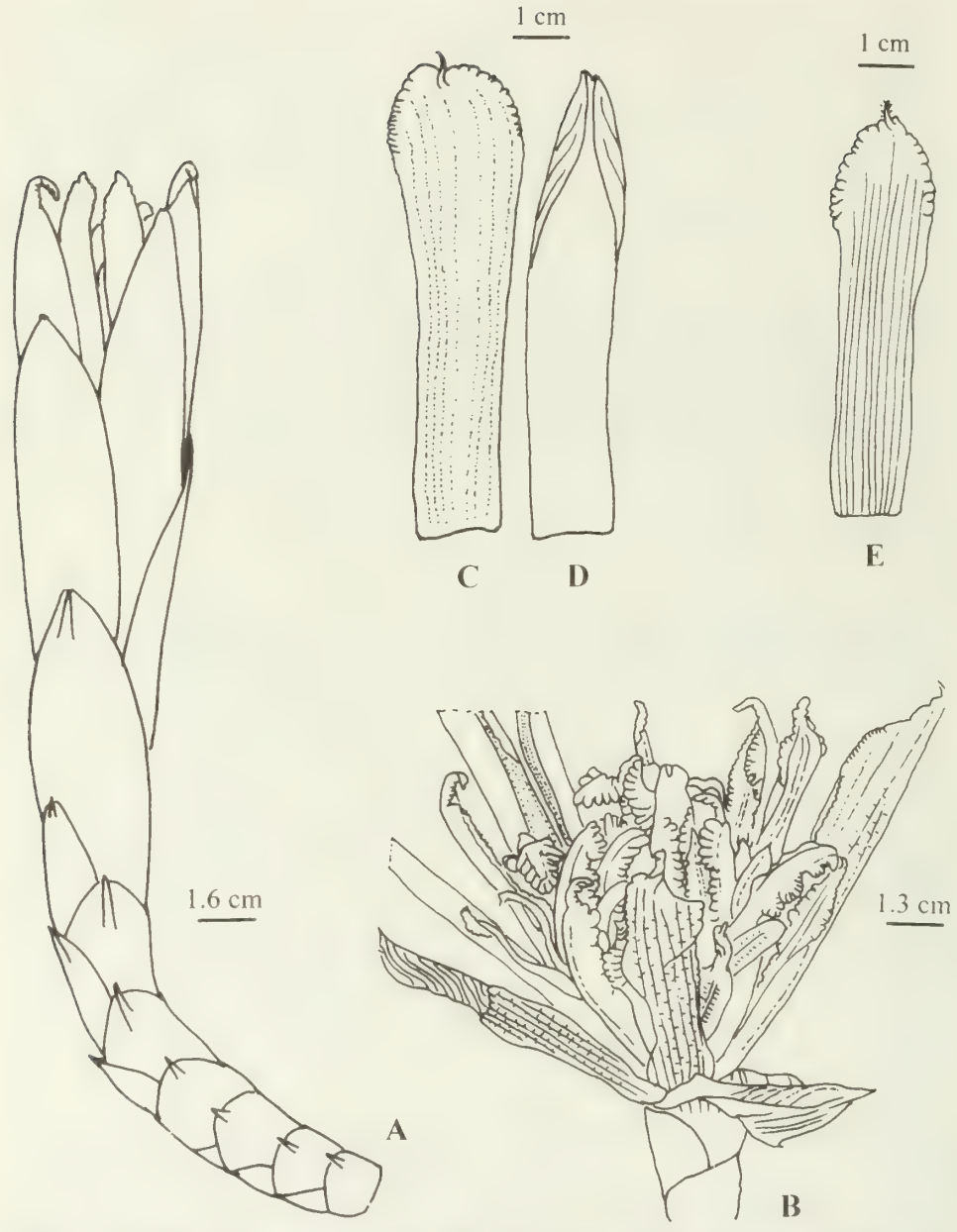
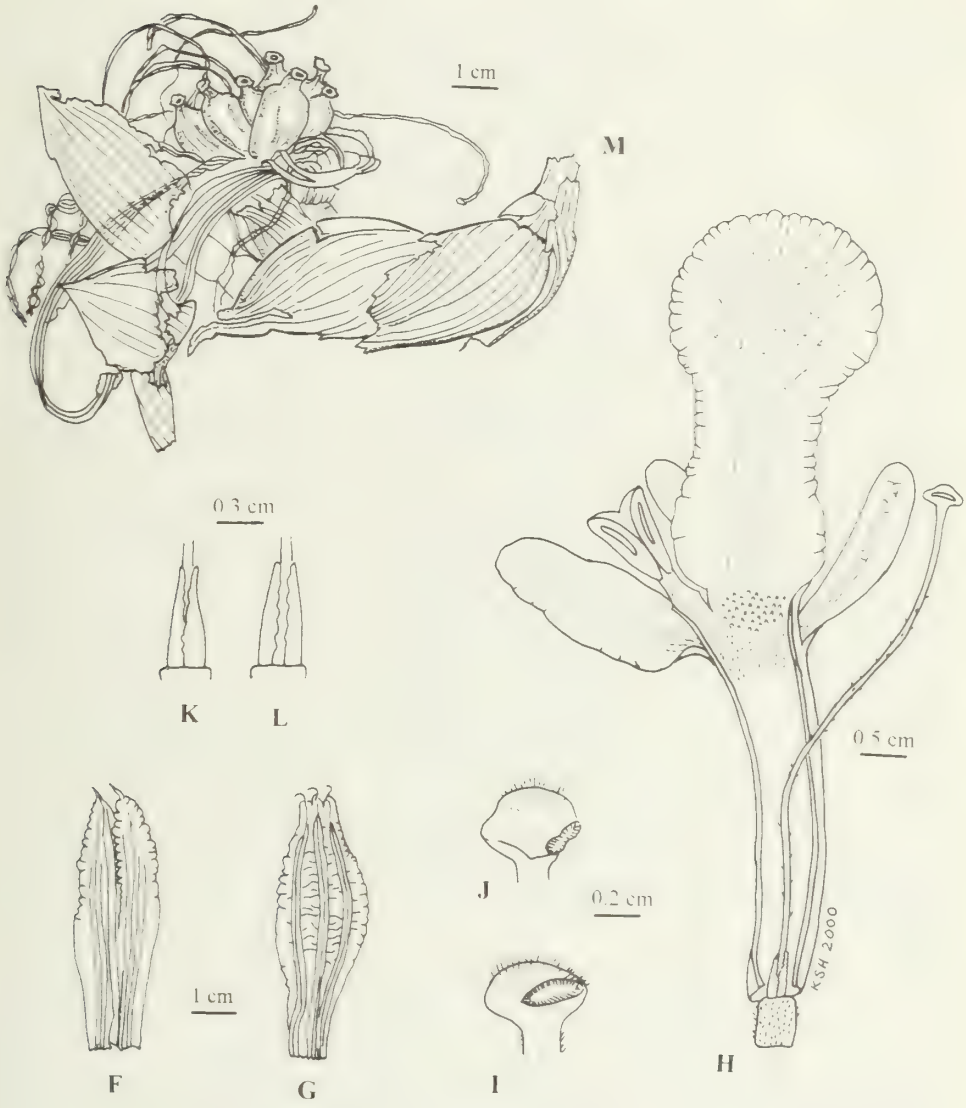


Figure 7. ***Etlingera pieeae*** S.H. Khaw, ***sp. nov.*** A, young inflorescence; B, inflorescence with sheaths and flower-head; C, sterile bract, abaxial view; D, sterile bract, adaxial view; E, floral bract, abaxial view; F, bracteole, flattened, abaxial view; G, calyx, flattened, abaxial view; H, flower dissected with style displaced; I, stigma, abaxial view; J, stigma, lateral view; K, epigynous glands, adaxial view; L, epigynous glands, abaxial view; M, infructescence with fruits surrounded by remnants of sheaths and bracts with skeletonized veins. (A-L from spirit material of *Khaw KSH 420*, M from dry material.)


1 cm
M
0.3 cm
K
L
0.5 cm
KSH 2000
H
J
0.2 cm
I
1 cm
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G

apex shortly pointed, *c.* 1 cm long. *Peduncle* to *c.* 48 cm long, horizontal, then erect, aerial, close to base of leafy shoot; sheaths *c.* 12, shortest at base from 1.5–13 cm, apex rounded with a sharp, hard, subapical spine *c.* 0.1 cm, overlapping, green, striped deep pink, dull purple-red at apex. *Inflorescence* raised well above the ground. *Fertile apical part of inflorescence* with well developed sterile bracts, loosely imbricating at the bases only, (not forming any conspicuous sub-cylindric structure), in side view the inflorescence head proper visible between the bracts. *Receptacle of inflorescence c.* 1 cm long, apex inflated and conical; bearing 20–35 flowers; 7–12 flowers open simultaneously; flower (from base of ovary to apex of labellum) *c.* 9 cm long long. *Sterile bracts* 5–8; 9-12 x 1.5–3 cm; rigid, spreading slightly, oblanceolate, longitudinally inflexed but not recurved; apex rounded, retuse, crisped, with subapical hairy spine *c.* 0.2 cm long; outer surface with white hairs, densely appressed hairy at apex and base; surface pale green, apex and margin red and longitudinally striped reddish-pink. *Outer floral bracts* like inner sterile bracts; 8.5–9.5 x 1.5–2.5 cm; *inner floral bracts* smaller, *c.* 6 x 0.5–1 cm. *Bracteole* 5–6.5 x c. 1.5 cm (when flattened); 2-lobed, apex of each lobe rounded with *c.* 3 cm slit on opposite side; surface densely covered with tawny hairs; pink. *Calyx* 4.5–6 x *c.* 1.5 cm (when flattened); 3-lobed, each with a glabrous, subapical tooth *c.* 0.1 cm; tube with *c.* 2 cm slit on opposite side; surface densely covered with appressed white hairs. *Corolla tube c.* 4 cm long, inner surface densely covered with long hairs at entrance of tube, rest of tube glabrous; *lobes (petals)* 1–2 cm longer than calyx, *c.* 2 cm long, apices rounded, not hooded, margins crinkled, red; dorsal lobe hiding the anther and stigma, *c.* 1 cm wide, lateral lobes narrower, *c.* 0.5 cm. *Labellum* held erect, blade elongate, 3.5–4 cm long, *c.* 2 cm wide; blade and basal lobes entirely bright pink-red; margin of blade crisped and crinkled; apex broadly rounded, slightly retuse. *Staminal tube c.* 0.5 cm long above the base of the corolla-lobes; inner surface of tube densely covered with long hairs especially below the anther, rest of surface densely covered by warts (glands?). *Filament* short, *c.* 0.3 x 0.4 cm, adaxially hairy. *Anther c.* 1 x 0.3 cm, white, hairy on pollen sacs. *Epigynous glands* 0.5–0.6 x *c.* 0.2 cm; comprising 2 fleshy, compressed blade-like structures, not encircling base of style, each blade not further lobed, apex glabrous, shortly-pointed, (surface not warty). *Ovary c.* 0.5 x 0.4 cm, densely covered with appressed, white, short hairs; *style* white or pale pink, hairy; *stigma* pink, *c.* 0.4 cm across. *Infructescence* a small spherical head, *c.* 2.5 x 5 cm (when dry), not surmounted by withered flowers, surrounded by remnants of sterile bracts with skeletonized veins persistent at fruit maturity, *c.* 10 fruits per fruit head. *Fruit* obovoid; *c.* 1.5 x 1 cm at the top (when dry); buff coloured; densely covered with appressed, short hairs; apex with remnant of calyx base only, *c.* 0.5 cm long (when dry);

pericarp smooth, not ridged longitudinally; pericarp 0.1–0.2 cm thick. *Seeds* irregularly angular, truncate.

Distribution: Endemic to Peninsular Malaysia: Perak and Kedah (in Ulu Muda F.R., Baling, Waduk, sighted only, not collected).

Ecology: By banks of shaded as well as more open, unshaded, small streams in lowland forest at *c.* 300 m altitude.

Notes: *Etlingera pieeae* closely resembles *E. triorgyalis* in vegetative characters. Both have tall leafy-shoots with sheaths that emit a strong peppery scent when crushed. They are often found growing near each other. However, its inflorescence shows that *E. pieeae* is a distinct species. It has a combination of floral characters of both the *Phaeomeria* and *Achasma* groups of *Etlingera*. It resembles the *Phaeomeria* group in having a long peduncle with its flower-head held well above the ground, but has overlapping peduncle-sheaths and a long labellum like those of the *Achasma* group. Its flower-head is neither cup-shaped (typical of the *Phaeomeria* group) nor sub-cylindric (most of the *Achasma* inflorescences). Instead, its inflorescence with slightly spreading oblanceolate, sterile bracts, loosely imbricating at the bases only, resembles that of *E. pauciflora* of the *Achasma* group. This combination of features in *E. pieeae* from the two groups makes it an interesting species, lending support to the union of *Phaeomeria* and *Achasma* into a single genus, *Etlingera*.

Table 2 summarises the differences between *E. pieeae* and *E. triorgyalis*, its closest relative.

This species is named for Mr. Abdullah Piee, who first discovered this new species, in appreciation for his assistance and companionship in ginger field trips.

Specimens seen: PERAK: Hulu Perak, Temenggor F.R., Sg. Emban, *Khaw KSH 603* (KLU), *KSH 604* (KEP); Belum F.R., Sg. Beruar, *Khaw KSH 420* (KEP, KLU).

7. *Etlingera pauciflora* (Ridl.) R.M. Sm., Notes Roy. Bot. Gard. Edinb. 43 (1986) 248. Syn.: *Hornstedtia pauciflora* Ridl., in J. Str. Br. Roy. Asiat. Soc. 32 (1899) 144; Mat. Fl. Malay. Penins. (1907) 38; Fl. Malay Penins. 4 (1924) 270; *Achasma pauciflorum* (Ridl.) Holttum, Gard. Bull. Sing. 13 (1950) 187. Type: Selangor, Gua Batu, *Ridley 8174, s.v.* (K).

Figure 1E, 2I & J, 3H, 4 E–G

Rhizomes 6–13 cm below the ground; *c.* 0.6 cm diam.; scale leaves overlapping, white. *Leafy shoots* 2–4 m tall; close together or widely spaced,

Table 2. Characters that distinguish *Etlingera pieeae* from *E. triorgyalis*.

	E. pieeae	*E. triorgyalis*
Peduncle length (cm)	to *c.* 48	5–15
Inflorescence	raised well above the ground	subterranean except for apices of sterile bracts and flowers
flower-head	sterile bracts loosely imbricating at the bases only, not forming any conspicuous subcylinder	sterile bracts tightly imbricating, forming a narrow subcylinder,
	the flower head visible between the bracts in side view	the subcylinder hiding *c.* 2/3 of the flower-head in side view
number of flowers	20–35	40–50
flower length (cm)	*c.* 9	*c.* 13.5
sterile bracts		
form	rigid, spreading slightly, oblanceolate, longitudinally inflexed but not recurved	rigid, erect, oblong-obovate, recurved at apical part, concave
width (cm)	1.5–3	3–6
colour	pale green, apex and margin red, longitudinally striped red	white or pale green, deep pink towards apex
corolla lobes	1–2 cm longer than calyx	equal to calyx
	dorsal lobe hiding anther and stigma	dorsal lobe not hiding anther and stigma
tube length (cm)	*c.* 4	5.8–6.5
labellum length (cm)	3.5–4	*c.* 5
staminal tube length (cm)	*c.* 0.5	*c.* 1.2
Infructescence size (cm)	*c.* 2.5 x 5 (dry)	*c.* 6 x 10
persistence of sterile bracts at fruit maturity	the bracts partially decay, remnants of bracts with skeletonized veins surrounding infructescence	bracts completely decayed
number of fruits	*c.* 10	20–35
Fruit		
colour	buff	dark red or pink
size (cm)	*c.* 1.5 x 1 (dry)	*c.* 3 x 3 cm
pericarp	smooth, not ridged longitudinally	ridged longitudinally, each ridge with many irregular fine spine-like processes

9–80 cm apart; sheaths slightly longitudinally ribbed with cross-bars covered by tufts of short, white hairs (clearer in young sheaths), without distinct scent when crushed; *ligule* 1–2.5 cm; apex rounded, entire; margin with short, brown hairs; surface glabrous; lamina often sessile or with *petiole* 0.5–1 cm long in laminas with unequal bases, surface reticulate. *Laminas c.* 11 pairs; (topmost) *c.* 37 x 6.5 cm, (middle) 44–65 x 9–11 cm, (basal) *c.* 40 x 12.5 cm; upper surface prominently ribbed; entirely green on both surfaces when young; lower surface glabrous; margins crisped, red with brown hairs; base cuneate, sometimes unequal. *Peduncle* 5–10 cm long; horizontal, then erect, entirely subterranean at base of leafy shoot or some distance away; sheaths *c.* 8, shortest at base 0.5–5.5 cm, apex acute with stiff apical spine *c.* 0.1 cm, overlapping, white. *Inflorescence* entirely subterranean except for apices of sterile bracts and flowers. *Fertile apical part of inflorescence* with 1–3 well developed sterile bracts loosely imbricating at the bases only, not forming any conspicuous, sub-cylindric structure; in side view the inflorescence head proper visible between the bracts; the sterile bracts not persisting to fruit maturity. *Receptacle of inflorescence c.* 0.5 cm long; apex inflated and rounded, bearing 1–3 flowers; 1 or 2–3 flowers open simultaneously; flower (from base of ovary to apex of labellum) 11.5–13 cm long. *Sterile bracts* 1–3; 5–6 x 1–1.5 cm; rigid, spreading slightly outwards from a loosely imbricating base; lanceolate, concave, apex acute, with a stiff, sharp point; outer surface glabrous; white. *Floral bracts* like sterile bracts, *c.* 5 x 1 cm. *Bracteole* 4.5–5 x 1.5–2 cm (when flattened); unequally 2-lobed; apex of lobe rounded with *c.* 3 cm slit on opposite side; glabrous; red. *Calyx* 6.5–7 x 1.5 cm (when flattened); 3 lobed, each lobe with an apical tuft of long, brown hairs; tube with *c.* 2.5 cm slit on opposite side; glabrous, tawny hairs at apex only; pink, red at apex. *Corolla tube* 4.5–6 cm long; inner surface densely covered with long hairs at entrance into tube, rest of tube glabrous; *lobes (petals) c.* 1–2 cm longer than calyx, 3–4 cm long; apices rounded, not hooded, red; the dorsal lobe hiding the anther and stigma, *c.* 1.5 cm wide, lateral lobes narrower, *c.* 1 cm. *Labellum* held horizontal; blade elongate, *c.* 5 cm long; *c.* 1.5 cm wide; blade yellow with red margins, basal lobes yellow tinged red; margin of blade crisped and crinkled, apex rounded, entire or slightly retuse. *Staminal tube c.* 1.5 cm long above the base of the corolla lobes; inner surface of the base of the tube densely covered with long hairs, (not warty). *Filament* short, *c.* 0.5 x 0.6 cm wide, back glabrous. *Anther c.* 1 x 0.5 cm; red, hairy on pollen sacs. *Epigynous glands* 0.6–0.7 cm by 0.2–0.3 cm; comprising 2 fleshy, compressed, blade-like structures, not encircling base of style, each blade not further lobed, apex glabrous, shortly-pointed, surface not warty. *Ovary c.* 0.5 x 0.5 cm, with white, short hairs; *style* pale-pink, hairy; *stigma* white, 0.3 cm across. *Infructescence* spherical; small, *c.* 4 x 4 cm in diameter; not

surmounted by withered flowers; bracts completely disintegrated at fruit maturity; 1—3 fruits per head. *Fruits* spherical; *c.* 2–4 x 3–4 cm wide at the middle; densely covered with appressed white, short hairs; apex with scar of calyx only, hardly 0.1 cm long; pericarp smooth, not ridged longitudinally; pericarp *c.* 0.1 cm thick; white. *Seeds* irregularly angular, truncate, *c.* 0.6 x 0.4 cm wide at the top.

Distribution: Endemic to Peninsular Malaysia. Although there are few collections, where this species occurs, it is common. Weber (1995) mentions that it has been found in Selangor, Pahang, Terengganu and Johor. It has also been found in Perak (Khaw, 2000).

Notes: This species is easily recognized in being few-flowered, usually with only 1–3 flowers. In flower coloration, it is similar to *Etlingera punicea* in that the lip has a yellow centre but it is a distinct species as the leafy shoots, inflorescence (Fig. 1E, F), flowers (Fig. 2I, J, M, N) and infructescence (Fig. 4, E–G, H) of *E. pauciflora* and *E. punicea* are entirely different.

Specimens seen: JOHOR: Kota Tinggi, *Holttum s.n.* (SING); Sg. Segun, G. Panti, *Corner SFN 30890* (2 sheets) (SING). TERENGGANU: Ulu Kajang, Kemaman, *Corner SFN 30430* (SING).

8. *Etlingera subterranea* (Holttum) R.M. Sm. Notes Roy. Bot Gard. Edinb. 43 (1986) 250. Syn.: *Achasma subterraneum* Holttum, Gard. Bull. Sing. 13 (1950) 187. Type: Pahang, Cameron Highlands, 5000 ft., *Holttum, SFN 31212* (SING).

Distribution: This species is endemic to Peninsular Malaysia.

Notes: I have not been able to locate this species in the field. It has only been collected twice, on both occasions from Cameron Highlands, Pahang. According to Holttum (1950): "This is like *A. sphaerocephalum* in flowers, but like *A. pauciflorum* in inflorescence. In leaf-characters it is rather between *A. sphaerocephalum* and *A. macrocheilos*, having a petiole of moderate length. ... The fruits agree exactly with the fruits of *A. megalocheilos* as described in Java by Valeton (Ic. Bog. 2: t. 199), but are only 2 or 3 instead of 12 or more".

Other specimen seen: PAHANG: Cameron Highlands, 4,600 feet, *Henderson SFN 23562* (SING).

9. *Etlingera punicea* (Roxb.) R.M. Sm. Notes Roy. Bot. Gard. Edinb. 43 (1986) 250. Syn.: *Alpinia punicea* Roxb., Fl. Indica 1 (1820) 73; *Achasma macrocheilos* Griff., Notul. Plant. Asiat. 3 (1851) 429, Ic. Plant. Asiat. (1851) t. 357; Holttum, Gard. Bull. Sing. 13 (1950) 188; *Amomum macrocheilos* Baker, Fl. Brit. India 6 (1892) 235; *Hornstedtia macrocheilos* Ridl., in J. Str. Br. Roy. Asiat. Soc. 32 (1899) 147; Fl. Malay Penins. 4 (1924) 271; *Hornstedtia metriocheilos* (Griff.) Ridl., in J. Str. Br. Roy. Asiat. Soc. 32 (1899) 147; Fl. Malay Penins. 4 (1924) 271 (not of Griffith). Type: Malacca, *Griffith s.n., s.v.* (specimen lost?).

Figure 1F, 2M & N, 3I, 4H

Rhizomes to *c.* 12 cm below ground; slender, *c.* 1.5 cm diam.; overlapping scale-leaves, green tinged dull red or pink. *Leafy shoots* 2–5 m tall; close together or widely spaced, 11–40 cm apart; sheaths conspicuously ribbed with cross bars covered by tufts of short, white hairs (clearer in young sheaths), sometimes smooth, green or yellowish with purple blotches, crushed sheaths without distinct scent; *ligule* 0.5–1 cm, apex broadly rounded, entire, margin and surface densely covered by short, brown hairs; *petiole* *c.* 0.5 cm or subsessile, surface reticulate. *Laminas* *c.* 10 pairs; (topmost) *c.* 58 x 9 cm, (middle) 62–91 x 14–17 cm, (basal) 18–22 x 7 cm; upper surface smooth or with slightly raised lateral veins; entirely green (sometimes with brown bars on lower surface of young leaves); lower surface glabrous; base cuneate, sometimes with auricles. *Peduncle* 5–10 cm; horizontal, then erect, entirely subterranean at base of leafy-shoot or some distance away; sheaths *c.* 13, shortest at base 0.5–5 cm long, apex acute, with a stiff spine 0.4 cm long, overlapping, pale green. *Inflorescence* entirely subterranean except for apices of sterile bracts and flowers. *Fertile apical part of inflorescence* with well developed sterile bracts tightly imbricating forming a narrow sub-cylindric structure, 10–13 x *c.* 4 cm wide, in side view hiding *c.* 2/3 or more of the inflorescence head proper; sterile bracts persisting to fruit maturity. *Receptacle of inflorescence* *c.* 0.5 cm long; apex inflated and rounded; bearing *c.* 30 flowers; 7–10 flowers open simultaneously; flower (from base of ovary to apex of labellum) 10.5–12.5 cm long. *Sterile bracts* *c.* 5; 5.5–6 x 2–2.5 cm; rigid, erect, lanceolate, broadest at middle, strongly concave; apex acute, with a stiff, sharp point; outer surface sparsely covered with white hairs, more densely hairy at base; white, pink towards apex. *Outer floral bracts* resembling the sterile bracts; *c.* 6 x 2 cm; *inner floral bracts* smaller *c.* 5 x 1 cm. *Bracteole* *c.* 4 x 1.5 cm (when flattened); 2-lobed, apex of lobe rounded with 1.5 cm slit on opposite side; surface with light brown hairs; pink. *Calyx* *c.* 7 x 1.5 cm (when flattened); 3-lobed, each lobe with a hairy, subapical tooth *c.* 0.1 cm; tube with *c.* 3 cm slit on opposite side; glabrous, with tawny hairs only at apex.

Corolla-tube *c.* 6 cm; inner surface with hairs mostly at upper 1/3 of tube; *lobes (petals)* *c.* 1–2 cm longer than calyx, *c.* 3 cm long, apices rounded, not hooded, red; dorsal lobe hiding the anther and stigma, *c.* 0.8 cm wide, lateral lobes narrower, *c.* 0.5 cm. *Labellum* held horizontal, blade elongate, 5.5–6 cm long, *c.* 1.5 cm wide; blade and basal lobes yellow with a narrow scarlet margin broadening to the spatulate apex, scarlet margins of the haft infolded so that the 'margin' appears to be yellow; margin of blade crisped and crinkled; apex rounded, retuse or deeply bilobed. *Staminal tube* 0.8–1 cm long above the base of the corolla-lobes; inner surface of tube glabrous or sparsely covered with long hairs, (not warty). *Filament* short, c. 0.3 x 0.3 cm, adaxially glabrous. *Anther* *c.* 1 x 0.5 cm; red, hairy on pollen sacs. *Epigynous glands* *c.* 0.5 x 0.2–0.3 cm; comprising 2 fleshy compressed blade-like structures, not encircling base of style, each blade not further lobed, apex glabrous, shortly-pointed, surface not warty. *Ovary* *c.* 0.5 x 0.4 cm; covered with appressed, white, short hairs; *style* white, hairy; *stigma* pink, 0.3 cm across. *Infructescence* globular; large *c.* 6 x 9 cm in diameter; not surmounted by withered flowers; sterile bracts at base of fruit head persisting to fruit maturity; floral bracts persistent with fruits at their axils; 5—15 fruits per head. *Fruits* obovoid; 3–3.5 x 3–4.5 cm wide at the top; densely covered with appressed short hairs; apex with remnant of calyx base only, less than 0.5 cm long; pericarp ridged longitudinally, each ridge with many irregular, coarse, spine-like processes; pericarp *c.* 0.2 cm thick (excluding ridges), pinkish-red. *Seeds* irregularly angular, truncate; *c.* 0.4 x 0.3 cm wide at the top.

Distribution: A common species found in lowland forests throughout the Peninsula. It also occurs in Thailand, Borneo, Java and Sumatra (Smith, 1986).

Notes: The conspicuous character of this species is the colour of the lip, yellow in the middle, the rest scarlet. There is variation in the details of the lip, especially the tip of the mid-lobe.

Specimens seen: PERAK: Tanjong Malim, *Burkill & Haniff 13476* (SING). SELANGOR: Genting Bidai, *Ridley 7812* (SING); Genting Simpah, *Hume 9722* (SING); Klang, Teluk Reserve, *Burkill SFN 5997*, Bukit Rajah Forest, *Burkill 15512* (SING); Ulu Gombak, *Yong FRI 99256* (KEP). NEGRI SEMBILAN: G. Tampin, *Burkill 3179* (SING); Seremban, G. Telapak Buruk, *Saw FRI 40052* (KEP). JOHOR: B. Tinjau Laut, *Corner SFN 37061* (2 sheets) (SING); Sg. Pelepah, G. Panti, *Md. Nur 20012* (SING); Kuala Tebing Tinggi, *Ridley s.n.* (SING); Batu Pahat, *Ridley s.n.* (SING); Sg. Kayu Ara, Mawai-Jemaluang Rd., *Corner SFN 31476* (SING); G. Pulai, *Ridley s.n.* (SING); G. Panti, *Ridley s.n.* (SING); 12 Mile Mawai-Jemaluang Road, *Corner SFN 29993* (SING); Sg. Tebrau, *Ridley s.n.* (SING). TERENGGANU: Sg. Kemaman, Kampong Ayer Puteh, *Corner SFN 30717* (KEP, SING).

10. *Etlingera metriocheilos* (Griff.) R.M. Sm. Notes Roy. Bot Gard. Edinb. 43 (1986) 247. Syn.: *Achasma metriocheilos* Griff., Notul. Plant. Asiat. 3 (1851) 427, Ic. Plant Asiat. (1851) t. 356; *Amomum sphaerocephalum* Bak. in Hook. *f.*, Fl. Brit. India 6 (1892) 234; *Amomum metriocheilos* Bak. in Hook. *f.*, Fl. Brit. India 6 (1892) 234; *Hornstedtia albomarginata* Ridl., in J. Str. Br. Roy. Asiat. Soc. 32 (1899) 145; Fl. Malay Penins. 4 (1924) 269; *Hornstedtia sphaerocephala* (Baker) K. Schum., Pflanzenr. Zingib. (1904) 192; *Achasma sphaerocephalum* (Bak.) Holtt., Gard. Bull. Sing. 13 (1950) 189. Type: Malacca, *Griffith 5758, s.v.* (K).

Figure 1G, 2K & L 3J, 4I

Rhizomes just below ground or creeping at soil surface; stout, 2–4.5 cm diam.; scale leaves overlapping, conspicuously pink, bright red or dull purple-red. *Leafy shoots* 2–6 m tall; close together or widely spaced, 10–80 cm apart; sheaths dull red or green, conspicuously ribbed longitudinally with cross-bars covered with tufts of short, white hairs or with sheaths bright red, surface slightly reticulate; crushed sheaths without distinct scent; *ligule c.* 1 cm long, apex broadly rounded, entire, margin and surface with short, brown hairs (densely, silky-hairy in var. *major*); *petiole* 0.5–1.5 cm (*c.* 3.5 cm in var. *petiolata*), surface reticulate. *Laminas c.* 15 pairs; (topmost) 22–55 x 3–4.5 cm, (middle) 57–80 x 9.5–14.5 cm, (basal) 9–25 x 5.5–8.5 cm; smooth (prominently ribbed in var. *petiolata*); entirely dark green above, when young dark purple-red beneath (or with brown-red bars on upper surface in var. *rubrostriata*); lower surface glabrous (with rather rough, short, brown hairs in var. *major*); base variable on the same leafy shoot, rounded or cuneate. *Peduncle* 4–10 cm; horizontal, then erect, entirely subterranean at base of leafy shoot or more usually some distance away; sheaths *c.* 7, shortest at base 1–4 cm long, apex acute with subapical spine to 0.2 cm, overlapping, red. *Inflorescence* entirely subterranean except for apices of sterile bracts and flowers. *Fertile apical part of inflorescence* with well developed sterile bracts tightly imbricating forming a narrow sub-cylindric structure 4–6 x *c.* 5 cm, hiding *c.* 1/3 of the inflorescence head proper in side view; sterile bracts persisting to fruit maturity. *Receptacle of inflorescence c.* 2 cm long; apex inflated and conical; bearing 25–60 flowers; 5–6 flowers open simultaneously; flower (from base of ovary to apex of labellum) 8–10.5 cm long. *Sterile bracts c.* 8; 3–4.5 x 2–3 cm; rigid, erect, oblong-elliptic, broadest below middle, strongly concave; apex acute, with a stiff spine 0.2 cm long; outer surface densely covered with appressed, brown hairs, hairs golden brown at base of bract; entirely red, or red at base and deep purple-red at apex. *Outer floral bracts* resembling the sterile bracts, *c.* 4.5 x 1.5 cm; *inner floral bracts* smaller, *c.* 4 x 1 cm. *Bracteole* 2.5–3 x *c.* 1.5 cm (when flattened); unequally 2-lobed, apex of lobe acute with

c. 1 cm slit on opposite side; surface with brown hairs, red. *Calyx* 5–6.5 x 1.5 cm (when flattened); 3-lobed, each lobe with a glabrous, subapical tooth *c.* 0.2 cm long; tube with 2.5–3 cm slit on opposite side; glabrous, only the apex with tawny hairs; red. *Corolla tube* 2.5–3.5 cm long; inner surface of tube at the entrance sparsely hairy, rest of tube glabrous; *lobes (petals)* variable: equal to, shorter or longer than calyx, 2–2.5 cm long, apices rounded, not hooded, red; dorsal lobe not hiding the anther and stigma, *c.* 0.5 cm wide, lateral lobes narrower, *c.* 0.4 cm. *Labellum* held horizontal, blade elongate, 3.5–5 cm long, *c.* 1.5–1.8 cm wide; blade and basal lobes crimson, margins of lobes white; margin of blade plain or slightly crisped; apex retuse or deeply bilobed. *Staminal tube* 1.5–2 cm long above the base of the corolla-lobes, inner surface of tube glabrous or sparsely covered with long hairs, (not warty). *Filament* short, *c.* 0.6 x 0.3 cm wide, adaxially glabrous. *Anther c.* 1 x 0.5 cm; crimson, hairy on pollen sacs. *Epigynous glands* 0.3–0.4 x 0.3 cm; comprising 2 rounded mounds, surrounding base of style, each mound minutely lobed, apices hairy, surface not warty. *Ovary c.* 0.5 x 0.4 cm; densely covered with appressed, white, short hairs; *style* pink, hairy; *stigma* dark purple, almost black, 0.4 cm across. *Infructescence* globular; large, *c.* 7 x 9 cm diam.; not surmounted by withered flowers; sterile bracts at base of fruit head and floral bracts persisting to fruit maturity; 25—45 fruits per head. *Fruits* obovoid; 3–4 x *c.* 2.5 cm wide at the top; densely covered with appressed, short hairs; apex with remnant of the base of the calyx only, less than 0.5 cm long; pericarp ridged longitudinally, each ridge with a shoulder-like apical mound, covered in prominent warts; pericarp *c.* 0.2 cm thick (excluding ridges); dark purple. *Seeds* irregularly angular, truncate, *c.* 0.4 x 0.3 cm wide at the top.

Distribution: Found in many parts of the Peninsula, in lowland forests and at moderate elevations on the mountains. It is also found in Borneo (Smith, 1986).

Notes: This species is variable and Holttum (1950) described four varieties, ranging from the few-flowered, small-sized var. *rubrostriata*, to the robust var. *petiolata*. The distinguishing characters of this species are: (1) the striking red or purple lower surface of young leaves and leaf-sheaths except for var. *rubrostriata*, which has a red-barred upper surface and is green beneath, (2) a sub-globose or sub-cylindric inflorescence, (3) the deep red or crimson involucral bracts that are distinctly shorter than the calyces, and (4) the deep crimson lip with white (never yellow) margins.

While noting it was possible that *Achasma sphaerocephalum* (Baker) Holttum was identical with *A. metriocheilos* Griff., Holttum (1950 p. 191) nevertheless thought it better to exclude Griffith's name. The reason he

cited was that the details given by Griffith were inadequate for him to decide with certainty whether the two species were conspecific.

Smith (1986 p. 247) combined *Achasma metriocheilos* Griff. with *Amomum sphaerocephalum* Bak. as *Etlingera metriocheilos* (Griff.) R.M. Sm.. However, she included in the combination, *Hornstedtia metriocheilos* (Griff.) Ridl., the species which Ridley (1899 p. 147) described as having a crimson lip with a yellow centre. However, this is a different species and, as Holttum had noted, it is in fact *Etlingera punicea*.

Types seen: Syntypes of *Hornstedtia albomarginata* Ridl., J. Str. Br. Roy. Asiat. Soc. 32 (1899) 145. — Penang, road to Penara Bukit, *Ridley s.n.* (SING); Selangor, Petaling, *Ridley s.n.* (SING).
Achasma sphaerocephalum (Bak.) var. *petiolatum* Holttum, in Gard. Bull. Sing. 13 (1950) 191. — Johor, Ulu Segun, G. Panti, *Corner SFN 30745* (SING).

var. *rubrostriatum* Holttum, in Gard. Bull. Sing. 13 (1950) 190. — Selangor, K. Kubu side of the Gap, *Corner SFN 30776* (SING).

var. *grandiflorum* Holttum, in Gard. Bull. Sing. 13 (1950) 191. — Terengganu, Kemaman, Bukit Kajang, *Corner SFN 30234* (SING).

var. *majus* Holttum, in Gard. Bull. Sing. 13 (1950) 190. — Terengganu, Kemaman, Bukit Kajang, *Corner SFN 30205* (SING).

Other specimens seen: PERAK: Maxwell's Hill, *Coll.? s.n.* (SING); Tea Gardens, *Curtis s.n.* (SING); Kuala Kangsar, Kg. Hitam Jong, Sg. Plus F.R., *Hashim Pendek KLC 119* (KEP). SELANGOR: Petaling, *Ridley s.n.* (SING); UPM campus, *Anthonysamy S.A 199* (KEP).

11. *Etlingera triorgyalis* (Baker) R.M. Sm. Notes Roy. Bot. Gard. Edinb. 43 (1986) 250. *Amomum triorgyale* Baker, in Hook. *f.*, Fl. Brit. India 6 (1892) 237; *Hornstedtia triorgyale* (Baker) Ridl., in J. Str. Br. Roy. Asiat. Soc. 32 (1899) 144; Mat. Fl. Malay. Penins. 1 (1907) 38; Fl. Malay Penins. 4 (1924) 269; *Achasma triorgyale* (Baker) Holttum, Gard. Bull. Sing. 13 (1950) 186. Type: Perak, Larut, *King's Collector 2105, s.v.* (K).

Figure 1D, 2G & H, 3G, 4D

Rhizomes just below ground; stout, 2.5–4.5 cm diam.; scale leaves overlapping, green tinged dull red or pink. *Leafy shoots* 5–6 m tall; close together or widely spaced to *c.* 1 m apart; sheaths conspicuously ribbed longitudinally with cross-bars covered by tufts of short, white hairs (especially in young sheaths), when crushed with a strong scent suggestive

of pepper; *ligule* 1–2.5 cm; apex rounded, entire; margin and surface with short, brown hairs; *petiole* 1.5–3 cm, surface reticulate. *Laminas c.* 15 pairs; (topmost) *c.* 43 x 3.5 cm, (middle) 80–100 x 6–21.5 cm, (basal) *c.* 25 x 7 cm; smooth or with slightly raised lateral veins, when young entirely green on both surfaces; lower surface softly hairy with short hairs; margin broadly crisped, red with brown hairs; base broadly cuneate, unequal, slightly decurrent. *Peduncle* short, 5–15 cm; horizontal, then erect, entirely subterranean at base of leafy shoot; sheaths *c.* 14, shortest at base 4–7.5 cm long, apex acute with subapical spine 0.2–1 cm long, white or pale green tinged deep pink, overlapping. *Inflorescence* subterranean except for distal parts of sterile bracts and flowers. *Fertile apical part of inflorescence* with well developed sterile bracts tightly imbricating, forming a narrow sub-cylindric structure 10–14 x *c.* 6 cm wide, in side view hiding *c.* 2/3 or more of the inflorescence-head proper, the sterile bracts not persisting to fruit maturity. *Receptacle of inflorescence c.* 1 cm, apex inflated and rounded; bearing 40–50 flowers; 8–17 flowers open simultaneously; flower (from base of ovary to apex of labellum) *c.* 13.5 cm long. *Sterile bracts c.* 7; 9–11 x 3–6 cm; rigid, erect, oblong-obovate, recurved at apex, concave, apex broadly rounded, retuse, with subapical spine *c.* 0.1 cm; outer surface with white hairs, hairs densely appressed at base; white or pale green, deep pink towards apex. *Outer floral bracts* resembling the sterile bracts, *c.* 10.5 x 2.5 cm; *inner floral bracts* smaller, *c.* 8.5 x 1 cm. *Bracteole c.* 8 x 2 cm (when flattened); 2-lobed, apex of lobe rounded with *c.* 2 cm slit on opposite side; surface with light-brown hairs; white with red apex. *Calyx* 7.5–9 x *c.* 2 cm (when flattened); 3-lobed, each lobe with a hairy, subapical tooth *c.* 0.1 cm long; tube with *c.* 4.5 cm slit on opposite side; glabrous, with tawny-hairs at apex only; white, pink-red at apex. *Corolla tube* 5.8–6.5 cm long, inner surface densely covered with long hairs at entrance of tube, rest of tube glabrous; *lobes (petals)* equal to calyx, *c.* 2.8 cm long, apices rounded, not hooded, red; dorsal lobe not hiding the anther and stigma, *c.* 1 cm wide, lateral lobes narrower, *c.* 0.7 cm. *Labellum* held horizontal, blade elongate, *c.* 5 cm long, *c.* 2.5 cm wide; blade and basal lobes entirely bright pink-red; margin of blade crisped and crinkled, apex broadly rounded and retuse. *Staminal tube c.* 1.2 cm long above the base of the corolla lobes; inner surface of tube densely covered with long hairs below anther only, rest of surface densely covered by warts. *Filament* short, 0.4 x 0.3 cm, adaxially hairy. *Anther c.*1 x 0.5 cm, red. *Epigynous glands c.*1 x 0.2–0.3 cm; comprising 2 fleshy compressed blade-like structures, not encircling base of style, each blade not further lobed, apex glabrous, shortly-pointed, surface not warty. *Ovary c.* 1 x 0.5 cm, densely covered with appressed, white short hairs; *style* pale pink, hairy; *stigma* pale pink, *c.* 0.5 cm across. *Infructescence* globular, large, *c.* 6 x 10 cm diam.; not surmounted by withered flowers;

bracts completely disintegrated at fruit maturity; 20—35 fruits per head. *Fruits* obovoid; *c.* 3 x 2.5–3 cm wide at the top; densely covered with appressed, short hairs; apex with remnant of calyx base only, less than c. 0.5 cm long; pericarp ridged longitudinally, each ridge with many irregular, fine spine-like processes; pericarp *c.* 0.2 cm thick (excluding ridges), dark red or pink. *Seeds* irregularly angular, truncate *c.* 0.4 x 0.3 cm wide at the top.

Distribution: In Peninsular Malaysia, recorded from Perak, Selangor and Pahang. It also occurs in Borneo and Sumatra (Smith, 1986).

Notes: The very broad bracts, recurved at the deep rose apices, together with the cherry red or deep rose lips are striking characters of this species.

Specimens seen: PERAK: Ipoh, foot of limestone rocks, Curtis *SFN 3317* (SING). SELANGOR: Genting Peras, *Ridley 7806* (SING). PAHANG: Ulu Sg. Sat, *Mohd. Shah & Mohd. Noor MS 1880* (KEP, SING); Temerloh, Sg. Nering, *Henderson 10583* (SING).

12. *Etlingera littoralis* (König) Giseke. Syn.: *Hornstedtia megalochilus* Ridl., in J. Str. Br. Roy. Asiat. Soc. 32 (1899) 146; Mat. Fl. Malay. Penins. 1 (1907) 38; Fl. Malay Penins. 4 (1924) 270; *Amomum megalocheilos* Baker, Fl. Brit. India 6 (1892) 236; *Achasma megalocheilos* Griff., Notul. Plant. Asiat. 3 (1851) 426, Ic. Plant. Asiat. (1851) t. 355; Valeton., Ic. Bog. 2 (1903) t. 188, 199.

Figure 1H, 2O & P, 3K

Rhizomes at surface or below ground to *c.* 10 cm deep; thick, 3–3.5 cm diam.; scale-leaves overlapping, green tinged dull red. *Leafy shoots* 3–6 m tall; close together or widely spaced, 12–48 cm apart; sheaths conspicuously ribbed longitudinally, with cross-bars covered by tufts of short, white hairs (clearer in young sheaths); crushed sheaths without distinct scent; *ligule* 1.5–2 cm long; apex broadly rounded, entire; margin with short brown hairs, surface with purple blotches, glabrous; *petiole* 1.5–4.5 cm; surface reticulate. *Laminas c.* 13 pairs; (topmost) *c.* 69 x 8 cm, (middle) *c.* 101 x 18 cm, (basal) *c.* 27 x 7 cm; smooth; entirely green, in young leaves sometimes flushed pink beneath; mostly glabrous, sometimes with short hairs; base variable on the same leafy shoot, cuneate, rounded or truncate, always unequal. *Peduncle* 4–10 cm; horizontal, then erect, entirely subterranean, at base of leafy shoot or some distance away; sheaths *c.* 11, shortest at base from 1.5–6 cm, apex acute with a stiff subapical spine 0.1 cm, overlapping, pale green or white tinged pink. *Inflorescence* subterranean except for apices of sterile bracts and flowers. *Fertile apical part of inflorescence* with

well developed sterile bracts tightly imbricating forming a narrow subcylindric structure *c.* 12 x 5 cm, in side view hiding *c.* 2/3 or more of the inflorescence-head proper. *Receptacle of inflorescence c.* 0.5 cm; apex inflated and rounded; bearing 30–35 flowers; 5–9 flowers open simultaneously; flower (from base of ovary to apex of labellum) 13–16 cm long. *Sterile bracts* 5 or 6; 6–8.5 x 2–5 cm; rigid, erect, oblong-obovate, broadest at middle, concave; apex acute, with a stiff spine 0.1 cm long; outer surface glabrous, densely covered with appressed, white hairs at base only; white, pink towards apex. *Outer floral bracts* resembling the sterile bracts; *c.* 8.5 x 1.5–2.5 cm; *inner floral bracts* smaller, *c.* 8 x 0.5 cm. *Bracteole* 7–7.5 x *c.* 1.5 cm wide (when flattened); 2-lobed, apex of lobe acute with 3 cm slit on opposite side; surface with brown hairs; pale pink. *Calyx* 7–9 x *c.* 1.5 cm (when flattened); 3-lobed; subapical tooth inconspicuous; tube with *c.* 3 cm slit on opposite side; glabrous, with tawny hairs at apex only; pink. *Corolla tube* 6–6.8 cm long, inner surface densely covered with long hairs at entrance oftube, rest of tube sparsely hairy; *lobes (petals)* equal to calyx, *c.* 2.5 cm long, apices rounded, not hooded, pink; dorsal lobe not hiding the anther and stigma, *c.* 1 cm wide, lateral lobes narrower, *c.* 0.5 cm. *Labellum* held horizontal, blade elongate, *c.* 7 cm long, *c.* 2 cm wide; blade and basal lobes entirely red or with a yellow margin sometimes not reaching the broad apex; margin of blade plain or crisped and crinkled; apex rounded, entire or slightly retuse. *Staminal tube c.* 1.5 cm long above the base of the corolla-lobes; inner surface of tube densely covered with long hairs, (not warty). *Filament* short, *c.* 0.5 x 0.4 cm wide, adaxially hairy. *Anther c.* 1 x 0.5 cm; red, hairy on pollen sacs. *Epigynous glands c.* 1 x 0.2–0.3 cm; comprising 2 fleshy, compressed, blade-like structures, not encircling base of style, each blade not further lobed, apex glabrous, shortly pointed, surface not warty. *Ovary* 0.5–0.6 x 0.5 cm; densely covered with appressed, yellow, short hairs; *style* pink, hairy; *stigma* red, 0.3 cm across. *Fruit* not known.

Distribution: Common in lowland forests throughout the Peninsula. It is also found in China, Thailand, Borneo, Java and Sumatra (Smith, 1986).

Notes: There is variation in lip colour in this species Most commonly encountered are plants with scarlet lips with a yellow margin. However, plants growing nearby may have scarlet lips edged orange-red or a third type with much narrower lips are scarlet with a thin yellow margin.

The description of the infructescence by Holttum (1950) was based on fruits described from Java by Valeton. I have attempted in the field to find the infructescence of this common species but without success. The inflorescences in a large patch growing in the Temenggor F.R., Perak,

were tagged and the site revisited two months later to look for the fruits but none was found. The fact that it has never been found in fruit in Peninsular Malaysia warrants further investigation.

Specimens seen: PERLIS: Wang Kelian, *Wan Fadhilah HI 919* (KLU); Mata Ayer F.R., *Saw, Kamarudin, Jamaludin & Baya FRI s.n.* (KEP). PERAK: Tambun limestone cliff, *Burkill SFN 6294* (SING); Upper Perak, *Wray 3444* (SING); SELANGOR: Gua Batu, *Ridley s.n.* (SING); Kuala Lumpur, *Ridley s.n.* (SING). MALACCA: Bukit Sadanen, *Ridley s.n.* (SING). JOHOR: Castleroad, *Ridley s.n.* (SING); Sg. Segun, G. Panti, *Corner SFN 30891, 30892* (SING); Batu Pahat, *Ridley s.n.* (SING); Kota Tinggi, *Ridley s.n.* (SING). KELANTAN: Sg. Lebir, *Ben. Stone & Mahmud Sidek 12507* (KEP). PAHANG: Jerantut, *Corner SFN 30768* (SING); Temerloh, Titi Bungor, *Henderson 10674* (SING); Telom, *Ridley 13832* (SING); Tanjong Gajah, *Ridley s.n.* (SING); Sg. Pertang, Bentong, *Burkill & Hanuff SFN 16515* (SING); Pekan, *Ridley 1632* (SING); Tahan Woods, *Ridley s.n.* (SING). TERENGGANU: Kemaman, Sg. Nipa, *Corner SFN 30581* (SING), Bukit Kajang, *Corner SFN 30378* (SING).

Acknowledgements

I thank Dr Saw Leng Guan, (KEP) for his encouragement, advice and providing photographs of the type and other specimens of *Phaeomeria venusta* from Kew and to the Curators of KEP, KLU and SING for permission to use their herbaria. I thank Dr J. Dransfield (Royal Botanic Gardens, Kew) for the Latin diagnosis. I also acknowledge with thanks Dr Saw Leng Guan, Dr Ruth Kiew and unnamed reviewers for advice on this paper. Thanks are due to the Malaysian Nature Society for help during the Malaysian Heritage and Scientific Expedition: Belum phase 1 (1993/1994) and phase 2 (1998). Advice from Dr E. Soepadmo (FRIM) during the Belum Expeditions is also gratefully acknowledged. Help and companionship in the field from Ms Rosema Abdullah and Mr Abdullah Piee are very much appreciated.

References

Burtt, B.L. and R.M. Smith. 1986. *Etlingera*: The inclusive name for *Achasma*, *Geanthus* and *Nicolaia* (Zingiberaceae). *Notes Royal Botanic Garden Edinburgh.* **43**: 235-241.

Holttum, R.E. 1950. The Zingiberaceae of the Malay Peninsula. *Gardens' Bulletin, Singapore.* **13**: 1-249.

Ibrahim, H. 1986. Notes on gingers of Pulau Tioman. *Nature Malaysiana.* **11(4)**: 10–13.

Khaw, S.H. 2000. A checklist of the Gingers (Zingiberaceae) of the Belum and Temenggor Forest Reserves in Perak, Peninsular Malaysia. *Malayan Nature Journal*. **54**: 227–232.

Larsen, K. 2000. Selection of *Etlingera corneri* J. Mood & H. Ibrahim (Zingiberaceae) as a future correct name. *Nordic Journal of Botany*. **20**: 475–476.

Larsen, K., H. Ibrahim, S.H. Khaw and L.G. Saw. 1999. *Gingers of Peninsular Malaysia and Singapore*. Natural History Publications (Borneo), Kota Kinabalu, Sabah. Malaysia. 135 pp.

Larsen, K.1970. The genus *Nicolaia* in Thailand. *Natural History Bulletin Siam Society*. **23**: 574–575.

Lim, C.K. 2000. Taxonomic notes on *Etlingera* Giseke (Zingiberaceae) in Peninsular Malaysia: the "*Nicolaia*" taxa. *Folia malaysiana*. **1**: 1–12.

Mood, J. & H. Ibrahim. 2000. A new species of *Etlingera* (Zingiberaceae) from Peninsular Malaysia and southern Thailand. *Nordic Journal of Botany*. **20**: 279–283.

Ridley, H.N. 1899. The Scitamineae of the Malay Peninsula. *Journal Straits Branch Royal Asiatic Society*. **32**: 85–184.

Ridley, H.N. 1924. Zingiberaceae. *Flora of the Malay Peninsula*. **4**: 233–285. Reeve & Co., London.

Smith, R.M. 1986. New combinations in *Etlingera* Giseke (Zingiberaceae). *Notes Royal Botanic Garden Edinburgh*. **43**: 243-254.

Weber, A. 1995. *Etlingera* gingers (Zingiberaceae) of Peninsular Malaysia. *Nature Malaysiana*. **20(3)**: 80-89.

Postscript: While the account above was in press, the note by Latiff (2001) appeared discussing the question of priority of *E. terengannuensis* C.K. Lim and *E. corneri* J. Mood & H. Ibrahim. As noted above, not all the specimens cited by Mood & Ibrahim (2000) belong to a single taxon and Lim confirms that *Corner SFN 32778* and "the Curtis specimen of 1890" belong to *E. fulgens* based on the purple undersides of their leaves. However, as Latiff points out, this does not affect the validity of the name *E. corneri*, which is based on the type so the fact that the specimens cited included more than one taxon is not relevant to the problem of the priority of names.

Detailed examination of the species in question based on living material has allowed accurate description of the species (see main text) based only on specimens of *E. corneri*.

Reference: Latiff, A. 2001. Notice of priority of *E. terengganuensis* C.K. Lim. *Folia malaysiana*. **2**(2): 75—68.

Gardens' Bulletin Singapore **53** (2001) 241–286.

The Limestone Begonias of Sabah, Borneo – Flagship Species for Conservation

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Abstract

The 18 *Begonia* (Begoniaceae) species now known from limestone and associated substrates in Sabah, Malaysia, are listed and a key provided for their identification. Twelve are described as new species: *Begonia antrorsa* Kiew, *B. baramiensis* Kiew, *B. bettinaeana* Kiew, *B. dondii* Kiew, *B. heliotropia* Kiew, *B. kevinii* Kiew, *B. lambii* Kiew, *B. layang-layang* Kiew, *B. malcolmii* Kiew, *B. mikilupa* Kiew, *B. pumilacerna* Kiew and *B. wrayana* Kiew. All these new species belong to sect. *Petermannia* (Klotzsch) A.DC., except for *B. dondii* that belongs to sect. *Diplocentrum* (Lind.) A.DC. Reasons for placing *B. amphioxus* Sands in sect. *Petermannia* and *B. guerriziana* Curtis in sect. *Platycentrum* (Klotzsch) A.DC. are given. *Begonia* is the most speciose genus on limestone in Sabah. Of the 18 species, only one, *B. guerriziana*, is widespread and also found on non-limestone substrates. Of the others, 12 species are known from single limestone hills and 5 are from hills within the same area. Habitat disturbance, which increases the risk of fire, therefore poses the greatest threat to the conservation of these species.

Introduction

As flagship species for the conservation of the limestone flora of Sabah, begonias meet all the criteria. Most are readily recognised as relatives of the begonia house plants, the majority of the limestone species are attractive (Kiew, 2000) and therefore have not only aesthetic appeal but also have commercial potential in horticulture as ornamental plants, as well as exemplifying the need to conserve the limestone flora to ensure its continued existence.

Begonias are instantly recognised by their leaves, which are usually very asymmetric. Although the Sabah species have relatively small flowers, they make up for this deficiency either in their decorative habit or the great variety of leaves. Some are small rosette plants, like *B. guerriziana* and *B. lambii*; others are tall cane-like plants, like *B. kevinii* Kiew with bright red, glossy stems; some have leaves coloured magenta underneath, like *B. keeana*; or have pink spots, like *B. malachovicii* Sands, or purple-magenta hairs, like *B. lambii*; others have unusually shaped leaves, such as the swallow begonia, *B. layang-layang*, with leaves curved like a swallow's wing, or *B. amphioxus* with bizarre, narrow peltate leaves pointed at both ends.

These attractive or unusual-looking species hold potential as ornamental plants and several have been successfully grown locally in the Agricultural Park at Tenom under Anthony Lamb's supervision.

That the limestone flora in Sabah is under threat is not in doubt. The major threat is from accidental fires that occur in the periodic drought periods, which are particularly severe in El Niño years. Of the 59 limestone hills in Sabah, only 22 fall within protected forest or a Virgin Jungle Reserve (Lim & Kiew, 1997). The other hills are either no longer surrounded by forest or else lie within commercial forest that has been, is or will be logged. The vegetation on these hills is particularly vulnerable to fire. Beaman *et al.*, (1985) showed that in the Great Burn of 1982/83, the frequency of burning was five times greater in logged-over forest than undisturbed forest. Indeed, the limestone vegetation that burned then, for example, on Bukit Dulong Lambu (Gomantong Cave), Bukit Batangan and Gunung Madai, has not yet recovered.

Other hills are under threat from quarrying as a source of cement, such as Pulau Balambangan and Bukit Tengar (Segarong Cave), or for marble, as at the Borneo Marble Quarry on the Segama River, or for road metal, for example, Batu Pang, Supu and Temambong. Yet others suffer disturbance from birdnest collecting activities, such as Gunung Madai and Bukit Dulong Lambu, where the latter has a village built on the summit. A few have become tourist attractions and are suffering degradation, such as Batu Tulug (Batu Putih) and Batu Punggul. Even protected status does not necessarily ensure protection as is demonstrated by the Virgin Jungle Reserve surrounding Bukit Baturong that has been logged twice (illegally) in the last ten years.

Conservation of the limestone flora therefore requires a strategy to protect its biodiversity and *Begonia* serves as a useful indicator as it is one of the most biodiverse groups of the limestone flora in Sabah being one of the ten most speciose families and the most speciose genus (Kiew, 1998a). In addition, it exhibits extremely high endemism. All its 18 species are endemic to Sabah. Only one species, *B. gueritziana*, is widespread; the rest are narrow endemics. Twelve species are found on single hills and five species on adjacent hills (Table 1). In addition, their distribution reflects the general regional differences of the limestone flora as a whole in Sabah because their distribution is mirrored by the distribution of other species (Kiew, 1998a). Therefore, by using the distribution of begonia species, a pattern emerges of those hills that are of greatest importance in order to protect the maximum biodiversity of the limestone flora. (The only limestone localities without begonia species are the northern islands of Balembangan and Banggi). *Begonia* is therefore an obvious choice as a conservation icon to illustrate the need for conserving a network of hills in

order to include maximum biodiversity

Table 1. Distribution of *Begonia* species on limestone in Sabah.

District	Locality	*Begonia* Species
(a) *species found on single hills*		
Pensiangan	Batu Punggul/Batu Tinahas	*amphioxus, anthonyi*
Pensiangan	Sapulut	*layang-layang*
Pensiangan	Batu Urun	*urunensis*
Pensiangan	Pun Batu	*punbatuensis*
Kinabatangan	Bukit Dulung Lambu	*gomantongensis, malachosticta*
Kinabatangan	Melikop	*melikopia*
Lahad Datu	Gunung Madai	*madaiensis*
Lahad Datu	Bukit Baturong	*baturongensis, berhamanii*
Semporna	Batu Tengar	*keithii*
(b) *species found on several hills in the same area*		
Pensiangan	Batu Punggul/Tinahas, Sapulut	*lambii*
Kinabatangan	Kinabatangan Valley (3 hills)	*postarii*
Kinabatangan	Kinabatangan Valley (2 hills)	*heliostrophe*
Lahad Datu	Segama River (5 hills)	*diwolii, keeana*
(c) *widespread on limestone in Sabah*		*gueritziana*

Two hills are outstanding for their variety of begonia species. Both Bukit Dulong Lambu and Batu Punggul are each home to four begonia species (Kiew, 1998b) as, besides those listed in Table 1, *B. gueritziana* also grows there.

While 17 species are narrow endemics, the eighteenth species, *B. gueritziana*, is not only widespread but is also the only species that is not confined to limestone. It grows on a variety of rock types usually by streams ranging from 30—750 m altitude, the latter on Gunung Kinabalu. However, although widespread, it has not been recorded from limestone in Sarawak. The distribution of begonias on limestone in Sarawak shows the same pattern of high endemism as in Sabah with species being restricted to

particular areas that also reflects the biodiversity patterns of other limestone species (Kiew, 1991), namely species are confined to the Bau area, the Subis area (Niah Cave) or to limestone in the Gunung Mulu National Park. The fact that only eight begonia species have been described from limestone in Sarawak, as opposed to 18 for Sabah, may be an indication of the lack of systematic botanical study than actual lower biodiversity.

Of the 18 species now known from limestone in Sabah, 12 are new species described below. Apart from *B. diwolii* in sect. *Diploclinium* and the widespread *B. gueritziana* in sect. *Platycentrum*, the other 16 species all fall within sect. *Petermannia*. Section *Petermannia* is said by Doorenbos *et al.* (1998) to have male flowers typically with two tepals. However, as more species from Borneo are described, it is likely that this character will prove not to be diagnostic for the section as the majority of the cane-like begonias on limestone in fact have male flowers with four tepals.

Section *Petermannia* is well represented in Borneo and includes several groups of similar species. One is the group of relatively short begonias recognised by Sands (1990) that have bristly stems, leaves that are narrow, obovate and with the midrib in line with the short petiole, the stipules persistent and becoming papery, and the flowers crowded into short inflorescences. From Sabah limestone, two species, *B. anthonyi* and *B. berhamanii*, belong to this group. These species do not grow directly on limestone but are common on the soil around the base of cliffs or on the steep slopes leading up to the hill, where they frequently form drifts.

Another group includes the cane-like begonias that grow directly on the limestone. All these species are extremely decorative, particularly those with an unusual leaf shape (narrow and acutely pointed at both ends), with daintily scalloped leaf margins often coloured bright red, or with attractive variegation. In addition, *B. keithii* has striking red, glossy stems and the many small carmine heart-shaped male flower buds (Kiew, 1998c). Some can withstand full sun and live on the exposed summits, such as *B. baturongensis*, *B. keithii*, and *B. madaiensis*. These species do not flower in deep shade. Of the other species that grow in light shade beneath the tree canopy, *B. amphioxus* and *B. layang-layang* have narrow leaves with a pointed base, *B. keeana*, *B. heliostrophe* and *B. malachosticta*, have, in contrast, broader leaves with a large rounded basal lobe. These cane-like species have great potential as ornamental plants (Kee, 2000). Indeed, Sands (1990) reported that *B. amphioxus* grows well in hanging baskets.

However, the affinity of some species in sect. *Petermannia*, such as *B. lambii*, *B. gomantongensis* Kiew, *B. melikopia*, *B. postarii* Kiew, *B. punbatuensis* and *B. urunensis*, is obscure. There is still a great deal to be learnt about the begonia flora of Borneo where the undescribed species outnumber those already named.

Key to Limestone Begonias in Sabah

1a. Small rhizomatous begonias with prostrate stems 2
1b. Begonias with erect stems 3

2a. Internodes up to 7.5 cm long, leaves well spaced; lamina margin hairy, fruit with 3 equal wings ..... 5. *B. diwolii*
2b. Internodes very short, leaves tufted; lamina margin glabrous, fruit with one wing longer than the other two ..... 7. *B. gueritizana*

3a. Stem short up to 13 cm tall with few (up to 4) leaves, lamina deeply corrugated ..... 11. *B. lambii*
3b. Stem more than 25 cm tall with many leaves, lamina plane 4

4a. Mature stem conspicuously bristly, leaf with pinnate venation, basal lobe scarcely developed; male inflorescence compact, up to 2 cm long 5
4b. Mature stem glabrous; leaf with palmate-pinnate venation, basal lobe well developed; male inflorescence a lax cymose panicle 7

5a. Lamina lanceolate, up to 3 cm wide, basal lobe cuneate or slightly rounded, fruit up to 12 mm wide ..... 4. *B. berhamanii*
5b. Leaf obovate, 3 cm or more wide, basal lobe cordate or auriculate, fruit more than 14 mm wide 6

6a. Leaf more than 2.5 times longer than wide, basal lobe cordate up to 4 mm long, fruit wing tip pointed ..... 2. *B. anthonyi*
6b. Leaf up to 2.5 times longer than wide, basal lobe auriculate up to 10 mm long, fruit wing tip rounded ..... 18. *B. urunensis*

7a. Lamina very hairy above ..... 16. *B. postarii*
7b. Lamina glabrous above 8

8a. Lamina at least 4 times longer than wide, base narrowed to a point, sometimes peltate 9
8b. Lamina less than 4 times longer than wide, base broad and rounded, never peltate 11

9a. Lamina red-spotted; fruit stalk less than 2.5 mm long, fruit oblong up to 13 x 7 mm ..... 1. *B. amphioxus*
9b. Lamina plain green or grey mottled; fruit stalk more than 12 mm long, fruit ovoid or deltoid, 18 x 15 mm or larger 10

10a. Stem and petiole crimson; petiole up to 1.5 cm long; lamina not peltate; fruit ovoid and narrower, up to 25 mm wide .. 10. *B. keithii*
10b. Stem and petiole pale green; petiole more than 2.5 cm long; lamina peltate; fruit deltoid and wider, more than 29 mm wide ..... 12. *B. layang-layang*

11a. Lamina less than 6 cm wide 12
11b. Lamina 6 cm or wider 14

12a. Lamina more than 3 times longer than wide, pink spotted; tips of fruit wings pointed ..... 14. *B. malachosticta*
12b. Lamina less than 3 times longer than wide, not spotted; tips of fruit wings rounded 13

13a. Petiole 3—4 cm long; fruit deltoid, shorter than wide, 22—28 mm wide ..... 3. *B. baturongensis*
13b. Petiole 1—3 cm long; fruit rhomboid (narrowed distally), longer than wide, 13—20 mm wide ..... 13. *B. madaiensis*

14a. Lamina more than twice as long as wide, apex pointing upwards ... 8. *B. heliostrophe*
14b. Lamina less than twice as long as wide, apex pointing downward... 15

15a. Lamina obliquely rotund; fruit oblong with pimply surface..... 6. *B. gomantongensis*
15b. Lamina obliquely ovate; fruit deltoid with smooth surface..... 16

16a. Lamina less than 10 cm long; young stems minutely hispid; male flowers with outer 2 tepals 14—15 mm long ..... 17. *B. punbatuensis*
16b. Lamina more than 10 cm long; young stems glabrous; male flowers with outer tepals 7—8 mm long 17

17a. Lamina up to 16 x 8.5 cm; petioles up to 7 cm long; female flowers solitary, male flowers with 4 tepals; fruit to 2.5 cm long ..... 9. *B. keeana*
17b. Lamina 15 x 12 cm or larger; petiole more than 8 cm long; female flowers in pairs; male flowers with 2 tepals; fruit 4—5.5 cm long .... 5. *B. melikopia*

1. Begonia amphioxus Sands
Section *Petermannia*
Sands. Kew Magazine. 7 (1990) 81 & Plate 149: Kiew. Gardenwise. 15 (2000) 13.
TYPE: Batu Punggul *Sands 4045* (not seen).

Distribution: Borneo – SABAH: Pensiangan District. Batu Punggul and Batu Tinahas.

Habitat: Not common. base of limestone cliffs and in light shade on flat tops of subpeaks below the canopy.

Notes: *Begonia amphioxus* is a striking begonia with reddish stems. peltate leaves narrowing sharply to a point at both ends. beautifully marked with deep crimson spots. It shows some variation in leaf shape (peltate or not). number of tepals in the female flower (3 to 5) and in the number of wings in the fruit (2 or 3). It is also unusual in having joined tepals in the female flower.

Sands (1990) referred this species to sect. *Platycentrum* on account of the specimens he collected having female flowers with 2 locules and styles and 3—5 tepals. the male having 4 tepals. and the fruit being 2-winged although he noted that 'a third wing may occasionally develop in some fruits ... it tends to be smaller.'

Collecting on Batu Punggul allowed the population at the type site to be reexamined as well as that on nearby Batu Tinahas. The majority of fruits on plants at the type site did indeed have fruits with two equal wings and two locules. but on the same plant. a few fruits with three wings (the third wing being smaller) could be found. On Batu Tinahas. plants mostly had fruits with three locules and three equal wings and only a few (on the same plant) had two locules and two wings. In all other respects the two populations were the same. The weak development of the third wing indicates a reduction from the typical state with three equal wings rather than the character state of sect. *Platycentrum* where the third wing is well developed and much larger.

It is certainly an aberrant species for sect. *Platycentrum*. which. as Doorenbos *et al.* (1998) point out. is a section that includes plants that always have fruits with three wings. one of which is markedly larger than the other two. They drew attention to this anomalous situation by listing *B. amphioxus* under the heading 'Species not attributable to any existing section'. As they noted. apart from the single character of the fruit being two locular. *B. amphioxus* is typical of sect. *Petermannia* in its erect habit. dichasial male inflorescences. solitary female flowers (which may have 4. 3

or 2 tepals but usually has 5) and the style, which is caducous in the fruit. On morphological grounds, there is therefore no doubt that *B. amphioxus* is a member of sect. *Petermannia*. In addition, recently Tebbitt (1999) using molecular data showed that it is affiliated with other species in sect. *Petermannia* and Tebbitt and Maciver (1999) demonstrated the presence of perforate base plates in its endothecial cells, again confirmation that it belongs to sect. *Petermannia*.

Begonia amphioxus is easy to grow. In the Agricultural Park at Tenom, Sabah, it seeds freely and spreads on a lightly shaded limestone rockery. At Kew, it has been propagated from nodal cuttings, grows on all types of soil mix but best on a fibrous mix and it flourishes in hanging baskets (Sands, 1990). It certainly deserves to be more widely known in cultivation.

Specimens examined: SABAH: Pensiangan District - Batu Punggul *Ruth Kiew & S. Anthonysamy RK4379* (KEP, L, SAN, SING), Batu Tinahas *Ruth Kiew & S. Anthony RK4337* (SAN, SAR, SING).

2. Begonia anthonyi Kiew, *sp. nov.*
Section *Petermannia*

A *Begonia cauliflora* Sands foliis basi cordatis et tepalis integris glabris differt — TYPUS: Batu Punggul *R. Kiew & S. Anthonysamy RK 4352* (holo SAN; iso K, SAR, SING).

Figure 1

Low, erect, unbranched herb, decumbent and rooting at nodes. *Stem* ferrugineous towards apex, 18—24 cm tall x 3—4(—6) mm diam., internodes 2—5.5 cm long, becoming woody, nodes not swollen. *Stipules* glabrous, narrowly lanceolate, 13—16 x c. 4 mm, margin entire, apex attenuate, persistent. *Leaves* alternate, distant, in life upstanding; *petiole* 2—4(—15) mm long, slightly grooved above; *lamina* very dark plain green, papery when dry, glossy above, obovate, sometimes slightly falcate, (12—)14(—17) x (3—)4.5(—6.2) cm, slightly asymmetric, narrow side curving inwards then rounded at base, broad side rounded (2—)3(—4) cm wide and cordate at base, basal lobes 2—4 mm long, margin dentate and sparsely fringed with bristly hairs, apex attenuate; *midrib* not at an angle to petiole, venation pinnate, lateral veins 6—7 pairs, branching towards margin, sometimes with 1 vein in basal lobe, impressed above and slightly prominent beneath. Plant protogynous. *Male inflorescences* from upper axils, erect, short flattened spike, 5—20 mm long of which peduncle is 5—7 mm, longer than petioles, continuously growing with one or sometimes two flowers open at

Figure 1. *Begonia anthonyi* Kiew
A Habit x 1/6. B & C Male inflorescences x 1/3 and x 3/4. D Male bud x 1/2. E Open male flower x 1. F Androecium x 4. G Stamen x 8. H Female flower x 1. I Open female flower x 1. J Style and stigma x 4, K T.S. ovary x 1 1/2, L Fruit x 3/4. (from *RK 4438*)

a time; *bracts* distichous, pale green, persistent. *Male flower* with pedicel 4—13 mm; *tepals* 2, totally white and scintillating, glabrous, slightly ovate, 9—12 x 6—7 mm, margin entire, apex rounded; *stamens* c. 30, in a sessile, globose cluster c. 4 x 3 mm, *filaments* c. 1.25 mm long, *anthers* pale lemon yellow, ellipsoid, c. 1 mm long, apex emarginate. *Female inflorescences* with 1 or 2 flowers produced from lower leaf axils; *bracts* 2, reddish brown. *Female flower* with *pedicel* 4—6 mm, sparsely hispid; *ovary* pinkish with minute red hairs, narrowly deltoid, 9—16 x 6—16 mm, wings 3, equal, locules 3, placentas axile, bilamellate with many ovules on both surfaces; *tepals* 5, white or rosy red, elliptic, 6—10 mm long, outermost c. 6 mm wide, innermost c. 4 mm wide, margin entire, apex rounded; *styles* 3, c. 5 mm long, joined c. half way then bifurcating; *stigma* papillose forming a continuous twisted band. *Fruit* pendent, pedicel stiff, 3—10 mm long, capsule broadly deltoid, 12—15 x 14—20 mm, locules 3, dehiscing between locules and wings, wings 3, 4—5 mm wide, thinly fibrous, tips pointed; *seeds* brown, minute, broadly ellipsoid, c. 0.25 mm long, base truncate, distally rounded.

Distribution: Borneo: SABAH – Pensiangan District, Batu Punggul, Batu Tinahas.

Habitat: On rocks or on steep earth slopes up to the base of the limestone hill, often gregarious.

Notes: *Begonia anthonyi* belongs to sect. *Petermannia* in being an erect, protogynous begonia with the ovary and fruit with three equal wings. Within sect. *Petermannia*, it conforms to the group of species recognised by Sands (1990) when he described *B. cauliflora* from Sabah that has hispid stems, short petioles, laminas that are widest at or above the middle and narrow to the base (rather than having a well developed basal lobe), has a midrib that is more or less in line with the petiole, and male flowers that are crowded in short axillary inflorescences. *B. berhamanii* described below also belongs to this group. In addition to the characters listed above, species in this group frequently have an unbranched stem, two tepals in the male flower, rather few stamens (to about 30), and the fruit stalk is thick and rigid. This last character contrasts with the other limestone species in this section where the pedicel is long and at fruit maturity is dry and thread-like so that the fruit is dangling.

Begonia anthonyi and *B. berhamanii* grow on soil close to the cliff base or on the steep slope up to the hill. They tend to grow gregariously forming carpets but are local and not found away from the limestone hill.

Begonia anthonyi is distinct from *B. cauliflora* in having a more asymmetric leaf with the broader side more rounded and it is cordate at

the base (not decurrent) and the lamina is green beneath (not crimson to brownish as in *B. cauliflora*), in the male tepals being white and glabrous (as opposed to pink and hirsute outside), and the female tepals glabrous and entire (hairy outside and serrate in *B. cauliflora*). In addition, in *B. anthonyi* flowers open one at a time, whereas *B. cauliflora* is shown as having several flowers open simultaneously on a single inflorescence.

The species is named for S. Anthonysamy, for many years herbarium assistant at Universiti Pertanian Malaysia, who accompanied me and helped with the preparation of plant specimens on many field trips, including the one to Batu Punggul and Batu Tinahas.

Specimens examined: SABAH: Pensiangan District - Batu Punggul the type and *L. Kuntil SAN 135786* (SAN), *Sumbing Jimpim SAN 136091* (SAN); Batu Tinahas *R. Kiew & S. Anthonysamy RK 4438* (SAN, SING).

3. Begonia baturongensis Kiew, *sp. nov.*
Section *Petermannia*

A *Begonia keithii* Kiew petiolis longioribus, foliis latioribus basi rotundatibus et fructibus latioribus differt — TYPUS: Batu Baturong *R. Kiew et al. RK 5026* (holo SAN; iso K, SAR, SING).

Cane-like, glabrous begonia. *Stem* reddish-brown, glossy, erect, 30—50 cm tall and 5—10 mm thick, internodes (5—)9.5 cm long, stems becoming horizontal with many leafy side shoots held horizontally, eventually falling and becoming pendulous, woody, slightly thicker and distinctly annular at nodes. *Stipules* pale green, slightly obovate to lanceolate, 25—28 x 10—11 mm, entire, midrib keeled, apex acute, caducous. *Leaves* alternate, distant, pendant; *petiole* 3—4 cm, slender, slightly grooved above; *lamina* of young plants with light green or grey spots, adult unfolding leaves yellow becoming plain mid-green above and slightly flushed reddish-crimson, sometimes light green beneath, margin red, slightly succulent in live state, thinly leathery when dry, slightly glossy, obliquely ovate, asymmetric, (5.5—)7 x 4.25—5.5 cm, narrow side lanceolate, broad side broadly lanceolate 3.25—4 cm long, base slightly cordate with basal lobe markedly rounded 2.5—4 cm long, margin red, shallowly dentate, apex shortly acuminate; venation palmate-pinnate, *midrib and lateral veins* 4, ± equal-sized, branched c. midway to margin, c. 3 in basal lobe, prominent beneath.
Plant protogynous. *Male inflorescence* axillary in distal leaf axils, glossy red, erect, cymose panicle to simple cyme in uppermost axil, longer than petioles, 3—4 cm long of which peduncle is 1.25—2 cm, much branched. *Male flower* with *pedicel* 2.5—5 mm long; *tepals* 4, outer surface of outer 2

cerise or deep rosy red, pinkish red inside, glabrous, outer two slightly cordate and concave, 6—7 x 6—8 mm, margin entire, apex acute, inner two pale pink, elliptic, 5—6 x 2.5—3.5 mm, apex acute; *stamens* more than 30, cluster globose, sessile, 2.5—4 x 3—3.5 mm, *filaments* c. 0.5—0.75 mm, *anthers* obovate, c. 0.75 mm long, apex emarginate. *Female flowers* solitary, up to 5 each produced at successive axils, *pedicel* erect, 11—14 mm long, enclosed by 2 large bracts green tinged red, caducous; *ovary* green, obovate, 16—20 x 12—17 mm, wings 3, equal, edges tinged red, locules 3, placentas axile, bilamellate with many ovules on both surfaces; *tepals* (4—)5, rosy red, subrotund, slightly convex, isomorphic, 10 mm long, entire, apex rounded, outer 8—10 mm wide, innermost one c. 6 mm wide; *styles* 3, golden yellow, 4—5 mm long, free almost to base, bifurcating; *stigma* papillose forming a continuous twisted band. *Fruit* dangling on fine thread-like pedicel, 10—30 mm, capsule broadly ovate, (16—)20(—24) x (22—)24(—28) mm, glabrous, locules 3, dehiscing between upper half of the locule and wing, wings 3 isomorphic, thinly leathery, truncate, c. 5 mm wide, thin and fibrous; *seeds* brown, minute, broadly ellipsoid, c. 0.3 mm long, base truncate, rounded distally.

Distribution: Borneo: SABAH – Lahad Datu District, Bukit Baturong.

Habitat: *Begonia baturongensis* grows on limestone rock below the canopy in light shade or on exposed rock ledges and crags.

Notes: This species is typical of sect. *Petermannia* in its cane-like habit and the ovary and fruits having three equal wings. In addition, the female flowers produced in the lower leaf axils with the male inflorescences in the upper ones is a condition found in species of this section.

Like *Begonia madaiensis* (described below), *B. baturongensis* has relatively small leaves, which decrease markedly in size towards the apex, which are well-spaced on long petioles with their apex pointing downwards resulting in the twigs having a dainty zigzag appearance, especially on the lateral horizontal branches. The juvenile leaves of both are variegated, but become plain green with age. The strikingly variegated juvenile leaves are illustrated by Kiew (2000). Male inflorescences are only produced after the female flowers have already become fruits.

In addition, these two species share the same niche growing fully exposed or in light shade on the summit and shoulders of cliff faces and, indeed, they do not flower in shade.

The two species have very different fruits: those of *B. baturongensis* are broader than long and have truncate wing tips, while those of *B. madaiensis* are longer than wide and are narrowed distally. The leaves are

also different, those of *B. baturongensis* have longer petioles (3—4 cm long) and the leaf margin is shallowly dentate, while the leaves of *B. madaiensis* have short petioles (up to 3 cm long) and the margin is scalloped. The flowers of *B. baturongensis* are more decorative being deep rosy red to cerise compared with the white flowers of *B. madaiensis*.

Specimens examined: SABAH: Lahad Datu District - Bukit Baturong: the type and *S.P. Lim et al. LSP 737* (SAN, SING).

4. Begonia berhamanii Kiew, *sp. nov.*
Section *Petermannia*

A *Begonia cauliflora* Sands foliis angustioribus et tepalis integris glabris differt — TYPUS: Batu Punggul *R. Kiew & S. Anthonysamy RK 5046* (holo SAN; iso SING).

Figure 2

Low, erect herb, becoming procumbent and rooting at nodes, indumentum of short hooked hairs, appressed and dense on stem, petiole and lower surface of veins. *Stem* reddish-brown, up to 25 cm tall and 2—3 mm diam., unbranched, woody, internodes 1.5—2 cm long, nodes swollen. *Stipules* lanceolate, 13—14 x 6—7 mm, midrib dorsally strongly keeled with minute scattered hairs, margin entire with a row of fine hairs, apex narrowly attenuate, persistent. *Leaves* alternate, distant, held horizontally; *petiole* 3—5 mm long, shallowly grooved above; *lamina* plain dark green and glabrous above, whitish green (sometimes faintly reddish) beneath, papery when dry, glossy above, slightly asymmetric, narrowly lanceolate and slightly falcate, 12.5—16 x 2.5—3.2 cm of which broad side 1.5—1.8 cm wide, basal lobe cuneate sometimes rounded, 2—3 mm long, margin shallowly dentate, apex attenuate; venation pinnate, *midrib and lateral veins* concolorous with lamina, 7—8 pairs, branching c. midway to margin, 1 vein in basal lobe, slightly impressed above, slightly prominent beneath.
Plant protogynous. *Male inflorescences* from upper leaf axils, sessile, to 2 cm long, shorter than petioles, sometimes bifurcating, flowers congested and covered by distichous, overlapping bracts, only one or two flowers open at a time; *bracts* deep rosy or brown red, lanceolate, c. 12 x 3.5—4 mm, margin dentate with fringe of hairs, persistent. *Male flower* with minutely hairy, pale pink *pedicel* 4—11 mm long, *tepals* 2, opening rosy red, fading to white faintly tinged pink outside, elliptic, 6—8 x 6—7 mm, margin entire, apex rounded; *stamens* 20—30, in hemispherical sessile cluster c. 3 mm across, *filaments* 0.5—1.5 mm long, *anthers* dull white, rotund, c. 0.75 mm long, apex emarginate. *Female flowers* solitary from lower leaf

axils; *pedicel* 2—3 mm long, with densely appressed hairs; *ovary* white, deltoid, 8—12 x 11—16 mm, locules 3, outer surface minutely hairy, wings 3, equal, 4—5 mm wide, glabrous, placentas axile, bilamellate with many ovules on both surfaces; *tepals* 5, rosy red, broadly elliptic, isomorphic, 5—10 mm long, apex rounded, outer 4.5—6 mm wide, inner 3—4.5 mm wide, margin entire; *styles* 3, 4—6 mm long, divided to base, bifurcating; *stigma* papillose forming a continuous twisted band. *Fruit* with stiff, decurved pedicel c. 3—4 mm long, the fruit becoming bent backwards and parallel to stem, capsule broadly deltoid, 11—13 x 10—16 mm, sparsely hispid, 3-locular, dehiscing between locule and wing, wings 3, isomorphic, 2.5—8 mm wide, tips slightly acute, thin almost papery; *seeds* brown, minute, almost globose, c. 0.2 mm long, narrowed to base, rounded distally.

Distribution: Borneo: SABAH – Lahad Datu, Bukit Baturong.

Habitat: Shaded base of limestone cliff on damp soil.

Notes: Like *Begonia anthonyi*, this species belongs to the group of species within sect. *Petermannia* with hispid stems, short petioles, slightly asymmetric laminas with a poorly developed basal lobe and with the midrib almost in line with the petiole. *B. berhamanii* more resembles *B. cauliflora* Sands in its narrowly lanceolate leaves with a slightly rounded basal lobe and in its dense clusters of male flowers. It is readily distinguished from *B. cauliflora* by its narrower leaves with an attenuate apex that are whitish green beneath (in *B. cauliflora* the leaves are 4.2–-6.4 cm wide, the apex is acute-acuminate and they are crimson to brownish beneath) and the glabrous, entire tepals of the male and female flowers (those of *B. cauliflora* are hairy outside and those of the female flower are serrate).

The species is named for Berhaman Ahmad who, while he was a research officer at the Forest Research Centre, Forest Department Sabah, ably organised several expeditions to explore and collect the limestone flora.

Specimens examined: SABAH: Lahad Datu District - Bukit Baturong the type and *S.P. Lim et al. LSP 715* (SAN, SING).

5. Begonia diwolii Kiew, *sp. nov.*
Section *Diploclinium*

A *Begonia speluncae* Ridl. caulibus pilosis, internodiis longioribus et foliis non-peltatis differt — TYPUS: Tempadong, Segama River *Ruth Kiew et al. RK 4767* (holo SAN, iso BRUN, K, L, SAR, SING).

Figure 2. *Begonia berhamanii* Kiew
A Habit x $^1/_2$, B Stipules x 2, C Male flowers x 2, D Fruit x $1^1/_2$. (from *LSP 715*)

Figure 3

Creeping, prostrate herb attached to substrate at each node by fibrous roots, old stems setose, indumentum of appressed, concolorous, uniseriate, eglandular hairs c. 1.5 mm long on the young stems, stipules, petiole, leaf margin, lower surface of lamina and particularly dense on veins. *Stem* pale purplish becoming deep reddish brown with age, up to c. 1 m long and 1.5—2 mm diam. near apex and to 4 mm in old stems, succulent, not swollen at nodes, internodes 4—12 mm apart at apex lengthening to 5.5—7.5 cm, stem slightly zigzag with short lateral prostrate branches, c. 10 cm long produced at wide intervals. *Stipules* pale reddish purple, broadly lanceolate, 9—19 x 3.5—8 mm, margin entire, apex distinctly setose, setae 4—5 mm long, persistent. *Leaves* alternate, distant, lamina positioned flat against rock surface; *petiole* brownish or reddish purple, more hispid than stem, 3—7 cm long up to 14.5 cm on pendent branches, 1—3 mm diam., terete; *lamina* rich deep plain green above, deep magenta beneath, thinly fleshy, matt, upper surface glabrous except for a few setose hairs on the veins, orbicular to reniform, smaller leaves slightly asymmetric, large leaves very asymmetric, (2—)4(—6.5) cm long and (2.5—)5(—6.5) cm wide of which the broader side is (1.5—)3(—4.5) cm wide, base slightly cordate but not overlapping, basal lobes shallowly rounded (0.5—)1.5(—3.5) mm long, margin slightly wavy and fringed by long hairs, apex rounded in orbicular leaves, acute in reniform leaves; venation palmate, *midrib and lateral veins* concolorous with lamina (occasionally paler), (2—)3, equal sized, bifurcating twice, first near petiole or more than half way towards margin, second close to margin, 1—2 veins in basal lobe, slightly impressed above, slightly prominent beneath.

Inflorescence protandrous, axillary from second node, cymose panicle, pale magenta, sparsely setose, erect, longer than petioles, 7—15 cm long, peduncle 6.5—10.5 cm long, each branch with 1 female flower and several male flowers eventually with up to 3 branches; *bracts* paired at base, brown and papery, narrowly acute with conspicuous midrib, 6—9 x 2.5—3 mm, margin entire, apex setose, caducous. *Male flowers* with pale pink *pedicel* 7—10 mm long; *tepals* 4, outer 2 with the upper tepal deep rosy pink outside, both suffused pink inside, glabrous, broadly oval, 6—9 x 5—7 mm, margin entire, apex rounded to acute, inner 2 almost completely white, oval, narrower, 7—8 x (2.5—)4 mm, apex bluntly rounded; *stamens* c. 30, cluster subglobose with torus c. 1 mm long, *filaments* c. 0.4 mm long, *anthers* lemon yellow, obovate, c. 0.6 x 0.5 mm, apex emarginate. *Female flower* with pale pink to magenta *pedicel* c. 6 mm long; *ovary* pale pink with margin of wings tinged green, sparsely pustulate with occasional short hairs, cordate, c. 3.5 x 3.5 mm, wings 3, equal-sized, c. 1.25 mm wide, base

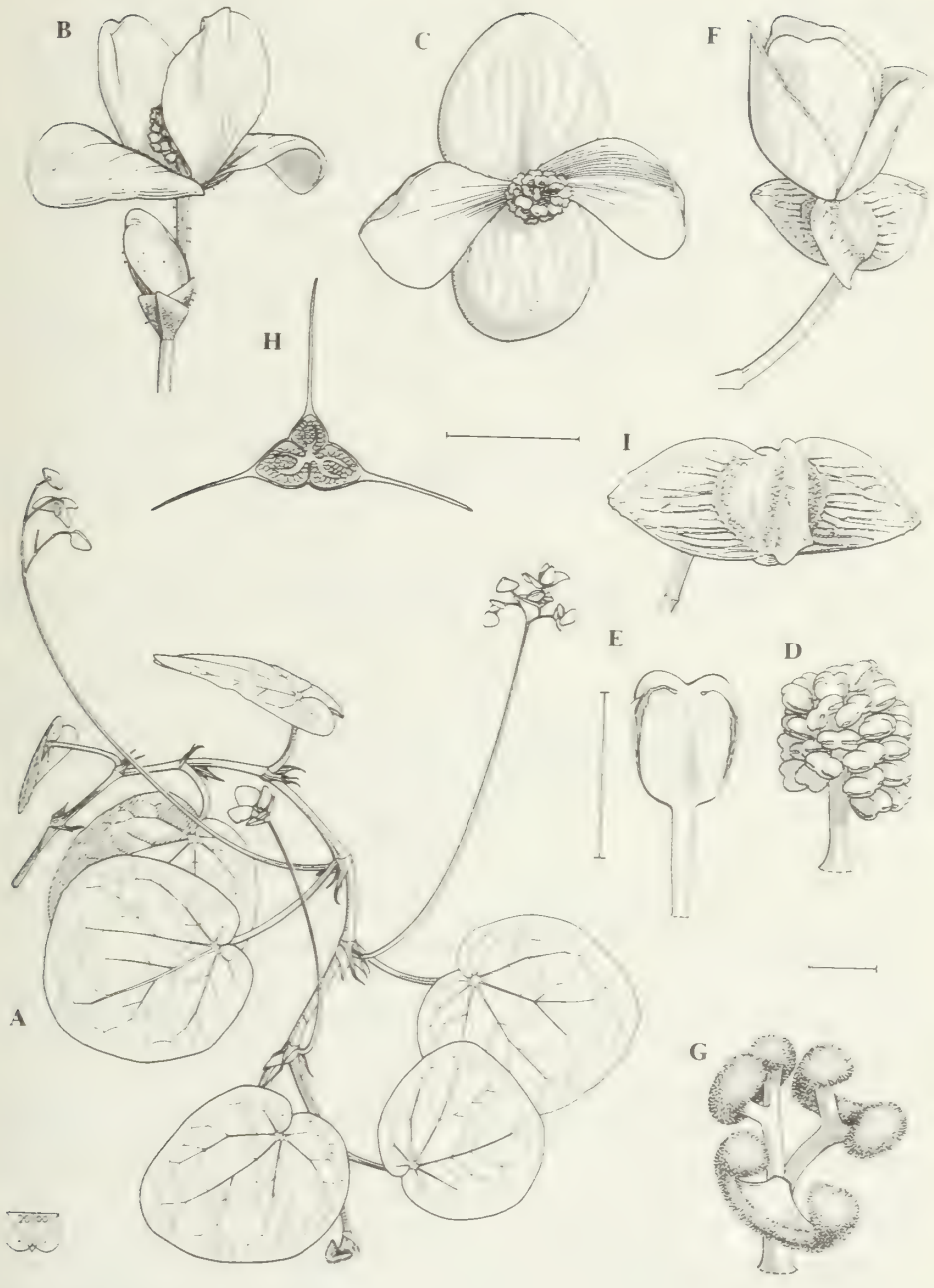

Figure 3. *Begonia diwolii* Kiew
A Habit x $\frac{1}{20}$. B Male flower. C Open male flower. D Androecium. E Stamen. F Female flower. G Style and stigma. H T.S. ovary. I Fruit. (from *RK 5073*)

rounded, narrowed to apex, locules 3, placentas axile, bilamellate with many ovules on both surfaces; *tepals* 4, c. 4.5—8 x 4—5 mm, margin entire, outer 2 slightly smaller, tinged magenta with outer surface paler inside, scintillating, microscopically pustulate, apex rounded; inner 2 slightly longer, pure white, apex truncate; *styles* 3, c. 3.5 mm long, joined at the base for c. 1.5 mm, then bifurcating; *stigmas* green-yellow, with a lunate, papillose band on each branch. *Fruits* up to 3 per infructescence, pendent, peduncle, branches and pedicels becoming thin, dry and hair-like, 12.5—16.5 cm long, *capsule* 10—13 x 3.5—5 mm, whole fruit becoming dry and papery, glabrous, locules 3, dehiscing between locule and wing, wings 3, equal-sized, broadly rounded, c. 4—5 mm wide; *seeds* brown, minute, broadly ellipsoid, c 0.25—0.3 mm long, base narrowed, apex rounded.

Distribution: Borneo – SABAH: Lahad Datu District, Segama River (Tempadong, Batu Belas, Borneo Marble Quarry and an unnamed hill by the Lahad Datu road).

Habitat: On vertical and horizontal rock faces from the cliff base in deep shade to light shade near the summit of limestone hills.

Notes: This new species is most distinctive in its habit of producing long prostrate, frequently zigzag stems that creep and root over the rock surfaces (illustrated in Kiew, 2000). The long internodes mean that the leaves are distant and so contrast with other rhizomatous limestone species with leaves with palmate venation, such as *B. gueritziana* in Sabah and *B. speluncae* Ridl. in Sarawak, which both have very short internodes so that their leaves are in a tuft. Furthermore, it cannot be mistaken for *B. gueritziana*, which has much larger and thicker leaves, and fruits with one wing much larger than the other two. In fruit shape (three equal, narrow, rounded wings), leaf shape (small and frequently orbicular) and the inflorescence being longer than the petiole, *B. diwolii* most closely resembles *B. speluncae* but it is readily distinguished from the latter, which not only has short internodes and tufted leaves, but is also glabrous, and the leaves are frequently peltate. In addition, *B. speluncae* is placed in sect. *Reichenheimia* by Doorenbos *et al.* (1998), a section that has placentas with one (not two) lamellae.

This new species belongs to sect. *Diploclinium* Group 1 of Doorenbos *et al.* (1998), which includes the rhizomatous species with palmately veined, often symmetric leaves, bisexual inflorescences that are usually protandrous, male flowers with four tepals and obovate anthers, female flowers with four tepals, and three-loculate fruits with three equal-sized wings and bilamellate placentas.

Many of these characters are shared by sect. *Petermannia*, although species in that section are less usually rhizomatous or palmately veined. However, the one character that does exclude *B. diwolii* from sect. *Petermannia* and places it in sect. *Diploclinium* is its protandry.

The fact that this species is protandrous is not always apparent from herbarium specimens. Observations in the field show that the inflorescences produce three branches in sequence, each of which produces one or two male flowers that open first, followed by a single female flower, then further male flowers, the entire inflorescence therefore eventually producing a maximum of three fruits. Unless a plant is observed in the initial male phase, it appears protogynous with a developing fruit below and young male flowers above.

This charming species with its dainty round leaves magenta beneath and bright pale flowers deserves to be introduced into cultivation. Experimentation in the Singapore Botanic Gardens shows that it grows well on old coral (Kee, 2000).

It gives me great pleasure to name this decorative species for Diwol Sundaling, Senior Herbarium Officer at SAN, who organised the expedition to the Segama River (and many others) and whose enthusiasm and support in the field is much appreciated.

Specimens examined: SABAH: Lahad Datu District – Tempadong the type and *Ruth Kiew et al. RK5073* Unnamed hill on Lahad Datu road (E, SAN, SING).

6. Begonia gomantongensis Kiew
Section *Petermannia*
Kiew, Gardens' Bulletin Singapore 50 (1998) 164.
TYPE: Bukit Dulang Lambu *James Awing SAN 47257* (holo SAN).

Distribution: Borneo: SABAH – Kinabatangan District, Bukit Dulong Lambu (Gomantong Cave).

Habitat: Base of limestone hill in deep shade on boulders or the foot of cliff faces.

Notes: A member of sect. *Petermannia*, it is distinct from the other limestone species in Sabah in its subrotund leaves, which are held horizontally on long petioles, and its oblong capsules with a pimply surface.

It is known only from Bukit Dulong Lambu.

Specimens examined: SABAH: Kinabatangan District - Bukit Dulong Lambu *James Awing*

SAN 47257 (SAN), *S.P. Lim & Ubaldus LSP 785* (SAN, SING), *R. Kiew & S.P. Lim BDL 3* (SAN, SING).

7. Begonia gueritziana Gibbs
Section *Platycentrum*
Gibbs, Linn. Soc. Bot. 42 (1914) 82 & figure.
TYPE: Kayoh Hills, Tenom *L.S. Gibbs 2892* (holo BM).

As more specimens are available, including ones with female flowers, additional information is provided here to supplement the original description:

Rhizome with crowded internodes. *Petiole* 6—13 cm long; *lamina* dark green above, often reddish-purple beneath, 5—8 x 5.5—7 cm, basal lobes scarcely developed 3—18 mm long. *Inflorescences* protandrous, longer than petiole, 11—22 cm long of which peduncle is 10—20 cm. *Male flower* outer two *tepals* broadly elliptic, 11—12 x 7.5—8 mm, inner two narrowly elliptic, c. 11 x 3 mm; *stamens* joined at base, torus c. 1 mm long. *Female flowers* with *ovary* pale green, glabrous, c. 5—9 mm long, locules 2, placentas axile, bilamellate, wing 3 unequal, longer wing c. 4—7 mm wide, two shorter c. 2 mm wide; *tepals* 4, rosy pink, outer two almost rotund, 5—9 x 5—8 mm, margin entire, apex rounded, inner two elliptic, c. 4—8 x 4—5 mm, apex cucullate; *styles* yellow, 2.5—3 mm long, bifurcating; *stigma* a twisted continuous papillose band. *Capsule* c. 10 mm long, longer wing 10—12 mm wide, broadly rounded, slightly concave, two shorter wings 4—5 mm wide, thin, apex slightly acute.

Distribution: Borneo – SABAH: Apart from islands and the coastal areas of the west and north coasts, *B. gueritziana* is widespread in Sabah both on and off limestone having been collected from the Tenom, Keningau, Kota Merudu, Ranau, Labuk Sugut, Kinabatangan and Tawau districts. However, it has not been collected further west than the Kallang Waterfall in Tenom (*Ruth Kiew & S.P. Lim RK 4280*). It has not been reported from Brunei (Sands, 1996) nor has it been collected from Gunung Api, in the Mulu National Park, Sarawak, the closest limestone to Sabah. It therefore is a Sabah endemic.

It is the only widespread begonia species on limestone in Sabah and is particularly common on all the Kinabatangan limestone hills (even on the smaller, disturbed ones like Supu and Batu Tulug) and has been collected from the Kelabangan Ridge, Batu Urun and Lian Cave. On the other hand, it is absent from limestone in the south (Segama River and

Madai-Baturong limestone) and in the west (Melikop, Pun Batu, Batu Punggul and Sungai Pangi).

Habitat: On limestone, *B. gueritziana* grows in light shade and is most frequent in soil-filled crevices and is particularly common on humus covered ledges (Kiew, 1998b).

Of the begonia species that grow on limestone in Sabah, it is the only species that has been collected from non-limestone substrates (basalt, gabbro and sandstone are cited on herbarium specimens). It has usually been collected from rocks by the edge of streams from near sea level (30 m) up to 750 m altitude on Gunung Kinabalu.

Notes: Gibbs (1914) originally placed *B. gueritziana* in sect. *Reichenheimia* as do Doorenbos *et al.* (1998). However, it is atypical of this section in the ovary having unequal wings, being 2-loculate and each locule having two placentas. These ovary characters clearly place it within sect. *Platycentrum*, with which it is in accordance for all other diagnostic characters, such as the rhizomatous habit, palmate leaf venation, the axillary, protandrous inflorescence (illustrated in Kiew, 2000), male flower with 4 tepals, and the nodding fruit, which dehisces on both sides of the narrower wings.

As in *B. diwolii*, examination of herbarium specimens can be misleading, because if the initial stage with only male flowers is not represented, the inflorescence may appear to be protogynous.

Compared with the begonia flora of Peninsular Malaysia, sect. *Platycentrum* is poorly represented in Sabah, the only other species being *B. adenostegia* Stapf from Gunung Kinabalu.

Although widespread in terms of geography, substrate and altitude, it is rather uniform in habit and leaf shape. However, the population on limestone at Kelabangan is different in having pure white flowers compared to the usual rosy pink ones.

It is apparently an easy species to grow, as at the Agricultural Park, Tenom, it seeds freely and has gone wild on shaded rocks in the Orchid Centre.

Specimens examined: The type and from limestone: SABAH: Kinabatangan District – Kinabatangan Valley, Batu Batangan *Ruth Kiew & S.P. Lim RK 4291* (SAN, SING), *Meijer SAN 23103* (locality misnamed Batu Bilit) (SAN); Batu Temambong Besar *Ruth Kiew & S.P. Lim RK 4192* (SAN, SING), *Lim et al. LSP 1151* (SAN, SING); Keruak FR *Ruth Kiew & S.P. Lim RK 4183* (SAN, SING); Bukit Dulong Lambu (Gomantong) *Meijer SAN 20754* (K), *S.P. Lim et al., SPL 616* (SAN, SING); Supu *J. Singh & Eging SAN 51826* (SAN), Batu Tulug (Batu Putih) *Dewol & Harun SAN 89912* (SAN, SING), *Puasa SAN 10115* (K), *S.P. Lim et al. LSP 625* (SAN, SING), *LSP 771* (SAN, SING); Pensiangan District - Batu Urun *Ruth Kiew & S. Anthony RK4463* (SAN, SING) – also observed on

Baladut and Sarupi (Kinabatangan Valley); Kelabangan (Pensiangan District).

8. Begonia heliostrophe Kiew, *sp. nov.*
Section *Petermannia*

A *Begonia malachosticta* Sands foliis majoribus sursum spectantibus differt — TYPUS: Batu Batangan *R. Kiew & Lim S.P. RK 4293* (holo SAN; iso BRUN, K, KEP, L, SAR, SING).

Figure 4

Bushy, cane-like, glabrous begonia, usually branched at base from a prostrate rhizome. *Stem* reddish brown or purple, up to 1.25 m x c. 7.5 mm diam., becoming woody, flowering at 60 cm, internodes 5—7 cm long, erect, branching at c. 30 cm, nodes swollen and almost articulate. *Stipules* pale green, lanceolate, 10—15 x 4—6 mm, margin entire, apex setose, caducous. *Leaves* alternate, distant, positioned with the apex held upwards; *petiole* reddish brown or purple, 5—7 cm long, grooved above; *lamina* sometimes with a silvery hue when immature, becoming flecked silver and finally uniformly mid-green at maturity, except for deep crimson patch at junction with petiole, beneath slightly reddish-green between veins, thinly succulent in life, thinly chartaceous dried, glossy above, asymmetric, narrowly ovate (10.5—)14—16(—19) x (3.5—)6—6.5 cm of which broad side is (2.5—)4.5—5 cm wide, basal lobe rounded, (2—)3.5—5 cm long, base cordate but not overlapping, margin reddish, serrulate, apex attenuate; venation palmate-pinnate, *midrib and lateral veins* 3—5 pairs along midrib and 1 pair at base, bifurcating once about halfway to margin and again close to the margin, 2—3(—4) veins in basal lobe, slightly raised above, plane and pale green beneath.
Inflorescences axillary, protogynous, much branched cymose panicle, bright deep magenta, erect, 7.5—10 cm long of which peduncle is 1.75—3.5 cm long, longer than petioles, with 1 or 2 female flowers proximally and many male flowers distally on thin, branches; *bracts* lanceolate, pale green or reddish green, c. 7 x 4 mm, margin entire, apex acute, caducous. *Male flower* with reddish *pedicel* c. 5 mm long; *tepals* 4, white or very pale green, suffused crimson towards base, inner surface glistening, margin entire, apex rounded, outer two concave, almost rotund 4—6 x 4.5—6 mm, inner two broadly elliptic 2—4 x 1.5 mm; *stamens* c. 60, cluster broadly conical, c. 3 mm long including a short torus c. 0.25 mm long, *filaments* c. 0.75 mm long, *anthers* lemon yellow, broadly oblong, c. 0.5 mm long, apex emarginate. *Female flower* pendent in bud then straightening so the open flower is held horizontally; *pedicel* 1.75—2 cm long, crimson, *ovary* glabrous, oblong, c.

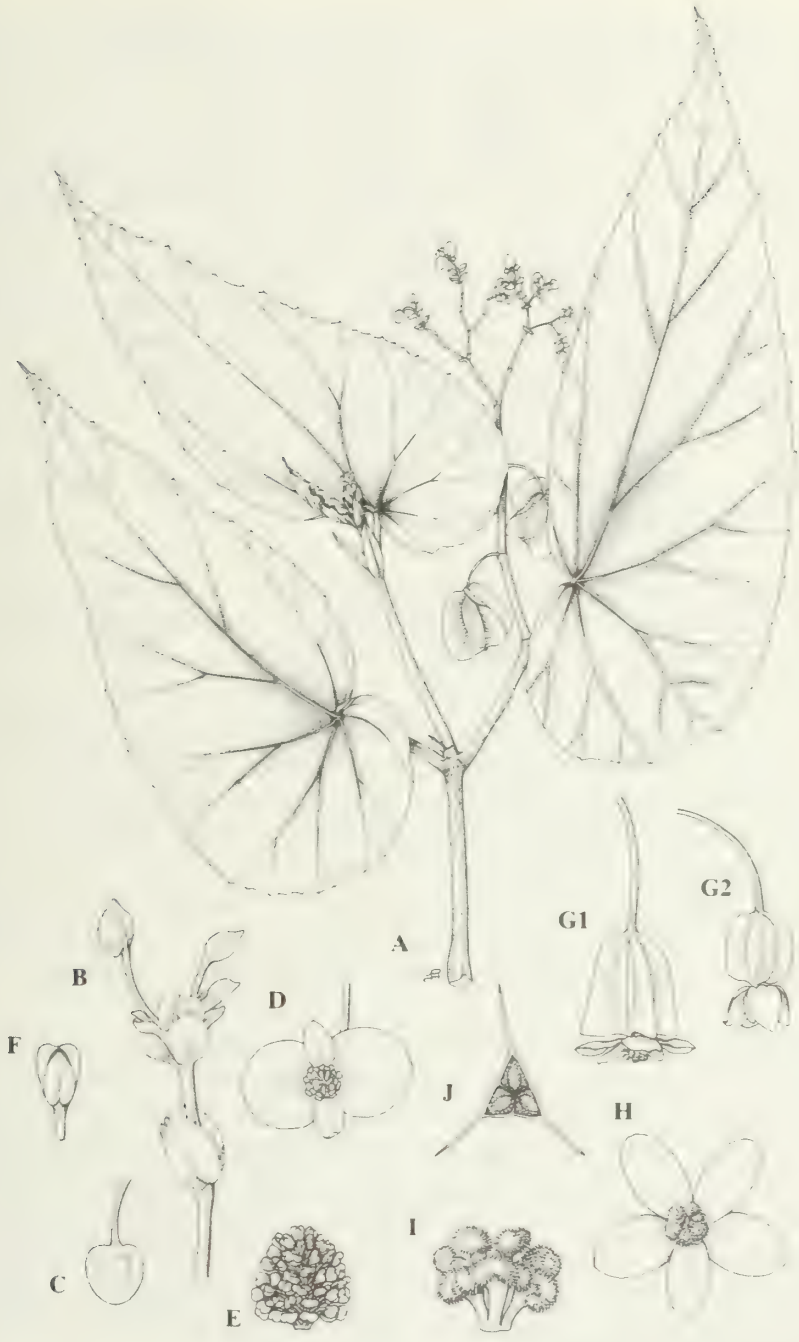

Figure 4. *Begonia heliostrophe* Kiew
A Habit x ½. B Branchlet of male inflorescence x 2. C Male bud x 2. D Open male flower x 2½. E Androecium x 5. F Stamen x 10. G 1&2 Female flower x 1. H Open female flower x 1½. I Style and stigma x 5, J T.S. ovary x 1. (from *RK 4293*)

15 x 9 mm wide proximally and 14 mm wide distally, wings 3, isomorphic, reddish when immature becoming green with slight reddish tinge on the margins at maturity, locules 3, placentas axile, bilamellate, many ovules on both surfaces; *tepals* 5(—6), pale yellowish green with a peachy tinge, elliptic, isomorphic, c. 10 mm long, outermost 6—9 mm wide, innermost c. 4 mm wide, margin entire, apex rounded; *styles* 3, c. 3 mm long, divided to base, bifurcating, *stigma* bright lemon yellow, papillose forming a continuous twisted band. *Fruit* dangling on a fine hair-like *pedicel*, 2—3 cm long; *capsule* broadly deltoid, 17—23 x 17—22 mm, glabrous, locules 3, dehiscing between locule and wing, wings isomorphic, rounded at base, 7—10 mm wide, tips rounded, thinly fibrous; *seeds* brown, minute, broadly ellipsoid, c. 0.25—0.3 mm long, base truncate, rounded distally.

Distribution: SABAH: Kinabatangan District, Kinabatangan Valley (Batu Batangan and Keruak).

Habitat: On soil at the base of cliffs or in crevices in vertical rock faces from the base to the crest of cliffs in deep or light shade, particularly common on soil-covered ledges in light shade.

Notes: In its cane-like habit, its female flowers with 5 tepals, 3 bifurcating styles that are caducous in the fruit, 3-loculate ovary and fruit with 3 equal wings and bilamellate placentas, it is typical of sect. *Petermannia* but like the majority of limestone begonias, it differs in having 4 tepals in the male flower instead of the typical 2.

It is unique among the limestone begonias in Sabah in that the leaf grows with its apex pointing upwards compared with the usual position where the apex points downward. The species epithet highlights this unusual feature.

It belongs to a group of cane-like begonias that grow in light shade on rock faces that have asymmetric, narrowly elliptic leaves with one basal lobe well-developed and rounded. On limestone, this group includes *Begonia malachosticta*, *B. keeana* and the above species. In addition to the orientation of the leaf, *B. heliostrophe* differs from *B. malachosticta* in its broader, plain (non-variegated leaves), many-flowered male inflorescences and rounded (non-arcuate) wings of the fruit, and from *B. keeana*, besides the orientation and non-variegation of the leaf, by its larger leaves (up to 12.5 x 8.5 cm in *B. keeana*) and yellowish green flowers (compared with the rosy red ones of *B. keeana*).

Specimens examined: SABAH: Kinabatangan District - Batu Batangan the type; Keruak *Amin & Matin SAN 108091* (SAN), *Ruth Kiew & Lim S.P. RK 4158* (E, K, L, SAN, SAR, SING), *RK 4175* (SAN, SING).

9. Begonia keeana Kiew, sp. nov.
Section *Petermannia*

A *Begonia malachosticta* Sands foliis latioribus et fructibus latioribus pedicello multo longiore suffultis — TYPUS: Tempadong *R. Kiew et al. RK 4766* (holo SAN; iso K, SING).

Cane-like begonia, glabrous, root stock woody with several stems. *Stem* reddish brown flecked white, smooth and glossy, to 1.25 m tall and 5—7 mm diam., flowering at c. 30 cm tall, internodes 2—8.5 cm, erect or pendent if growing on edge of cliff face, older stems branching sparingly in the upper 50 cm, branches at 45° to main stem, woody, slightly swollen at nodes. *Stipules* pale green, broadly lanceolate, 14—23 x 7—10 mm, margin entire, apex setose, persistent. *Leaves* alternate, distant, lamina pendent held at 45° on erect petioles; *petiole* concolorous with stem, in lower leaves c. 3—7 cm x 3—4 mm long, in upper leaves 1—1.5 cm x c. 2 mm long, terete; *lamina* variegated, margin silvery grey, veins dark green, lamina between veins either completely silvery grey to the base of the veins or with a few, large grey-green blotches, beneath uniform deep purple magenta, fleshy (brittle and snapping in live state), thinly chartaceous in dried state, glossy above, obliquely narrowly ovate, asymmetric, 11.5—16 x 7—8.5 cm, the broader side 5—5.5 cm wide, base cordate but not overlapping, basal lobes rounded, 4—5 cm long, margin slightly scalloped between veins and minutely serrulate, apex attenuate; venation palmate-pinnate, *midrib and lateral veins* 3—4, equal-sized, branching midway to margin, 2 veins in the basal lobe, slightly indented above, slightly prominent and concolorous beneath.
Plant protogynous. *Male inflorescence* produced after and in the same axil as a fruit or from the upper leaf axils, an erect, cymose panicle with third order branching, reddish brown or deep purple red, longer than subtending petiole, 4—15.5 cm long of which peduncle is 2.5—7.5 cm long; *bracts* pale green, ovoid, 6—9 x 5—6 mm, margin entire, apex acute, persistent. *Male flowers* with *pedicel* rosy red, 13—18 mm in open flower, very slender, *tepals* 4, pale rosy red deeper red towards centre, margin entire, outer two ± rotund, cucullate, 7—8 x 7—9 mm, glabrous, inner two oblong, apex rounded, 6—8 x 2—3.5 mm; *stamens* more than 40, cluster hemispherical, 3(—4) x 3(—4) mm including torus c. 0.5 mm long, *filaments* c. 0.75—1 mm long, *anthers* pale yellow, 0.75—1 mm long, apex emarginate. *Female flowers* solitary, produced at 1 or 2 (—3—4) successive leaf axils; *pedicel* c. 15—16 mm long; *ovary* deep rosy red, oblong, 16—24 x 15—22 mm, wings 3, equal, locules 3, paler, placentas axile, bilamellate with many ovules on both surfaces; *tepals* 5, outermost glossy, rosy red (paler than wings), broadly

oval c. 9—10 x 8—9 mm, innermost isomorphic and slightly smaller c. 7 x 6 mm, sometimes narrowly elliptic c. 8 x 4 mm, margin entire, apex rounded; *styles* 3, pale yellow, c. 4 mm long, joined at base for c. 1.5 mm, bifurcating; *stigma* papillose forming a continuous twisted band. *Fruit* dangling, pedicel drying to fine thread, 23—30 mm long, *capsule* broadly deltoid, 25—31 x 25—29 mm, glabrous, locules 3, dehiscing on upper half between locules and wing, wings 3, equal, 13—15 mm wide, very thin and fibrous, tip rounded; *seeds* brown, minute, ellipsoid, c. 0.3 mm long, truncate at base, rounded distally.

Distribution: Borneo – SABAH: Lahad Datu District, Tempadong and Batu Belas on Segama River and Tabin Wildlife Reserve.

Habitat: At base of cliffs, in crevices in rock face or on exposed shoulders of cliffs below tree canopy in light shade.

Notes: It is a typical member of sect. *Petermannia* in its erect cane-like habit, asymmetric leaves, in being protogynous with solitary female flowers produced before the distal, many flowered male inflorescences, in having a 3-loculate ovary with the placentation axile, bilamellate placentas, and the fruit having three equal wings and caducous style.

It most resembles *B. malachosticta* Sands in its habit and leaf shape but differs in the pattern of variegation (*B. malachosticta* has pink spotted leaves), much wider leaves (they are less than 5 cm wide in *B. malachosticta*), much branched male inflorescence (that of *B. malachosticta* is a simple cyme with three flowers or is once branched and just 4 cm long with about six flowers), larger male flowers (3—7.5 mm long in *B. malachosticta*) and the broader fruit with rounded wings (fruit is narrower, 10—17 mm wide, and has arcuate wings in *B. malachosticta*).

Local people eat the young, succulent shoots of this new species as a vegetable. Most begonia leaves have a sourish taste, but in Sabah relatively few are actively gathered for food. Another such esculent species, *Begonia lazat* Kiew & Reza Azmi, was discovered during the course of an ethnobotanical study (Reza Azmi and Kiew, 1998). The fact that species known to local people as food plants are still unknown to science indicates how little is still known about the begonia flora in Sabah.

This is a handsome begonia illustrated in Kee (2000) and Kiew (2000), which has lush, glossy leaves with silvery variegations on the upper surface and a deep magenta underside. It grows well on old porous coral in the nursery at Singapore Botanic Garden (Kee, 2000). That it adopts a pendulous habit when growing on the edge of cliffs indicates its potential for being grown in hanging baskets.

This new species is named for Andrea Kee, horticulturalist at Singapore Botanic Gardens, who was a member of the expedition that discovered this new species and who has carried out trials on its cultivation.

Specimens examined: SABAH Lahad Datu District - Segama River - Batu Belas *Ruth Kiew et al. RK 4765* (SAN, SING). Tempadung the type. Tabin Wildlife Reserve Ruth Kiew RK 5118 (SAN, SING, University of Sabah).

10. Begonia keithii Kiew
Section *Petermannia*
Kiew, Gardens' Bulletin Singapore 50 (1998) 189 & Fig. 4.
TYPE: Batu Tengar Cave *Kiew, Anthony & Lim RK4327* (holo SING; iso K, KEP, L, SAN, SAR).

Figure 5

Distribution: Borneo - SABAH: Semporna District, Batu Tengar Cave (Segarong Cave).

Habitat: In light shade or full sun, growing in crevices on the limestone hill, dominating exposed shoulders and summit of the hill, where it forms thickets with its woody cane-like stems, illustrated in Kiew (2000).

Notes: This is one of the most decorative of Sabah begonias with its polished red stems that give them a lacquered appearance, the dainty pointed leaves with a crimson scalloped margin and the many carmen, heart-shaped male buds set on slender sprays. It would be a fine addition to the cultivated begonias and, considering the harsh conditions under which it grows, would probably mean it is easier to cultivate than the forest species that grow in deep shade.

Specimens examined: SABAH Semporna District - Batu Tengar Cave (Segarong Cave) *Sompagon & Agama 9312* (K, SING), *Kiew 4940* (K, SING), *Kiew et al. RK 4327* (SAN, SING).

11. Begonia lambii Kiew, *sp. nov.*
Section *Petermannia*

A *Begonia inostegia* Stapf foliis dense hirsutis obovatis brevipetiolatis et fructibus oblongis differt — TYPUS: Batu Tinahas *R. Kiew & S. Anthonysamy RK 4405* (holo SAN; iso K, SING).

Figure 5. *Begonia keithii* Kiew
A Habit x $^1/_2$, B & C Branchlet of male inflorescence x $^1/_2$ and x 1, D Male flower bud x $1^1/_2$, E Male flower x $1^1/_2$, F. Androecium x 5, G Stamen x 10, H Female flower x 1, I Open female flower x $1^1/_2$, J Style and stigma x 5, K T.S. ovary x 2, L Fruit x 1. (from *RK 4327*)

Figure 6

Rosette herb with 3—4 leaves held ± flat on the leaf litter layer. Stem and petioles with brown and scurfy indumentum giving a felted appearance with additional sparse long hairs. *Stem* unbranched, becoming woody, erect, to 10—13 cm tall and 3—5 mm diam., internodes 1.25—2.5 cm long. *Stipules* pale green, lanceolate, c. 14 x 14 mm, margin entire, midrib keeled, apex cuspidate, caducous. *Leaves* alternate, distant, held horizontally; *petiole* 1—2.5 cm, shallowly grooved above; *lamina* plain dark green above, green or reddish brown or maroon beneath, hairs on upper surface upstanding, eglandular, uniseriate, c. 1.5 mm long, translucent in completely green leaves, reddish brown, purple or magenta where lamina is coloured beneath, glabrous beneath, thin, matt, broadly obovate, strongly asymmetric, 12—14.5 cm x 7.5—11cm, narrower side slightly concave, broader side 5—7.5 cm wide rounded, base unequally cordate, basal lobe 1—3 cm long, margin denticulate with each tooth tipped by long hair, apex rounded or shortly acuminate (acumen 4—5 mm long); venation palmate. *midrib and veins* brown or deep purple and densely hairy beneath, 5—7 veins, midrib ± same size as the laterals, branching dichotomously 3—4 times before reaching margin, c. 3 veins in larger basal lobe, veins deeply impressed above giving the lamina a corrugated appearance.

Inflorescence protogynous, from axil of new leaf, densely hairy, erect, longer than petioles, at first compact and cymose 1—3 cm long with one female flower, then producing a spike 7.5—10 cm long of distant cymules with crowded male flowers, peduncle 1.25— 2.5 cm; *bracts* pale green, narrowly lanceolate, 5 x 1.5 mm, entire, persistent. *Male flower* with white *pedicel* 4—5 mm long, densely hairy; *tepals* 2, pure white, densely hairy on outer convex central portion, broadly elliptic, 5—9 x 4.5—8, entire, apex rounded; *stamens* c. 30, cluster conical, 2—3.5 x 3—3.5 mm, usually sessile, *filaments* 0.5—0.75 mm long, *anthers* obovate, c. 1.5 x 0.75 mm, apex not emarginate. *Female flower*: *pedicel* c. 4—7 mm long, white, densely hairy; *ovary* green, sparsely hairy on the wings, densely hairy on the locules, oblong with wings expanding slightly distally, 5—9 x 3—8 mm, wings 3, reddish, isomorphic, wings c. 1—2 mm wide, locules 3, placentas bilamellate; *tepals* 5, white, outer surface with long hairs, ± isomorphic, innermost slightly narrower, elliptic, 9—12 x 5—8 mm in outer 4 tepals and 4—5 mm wide in innermost tepal, entire, apex acute; *styles* 3, greenish, c. 4 mm long, joined for c. 1 mm at base, distally bifurcating, *stigma* papillose forming a continuous twisted band. *Fruit* decurved and pendent, pedicel rigid, 1—2 cm long, capsule oblong, rounded at base, truncate or rounded at apex, 15—18(—25) x 10—13(—14) mm, hispid particularly on locules, style caducous, locules 3, dehiscing between locule and wing, wings 3, equal,

thin, 2—4 mm wide; *seeds* brown, minute, broadly ellipsoid, c. 0.2—0.25 mm long, tapered to base, rounded distally.

Distribution: Borneo – SABAH: Pensiangan District, Batu Punggul and Batu Tinahas; Sapulut.

Habitat: Steep earth slopes up to or on flat areas at the base of limestone cliffs.

Notes: The species is striking in several respects. Its deeply corrugate, obovate leaves with a dense covering of magenta or purple hairs contrasting with the dark green lamina make it a distinctive species. Its habit too, where the dark green leaves lie on and blend with the leaf litter, is also unusual. It is illustrated in Kiew (1998d, 2000).

It is a typical member of Section *Petermannia* in having an upright habit, being protogynous, the female flowers having 5 sepals, a 3-loculate ovary with bilamellate placentas, the male flowers having 2 tepals, obovate anthers that are not emarginate, and the capsule having 3 isomorphic wings and caducous styles.

In inflorescence structure, it is closely similar to *B. inostegia* Stapf from Gunung Kinabalu. Both at first have a short inflorescence, which produces the single female flower, as this matures into the fruit, an erect axis is produced with a few distant, short lateral branches that produce bunches of crowded male flowers. The inflorescence is thus protogynous and the single female flower is basal to the many male flowers. However, the leaves of these two species are very different, those of *B. inostegia* are long-petioled, ovate with a cuspidate apex, and the capsule is obovoid. In addition, *B. lambii* also does not have the peculiar ovate, fimbriate stipules characteristic of *B. inostegia*.

This decorative species is named for Anthony Lamb of the Agricultural Park, Sabah, whose deep interest in Sabah plants has inspired him to bring this species (and many others of horticultural potential) into cultivation.

Specimens examined: SABAH: Pensiangan District - Batu Punggul *Ali Ibrahim AI 135* (SING), *Sumbing Jimpin SAN 135991* (SAN), Batu Tinahas the type and *R. Kiew & S. Anthonysamy RK 4408* (K, SAN, SING); Sapulut (near Kampung Naaturan) *R. Kiew & S. Anthonysamy RK 4345* (SING). It is also cultivated at the Agricultural Park, Tenom.

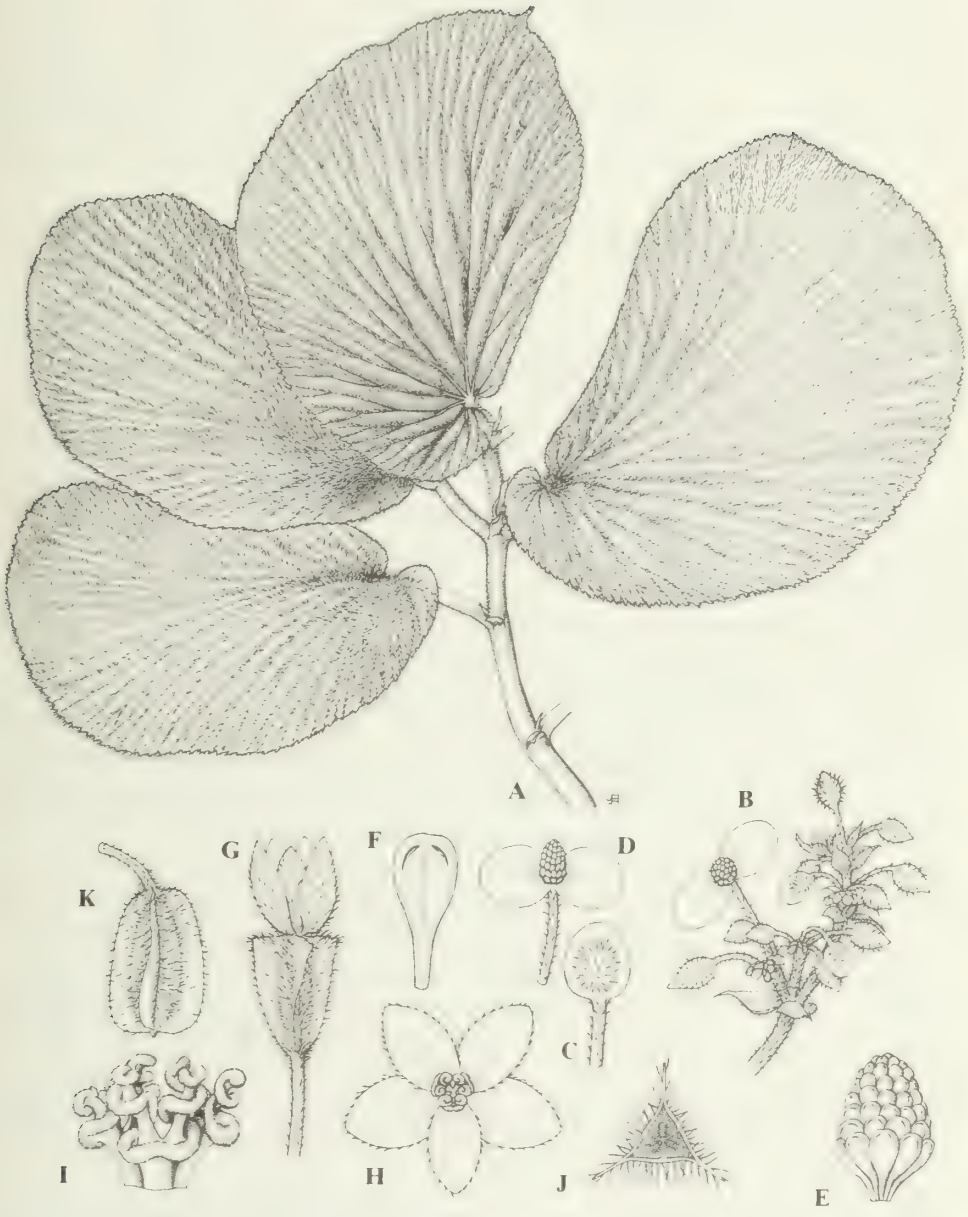

Figure 6. *Begonia lambii* Kiew
A Habit x ½. B Male inflorescence x 1. C Male bud x ½. D Open male flower x 1. E Androecium x 4. F Stamen x 10. G Female flower x 1. H Open female flower x 1. I Style and stigma x 4. J T.S. ovary x 1½. K Fruit x 1. (from *RK 4408*)

12. Begonia layang-layang Kiew, *sp. nov.*
Section *Petermannia*

A *Begonia amphioxo* Sands foliis latioribus et fructibus majoribus pedicello longiore suffultis — TYPUS: Sapulut *R. Kiew & S. Anthonysamy RK 4441* (holo SAN; iso BRUN, K, L, SAR, SING)

Cane-like, glabrous begonia. *Stem* pale green at first, becoming brown, c. 1 m tall and 3—6 mm diam., woody, internodes up to 4 cm long, erect, branching dichotomously, young branches conspicuously zigzag, nodes annular. *Stipules* pale green, narrowly lanceolate, to 12—14 x 2—4 mm with prominent midrib, margin entire, apex acute, caducous. *Leaves* alternate, distant, pendent; *petiole* pale green, (2.5—)3.5(—5.5) cm and in dried state 1 mm thick, slightly grooved above; *lamina* plain dark green above except for the red patch at point of attachment with petiole, pale green or sometimes reddish beneath, succulent drying slightly leathery, slightly glossy above, peltate, slightly asymmetric, narrowly elliptic, (8—) 10(—11.5) x (2—)2.2(—4.5) cm, the broader side (1.7—)2(—2.7) cm wide, basal lobe acute to pointed sometimes slightly oblique, length of basal lobe (3.5—)4.2(—5.5) cm, margin red with fine distant teeth becoming closer and more prominent towards apex, apex attenuated; venation palmate-pinnate, *midrib and lateral veins* concolorous with lamina, 1—4 unbranched pairs, 3 veins in basal lobe, plane above, slightly prominent beneath.
Plant protogynous. *Male inflorescences* from upper leaf axils, green, erect, longer than petioles, a slender, lax three times-branched panicle with c. 15 flowers, 3.7—5.2 cm long of which peduncle is 2.2—3.7 cm; *bracts* lanceolate, thin, green, lower ones c. 12 x 3 mm, becoming smaller towards stem apex, midrib prominent, margin entire, caducous. *Male flowers* with whitish *pedicel* (3—)5—7 mm long, *tepals* 4, outer two pinkish outside, white inside, glabrous, subrotund, c. 6 x 5.5 mm, entire, apex rounded, inner two white, narrowly elliptic, c. 5 x 1.75 mm, apex rounded; *stamens* over 50, cluster conical, sessile, c. 3 x 2.5 mm, *filaments* c. 1—1.25 mm, *anthers* golden yellow, obovate, c. 0.75—1 mm long, apex emarginate. *Female flowers* solitary (rarely 2 per axil) in lower leaf axils; *pedicel* 17—27 mm long; *ovary* deltoid, 17—27 x 19—30 mm, wings 3 equal reddish, c. 4—8 mm wide, locules 3, placentas axillary, bilamellate with many ovules on both surfaces; *tepals* 5, free, greenish white, outer four broadly elliptic, slightly tapered to base, 9—15 x 5—9 mm, entire, apex rounded, inner one narrower, slightly obovate, 10—12 x 4—5 mm, apex rounded; *styles* 3, dark yellow, 4—5 mm joined for c. 1.75 mm at base, distally bifurcating; *stigma* papillose forming a continuous twisted band. *Fruit* dangling, pedicel extremely fine, (1.3—)2.8(—3.7) cm, capsule broadly deltoid, distal edge straight, (20—)

24.5(—29) x (22—)26(—33) mm, locules 3, dehiscing between upper half of wing and locule, wings 3, isomorphic, rounded proximally, truncate distally, 7(—8) mm wide, thinly fibrous, style caducous; *seeds* brown, minute, broadly ellipsoid, c. 0.3 mm long, base narrowed, rounded distally.

Distribution: Borneo – SABAH: Pensiangan District, Sapulut.

Habitat: In shade below tree canopy on rocks at base of cliff and on subsummits.

Notes: It is a typical member of sect. *Petermannia* having a cane-like habit, being protogynous and having fruits with three equal wings and a caducous style.

In its peltate and relatively narrow leaves, it most resembles *B. amphioxus*. However, it is clearly distinct from this species in its non-variegated leaves (those of *B. amphioxus* are red spotted), which are broader and less than four times longer than wide (compared with 8—28 mm wide and at least five times longer than wide in *B. amphioxus*), the tepals of the female flower are always free (frequently joined in *B. amphioxus*), and the much larger fruits on long pedicels with three broad equal wings. The fruits of *B. amphioxus* are smaller, 9—13 x 5—14 mm, frequently are two-winged, the wings are only 2—5 mm wide and the pedicels 2—2.5 cm long. (Sands, *pers. comm.*, informs me that 2—2.5 mm given as pedicel length in his type description is in error and should read 2—2.5 cm).

Both *B. layang-layang* and *B. amphioxus* grow in moderate shade on rock faces quite close to the base of the cliff. In this they differ from *B. baturongensis*, *B. keithii* and *B. madaiensis* that grow fully exposed or in light shade and do not flower in deep shade.

This species takes its name from the local one, *layang-layang* meaning swallow in Malay, because of the resemblance of the leaf shape to a swallow's wings. It is illustrated in Kiew (1998d) as 'the swallow begonia'.

Specimens examined: SABAH: Pensiangan District - Sapulut (near Kampung Labang) the type and *Diwol Sundaling SAN 13522* (SAN), *Aban & Singh SAN 107961* (SAN).

13. Begonia madaiensis Kiew, *sp. nov.*
Section *Petermannia*

A *Begonia baturongensi* Kiew fructibus longioribus quam latioribus apice acutis — TYPUS: Gunung Madai *R. Kiew et al. RK 5057* (holo SAN; iso K, SAR, SING).

Figure 7

Cane-like, glabrous begonia with several stems arising from prostrate rhizome. *Stem* reddish brown when young, at first erect, then becoming prostrate or pendent if growing on cliffs, to 1.7 m tall x 4—10 mm diam., internodes 3.5—10 cm long, woody, slightly thicker at nodes much branched, twigs zigzag to 60 cm long, maroon. *Stipules* pale rosy purple, narrowly lanceolate, c. 20—21 x 5—6 mm, margin entire, midrib keeled, apex attenuate, caducous. *Leaves* alternate, distant, pendent; *petiole* maroon, 1.2—5 cm x 1—3 mm long, terete; *lamina* green, dark green or brown-green, beneath maroon or pinkish light green, margin red, veins red above and beneath, young leaves variegated above with oval whitish-green or silvery spots of varying size between the veins, sometimes coalescing, and with tiny spots along the margin, veins deep ruby red above and rosy purple beneath, expanding leaf strongly pleated, succulent and brittle in live state, membranous when dried, surface slightly scintillating and appearing finely velvety, obliquely ovate, asymmetrical, (5—)10(—13.5) x (1.7—)4(—6) cm, the broader side being (1—)2.2(—3.2) cm wide, basal lobe broadly rounded (1.2—)2.5(—5) cm long, margin scalloped, apex acuminate; venation palmate-pinnate, *midrib and lateral veins* red beneath, (2—)3 veins branching c. midway to the margin with (1—)2 veins in the basal lobe, plane above, slightly prominent beneath.

Plant protogynous. *Male inflorescences* about 5 produced from upper axils, brownish red, erect, slightly longer than petioles, once-branched cyme with up to 7 flowers, 3.7—4 cm long of which 2—2.7 cm is the peduncle; *bracts* narrowly lanceolate, c. 12—14 x 3 mm, caducous. *Male flower* with pink *pedicel* 7—9 mm; *tepals* 4, outer two white or rosy pink, glabrous, subrotund, (5—)7(12) x (6—)7(—9) mm, margin entire, apex rounded, inner two pure white, narrowly obovate, 6—7 x 2 mm, margin entire, apex rounded; *stamens* c. 40, cluster broadly ovoid, sessile, c. 4 x 3 mm, *filaments* 0.5—0.75 mm, *anthers* golden or pale yellow, obovate, c. 1 mm long, apex emarginate. *Female flowers* solitary from lower leaf axils, up to 5 produced; *pedicel* 9—11 mm long, pale red; *ovary* pale green-white with edge of wings reddish, oblong, c. 11—12 x 9 mm, wings 3, equal, locules 3, placentas axile, bilamellate with many ovules on both surfaces; *tepals* 5, white faintly pink towards edge, elliptic, margin entire, apex acute, isomorphic, the inner slightly narrower, outer four c. 9 x 6 mm, inner one c. 9 x 4 mm; *styles* 3, yellowish green or golden yellow, 4 mm long joined for c. 0.5 mm at base, bifurcating; *stigmas* papillose forming a continuous twisted band. *Fruit* pedicel withering and becoming thread-like so the fruit dangles, (6—)14(—20) mm long, capsule obovate, (17—)25(—29) x (10—)18(—20) mm, glabrous, locules 3, dehiscing between locule and wing in the upper half of

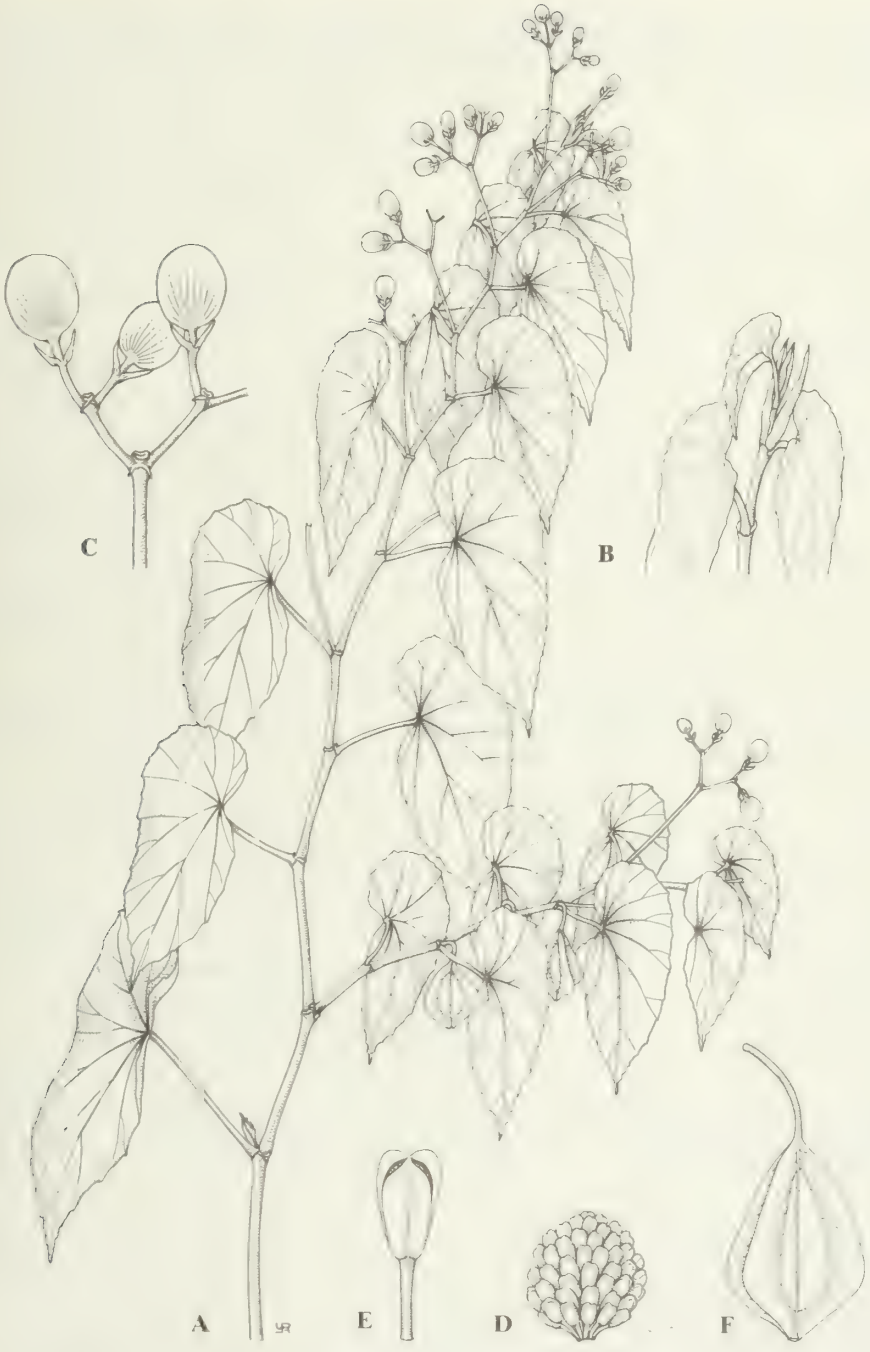

Figure 7. *Begonia madaiensis* Kiew
A Habit x $^1/_2$. B Stipules x 1, C Branchlet of male inflorescence x 2, D Androecium x 5. E Stamen x 15, F Fruit x 1. (from *LSP 672*)

capsule, wings 3, equal, rhomboid, (3—)5(—7) mm wide, thinly fibrous; *seeds* brown, minute, broadly ellipsoid, c. 0.25—0.3 mm long, base truncate, distally rounded.

Distribution: Borneo – SABAH: Lahad Datu District, Gunung Madai.

Habitat: Growing directly on limestone rocks and cliff faces in light shade.

Notes: In its erect habit, being protogynous with solitary female flowers below and male inflorescences above, in the 3-loculate ovary with bilamellate placentas and capsule with 3 equal wings and a caducous style, it is typical of sect. *Petermannia*. However, the male flowers have four tepals.

Among the cane-like begonias on limestone in Sabah, *B. madaiensis* is most similar to *B. baturongensis* in their leaves being broader and having a rounded basal lobe compared with those of *B. amphioxus* and *B. keithii*, and in being smaller than those of *B. heliostrophe*, *B. keeana* and *B. malachostica*. *B. madaiensis* can easily be told apart from *B. baturongensis* by its fruit, which narrows to the apex, giving it a rhomboid outline. Besides fruit shape, it also differs from *B. baturongensis* in several other features, such as its scalloped leaf margin, smaller bracts, less branched male inflorescence, white or pale pink flowers, tepals of the male flower that are longer than broad, and the leaves, which are strongly pleated before they expand.

The leaves of young plants are larger (about twice the size of those on fertile shoots) and can be conspicuously variegated, but this coloration is not expressed in older leaves. Plants growing in deeper shade tend to have greener, less maroon leaves and plants in deep shade, i.e. at the base of cliffs, do not flower. Flowering on a single twig is effectively unisexual as the female phase does not overlap with the later male phase.

Specimens examined: SABAH: Lahad Datu District - Gunung Madai the type and *W. Meijer SAN 37950* (SAN), *SAN 37959* (SAN), *S.P. Lim et al. LSP 672* (SAN, SING), *LSP 702* (SAN, SING).

14. Begonia malachosticta Sands
Section *Petermannia*
Sands, Kew Magazine. 7 (1990) 64 & Plate 145.
TYPE: Bukit Dulong Lambu *Sands & Young - Sands 3933* (not seen)

Distribution: Borneo – SABAH: Kinabatangan District, Bukit Dulong Lambu (Gomantong Cave).

Habitat: In rocky crevices in the sheer cliffs where the tree canopy begins to open up, as well as on exposed jagged outcrops. It is no longer common on the summit, which is greatly disturbed by the village of birdnest collectors that is established on the summit plateau.

Notes: This is a strikingly beautiful species with pink spotted leaves with a red underside. It has been introduced into cultivation at Kew where it is grown in a 50:50 mix of peat and sand. It is propagated easily from nodal cuttings (Sands, 1990).

It is eaten as a vegetable but is reportedly very sour (*Kamideh SAN 66578*).

Specimens examined: SABAH: Kinabatangan District - Bukit Dulang Lambu (Gomantong Cave) *James Ah Wing SAN 38108* (SAN), *SAN 47263* (SAN); *Kamideh Bangillan SAN 66578* (SAN).

15. Begonia melikopia Kiew, *sp. nov.*
Section *Petermannia*

A *Begonia erythrogyna* Sands foliis latioribus, inflorescentiis minoribus, tepalis rubris et fructibus angustioribus differt — TYPUS: Gua Melikop *Ruth Kiew et al. RK 5011* (holo SAN; iso BRUN, K, L, SAR, SING).

Cane-like, glabrous begonia with prostrate rhizome with several spaced erect *stems* to 1.5 m tall x 5—7 mm diam., base becoming woody, young stems brittle at swollen nodes, reddish above nodes, otherwise green, leaf scars very conspicuous, internodes 2.5—5.5 cm long, slightly ribbed, stems with 1—2 branches. *Stipules* green, strongly keeled, lanceolate, 23—25 x 9—11 mm, margin entire, apex acute, caducous. *Leaves* alternate, distant, in a bunch at top of stem, held horizontally; *petiole* completely reddish or reddish proximally and distally but green in between, 8.5—13 cm x 4—6 mm, grooved above; *lamina* plain mid-green above, beneath completely magenta or with magenta blotches and green veins, seedling leaves with white spots, succulent and brittle in life, thinly chartaceous in dried state, glossy above, asymmetric, broadly ovate, sometimes almost reniform, 15—19.5 x 12—18.5 cm of which broader side is 7.5—11.5 cm wide, basal lobes broadly rounded, 3.5—7.5 cm long, base cordate but not overlapping, margin scalloped between veins and minutely and distantly dentate, apex cuspidate; venation palmate-pinnate, *midrib and lateral veins* concolorous with lamina above, 5—7 pairs, branching twice dichotomously, first less than halfway to margin, then c. halfway to margin, 1—2 veins in basal lobe, impressed above, prominent beneath.

Inflorescence axillary, protogynous with 2 female flowers at base of the erect cymosely branched panicle of male flowers, shorter than petioles, 6—7.5 cm long of which peduncle is 1.7—2.5 cm with diam. c. 2 mm, branching c. 3—4 times, c. 4—8 main branches 4—15 mm long, ultimate branches 8—20 mm long, knobbly from congested scars of fallen flowers, each terminating in 1 bud or 1 bud and 1 one flower. *Male flower* with slender *pedicel* 7—12 mm long, *tepals* 2, flame-coloured darker towards base, glabrous, oval, 8—11 x 4—5 mm, margin entire, apex rounded; *stamens* c. 25, cluster conical, 3.5—4 x 2.5—3 mm, sessile, *filaments* c. 0.75 mm long, *anthers* pale yellow, spathulate, c. 1.2 mm long, apex not emarginate. *Female flower* not known. *Fruit* pendent and dangling on fine and thread-like pedicel 25—38 mm long, capsule narrowly deltoid narrowed into pedicel, 40—55 x 10—27 mm, glabrous, locules 3, placentas axile, bilamellate with many seeds on both surfaces, dehiscing between wing and locule, wings 3, equal, 6—7 mm wide, becoming thin and papery, tip acute or sometimes rounded; *seeds* brown, minute, almost globose, c. 0.2 mm long, base tapered, rounded distally.

Distribution: Borneo: SABAH – Kinabatangan District, Gua Melikop.

Habitat: Gua Melikop is an exposed cliff face on a hillside at about 400 m altitude. Its summit is covered by a deep layer of peat, which does not support a limestone flora.

Begonia melikopia grows rooted in cracks in the sheer limestone rock face in deep shade below the canopy but c. 1.5—2 m above base of limestone cliff. (Some seedlings were found growing in soil near the base of the cliff but no adult plants were found on soil, suggesting that these seedlings might not survive to maturity).

Notes: In its large, broadly ovate leaves, paniculate male inflorescence and large deltoid fruits pendent on long pedicels, it resembles *B. erythrogyna* Sands. However, it is distinct from this species in its much broader leaves (those of *B.erythrogyna* are less than 16 cm wide), its shorter, axillary male inflorescence (terminal and 7—14 cm long in *B. erythrogyna*), the male flowers are flame-coloured (they are white to pale green in *B. erythrogyna*), and the fruit, which is more than twice as long as wide (in *B. erythrogyna* it is less than twice as long as wide).

Begonia melikopia is typical of sect. *Petermannia* in its cane-like habit, in being protogynous, having male flowers with two tepals, and the fruits with three equal wings and three locules each with bilamellate placentas.

Specimens examined: Known only from the type population.

16. Begonia postarii Kiew
Section *Petermannia*
Kiew, Gardens' Bulletin Singapore. 50 (1998) 165 & Fig. 1.
TYPE: Bukit Panggi *Kiew & Lim RK 4221* (holo SAN; iso SING).

Figure 8

Distribution: Borneo – SABAH: Kinabatangan District, Kinabatangan Valley (Bukit Panggi, Bukit Dulong Lambu (Gomantong Cave) and Subuk Estate).

Habitat: At base of limestone hills (but not on cliff faces) growing in deep shade in sheltered damp habitats on soil, low limestone boulders or the base of tree trunks.

Notes: This softly hairy begonia with hairy tepals in the male flower and the hairy fruit is quite unlike any other limestone species in Sabah.

Specimens examined: SABAH: Kinabatangan District - Bukit Dulong Lambu *Joseph B. et al. SAN 122763* (SAN), *Lim S.P. & Ubaldus LSP 802* (SAN, SING), *Ruth Kiew & Lim S.P. BDL 4* (K, SAN, SAR, SING); Bk. Panggi *Ruth Kiew & Lim S.P. RK 4221* (SAN, SING); Subak Estate (Lower Kinabatangan River) *J. Dransfield et al. JD 5770* (SAN).

17. Begonia punbatuensis Kiew, *sp. nov.*
Section *Petermannia*

A *Begonia burbidgei* Stapf fructibus minoribus, pedicellis filiformibus 2.5—3 cm longis differt — TYPUS: Pun Batu *R. Kiew & A. Berhaman RK 4260* (holo SAN; iso BRUN, K, L, SAR, SING).

Figure 9

Cane-like begonia. *Stem* robust, dark brown, up to 1.3 m tall and 6 mm diam., erect, little branched, woody, internodes up to 4—5.5 cm long, nodes conspicuously swollen with conspicuous leaf scars, eglandular uniseriate hairs c. 0.5—0.75 mm long, scattered on the young stem, becoming glabrescent. *Stipules* pale green, glabrous except for a few scattered hairs on the outer surface of the midrib, slightly obovate, 2—3.5 x 1—1.3 cm, margin entire, apex acute, persistent. *Leaves* alternate, distant; *petiole* green with brown bristly hairs, 2.5—6 cm long, grooved above; *lamina* plain mid-green above and beneath except for crimson patch on upper surface at the junction with the petiole, succulent and brittle in life, thinly leathery in

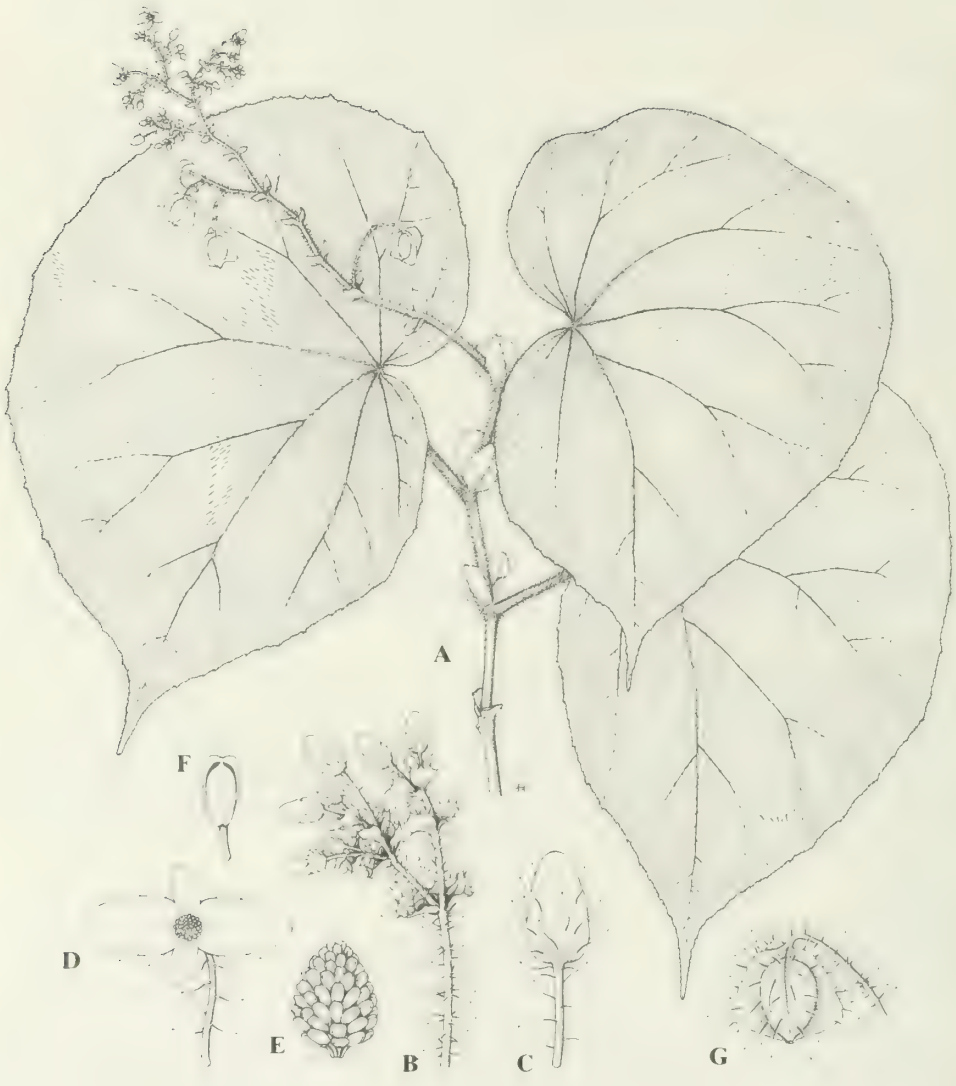

Figure 8. *Begonia postarii* Kiew
A Habit x $^1/_3$, B Branchlet of male inflorescence x $1^1/_2$, C Male bud x 1, D Male flower x 2, E Androecium x $4^1/_2$, F Stamen x 8, G Fruit x 1. (from *RK 3838*)

dried state, glossy above, obliquely ovate, strongly asymmetric, 5—9 x 6—10 cm, narrow side lanceolate, broad side broadly ovate 4.5—7 cm wide, base cordate, not overlapping, basal lobe 1.7—4 cm long, margin shallowly dentate, faintly red in young leaves, apex acute; venation palmate, *midrib and lateral veins* concolorous with lamina, sparsely hairy beneath, 3—4, ± equal-sized, branching dichotomously twice before reaching the margin, first close to petiole, second towards the margin, 1 vein in basal lobe, plane above, prominent beneath.

Inflorescences protogynous, in the axils of upper leaves, pale green, glabrous, ± erect, longer than adjacent petiole, cymose, with up to 4 inflorescences at successive leaf axils, each branched at base, one axis with 2 female flowers on peduncle 2.5—3 cm long, the other axis bears the male inflorescence with c. 4 lateral branches, conspicuously jointed, 5.5—9 cm long of which peduncle 3.2—4.5 cm long; *bracts* pale green, obovate, those at base c. 20 x 15 mm, those subtending male flowers c. 10 x 9 mm, persistent. *Male flowers* with whitish green, glabrous *pedicel* 17 mm long; *tepals* 4, rosy or pale pink, glabrous, outer two broadly oval, 14 x 13 or 15 x 10 mm, inner two narrowly elliptic, c. 9 x 5 mm, margin entire, apex rounded; *stamens* c. 50, cluster conical, sessile, 9 x 4 mm, *anthers* subsessile, golden yellow, narrowly oblong, c. 2 x 1 mm, apex emarginate. *Female flower* with pale green, glabrous *pedicel*; *ovary* pale greenish white, glabrous, ovoid, 15 x 15—17 mm, wings 3, isomorphic, 3 locules, placentas axile and bilamellate with many ovules on both surfaces; *tepals* 5, pale rosy pink, broadly elliptic, outer 17 x 10 mm, inner 14 x 7 mm margin entire, apex slightly acute; *styles* 3, golden yellow, c. 5—6 mm long, bifurcating; *stigma* papillose forming a continuous twisted band. *Fruits* pendent, dangling on fine, thread-like pedicel 2.5—3 cm long, *capsule* 17—22 x (12—)20—28 mm, glabrous, locules 3, dehiscing between upper half of locule and wing, wings 3, isomorphic, truncate distally (4—)6—7 mm wide, thinly fibrous; *seed* brown, minute, ellipsoid, c. 0.5 mm long, base truncate, distally rounded.

Distribution: Borneo – SABAH: Keningau District, Pun Batu.

Habitat: Summit of the limestone hill growing on exposed peat-covered rocks.

Notes: Pun Batu is an isolated tower karst hill and its summit is covered in a deep peat layer. Its unique begonia grows in this habitat and as yet has not been found on any other limestone hill. The surrounding forests are actively being logged but when we visited in 1996, its surrounding foothills were still pristine.

In its upright habit, in being protogynous, and with the fruit being 3-

Figure 9. *Begonia punbatuensis* Kiew
A Habit x ¼. B Branchlet male inflorescence x 1. C Male bud x 1½. D Male flower x 1. E Androecium x 3, F Stamen x 10, G Fruit x 1. (from *RK 3898*)

loculate with three equal wings and a bilamellate placenta and caducous style, it falls within sect. *Petermannia*.

Begonia punbatuensis resembles *B. burbidgei* from Gunung Kinabalu in its robust, woody stems with swollen nodes, large stipules on the young stems and in its leaf shape and venation. However, *B. burbidgei* is a larger plant growing to c. 2—2.7 m tall, its leaf apex is acuminate to cuspidate, its inflorescences have larger bracts, the male flowers have much larger tepals (the outer two tepals measuring c. 25 x 20 mm), and the fruits are also much larger (up to 27 x 46 mm), the wings are not truncate and the fruit stalk is stiff and short (c. 15 mm long).

Although its bracts are quite conspicuous, *B. punbatuensis* does not belong to sect. *Bracteibegonia sensu* Doorenbos *et al.* (1998), which includes just three species from Java and Sumatra. These differ from species in sect. *Petermannia* in having pinnate venation, few flowered bisexual inflorescences and persistent styles in the fruit. Doorenbos *et al.* therefore transferred the Bornean species with conspicuous bracts, previously placed in sect. *Bracteibegonia* (such as *B. burbidgei* Stapf and *B. imbricata* Sands), to sect. *Petermannia*, to which they conform in their venation, inflorescence structure and caducous style.

Specimens examined: SABAH: Pensiangan District – Pun Batu the type and *Ruth Kiew & A. Berhaman RK 4279* (E, KEP, SAN, SING).

18. Begonia urunensis Kiew, *sp. nov.*
Section *Petermannia*

A *Begonia anthonyi* Kiew and *B. berhamanii* Kiew caulibus ramosis, foliis latioribus et inflorescentiis masculis paniculatis differt — TYPUS: Batu Urun *R. Kiew & S. Anthonysamy RK 4473* (SAN, SING).

Low, erect, bushy herb, trichomes uniseriate c. 0.5 mm long, dense on young stems, stipules, petioles, lower surface of veins, inflorescence and pedicels, sparse on lamina. *Stem* to 33 cm tall and 5—7 mm diam., woody towards the base, lowermost internodes 4.5—10 cm long, lower nodes swollen, upper internodes 3—4.5 cm long, producing short branches which sometimes branch again. *Stipules* lanceolate, 5.5—17 x 2.5—3.5 mm, margin entire, apex attenuate to setose, caducous. *Leaves* alternate, distant, towards apex some leaves subopposite; *petiole* 6—15 mm long in lower leaves, 4—7 mm in the upper; *lamina* plain mid-green above, (12.5—)15—(15.5) x (5—) 6.5(—8) cm, slightly succulent in life, papery when dry, obovate, sometimes rhomboid and widest midway, slightly asymmetric, narrow side concave towards the base, broad side rhomboid, 3—4.2 cm wide, base unequally

cordate, basal lobe 2.5—7.5 mm long and auriculate, margin minutely and distantly dentate, apex narrowly attenuate; venation pinnate, *lateral veins* 6—7 pairs, branching once, sometimes twice before reaching the margin, 1 vein in basal lobe, prominent above and beneath.
Plant protogynous with 2 female flowers and a male inflorescence from each of upper leaf axils. *Male inflorescence* erect, 0.8—2.5 cm long of which peduncle is to 1 cm long longer than petioles, central axis with several tiers of three times branched side branches c. 7 mm long; *bracts* lanceolate, c. 7 x 2 mm, margin entire, apex setose, caducous. *Male flowers* with *pedicel* 3—5 mm long; *tepals* 2, pinkish, densely hispid outside, elliptic, c. 5 x 3.5 mm, margin entire, apex rounded; *stamens* c. 40—50 in conical, sessile cluster; *filaments* c. 0.5 mm long; *anthers* orange, spathulate, c. 0.75 mm long, apex not emarginate. *Female flower* not known. *Fruit* with decurved, stiff pedicel (4—)7(—9) mm long; capsule broadly oblong, (14—) 18(—21) x (15—)17(—19) mm, glabrous, locules 3, placentas axile, bilamellate with many seeds on both surfaces, dehiscing along entire length between locule and wing, wings 3, isomorphic, tip rounded, (4—)6(—7) mm wide, thinly fibrous; *seed* brown, minute, broadly ellipsoid, c. 0.2 mm long, base truncate distally rounded.

Distribution: Borneo – SABAH: Pensiangan District, Batu Urun.

Habitat: Deeply shaded forest on soil on steep slopes up to and at the base of limestone.

Notes: Its erect habit, three locular ovary and fruit with three equal wings place this species within sect. *Petermannia*. Among the limestone species, it groups with *B. anthonyi* and *B. berhamanii*, which are short begonias with bristly stems, their leaves are only slightly asymmetric, the petioles short and the midrib more or less in line with the petiole, the male flowers have two tepals, and the fruits do not have long, thin, thread-like pedicels. However, it is not typical of this group of begonias in two respects. Firstly, it differs in habit. In *B. urunensis*, the stem branches once or sometimes twice to produce flat sprays of leaves giving it a bushy appearance. (The stems of *B. anthonyi* and *B. berhamanii* are unbranched). Secondly, the male inflorescences are produced from the same leaf axil as the female flowers and are erect and paniculate, whereas in *B. anthonyi* and *B. berhamanii*, the female flowers are produced from the lower axils and the short, spicate male inflorescence from the upper. *B. urunensis* can also be told apart from these two species by its broader leaf, which is less than 2.5 times longer than broad as compared with 2.7—4 and 5 times, respectively for *B. anthonyi* and *B. berhamanii*.

Batu Urun is one of the most remarkable limestone formations in Sabah being unique in its cave, which has its mouth on the side of a deep and wide basin below soil level. From the mouth of the cave a dangerously steep scree slopes precipitously down to a subterranean river, which to judge from the large tree trunks lodged in it carries strong currents in rainy weather. On one side of the basin is a vertical wet cliff face that is covered in an undescribed species of *Monophyllaea* (Gesneriaceae), one of two *Monophyllaea* species to be found on limestone in Sabah (Kiew,1998a). Above soil level surrounding this basin is a wide area where the limestone projects just above the soil surface, forming an uneven and pitted rock pavement, or it outcrops as low cliffs up to 4—5m high or as boulders of various sizes, all in deep shade below the canopy. It is on soil over limestone that this new begonia species is found.

Specimens examined: SABAH: Pensiangan District Batu Urun, the type and *Ruth Kiew & S. Anthonysamy RK 4472* (K, SAN, SING).

Acknowledgements

This paper forms part of the results from 'The Biodiversity and Conservation of the Limestone Flora of Sabah' project carried out in collaboration with the Forest Research Centre (FRC), Sabah Forest Department. The author thanks the Singapore Botanic Gardens and the Ministry of Science, Technology and Environment, Malaysia (under IRPA Grant No. 52858) for sponsorship; the staff at FRC, Robert C. Ong, K.M. Wong, Diwol Sundaling, A. Berhaman and S.P. Lim, for their logistic help and enthusiastic support; Anthony Lamb, Herbert Lim and Andy Surat of Agricultural Park, Tenom, for showing us localities in the Pensiangan District; J.H. Tan with whose support Melikop was located; Mdm P.H. Yap and Jaap J. Vermeulen for their excellent botanical illustrations; Andrea Kee for carrying out horticultural trials; to the Curators of the BM, E and SAN herbaria for permission to examine specimens in their care; to Mark J.E. Coode for comments on the manuscript and for correcting the Latin and to Martin J.S. Sands for his detailed and helpful comments.

References

Beaman, R.S., J.H. Beaman, C.W. Marsh & P.V. Woods. 1985. Drought and forest fires in Sabah in 1983. *Sabah Society Journal*. **8**: 10—30.

Doorenbos, J., M.S.M. Sosef and J.J.F.E. de Wilde. 1998. *The Sections of*

Begonia Including Descriptions, Keys and Species Lists. Wageningen Agricultural University Paper **98-2**: 1—266.

Kee, A. 2000. Collecting begonias from the wild. *Gardenwise*. **15**: 14—15.

Kiew, R. 1991. The limestone flora. In: R. Kiew (ed.). *The State of Nature Conservation in Malaysia*. Malayan Nature Society, Malaysia. pp. 42—50.

Kiew, R. 1998a. Towards a limestone flora of Sabah. Paper presented at *B.C. Stone Memorial Symposium*, Kuala Lumpur. Malaysia.

Kiew, R. 1998b. Niche partitioning in limestone begonias in Sabah, Borneo, including two new species. *Gardens' Bulletin Singapore*. **50**: 161—169.

Kiew, R. 1998c. The unique elements of the limestone flora of Batu Tengar Cave (Segarong), Sabah, Malaysia. *Gardens' Bulletin Singapore*. **50**: 185—196.

Kiew, R. 1998d. Wanderings in the great forests of Borneo. *Gardenwise*. **11**: 8—11.

Kiew, R. 2000. Decorative limestone begonias from Sabah. *Gardenwise*. **15**: 12—13, 15.

Lim, S.P. & R. Kiew. 1997. Gazetteer of limestone localities in Sabah, Borneo. *Gardens' Bulletin Singapore*. **49**: 111—118.

Reza Azmi and R. Kiew. 1998. *Begonia lazat* (Begoniaceae), a new culinary begonia from Borneo. *Gardens' Bulletin Singapore*. **50**: 43—48.

Sands, M.J.S. 1990. Six new begonias from Sabah. *Kew Magazine*. **7**: 57—85.

Sands, M.J.S. 1996. Begoniaceae. In: M.J.E. Coode, J. Dransfield, L.L. Forman, D.W. Kirkup and Idris M. Said (eds.) *A Checklist of the Flowering Plants and Gymnosperms of Brunei Darussalam*. Forestry Department, Brunei & Royal Botanic Gardens, Kew. pp. 38—40.

Tebbit, M.C. 1999. A revised classification of selected Asian begonias based on evidence from morphology and molecules. In: S. Andrews, A.C. Leslie and C. Alexander (eds.), *Taxonomy of Cultivated Plants*. Royal Botanic Gardens, Kew. pp. 401—402.

Tebbitt, M.C. and C.M. Maciver. 1999. The systematic significance of the endothecium in Begoniaceae. *Botanical Journal Linnean Society*. **131**: 203—221.

Gardens' Bulletin Singapore **53** *(2001) 287–289.*

Begonia conipila Irmsch. *ex* Kiew (Begoniaceae) from the Gunung Mulu National Park, Sarawak, Malaysia

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Abstract

Irmscher's name, *Begonia conipila*, is validated for the striking species that grows on the Melinau limestone in Sarawak, Borneo.

Introduction

The scientific name of this most distinctive species was in fact never validly published although, following Irmscher's annotated specimens, it has become the accepted name and specimens of it are correctly identified in herbaria and the name has appeared in print (Anderson & Chai, 1982; Jangowe, 1999). It is timely therefore to validate the name of his species, particularly because it is seen by most visitors who climb Gunung Api in the Gunung Mulu National Park.

Low's specimen is selected as the lectotype as it is the earliest collection and was annotated as a new species by Irmscher.

Begonia conipila Irmsch. *ex* Kiew
Section *Petermannia*

A *Begonia havilandii* Ridl. foliis minoribus, tepalis masculis 2 et fructibus oblongis differt - LECTOTYPUS: 'Mooloo' (Gunung Mulu National Park) *Low s.n.* (K).

Creeping herb or low root climber, roots fibrous produced at nodes in contact with substrate, indumentum of stiff, white, uniseriate, eglandular trichomes, c. 2—5 mm long, each on a raised conical base, dense on young stem, petiole, on stipule margin and outer surface of stipule midrib, on the lamina dense on the upper surface, margin and lower surface of veins, some on lower lamina surface. *Leafy stem* 15—25 cm long and 2—3(—4) mm diam., little branched, internodes 2.5—5 cm long. *Stipules* lanceolate with a distinct midrib, 7—12 x 4—7 mm, margin entire, apex setose, persistent. *Leaves* alternate, distant, *petiole* 1—2 cm in upper leaves elongating to 2—5 cm in lower leaves, *lamina* somewhat bullate, variegated,

upper surface dark green to blackish purple, paler between veins, the lower surface reddish, rarely light green, in dried state thin and papery, conical hair bases giving a pustulate appearance above, asymmetric, broadly ovate to reniform, 4—7.5 x 3.5—8.5 cm, broader side (2.25—)3.5—5 cm wide, base rounded to cordate, lobes slightly overlapping, basal lobes rounded, (0.75—)2—3.5 cm long, margin irregularly serrate, each tooth setose, apex cuspidate; *venation* palmate, main veins 3, equal-sized, branching c. halfway to margin, with another 1—2 veins in basal lobes, impressed above and prominent beneath.

Inflorescence axillary, whitish or light green, hispid, erect, longer than petioles, racemose, 3.5—9.5 cm long of which peduncle is 1.5—6 cm, protogynous with a single basal female flower and many male flowers distally on 2 short lateral branches c. 3—11 mm long and crowded in a terminal cluster; *bracts* similar to stipules, c. 5—6 x 3 mm, persistent; *bracteoles* light green or whitish, broadly ovate, 0.75 x 0.25 mm, apex setose, persistent. *Flowers* with white, translucent tepals. *Male flower* with whitish or light green *pedicel*, c. 1—3 mm long; *tepals* 2, sparsely hispid on upper half of outer surface, broadly elliptic, c. 5 x 3.5—4.5 mm, margin entire, apex rounded; *stamens* yellow, c. 10—11, in hemispherical cluster joined in a torus c. 0.5—0.75 mm, *filaments* between 0.25 mm on lower stamens to 1 mm long in the distal ones, *anthers* bright yellow, obovate, c. 0.75—1 mm long, emarginate, opening by pores. *Female flower* with *pedicel* c. 3—5 mm long, light green, finely hispid; *ovary* narrowly oblong, c. 7.5—11 x 3—5 mm, wings 3, subequal, two shorter 1.5 mm and broader one 2 mm wide, locules 3, placentas axile, bilamellate with many ovules on both surfaces; *tepals* 5, isomorphic, narrowly lanceolate, c. 7—7.5 x 3—4 mm, margin entire, apex acute, sparsely hispid on outer surface; *styles* 3, free to base, 5 mm long, bifurcating; *stigma* greenish, papillose forming a continuous twisted band. *Fruit* pedicel stiff, decurved, (2—)4—6(—8) mm long, *capsule* oblong, c. (11—)18—20 x 10—15 mm, sparsely hispid, locules 3 but one scarcely developed, dehiscing between wing and locule, wings thin, narrowed to base, truncate distally, two narrower wings, c. 3—5 mm wide, broader wing c. 5—7 mm wide, style not persistent.

Distribution: Borneo - SARAWAK: endemic to the Melinau limestone in the Gunung Mulu National Park (on Gunung Api and low limestone outcrops along the Sungai Melinau).

Habitat: It grows from the base of limestone outcrops to c. 1170 m in lower montane limestone forest on Gunung Api, usually on limestone boulders but also on steep screes in deeply shaded habitats.

Notes: *Begonia conipila* is typical of section *Petermannia* in possessing upright (although weak) stems (as opposed to prostrate rhizomes), protogynous inflorescences with the female flower basal and the male flowers distal, male flowers with two tepals and obovate anthers that open by pores, and female flowers with five tepals, three free styles and a 3-loculate ovary with bilamellate placentas. The fruit is interesting in that one locule is hardly developed (it is about a quarter the size of the other two). A similar situation is seen in *B. amphioxus* (Kiew, 2001).

In its creeping stem with erect branches, broadly obovate leaves with stiff pale hairs, serrate leaf margin with each tooth tipped by a long hair, the few stamens in the male flowers, and the 3-loculate ovary with bilamellate placentas, it resembles *B. havilandii* Ridl. from Sarawak. However, it is distinct from this species as *B. conipila* has smaller leaves (they are c. 6—10 cm long in *B. havilandii*), male flowers with two tepals (four in *B. havilandii*) and an oblong capsule (orbicular in *B. havilandii*).

With its small, variegated leaves, it is as Low noted on his specimen, 'a charming plant'. Jangowe (1999) illustrates this species with a fine colour photograph.

Specimens examined: SARAWAK: Gunung Mulu National Park - *Low s.n.* 'Mooloo' (K); Gunung Api - *Abang Moktar S49606* (SAN, SAR), *Anderson S4287* (K, SAR), *S30732* (SAR, SING), *B.L. Burtt B8354* (SAR), *P. Chai S30054* (SAR), *S35790* (SAR), *C. Hansen 102* (SAN, SAN), *P.J. Martin S38257* (SAR), *I. Nielsen 502* (SAR), *B.C. Stone 13693* (SAR), *Yii P.C. & Abu Talib S58845* (SAR); limestone on Sungai Melinau *Chew Wee Lek CWL 1055* (SAR, SING), *B.C. Stone 13598* (KLU, SAR).

Acknowledgements

The author thanks the curators of the herbaria at BM, E, K, KLU, SAN and SAR for permission to examine specimens in their care, to Mark J.E. Coode for his patience in correcting the Latin, and to M.J.S. Sands for comments on the manuscript.

References

Anderson, J.A.R. and P.P.K. Chai. 1982. Gunung Mulu National Park, Sarawak. 9. Vegetation. *Sarawak Museum Journal*. **30**: 195—206.

Jangowe, J. 1999. Begonias of the national parks of Malaysian Borneo. *Begonian*. July/Aug: 144—145.

Kiew, R. 2001. The limestone begonias of Sabah, Borneo – Flagship species for conservation. *Gardens' Bulletin Singapore*. **53**: 241—286.

Gardens' Bulletin Singapore **53** *(2001) 291–313* .

New Species, Varieties and Reductions in *Diospyros* (Ebenaceae) in Borneo and Peninsular Malaysia including Peninsular Thailand

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Abstract

In the genus *Diospyros*, seven new species (*D. beccarioides* Ng, *D. brainii* Ng, *D. crockerensis* Ng, *D. keningauensis* Ng, *D. lunduensis* Ng, *D. multinervis* Ng and *D. parabuxifolia* Ng) and six new varieties (*D. currani* Merr. var. *kalimantanensis* Ng; *D. ferruginescens* Bakh. var. *rufotomentosa* Ng; *D. lanceifolia* Roxb. var. *iliaspaiei* Ng, var. *renageorgei* Ng, var. *saliciformis* Ng; *D. penibukanensis* Bakh. var. *scalarinervis* Ng) are described. Thirty species or varieties are reduced to synonymy.

Introduction

In revising the genus *Diospyros* for the Tree Flora of Sabah and Sarawak, I took the opportunity to review the genus for Borneo and Peninsular Malaysia. This has resulted in the recognition of seven new species and six new varieties, and the reduction of 30 species or varieties to synonymy.

New Species

1. ***Diospyros beccarioides*** Ng, **sp. nov.**

Arbor ad 20 m alta; rami dense rubro-brunnee pubescentes demum glabrescentes. Folia membranacea ad chartacea, glabra, oblonga ad ovato-oblonga 16–30 cm longa 5.5–11 cm lata, basi cuneata leviter attenuata rare rotundata, apice acuminato, costa supra immersa plana vel 'marginibus' elevatis provisa, infra nervis lateralibus prominentibus paribus 7–13 incurvatis ante margines anastomosantibus venam intra-marginalem plus minusve distinctam formantibus, venatione intercostali prominula laxe scalariformi; petiolus 0.8–1.5 cm longus. Inflorescentia mascula cymis subsessilis condensatis floribus ut videtur 3 vel plus sed ignotis. Fructus 1–3 pedicellis 0.3–0.8 cm longis suffulti, globosi ad 2.5 cm diam, glabri, calyce in lobis 4 vel 5 erectis folioso-coriaceis plicatis accrescentibus ad c. 2 cm longis 1.5 cm latis diviso. **Typus:** *Yii et al. S 50325*, Sarawak (KEP holo, SAR iso).

Figure 1

Tree to 20 m tall. *Twigs* densely reddish brown pubescent, becoming glabrous with age. *Leaves* membranaceous to chartaceous, glabrous; oblong or oblong-obovate, 16–30 x 5.5–11 cm, base cuneate and slightly attenuate, rarely rounded, apex acuminate; midrib above sunken, flat, or sunken with raised sides; lateral veins prominent below, 7–13 pairs, inarching and anastomosing at the margins to form a more-or-less distinct intramarginal vein; intercostal venation prominulous below, laxly scalariform; petiole 8–15 mm long. *Male inflorescences* subsessile condensed cymes of 3 or more flowers. *Flowers* unknown. *Fruits* 1–3, on 3–8 mm long stalks, globose, to *c.* 2.5 cm diam., glabrous. *Fruit calyx* divided into 4–5 valvate lobes, the lobes erect, leafy-coriaceous, plicate, accrescent, to *c.* 2 x 1.5 cm.

Distribution and habitat: Sumatra (*Jacobs 8341*, Lampung Prov.); Borneo, Sarawak (*S 8633*, *S 16177*, *S 31817*, *S 32625*, *S 50325*, *S 65187*; *Chew CWL 1100*, *1141*); Kalimantan (*Endert 5164*, *5380*; *Kessler et al. 824*, *969*); Sulawesi (*Vogel & Vermuelen 6981*). In Sarawak, the species is found on limestone hills, up to 200 m altitude.

Notes: Bakhuizen in Bull. Jard. Bot. Btz. Ser. iii. 15 (1938) 239 had included specimens of three species under *Diospyros beccarii* Hiern. The two syntypes of *D. beccarii* Hiern belong to *D. sumatrana* Miq., hence *D. beccarii* has to be reduced to *D. sumatrana*. At least two other of his cited specimens, *bb. 12051* and *bb. 14750*, belong to *D. daemona* Bakh.. The third element, represented by, for example, *Endert 5164* belongs to this new species, *D. beccarioides*, which can be distinguished from *D. sumatrana* by its larger fruits with accrescent calyx lobes up to 2 cm long, and larger leaves, with a stronger tendency to form an intramarginal vein.

2. ***Diospyros brainii*** Ng, **sp. nov.**

Arbores mediocres ad 29 m altae. Folia mediocra ad magna, oblongo-ovata, 11.5–19.5 x 2.5–6 cm, apice acuminata, basi cuneata, lamina chartacea, glabra, costa supra immersa; nervi secundarii infra prominuli ad prominentes 8–10 pares intus curvati in nervo intramarginali inconspicuo ad circa tertiam spatiam inter marginem costamque anastomosantes; nervi tertiarii inconspicui reticulati; petiolus 0.5–1 cm. Flores ignoti. Fructus solitarius, sessilis, globosus ad 4.5 cm diam., glaber, in sicco valde rugosus. Calyx accrescens, in lobis 4 vel 5 coriaceis valvatis 1.5 cm longis profunde divisus, in quoque axe principali sursum curvato fructus curvaturam secundo sed marginibus inter se deorsum curvatis. **Typus:** *Brain anak Tada*, *S 15932*,

Figure 1. *Diospyros beccarioides* Ng. A. leafy twig; and B. fruit. (A–B from *S 50325*).

Figure 2. *Diospyros brainii* Ng. A. leafy twig and B. fruit. (A–B from *S 15932*).

Borneo, Sarawak (SAR holo, SAN, SING iso).

Figure 2

Medium trees to 29 m tall. *Leaves* medium-sized to large, oblong-obovate, 11.5–19.5 x 2.5–6 cm, apex acuminate, base cuneate; lamina chartaceous, glabrous; midrib sunken above; lateral veins prominulous to prominent below, 8–10 pairs, inarching and anastomosing to form a faint looping intramarginal vein at one third of the distance from the margin to the midrib; intercostal venation faint, reticulate; petiole 5–10 mm long. *Flowers* unknown. *Fruit* solitary, sessile, globose, to 4.5 cm diam., drying much wrinkled and shrivelled, glabrous. *Fruit calyx* accrescent, divided deeply into 4–5 coriaceous valvate lobes, 1.5 cm long, the main axis of each lobe curved upwards following the curvature of the fruit base, but the sides bent backwards towards each other.

Distribution and habitat: Endemic to Borneo: Sarawak (*S 15932* and *S 27961*). Lowland forest at Bintulu.

Notes: The location of the intramarginal vein at some distance from the margin is reminiscent of *Diospyros neurosepala* Bakh., which differs in having leafy calyx lobes. The fruiting calyx recalls that of *D. sulcata* Kosterm., which differs in the absence of an intramarginal vein in the leaf.

3. ***Diospyros crockerensis*** Ng, **sp. nov.**

Arbores parvae ad 11 m altae; ramuli dense velutini. Folia mediocra, elliptica, 7–17 x 2.5–8.3 cm, apice acuminata, basi cuneata, lamina chartacea infra dense pubescentia, costa supra immersa sulco puberulo; nervi secundarii subtus prominentes 6–9 pares; nervi tertiarii subtus prominuli laxe scalariformes; petioli c. 0.5 cm longi dense velutini. Flores masculi 3–9 vel plus ad extremos cymarum elongatarum 2–4.5 cm dispositi, calyx in lobis 4 anguste oblongis imbricatis profunde divisus, corolla salveriformis ad 0.8 cm longa. Flores feminei c. 3-floris ad extremos cymarum elongatarum 0.8–2.8 cm dispositi, calyx in lobis 4 imbricatis profunde divisus. Pedicellus in fructu 0.8–2.8 cm. Calyx non-accrescens, lobis c. 0.2 x 0.1 cm. Fructus plerumque solitarii, oblongo-ovoidei ad 3.5 x 1.5 cm, velutini, apice in acumine acuto gradatim contracto, pericarpio tenui lignoso. **Typus:** *Dewol & Karim SAN 78389*, Borneo, Sabah, Crocker Range (SAN holo, SING iso).

Figure 3. *Diospyros crockerensis* Ng. A. leafy twig; B. fruit; C. female flowers after shedding of corollas; D. male flower bud; E. male flower bud in longitudinal section. (A–C from *SAN 78389*, D–E from *S 25273*).

Figure 3

Small trees to 11 m tall. *Twigs* densely velvety. *Leaves* medium-sized, elliptic, 7–17 x 2.5–8.3 cm, apex acuminate, base cuneate; lamina chartaceous, densely hairy below; midrib sunken above, the groove covered with short hairs; lateral veins prominent below, 6–9 pairs; intercostal venation prominulous below, laxly scalariform; petiole *c.* 5 mm long, densely velvety. *Male flowers* in clusters of 3–9 or more, at the ends of elongated 2–4.5 cm long cymes; calyx divided deeply into 4 narrowly oblong imbricate lobes; corolla salverform, to 8 mm long. *Female flowers* in clusters of about 3, at the ends of elongated 8–28 mm cymes; calyx divided deeply into 4 imbricate lobes. *Fruits* usually solitary, on 8–28 mm stalks, oblong-ovoid, with the apex gradually tapered to a sharp point, to 3.5 x 1.5 cm, velvety, with thinly woody wall. *Fruit calyx* non-accrescent, the lobes *c.* 2 x 1 mm.

Distribution and habitat: Endemic to Borneo: Sabah (*SAN 78389*, *SAN 11589*, *SAN 130109*) and Sarawak (*S 25273*). In hill forests.

4. ***Diospyros keningauensis*** Ng, **sp. nov.**

Arbores mediocres ad magnae, ad 40 m altae. Folia minuta ad mediocra, anguste elliptica ad ovata 3.5–13 x 1.5–4 cm, apice acuminata, basi cuneata ad rotundata, lamina chartacea glabra ad infra sparse appresse pubescentia, proprie rugosa in sicco, costa supra prominula in juventute appresse pubescens; nervi secundarii subtus prominentes 5–8 pares; nervi tertiarii subtus prominuli scalariformes; petioli 0.5–1 cm. Flores masculi 3–5 in cymis 0.5–1.5 cm dispositi, quae in quoque nodo 2 vel plus glomeratae possunt; calyx in lobis 4 valvatis divisus; corolla salveriformis 1.4 cm longa. Flos femineus solitarius pedunculo 0.5–1 cm; calyx lobis valvatis 4 (5) divisus. Pedicellus in fructu 0.5–1 cm. Calyx non-accrescens, lobi c. 0.5 x 0.5 cm. Fructus solitarius, globosus ad 4.5 cm diam., in juventute dense pubescens, in sicco pericarpio crasso irregulariter rugosus. **Typus:** *Leopold & Saikah SAN 74495*, Borneo, Sabah (KEP holo, SAN, SING iso).

Figure 4

Medium and big trees to 40 m tall. *Leaves* small to medium-sized, narrowly elliptic to ovate, 3.5–13 x 1.5–4 cm, apex acuminate, base cuneate to rounded; lamina chartaceous, glabrous to sparsely appressed hairy below, drying characteristically wrinkled; midrib prominulous above, appressed hairy when young; lateral veins prominent below, 5–8 pairs; intercostal veins prominulous below, scalariform; petiole 5–10 mm long. *Male flowers*

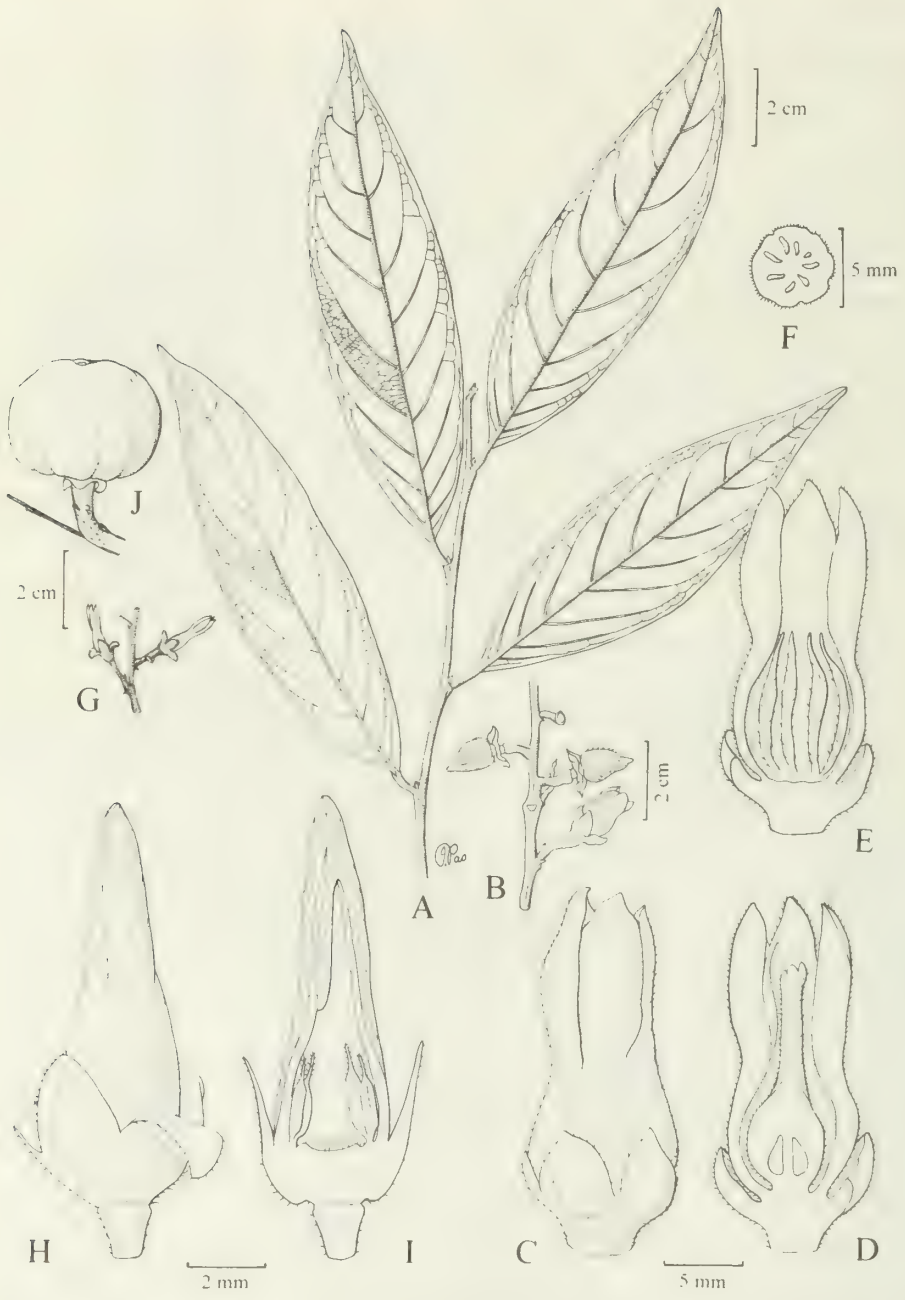

Figure 4. *Diospyros keningauensis* Ng. A. leafy twig; B. female inflorescence; C. female flower; D. female flower in longitudinal section; E. as D but after removal of ovary to show staminodes; F. ovary in transverse section. G. male inflorescence; H. male flower bud; I. male flower bud in longitudinal section; J. fruit. (A–F from *SAN 26704*, B–D from *SFN 27136*, G–I from *SFN 27136*, J from *SAN 74495*).

in clusters of 3–5 on 5–15 mm long cymes, which may be clustered in 2 or more to each node; calyx divided into 4 valvate lobes; corolla salverform, *c.* 1.4 cm long. *Female flowers* solitary on a 5–10 mm peduncle; calyx divided into 4(–5) valvate lobes; corolla 4(–5)-lobed; staminodes 8; ovary bearing 8 ovules. *Fruits* solitary, on 5–10 mm long stalks, globose, irregularly wrinkled on drying, thick-walled, to 4.5 cm diam., densely hairy when young. *Fruit calyx* not accrescent, the lobes about 5 x 5 mm.

Distribution and habitat: Endemic to Borneo: Sabah (*Carr SFN 27136*; *SAN 26704*, *SAN 33783*, *SAN 71930*, *SAN 74495*). Lower montane and montane forests at 1300–1500 m in the vicinity of Mt Kinabalu (Keningau, Ranau).

5. ***Diospyros lunduensis*** Ng, **sp. nov.**

Arbores mediocres ad 25 m altae. Folia mediocra, elliptica ad oblongo-elliptica 5.6–14 x 2.8–6 cm, apice breviter acuminata vel acuta, basi rotundata ad subcordata, lamina coriacea, glabra, supra in sicco ad nigra vergentia, costa supra immersa; nervi secundarii subtus prominentes 5–7 pares; nervi tertiarii supra prominuli laxe reticulati; petioli 0.5–0.8 cm. Flores masculi ignoti, feminei solitarii pedicellis 0.2–0.4 cm longis suffulti, calyce in lobis 4 rotundatis imbricatis pubescentibus profunde diviso. Pedicelli in fructu 0.2–0.4 cm longi. Calyx non-accrescens, lobis ad 0.6 x 0.6 cm patentibus ad reflexis. Fructus solitarius, globosus ad 2 cm diam., glaber vel sparse appresse pubescens. **Typus:** *Othman S 49996*, Borneo, Sarawak, Lundu, G. Pueh (KEP holo, SAN iso).

Figure 5

Medium-sized trees to 25 m tall. *Leaves* medium-sized, elliptic to oblong-elliptic, 5.6–14 x 2.8–6 cm, apex shortly acuminate or acute, base rounded to subcordate; lamina coriaceous, glabrous, tending to dry black above; midrib sunken above; lateral veins prominent below, 5–7 pairs; intercostal venation prominulous below, laxly reticulate; petiole 5–8 mm long. *Male flowers* unknown. *Female flowers* solitary, on 2–4 mm long stalks; calyx deeply divided into 4 rounded imbricate hairy lobes; corolla 4-lobed; staminodes 4; ovary with 4 ovules. *Fruits* solitary, on 2–4 mm long stalks, globose, to 2 cm diam., glabrous or sparsely appressed hairy. *Fruit calyx* not accrescent, the lobes to 6 x 6 mm, spreading to reflexed.

Distribution: Endemic to Borneo: Sarawak (*S 49996* and *S 25482*).

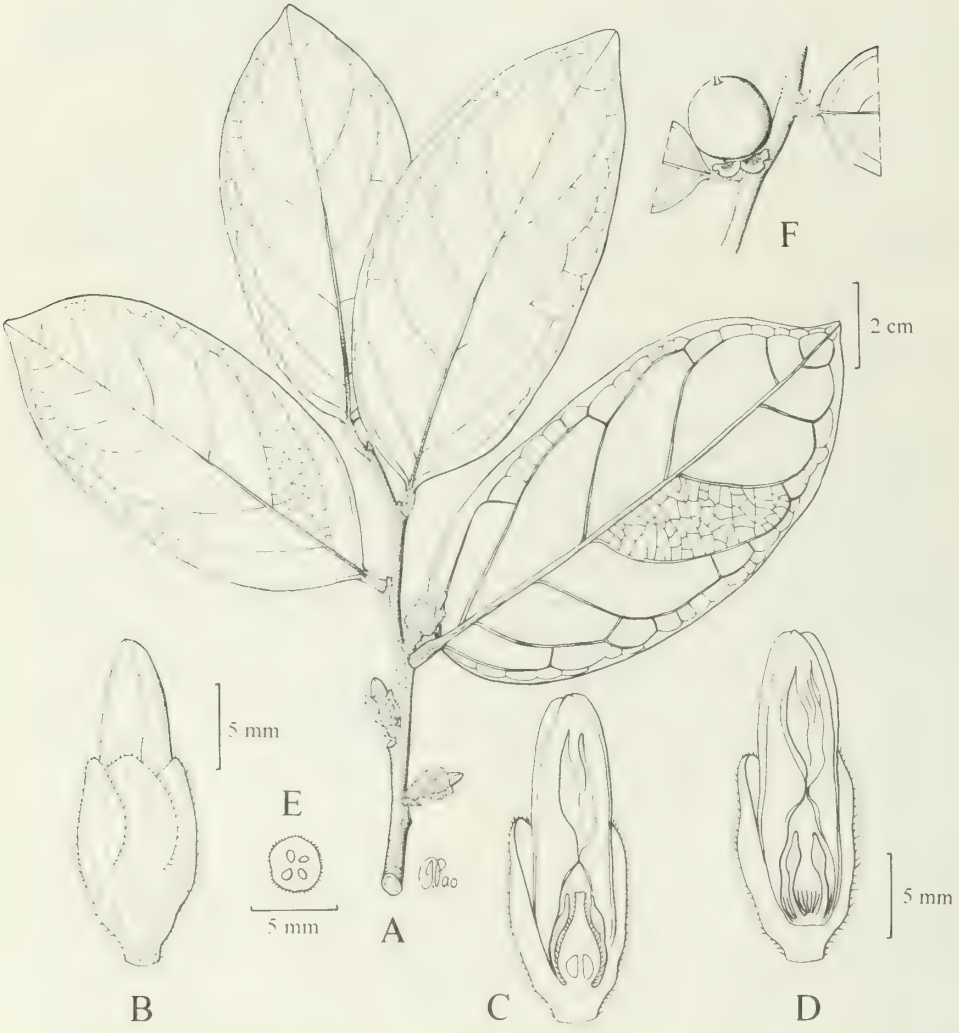

Figure 5. *Diospyros lunduensis* Ng. A. leafy flowering twig; B. female flower bud; C. female flower bud in longitudinal section; D. as C but with ovary removed to show staminodes; E. ovary in transverse section; F. fruit. (A–E from *S 25482*, F from *S 49996*).

6. ***Diospyros multinervis*** Ng, **sp. nov.**

Arbores mediocres ad 20 m altae. Folia magna, oblongo-lanceolata 21–32 x 5.8–9.2 cm, apice acuminata, basi subcordata, lamina chartacea glabra, costa supra immersa; nervi secundarii subtus prominentes 15–17 pares; nervi tertiarii subtus prominentes incerte scalariformes; petioli 0.8–1 cm. Flores ignoti. Cymae in fructu laxe ramosae 2.5–3.5 cm longae; pedicelli 1–1.5 cm. Calyx patelliformis, 4-radiatus, in lobis 4 valvatis divisus marginibus coreaceis reflexis c. 2 cm diam. Fructus 3–5, globosi 2–3 cm diam., glabri. **Typus:** *Burley et al. 2726*, Borneo, Kalimantan (KEP holo).

Figure 6

Medium-sized trees to 20 m tall. *Leaves* large, oblong lanceolate, 21–32 x 5.8–9.2 cm, apex acuminate, base subcordate; lamina chartaceous, glabrous; midrib sunken above; lateral veins prominent below, 15–17 pairs; intercostal venation prominent below, vaguely scalariform; petiole 8–10 mm long. *Flowers* unknown. *Fruits* 3–5, with 1–1.5 cm pedicels on laxly branched cymes 2.5–3.5 cm long, globose to elliptic, 2–3 cm diam., glabrous, puckered on drying. *Fruit calyx* c. 2 cm diameter divided into 4 valvate lobes, forming a 4-pointed plate, with the sides of the lobes coriaceous and reflexed.

Distribution and habitat: Endemic to Borneo: Kalimantan (*Burley et al. 2472* and *2726*, G. Bentuang area of W. Kalimantan). Lowland forest.

Notes: This species is very close to *Diospyros wallichii* King & Gamble, differing in the glabrous fruits borne on individual pedicels 1–1.5 cm long, which arise from peduncles 1–2 cm long (adding up to an infructescence c. 3.5 cm long excluding the fruits). Overall, the inflorescence infructescence is much longer than that of *D. wallichii*.

The local Malay name *tuba monyet* (monkey tuba) indicates that the fruits are used as a kind of fish poison.

7. ***Diospyros parabuxifolia*** Ng, **sp. nov.**

Arbores mediocres, ad 15 m altae. Folia minuta, obovata 1.5–2 x 0.8–1.5 cm, apice rotundata acuta vel breviter acuminata, basi cuneata ad attenuata, lamina chartacea glabra, costa supra immersa ad prominens; nervi secundarii et tertiarii invisibiles; petioli 0.1–0.2 cm. Flores ignoti. Pedicelli in fructu elongati 1.5–2 cm. Calyx non-accrescens, in lobis 4 imbricatis rotundatis 0.2 x 0.2 cm profunde divisus. Fructus solitarius, ellipsoideus c. 2 x 1 cm, pericarpio angusto in sicco corrugato fere glabro. **Typus:** *Ilias Paie S 33017*,

Figure 6. *Diospyros multinervis* Ng. A. leafy twig and B. fruit. (A–B from *Burley et al. 2726*).

Borneo, Sarawak, Lawas, Bukit Batanga (KEP holo; SAN, SAR iso).

Figure 7

Medium-sized trees to 15 m tall. *Leaves* small, obovate, 1.5–2 x 0.8–1.5 cm, apex rounded, acute or shortly acuminate, base cuneate to attenuate; lamina chartaceous, glabrous; midrib sunken to raised above; lateral veins invisible; intercostal venation pattern invisible; petiole 1–2 mm long. *Flowers* unknown. *Fruits* solitary, on elongated 1.5–2 cm long stalks, ellipsoid, *c.* 2 x 1 cm, thin-walled and puckered on drying, almost glabrous. *Fruiting calyx* not accrescent, divided deeply into 4 imbricate rounded lobes, *c.* 2 x 2 mm.

Distribution and habitat: Endemic to Borneo: Sarawak, Lawas and Kapit (*S 33017*, *S 60062*). Lower montane forests at 1030–1500 m altitude.

Notes: This species differs from *Diospyros buxifolia* (Blume) Hiern mainly in its elongated fruit stalk. From *D. graciliflora* Hiern, which also has an elongated fruit stalk, it differs in the fruit, which is ellipsoid (not globose). In addition, the fruit stalk of *D. graciliflora* is much more slender.

New Varieties

1. ***Diospyros curranii*** Merr., Phil. J. Sc. Bot. 4 (1909) 306.

var. ***curranii***

Synonym: *D. curraniopsis* Bakh., Gard. Bull. S. S. 7 (1933) 168, **syn. nov.;** types: *Endert 4883*, Borneo, Kalimantan (BO), *Elmer 21464*, Borneo, Sabah (BO).

var. ***kalimantanensis*** Ng, **var. nov.**

A varietate typica in calyce frutescenti patenti nec reflexo multo amplificato quo fundibulum fructu centrali formanti differt. **Typus:** *Veldkamp 8148*, Borneo, Kalimantan, Tumbang Tubus S of Bukit Raya (KEP holo, BO, L iso).

Distribution: Borneo, Kalimantan, at Bukit Raya (*Mogea 3569*, *3585*, *3621*; *Veldkamp 8148*).

Notes: This differs from the typical variety in the fruiting calyx being outstretched instead of reflexed, and much enlarged, so that the calyx

Figure 7. *Diospyros parabuxifolia*. A. leafy twig and B. fruit. (A–B from *S 33017*)

forms a 5-lobed funnel with the fruit in the centre. This variety appears to replace var. *curranii* in the vicinity of Bukit Raya, so male and sterile collections from Bukit Raya can be assumed to belong to this variety rather than the type variety.

2. ***Diospyros ferruginescens*** Bakh., Bull. Jard. Bot. Btz. Ser. iii, 15 (1941) 409.

var. ***rufotomentosa*** Ng, **var. nov.**

A varietate typica praecipue in foliis infra dense rufe tomentosis differt: folia etiam latiora (ad 5.5 cm lata) possunt, nervis secundariis prominentioribus distincte incurvatis. **Typus:** *Maikin et al. SAN 132942*, Borneo, Sabah, Lumaku FR (SAN holotype).

Medium-sized trees to 20 m tall. *Twigs* densely rusty hairy. *Leaves* medium-sized, oblong-elliptic, 6.5–11.5 x 3–5.5 cm, apex acuminate, base acute; lamina chartaceous, densely rusty hairy below, tending to dry black above; midrib sunken above, the groove often filled with hairs; lateral veins prominent below, 6–10 pairs, inarching strongly at the margins; intercostal veins prominent below, reticulate; petiole *c.* 5 mm long. *Male flowers* in clusters of 3–9, shortly pedicelled, sharing a common 5–7 mm peduncle; calyx divided into 4 small triangular valvate teeth; corolla salverform, 5–7 mm long. *Female flowers* not known. *Fruits* solitary, on 1–2 mm long stalks, ovoid to globose, to 1.5 cm diam., densely rusty hairy. *Fruit calyx* accrescent, divided deeply into 4–5 triangular valvate lobes, forming a 4–5 pointed star, each lobe *c.* 5 x 4 mm.

Distribution and habitat: Endemic to Borneo: Sabah (*SAN 55535*, *SAN 66013*, *SAN 102122*, *SAN 113977*, *SAN 132942*, *SAN 139235*), Kalimantan (*Kostermans 8778*). Lowland and hill forests up to 700 m.

Notes: This differs from the typical variety mainly in the underside of the leaves, which is densely rusty-hairy. The leaves may also be broader (to 5.5 cm wide) with the lateral veins more prominent and distinctly inarching.

3. ***Diospyros lanceifolia*** Roxb., Hort. Beng. (1814) 93.

var. ***iliaspaiei*** Ng, **var. nov.**

Arbores mediocres ad 27 m altae; ramuli dense ferrugineo-pubescentes.

Folia mediocra ad magna, oblonga ad oblongo-lanceolata 13.5–35 x 3.5–14 cm, apice acuminata ad acuta, basi cuneata ad rotundata interdum fovearum glandulosarum pare uno instructa, lamina coriacea infra dense ferrugineo-pubescentia inter venas bullata, costa supra immersa; nervi secundarii subtus prominentes, supra immersi, 15–24 paribus incurvatis ad marginem in nervo intramarginali conspicuo anastomosantibus; nervi tertiarii subtus prominentes supra immersi transverse reticulati; petioli 1–2.4 cm. Flores feminei c. 3, in cymis brevibus 0.2–0.5 cm dispositi. Pedunculi in fructu breves, 0.2–0.5 cm longi. Calyx lobis c. 1 x 0.8 cm marginibus reflexis. Fructus 1–3, globosi nitide nigri, ad 2 cm diam, in juventute velutini. A var. *consanguinea* in nervis secundariis laminae quoque latere in nervo intramarginali valde evoluto anastomosantibus differt. **Typus:** *Ilias Paie S 50180*, Borneo, Sarawak (KEP holo, SAN, SAR iso).

Medium-sized trees to 27 m tall. *Twigs* densely rusty hairy. *Leaves* medium-sized to large, oblong to oblong-lanceolate, 13.5–35 x 3.5–14 cm, apex acuminate to acute, base cuneate to rounded, sometimes bearing a pair of pit-glands; lamina coriaceous, densely rusty hairy below, bullate between the veins; midrib sunken above; lateral veins sunken above, prominent below, 15–24 pairs, inarching and joining at the margins to form a prominent intramarginal vein; intercostal venation sunken above, prominent below, reticulo-transverse; petiole 1–2.4 cm long. *Female flowers* in clusters of *c.* 3 on short 2–5 mm long cymes. *Fruits* 1–3, on short 2–5 mm long stalks, globose, shiny black, to 2 cm diam., velvety when young. *Fruit calyx:* lobes *c.* 10 x 8 mm, with sides reflexed.

Distribution and habitat: Endemic to Borneo: Sarawak (*S 24803*, *S 39109*, *S 41224*, *S 50180*, *AZ 5671*). Lowland forests.

var. ***renageorgei*** Ng, **var. nov.**

Arbores mediocres ad 21 m altae. Folia mediocra, elliptica ad ovata 6–19.5 x 4–8.5 cm, apice acuminata, basi rotundata paullo attenuata saepe fovearum glandulosarum pare uno provisa, lamina chartacea glabra supra plerumque subtus interdum nitentia, inter venas paullo bullatum, costa supra immersa; nervi secundarii supra immersi, subtus prominentes 6–12 pares; nervi tertiarii supra immersi subtus prominuli transverse reticulati; petioli 0.8–1.5 cm. Flores feminei 1–5 in cymis ad 0.6 cm longis dispositi. Pedicelli in fructu 0.3–0.6 cm. Calyx lobis ad 1 x 1 saltem marginibus reflexis. Fructus circa 3, globosi 1.3 cm diam., velutini. A var. *lanceifolia* in laminae basi rotundata nec cuneata differt. **Typus:** *Rena George S 43068*, Borneo, Sarawak, Limbang (KEP holo, SAN iso).

Medium-sized trees to 21 m tall. *Leaves* medium-sized, elliptic to ovate, 6–19.5 x 4–8.5 cm, apex acuminate, base rounded, slightly attenuate, and often bearing a pair of pitted glands; lamina chartaceous, glabrous, usually shiny on the upper surface and sometimes on the lower surface, slightly bullate between the veins; midrib sunken above; lateral veins sunken above, prominent below, 6–12 pairs; intercostal venation sunken above, prominent below, reticulo-transverse; petiole 8–15 mm long. *Female flowers* in clusters of 1–5 on cymes up to 6 mm long. *Fruits* about 3, on 3–6 mm long stalks, globose, *c.* 1.3 cm diam., velvety. *Fruit calyx* with lobes up to 1 x 1 cm, the lobes or at least their sides reflexed.

Distribution and habitat: Endemic to Borneo: Sabah (*SAN 99668*), Sarawak (*S 17862*, *S 17897*, *S 42254*, *S 43068*, *S 47134*) and Brunei (*Coode 7050*). Lowland forests.

Notes: Named in honour of Rena George, 1956—1994, botanist of the Sarawak Forestry Department, who sacrificed her life for the sake of advancing botanical knowledge.

Specimen *S 36348* from Kapit at 950 m altitude is placed here with some doubt: its leaves are not shiny like the others.

var. ***saliciformis*** Ng, **var. nov.**

Arbores mediocres ad 20 m altae. Folia elongata, saliciformia 5.5–11.5 x 1–3.2 cm, apice gradatim contracta, basi gradatim contracta et attenuata (glandes desunt), lamina chartacea glabra, costa supra immersa; nervi secundarii prominuli ad fere invisibiles 5–7 pares; nervi tertiarii subtus fere invisibiles; petioli 0.3–0.5 cm. Flores ignoti. Pedicelli in fructu 0.1–0.2 cm. Calyx stellae 4-radiatae similis, lobis ad 0.6 x 0.4 cm. Fructus solitarius, subsessilis, globosus ad 1.5 cm diam., velutinus glabrescens ad glaber. A varietatibus ceteris in laminis angustis saliciformibus differt. **Typus:** *Coode 7826*, Borneo, Brunei (KEP holo, BRUN, SAN, SING iso).

Medium-sized trees to 20 m tall. *Leaves* elongated, willow-like, 5.5–11.5 x 1–3.2 cm, apex gradually tapered, base gradually tapered and attenuate, without pit-glands; lamina chartaceous, glabrous; midrib sunken above; lateral veins prominulous to almost invisible, 5–7 pairs; intercostal venation practically invisible below; petiole 3–5 mm long. *Flowers* unknown. *Fruits* solitary, subsessile on 1–2 mm stalks, globose, velvety becoming glabrous, to 1.5 cm diam. *Fruit calyx* a 4-pointed woody star with the lobes up to 6 x 4 mm.

Distribution and habitat: Endemic to Borneo: Sarawak (*Chew 1170, S 49201*) and Brunei (*Coode 7826*). Lowland forest.

Notes: The leaves of *Diospyros lanceifolia* var. *saliciformis* are superficially similar to those of *D. eucalyptifolia* Bakh. and the narrow-leafed riverine form of *D. andamanica* (Kurz) Bakh.

3. ***Diospyros penibukanensis*** Bakh., Bull. Jard. Bot. Btz. Ser. iii, 15 (1937) 124.

var. ***scalarinervis*** Ng, **var. nov.**

A var. *penibukanensi* in foliis subtus glabris nec dense pubescentibus, nervis tertiariis scalariformibus remotioribus, ramulorum et foliorum pilis tenuibus appressis nec patentibus differt. Varietates etiam geographicaliter disjunctae prima Sarawak secunda Sabah incola. **Typus:** *S 56607*, Borneo, Sarawak (KEP holo, SAN, SAR iso).

Small trees to 10 m tall, rarely to 25 m. *Twigs* velvety on young parts. *Leaves* medium-sized to large, elliptic to broadly obovate or oblong-obovate, 11–38 x 4–15 cm, apex acuminate, base subcordate, rarely only rounded; lamina chartaceous, glabrous except the veins; midrib sunken above; lateral veins prominulous below and finely appressed hairy, 5–24 pairs; intercostal venation prominent below, scalariform; petiole 8–5 mm long. *Male flowers* up to 10 in a condensed cyme *c.* 5 mm long; calyx with 4 imbricate triangular lobes. *Female flowers* up to 10 in a condensed cyme *c.* 5 mm long; calyx with 4 imbricate semicircular lobes. *Fruits* in clusters of 1–3, on *c.* 5 mm long stalks, globose, to 2.5 cm diam., velvety. *Fruit calyx* not accrescent, the calyx lobes rounded, coriaceous, 4–6 x 5–8 mm.

Distribution and habitat: Endemic to Borneo: Sarawak (*S 13586, S 13681, S 13702, S 18639, S 34482, S 34935, S 34962, S 35271, S 41850, S 49997, S 56607*). Lowland, hill and heath forests.

Notes: Variety *scalarinervis* differs from var. *penibukanensis* in its leaves, which are glabrous below (instead of densely hairy), the scalariform intercostal venation being spaced further apart, and the hairs on its twigs and leaves being fine and appressed (instead of spreading). They are also geographically disjunct, the former in Sarawak and the latter in Sabah.

Reductions

1. ***Diospyros andamanica*** (Kurz) Bakh., Bull. Jard. Bot. Btz. Ser. iii, 15 (1937) 74, (1941) 382.
Synonyms: *D. tahanensis* Bakh., Gard. Bull. S.S. 7 (1933) 163, **syn. nov.;** type: *Ridley s.n.*, Peninsular Malaysia, Pahang (SING). *D. longepedunculata* Kosterm., Blumea 23 (1977) 462, **syn. nov.;** type: *SAN 29807*, Borneo, Sabah (KEP, SAN, SAR, SING).

2. ***Diospyros areolata*** King & Gamble, J. As. Soc. Beng. 74, 2 (1905) 228.
Synonyms: *D. bantamensis* Koord. *et* Valeton *ex* Bakh., Gard. Bull. S.S. 7 (1933) 165, **syn. nov.;** type: *Koorders 1718*, Java (BO). *D. malam* Bakh., Gard. Bull. S.S. 7 (1933) 176, **syn. nov.;** types: *bb. 6335, bb. 8037*, Borneo, Kalimantan (BO).

3. ***Diospyros blancoi*** A.DC., Prod. 8 (1844) 151.
Synonym: *D. durionoides* Bakh., Gard. Bull. S.S. 7 (1933) 169, **syn. nov.;** types: *bb. 7978, 10050* and *12456*, Borneo, Kalimantan (BO).

4. ***Diospyros buxifolia*** (Blume) Hiern, Trans. Cambr. Phil. Soc. 12, 2 (1873) 218.
Synonym: *D. elegantissima* Bakh., Gard. Bull. S.S. 7 (1933) 169, **syn. nov.;** type: *Ridley 16349*, Peninsular Malaysia, Pahang (SING).

5. ***Diospyros elliptifolia*** Merr., Phil. J. Sci. 30 (1926) 247.
Synonym: *D. kinabaluensis* (Bakh.) Kosterm., Blumea 23 (1977) 460, **syn. nov.** [basionym: *D. elliptifolia* forma *kinabaluensis* Bakh., Bull. Jard. Bot. Btz. Ser. iii, 15 (1935) 233]; types: *DeVoogd 1486*, Sumatra (BO); *Haviland 1322*, Borneo, Sabah (SING, SAR).

6. ***Diospyros foxworthyi*** Bakh., Gard. Bull. S.S. 7 (1933) 171.
Synonyms: *D. levigata* Bakh., Gard. Bull. S.S. 7 (1933) 175, **syn. nov.;** types: *bb. 8053, 11089, 11255*, Borneo, West Kalimantan (all at BO). *D. cylindrocarpa* Kosterm., Blumea 23 (1977) 456, **syn. nov.;** type: *SAN 7119*, Borneo, Sabah (SAN, SING).

7. ***Diospyros korthalsiana*** Hiern, Trans. Cambr. Phil. Soc. 12, 2 (1873) 168.
Synonym: *D. myrmecocalyx* (Hiern) Bakh., Gard. Bull. S.S. 7 (1933) 178, **syn. nov.** [basionym: *Maba myrmecocalyx* Hiern, Trans. Cambr. Phil. Soc. 12, 2 (1873) 139]; type: *Beccari 3568*, Borneo, Sarawak (K).

8. ***Diospyros lateralis*** Hiern, Trans. Cambr. Phil. Soc. 12, 2 (1873) 167.
Synonym: *D. crassipes* Bakh., Gard. Bull. S.S. 7 (1933) 167, **syn. nov.;** type: *Beccari 2041*, Borneo (K).

9. ***Diospyros mindanaensis*** Merr., Phil. J. Sci. 4 (1909) 309.
Synonym: *D. endertii* Bakh., Gard. Bull. S.S. 7 (1933) 169, **syn. nov.;** type: *Endert 4017*, Borneo, Kalimantan (BO).

10. ***Diospyros montana*** Roxb., Pl. Corom. 1 (1795) 37.
Synonym: *D. pubicalix* Bakh., Gard. Bull. S.S. 7 (1933) 182, Bull. Jard. Bot. Btz. 15 (1955) Plate 39, **syn. nov.;** type: *Hamid C.F. 3827*, Peninsular Thailand (BKF, BO, KEP, SING).

Notes: Diospyros pubicalix has been an enigmatic species known only from its type specimen. It is well illustrated by Bakhuizen (1955). The shoots grow in flushes from resting buds, with the leaves exhibiting a characteristic sequence of changes. The first leaves are small and have cordate to subcordate bases. They are followed by larger leaves with rounded bases and finally leaves with cuneate bases. On some specimens, only parts of the sequence are evident, misleading authors not aware of this source of variation to create new species.

11. ***Diospyros pilosanthera*** Blanco, Fl. Filip. Ed. 1 (1837) 304.
var. ***pilosanthera***
Synonym: *D. cubica* Bakh., Gard. Bull. S.S. 7 (1933) 168, **syn. nov.;** type: *Beccari 830*, Borneo, Sarawak (K)

var. ***elmeri*** (Merr.) Ng, Malay. Forester 40 (1977) 238.
Synonym: *D. nidus-avis* Kosterm., Blumea 23 (1977) 464, **syn. nov.;** type: *S 32181*, Borneo, Sarawak (SAN, SAR, SING).

12. ***Diospyros plectosepala*** Hiern, Trans. Cambr. Phil. Soc. 12, 2 (1873) 201.
Synonyms: *D. poiensis* Bakh., Gard. Bull. S.S. 7 (1933) 181, **syn. nov.;** type: *Clemens 20304* (BO, SAR). *D. setosa* Bakh., Gard. Bull. S.S. 7 (1933) 184, **syn. nov.;** type: *Haviland 2324*, Borneo (K).

13. ***Diospyros ridleyi*** Bakh., Gard. Bull. S.S. 7 (1933) 354.
Synonym: *D. dajakensis* Bakh., Gard. Bull. S.S. 7 (1933) 168, **syn. nov.;** type: *bb. 10490*, Borneo, Kalimantan (BO).

14. ***Diospyros rufa*** King & Gamble, J. As. Soc. Beng. 74, 2 (1905) 228.

Synonym: *D. swingleri* Kosterm., Blumea 23 (1977) 172, **syn. nov.:** type: *S 26969*, Borneo, Sarawak (SAR, SING).

15. ***Diospyros simaloerensis*** Bakh., Gard. Bull. S.S. 7 (1933) 185.
Synonym: *D. paraoesi* Bakh., Gard. Bull. S.S. 7 (1933) 180, **syn. nov.:** type: *bb. 10162*, Borneo, Kalimantan (BO).

16. ***Diospyros styraciformis*** King & Gamble, J. As. Soc. Beng. 74, 2 (1905) 216.
Synonyms: *D. styraciformis* var. *sarawakana* (Bakh.) Ng, Malay. Forester 40 (1977) 241, **syn. nov.** [basionym: *Diospyros sarawakana* Bakh., Gard. Bull. S.S. 7 (1933) 184]: type: *Haviland 2316*, Borneo, Kuching (K, SAR, SING). *D. clavipes* Bakh., Gard. Bull. S.S. 7 (1933) 166, **syn. nov.:** type: *Teysmann 11397*, Borneo, Kalimantan (BO).

17. ***Diospyros subrhomboidea*** King & Gamble, J. As. Soc. Beng. 74, 2 (1905) 209.
Synonyms: *D. contusa* Bakh., Gard. Bull. S.S. 7 (1933) 167, **syn. nov.:** type: *Baker s.n.*, Singapore (KEP, SING). *D. jaheri* Bakh., Gard. Bull. S.S. 7 (1933) 173, **syn. nov.:** type: *Jaheri 128*, Borneo, Kalimantan (BO).

18. ***Diospyros sumatrana*** Miq., Pl. Jungh. (1851–55) 203.
Synonyms: *D. monticola* Kosterm., Blumea 23 (1977) 463, **syn. nov.:** type: *Clemens 32541*, Borneo, Sabah (BO). *D. beccarii* Hiern, Trans. Cambr. Phil. Soc. 12, 2 (1873) 204, **syn. nov.:** types: *Beccari 2492* and *2591*, Borneo (K).

19. ***Diospyros venosa*** Wall. *ex* A. DC., Prod. Syst. Nat. 8 (1844) 233.

var. ***venosa***
Synonym: *D. bintuluensis* Kosterm., Blumea 23 (1977) 453, **syn. nov.:** type: *S 15912*, Borneo, Sarawak (SAN, SAR).

var. ***olivacea*** (King & Gamble) Ng, Malay. Forester 40 (1977) 246.
Synonym: *D. olivacea* (King & Gamble) Kosterm., Blumea 23 (1977) 465, **syn.** and **stat. nov.**, [basionym: *Maba olivacea* King & Gamble in Williams, Bull. Herb. Boiss. II, 5 (1905) 227]: type: *King's Collector 7877*, Peninsular Malaysia, Perak, Batang Padang (K, SING).

20. ***Diospyros wallichii*** King & Gamble in Williams, Bull. Herb. Boiss. 2,5 (1905) 429.
Synonym: *D. pulchrinervia* Kosterm., Blumea 23 (1977) 460, **syn. nov.:**

type: *Kostermans 21583*, Borneo, Kalimantan (KEP, SAR, SING).

Acknowledgements

I am very grateful to the Director-General of Forest Research Institute Malaysia for providing research funds and facilities under the Tree Flora of Sabah and Sarawak Project, to the curators of the herbaria at BO, K, KEP, L, SAN, SAR and SING for the loan of specimens and/or the excellent help and facilities given during visits to their herbaria, to Dr. J.F. Veldkamp, National Herbarium of the Netherlands, Leiden Branch, for the Latin descriptions and to Mr Joseph Pao, Sarawak Forestry Department, for meticulously preparing the illustrations.

Alphabetic List of *Diospyros* Species and Varieties Reduced

D. bantamensis Koord. *et* Valeton *ex* Bakh. to ***D. areolata*** King & Gamble
D. beccarii Hiern to ***D. sumatrana*** Miq.
D. bintuluensis Kosterm. to ***D. venosa*** Wall. *ex* A.DC. var. ***venosa***
D. clavipes Bakh. to ***D. styraciformis*** King & Gamble
D. confusa Bakh. to ***D. subrhomboidea*** King & Gamble
D. crassipes Bakh. to ***D. lateralis*** Hiern
D. cubica Bakh. to ***D. pilosanthera*** Blanco. var. ***pilosanthera***
D. curraniopsis Bakh. to ***D. curranii*** Merr. var. ***curranii***
D. cylindrocarpa Kosterm. to ***D. foxworthyi*** Bakh.
D. dajakensis Bakh. to ***D. ridleyi*** Bakh.
D. durionoides Bakh. to ***D. blancoi*** A.DC.
D. elegantissima Bakh. to ***D. buxifolia*** (Bl.) Hiern
D. endertii Bakh. to ***D. mindanaensis*** Merr.
D. jaheri Bakh. to ***D. subrhomboidea*** King & Gamble
D. kinabaluensis (Bakh.) Kosterm. [Basionym: *D. elliptifolia* forma *kinabaluensis* Bakh.] to ***D. elliptifolia*** Merr.
D. levigata Bakh. to ***D. foxworthyi*** Bakh.
D. longepedunculata Kosterm. to ***D. andamanica*** (Kurz) Bakh.
D. malam Bakh. to ***D. areolata*** King & Gamble
D. monticola Kosterm. to ***D. sumatrana*** Miq.
D. myrmecocalyx (Hiern) Bakh. [Basionym: *Maba myrmecocalyx* Hiern] to ***D. korthalsiana*** Hiern
D. nidus-avis Kosterm. to ***D. pilosanthera*** Blanco var. ***elmeri*** (Merr.) Ng
D. olivacea (King & Gamble) Kosterm. [Basionym: *Maba olivacea* King & Gamble] to ***D. venosa*** Wall. *ex* A.DC. var. ***olivacea*** (King & Gamble) Ng

D. paraoesi Bakh. to ***D. simaloerensis*** Bakh.
D. poiensis Bakh. to ***D. plectosepala*** Hiern
D. pubicalix Bakh. to ***D. montana*** Roxb.
D. pulchrinervia Kosterm. to ***D. wallichii*** King & Gamble
D. setosa Bakh. to ***D. plectosepala*** Hiern
D. styraciformis var. *sarawakana* (Bakh.) Ng [Basionym: *D. sarawakana* Bakh.] to ***D. styraciformis*** King & Gamble
D. swingleri Kosterm. to ***D. rufa*** King & Gamble
D. tahanensis Bakh. to ***D. andamanica*** (Kurz) Bakh.

Gardens' Bulletin Singapore **53** *(2001) 315–322.*

New and Noteworthy Records of Mosses from Mindoro, the Philippines, and Their Biogeographical Implication

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Abstract

A recent, small collection of mosses from Mt. Halcon, Mindoro Island, the Philippines, has yielded two new records for the country (*Rhacocarpus alpinus* (Wright) Par. and *Dicranoloma daymannianum* Bartr.) and eight new records for the island. Relevant ecological, morphological and biogeographical notes for the 15 species collected are provided.

Introduction

Floristic exploration was conducted from 1996—1997 around the summit of Mt. Halcon in Mindoro, the seventh largest island in the Philippines (Fig. 1). The actual summit stands at 2,582 m asl and has a grid coordinate of 13° 15'46" N and 120° 59'29" E. The exploration was carried out principally to classify and describe the vegetation types found on the northeastern summit zone (Mandia, 1998). In addition to a good number of new records of vascular plants for the island and the Philippines that will be reported separately by the second author, the exploration has yielded two species of mosses new to the country (*Rhacocarpus alpinus* and *Dicranoloma daymannianum*), and eight new records for the island. In the case of little known moss flora of Mt. Halcon, these additions are rather significant. Furthermore, the new records highlight the Mindoro-Palawan connection, a noteworthy feature of the island's biogeography.

Summit Vegetation

The summit vegetation of Mt. Halcon extends from 1,950 to 2,582 m altitude and consists largely of open, low growing species of *Leptospermum*,

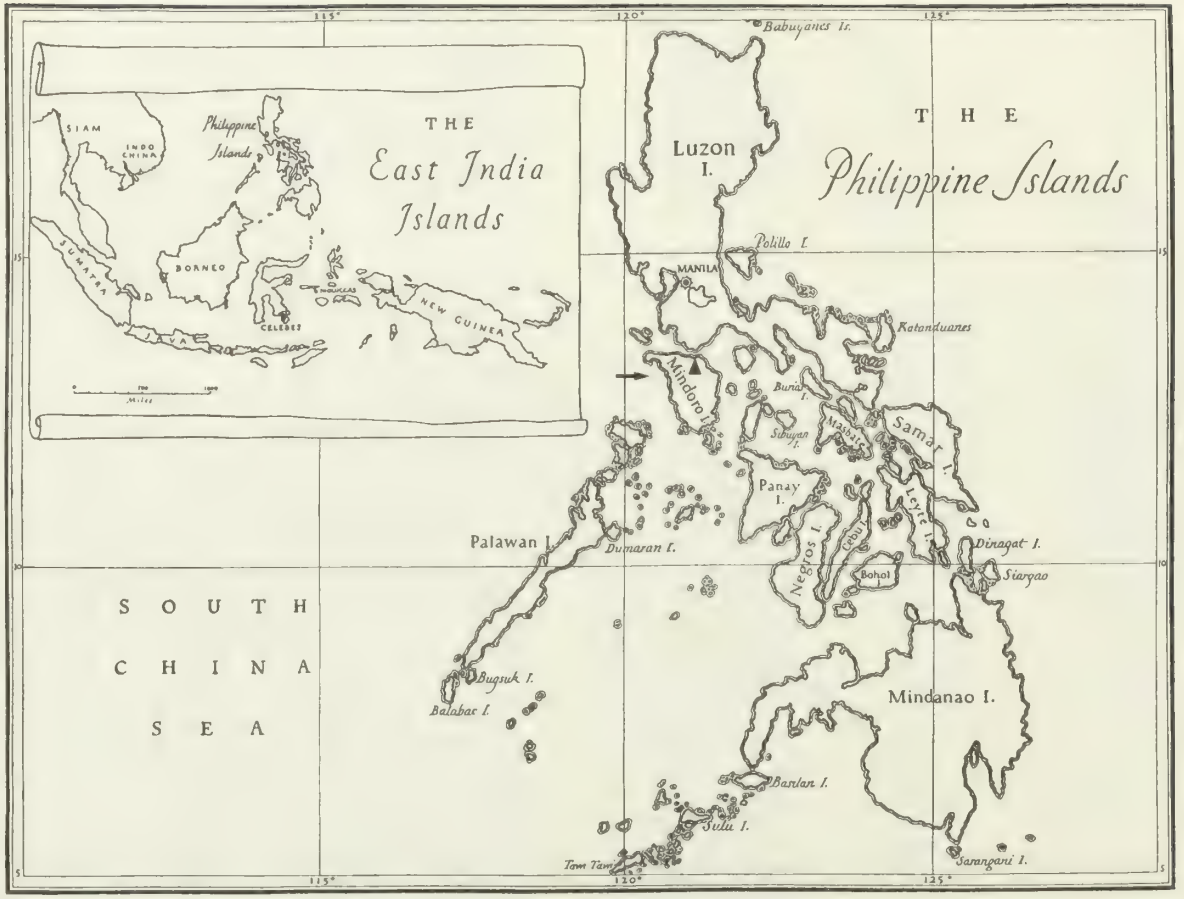

Figure 1. The location of Mt. Halcon (▲) on Mindoro Island, the Philippines

podocarps, ericoids, sedges, lycopods, ferns, ground lichens and bryophytes, interrupted by patches of shrubs and mossy forest. Vascular cushion plants and geophytes, such as the sundews (*Drosera*), *Centrolepis philippinensis* Merr. (Centrolepidaceae), *Trachymene saniculifolia* Stapf (Umbelliferae), *Aletris foliolosa* Stapf (Melanthiaceae), *Oreobulus ambiguous* Kukenth. & Steenis (Cyperaceae), *Patersonia lowii* Stapf (Iridaceae), *Gentiana luzoniensis* Merr. (Gentianaceae), *Schoenus melanostachys* R. Br. and *S. curvulus* F. Muell. (Cyperaceae) abound. The soil is shallow, acidic and oligotrophic, deriving from mica schist and white quartz.

Geological Origin and Biogeography of Mindoro

Little is known about the geology and geological history of Mt. Halcon, except that the mountain mass consists of mainly metamorphic rocks of continental crust origin uplifted since mid-Miocene (Fernandez, 1982; JICA-MMAJ, 1984). Geologically, Mindoro, with Mt. Halcon, is interesting, being ascribed to be part of a Tertiary micro-continent, the North Palawan Block (Holloway, 1982). Others, such as Hamilton (1981), included only the southern Mindoro in the North Palawan Block, giving the northern portion a separate origin. The arrival of North Palawan Block from its pre-drift position contiguous with the south China mainland to its present day position in the Philippine archipelago has been postulated to be in mid- to late Pleiocene (Holloway, 1982; Hall, 1996, 1998). The event became a crucial step in the evolution of the modern Philippine biota because the resulting island chain provided the necessary land habitats for two-way migrations of plants and animals between Borneo and Luzon. Furthermore, the drifting of the ancient North Palawan Block across the South China Sea might also have carried with it some continental Asiatic plants and animals, which have become incorporated into the Philippine biota (Tan *et al.*, 1988). Seen in this light, the study of Mindoro mosses becomes relevant in understanding the biogeography of the island.

Floristic Affinity of Mindoro Mosses

Floristically, the vascular plant flora of Mindoro has been identified more with the Luzon flora than with the Palawan flora (Merrill, 1928). Its incompletely known moss flora also supported a strong Luzon connection (Tan and Iwatsuki, 1991). It is therefore of phytogeographical significance that *Rhacocarpus alpinus*, *Dicranoloma daymannianum* and *Acroporium johannes-winkleri* were identified among the new collection of mosses from Mt. Halcon. These three Malesian taxa are widespread in distribution, at

least in Borneo, but had either no prior Philippine record in the case of *R. alpinus* and *D. daymannianum*, or were not previously known from Mindoro, like *Acroporium johannes-winkleri* Broth. For all three taxa, Mt. Halcon represents the northernmost penetration of their ranges in Malesia north of the equator.

Rhacocarpus is a widespread austral genus of 7 species (Frahm, 1996), with *R. alpinus* distributed from Sumatra, Borneo, Sulawesi to New Guinea (Koponen and Norris, 1986). Its presence on Mt. Halcon shows the Gondwana influence on the mountain flora, albeit a tenuous one, which hitherto had not been apparent. The Mt. Halcon record also foretells the likely presence of this species in Palawan. Likewise, the new Mindoro record of *Acroporium johannes-winkleri* reinforces the important role of Palawan as a Pleistocene land bridge in the island hopping of mosses in the area. Earlier, Tan (1994) reported *Acroporium johannes-winkleri* from two localities in Palawan, and one locality each from Mindanao (Mt. Apo) and Sibuyan Island (Mt. Giting-Giting).

It is worthwhile to note that eight moss taxa reported from Mindoro (see below) have no Palawan record. Under-collection is one reason for this phenomenon. Compared with Mindoro, however, Palawan has a better known moss flora owing to the four recent explorations undertaken between 1987—1993 by the senior author (Tan, 1996). An alternative explanation for the dissimilar distribution of taxa in these two islands may lie in the relatively "short" time available for the full exchange of biota since the late Pliocene when the two islands drifted close to each other geographically.

Annotation of the new collection of Mt. Halcon mosses

Below we present the list of 15 moss species collected from Mt. Halcon, together with brief comments on their morphology and ecology. The collection numbers belong to the second author, with voucher specimens deposited at SINU and herbarium of De La Salle University-Manila campus.

The single asterisk (*) indicates a new record for Mindoro, and double asterisk (**), new to the Philippines.

**Acroporium johannis-winkleri* Broth. [EHM 78]. Epiphytic on branches, this is a medium-sized *Acroporium* with rather stiff-looking and spreading leaves. Stems measure to 2 cm tall. It is a West Malesian endemic, being common in Peninsular Malaysia and Borneo.

Braunfelsia dicranoides (Dozy & Molk.) Broth. [EHM 82]. This dicranaceous moss is easily recognized among its congeners by the

strongly falcate, non-plicate and unicostate leaves. Its long, sheathing perichaetial leaves are also diagnostic. It is a common mossy forest epiphyte throughout Malesia.

**Breutelia arundinifolia* (Duby) Fleisch. [EHM 76, 83]. This large moss is recognized by its big antheridial head, widely spreading to somewhat squarrose and sheathing leaves, and tomentose stems (cf. Virtanen, 1997). Widespread in East Asia and Oceania, the species is a common ground dweller on open sites at high elevations in the Philippines. It has no Palawan record (Tan, 1996).

**Campylopus exasperatus* (Nees & Blume) Brid. [EHM 77]. This is an easily recognized *Campylopus* in the Philippine mountains. The leaves are often broadly lanceolate, acute to blunt, with a percurrent and broad costa that is poorly defined. The plants from Mt. Halcon are large, measuring to 12 cm tall and carpeting the soil underneath the *Falcatifolium* forest and heath vegetation.

**C. hemitrichius* (C. Muell.) Jaeg. [EHM 86, 92]. Distinctive in having narrowly lanceolate leaves with concolorous, excurrent costa, this species is a ground dweller in open sites at the summit of Mt. Halcon. There seem to be two ecotypes on this mountain, one with erect, appressed leaves and the other with somewhat secund leaves. Tan (1983) clarified the taxonomic confusion of this species vis-à-vis other related Philippine congeners. At present, *Campylopus hemitrichius* has no Palawan record.

Dicranoloma assimile (Hampe) Par. [EHM 84]. This is a widespread *Dicranoloma* in Philippine mountains growing mainly on trunks and branches, sometimes on soil.

***Dicranoloma daymannianum* Bartr. [EHM 85]. Found attached to the base of trunks and branches of shrubs in the *Podocarpus-Falcatifolium* scrub, the present species resembles a small form of *D. braunii* without the filamentous propagules. The presence of a central strand in stem cross-section and the short, upper laminal cells further distinguish it from *D. braunii*. Klazenga (1999) discussed and illustrated well this uncommon Malesian taxon. Its presence in Palawan can be predicted.

Leucobryum javense (Brid.) Mitt. [EHM 81]. This is the largest *Leucobryum* found commonly in Philippine forests.

L. sanctum (Brid.) Hampe [EHM 80]. This is another common forest species in Malesia including the Philippines. The opening of perichetial bud of this epixylic and epipetric species are thickly covered with highly branched rhizoids that arise mainly from the abaxial side, but toward the base, of inner perichaetial leaves. The

larger outer perichaetial leaves, oddly, do not form any rhizoidal outgrowth. Yamaguchi (1993) illustrated and labeled this structure as a "tomentum" without any taxonomic comment.

**Macrothamnium javense* Fleisch. [EHM 75]. The species is found attached to prostrate branches. The strongly spinose and toothed leaf margin of this species is characteristic among its congeners. All Philippine records, thus far, are from Luzon island.

**Racomitrium lanuginosum* [EHM 90]. Growing in open heath vegetation at the summit, the species is identified by its whitish and strongly erose leaf apices. Mt. Halcon is the second locality in the Philippines for this nearly cosmopolitan moss. Its first Philippine record came from Mt. Giting-Giting in Sibuyan Island in central Philippines (Tan, 1993).

***Rhaccocarpus alpinus* (Wright) Par. [EHM 72]. This is the northernmost locality of this species in the old world tropics. The closest population to Mt. Halcon is on Mt. Kinabalu in NE Borneo. Plants are abundant on Mt. Halcon forming extensive carpets under cushion-forming seed plants. Its presence at high mountain peaks in Palawan should be sought for.

Schlotheimia wallisii C. Muell. [EHM 91]. Epiphytic on trunk bases and prostrate branches, this Malesian endemic is known from Borneo, the Philippines and New Guinea (Vitt *et al.*, 1993). The other Philippine localities include Luzon, Negros and Mindanao, but not Palawan.

Sphagnum junghuhnianum Dozy & Molk. [EHM 88]. Plants are abundant on wet soil under the thick growth of *Miscanthus* grasses. It is the most common species of *Sphagnum* in Philippine mountains.

S. sericeum C. Muell. [EHM 87]. This is the other species of *Sphagnum* found on wet soil beneath heath vegetation on Mt. Halcon. In the Philippines, this species is known also from Negros and Mindanao.

Acknowledgements

We are grateful to Dr. R. Seppelt for his help in making available the article on a revision of *Rhacocarpus* by J.-P. Frahm. We are equally thankful to Dr. N. Klazenga for his critical review of the manuscript.

References

Fernandez, J.C. 1982. *Geology and Mineral Resources of the Philippines. Vol. One, Geology*. Bureau of Mines and Geo-Sciences, Ministry of Natural Resources, Manila, the Philippines.

Frahm, J.-P. 1996. Revision der Gattung *Rhacocarpus* Lindb. (Musci). *Cryptogamie, Bryologique et Lichénologique*. **17**: 39—65.

Hall, R. 1996. Reconstructing Cenozoic SE Asia. In: R. Hall & D. Blundell (eds.) *Tectonic Evolution of Southeast Asia*. The Geological Society, London, U.K. pp. 153—184.

Hall, R. 1998. The plate tectonics of Cenozoic SE Asia and the distribution of land and sea. In: R. Hall and J.D. Holloway (eds.). *Biogeography and Geological Evolution of SE Asia*. Backhuys Publishers, Leiden, Netherlands. pp. 99—131.

Hamilton, W. 1981. *Tectonics of the Indonesian Region* (second printing). Geological Survey Professional Paper 1078. United States Government Printing Office, Washington DC. U.S.A.

Holloway, N.H. 1982. North Palawan Block, Philippines – its relation to Asian mainland and role in the evolution of South China Sea. *American Association of Petroleum Geologists Bulletin*. **66**: 1355—1383.

JICA-Metal Mining Agency of Japan (MMAJ). 1984. *Report on the Geological Survey of Mindoro Island*. Philippine Bureau of Mines, Manila, the Philippines.

Klazenga, N. 1999. A revision of the Malesian species of *Dicranoloma* (Dicranaceae, Musci). *Journal of Hattori Botanical Laboratory*. **87**: 1—130.

Koponen, T. and D. H. Norris. 1986. Bryophyte flora of the Huon Peninsula, Papua New Guinea. XVII. Grimmiaceae, Racopilaceae and Hedwigiaceae (Musci). *Acta Botanical Fennica*. **133**: 81—106.

Mandia, E.H. 1998. *The Vegetation on the Northeastern Summit Zone of Mt. Halcon, Mindoro Island, Philippines*. PhD Dissertation. University of the Philippines at Los Banos, Laguna. 210 pp.

Merrill, E.D. 1928. Flora of the Philippines. In: R.E. Dickerson. *Distribution of Life in the Philippines*. Bureau of Printing, Manila, the Philippines. pp. 130—167.

Tan, B.C. 1983. The status of *Campylopus hemitrichius* (C. Muell.) Jaeg. *Cryptogamie, Bryologique et Lichénologique.* **4**: 357—361.

Tan, B.C. 1993. Noteworthy range extension of Malesian mosses. *Journal of Hattori Botanical Laboratory.* **74**: 227—233.

Tan, B.C. 1994. The bryophytes of Sabah (North Borneo) with special reference to the BRYOTROP transect of Mount Kinabalu. XIX. The genus *Acroporium* (Semaophyllaceae, Musci) in Borneo, with notes on species of Java and the Philippines. *Willdenowia.* **24**: 255—294.

Tan, B.C. 1996. Biogeography of Palawan mosses. *Australian Systematic Botany.* **9**: 193—203.

Tan, B.C. & Z. Iwatsuki. 1991. A new annotated Philippine moss checklist. *Harvard Papers in Botany.* **3**: 1—64.

Tan, B.C., Z.-H. Li and P.-C. Lin. 1988. The Hainan-Mindoro connection, an obscure pathway for plant migration in Southeast Asia. *Natural History Bulletin of Siam Society.* **36**: 7—15.

Vitt, D.H., T. Koponen and D.H. Norris. 1993. Bryophyte flora of the Huon Peninsula, Papua New Guinea. LIII. *Ulota* and *Schlotheimia* (Orthotrichaceae, Musci). *Acta Botanica Fennica.* **148**: 5—25.

Virtanen, V. 1997. The genus *Breutelia* (Bartramiaceae, Musci) in Southeast Asia and Oceania. *Bryologist.* **100**: 324-348.

Yamaguchi, T. 1993. A revision of the genus *Leucobryum* (Musci) in Asia. *Journal of Hattori Botanical Laboratory.* **73**: 1—123.

Gardens' Bulletin Singapore **53** *(2001) 323–325.*

New Combinations in Malesian Myricaceae

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Abstract

In line with recent opinion favouring the splitting of the genus *Myrica* L. *sensu lato*, new combinations in *Morella* Lour. (*Morella esculenta* (Buch.-Ham.) I.M. Turner and *M. javanica* (Blume) I.M. Turner) are provided for the two Malesian species of Myricaceae.

Introduction

The genus *Myrica* L. as traditionally circumscribed consists of some 40—50 extant species of trees and shrubs ranging from the arctic to the tropics. The generally accepted type of the genus, circumboreal *Myrica gale* L., and the Californian endemic *Myrica hartwegii* S. Watson differ significantly from the rest of the species. This is manifested principally in having inflorescences inserted at the ends of the previous year's growth rather than on the old wood, and smooth fruits with a pair of adnate bracteoles rather than papillate fruits lacking adnate bracteoles (MacDonald 1989, Wilbur 1994). Chromosome numbers and essential oil chemistry also distinguish the groups (MacDonald 1989). This division has often been recognised at infrageneric rank (e.g. Kubitzki 1993) but, despite long-standing reluctance by botanists to split *Myrica*, the tide seems to have turned to favour the recognition of at least two genera. Unfortunately as *Myrica* is typified by *Myrica gale* L. the generic name has to remain with the numerically minor element and the many warm temperate and tropical species have to be placed in a different genus. A proposal to conserve *Myrica* with a conserved type (Verdcourt and Polhill 1997) was made in order to reduce the number of necessary name changes. This was rejected (Brummitt 1999, p. 367) largely on the grounds that, as the split was unsettling to the nomenclature of important species whichever element was maintained as *Myrica*, accepted typification and nomenclatural priority should be upheld.

The next oldest generic name available for the tropical segregate is *Morella* Lour., typified by *Morella rubra* Lour., better known as *Myrica rubra* (Lour.) Sieb. & Zucc., a relatively important fruit tree in China and Japan. New combinations in *Morella* have already been published for species from North American (Wilbur 1994) and Africa (Killick, Polhill and

Verdcourt 1998). Even if the proposal to conserve *Myrica* had been accepted it might not have prevented the resurrection of *Morella* because the proposed conserved type was to be *Myrica cerifera* L.. This is one of the waxy-fruited North American species that are possibly generically distinct from the fleshy-fruited African and Asian species.

In Malesia, two species of *Myrica* have long been recognised: *Myrica esculenta* Buch.-Ham. and *Myrica javanica* Blume. See Backer (1951) and Noorsiha (1996) for extensive synonymies, description, illustrations and notes on ecology and uses. Both species are widespread, common and ecologically important, as well as possessing traditional utility. Both are clearly best placed in *Morella* rather than *Myrica sensu stricto* and new combinations effecting this change are made below:

Morella esculenta (Buch.-Ham.) I.M. Turner, **comb. nov.**
Basionym: *Myrica esculenta* Buch.-Ham. in D. Don, Prodr. Fl. Nep. (1825) 56.
Type: Nepal, *Hamilton s.n.* (K).

Distribution: India and Nepal, China, Indo-China, Malesia (excluding New Guinea).

Morella javanica (Blume) I.M. Turner, **comb. nov.**
Basionym: *Myrica javanica* Blume, Bijdr. Fl. Ned. Ind. (1825) 517.
Type: Java, Mt. Gede, *Reinwardt s.n.* (L).

Distribution: Malesia except Malay Peninsula.

References

Backer, C.A. 1951. Myricaceae. *Flora Malesiana, series I.* **4**: 277—279.

Brummitt, R.K. 1999. Report of the committee for Spermatophyta: 48. *Taxon.* **48**: 359—371.

Killick, D.J.B., R.M. Polhill and B. Verdcourt. 1998. New combinations in African Myricaceae. *Kew Bulletin.* **53**: 993—995.

Kubitzki, K. 1993. Myricaceae. In: K. Kubitzki, J.G. Rohwer & V. Bittrich (eds.) *The Families and Genera of Vascular Plants. Vol. II Flowering Plants · Dicotyledones. Magnoliid, Hamamelid and Caryophyllid Families.* Springer Verlag, Berlin, Germany. Pp. 453—457.

MacDonald, A.D. 1989. The morphology and relationships of the Myricaceae. In: P.R. Crane & S. Blackmore (eds.) *Evolution, Systematics, and Fossil History of the Hamamelidae, Volume 2: 'Higher Hamamelidae'*. Clarendon Press, Oxford, U.K. Pp. 147—165.

Noorsiha, A. 1996. Myricaceae. *Tree Flora of Sabah and Sarawak*. **2**: 245—249.

Verdcourt, B., and R. Polhill. 1997. (1291-1292) Proposals to conserve the names *Myrica* and *Gale* (Myricaceae) with conserved types. *Taxon*. **46**: 347—348.

Wilbur, R.L. 1994. The Myricaceae of the United States and Canada: genera, subgenera, and series. *Sida*. **16**: 93—107.

Gardens' Bulletin Singapore **53** *(2001) 327–341.*

Sectional Placement of Three Bornean Species of *Musa* (Musaceae) based on Amplified Fragment Length Polymorphism (AFLP)

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Abstract

The traditional approach to the classification of *Musa* species (Musaceae) is the separation into four sections (*Musa*, *Rhodochlamys*, *Callimusa* and *Australimusa*) based on chromosome number and morphological characters. The sectional placing of *Musa beccarii* N.W. Simmonds is still unresolved due to its unique chromosome number. The sections of two new species from Sabah, Malaysia, *M. monticola* [Hotta ex] Argent and *M. suratii* Argent, were also undetermined. This study employs Amplified Fragment Length Polymorphism (AFLP) as a molecular tool to determine the sectional placement of these three species within *Musa*. Eight primer combinations generated 17 genetic markers, which confirmed *M. monticola* and *M. suratii* as distinct species. AFLP data support the inclusion of *M. beccarii* and *M. monticola* in sect. *Australimusa*, while results show *M. suratii* falling between sect. *Callimusa* and sect. *Australimusa* suggesting that the two sections can no longer be maintained as distinct.

Introduction

Banana, *Musa* L. (Musaceae), is an important perennial crop cultivated in the tropics for food, fibre and as ornamental plants. Plagued by a complex genetic system of sterility, interspecific hybrid constitutions, heterozygosity and polyploidy (Novak, 1992), taxonomic classification of *Musa* is still in need of improvement. While the genetic diversity and classification of cultivated edible *Musa* are extensively studied (Simmonds and Shepherd, 1955; Bhat *et al.*, 1992; Kaemmer *et al.*, 1992), those of wild *Musa* are less emphasised.

The traditional approach to wild *Musa* classification is the separation of *Musa* into four sections (*Musa* Baker, *Rhodochlamys* Sagot, *Callimusa*

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Cheesman and *Australimusa* Cheesman) based on chromosome number and morphological characters (Cheesman, 1947; Simmonds, 1962). A fifth section, sect. *Ingentimusa* Argent, was recognised by Argent (1976) to include *Musa ingens* N.W. Simmonds from New Guinea. Section *Musa* is the largest and most diversified section ranging from South India to Japan and Samoa. Most edible banana cultivars, including their progenitors *M. acuminata* Colla and *M. balbisiana* Colla, belong to this section. Derived from wild species in sect. *Australimusa* are the Fe'i banana cultivars mainly distributed in New Guinea. The popular Filipino abaca originates from *M. textilis* Née, also of this section. Section *Callimusa* is distributed from Indochina to Indonesia and consists mainly of ornamental species, the best known being *M. coccinea* Andr. Section *Rhodochlamys*, ranging from India to Indochina, also consists of ornamental species, best represented by *M. ornata* Roxb..

However, for some species it is not clear to which section they belong. The sectional placing of *M. beccarii* N.W. Simmonds, *M. monticola* [Hotta ex] Argent and *M. suratii* Argent are yet to be determined.

Simmonds (1960) described *M. beccarii* from Sabah, Malaysia. He noted it superficially resembled *M. coccinea* (sect. *Callimusa*) but is distinct from this species in the bracts, male buds, fruits and seeds, which are more similar to species from sect. *Rhodochlamys*. Its chromosome number, n = 9 (Shepherd, 1959), is unlike any other *Musa* species: n = 10 in sect. *Callimusa* and sect. *Australimusa*; n = 11 in sect. *Musa* and sect. *Rhodochlamys*; and n = 7 in sect. *Ingentimusa*, although the chromosome number n = 10 has also been reported for *M. beccarii* (Shepherd, 1959). Hence, the formal position of *M. beccarii* within *Musa* is still undetermined.

Musa monticola, found in montane regions of Sabah (Mt. Kinabalu and the Crocker Range) is a new species of undetermined section (Argent, 2000). Argent eliminated the possibility of it belonging to sect. *Callimusa* and sect. *Rhodochlamys* on the grounds of it being distinct in seed structure and anatomy, and the male axis habit, respectively. Instead, the polished bracts and absence of wax suggested placement in sect. *Australimusa* (Hotta, 1987). Recent cytological examination of the species shows its chromosome number to be n = 10 (Jong and Argent, 2001), which supports its placement in sect. *Australimusa*.

Another new species described by Argent (2000) is *M. suratii*, from Sabah and Sarawak, Malaysia. This species is morphologically distinct within *Musa* in possessing minute seeds, giving no clue as to its formal placement within *Musa*. Jong and Argent (2001) determined its chromosome number as n = 10.

Amplified Fragment Length Polymorphism (AFLP) is a reliable and robust fingerprinting technique widely used in genetic diversity studies of

plants and animals (Vos *et al.*, 1995). Applications of AFLP include inferring phylogenetic relationships (Aggarwal *et al.*, 1999), analysing genetic diversities of populations and cultivars (Paul *et al.*, 1997; Loh *et al.*, 1999), evaluating gene flow and dispersal (Travis *et al.*, 1996), introgression (Tohme *et al.*, 1996) and hybridisation (Beismann *et al.*, 1997). AFLP has the advantage over other molecular techniques, such as RFLP, RAPD and microsatellites, in that it is highly reproducible, requiring no prior knowledge of genome sequence, relatively fast and easy to use, and in being able to generate multiple loci per assay. In 1999, Crouch *et al.* reported polymorphism in *Musa* generated by AFLP markers to be as high as that obtained using microsatellites, contrary to previous reports utilising soybean (Powell *et al.*, 1996). Consequently, Crouch *et al.* (1999) concluded that AFLP is most effective and suitable for genetic diversity studies of *Musa*.

Hence, this study aims to resolve the sectional placement of *M. beccarii*, *M. monticola* and *M. suratii* within *Musa* using AFLP. (Section *Ingentimusa* could not be included in this analysis due to lack of material).

Materials and Methods

Plant materials

This study employed a total of fifteen *Musa* species with sample sizes ranging from one to five (Table 1). The materials included representatives from four sections of *Musa* of both wild and cultivated origin, and from a variety of introductions (material of the fifth section, sect. *Ingentimusa*, was not available). The samples were collected from wild populations, and plants grown in the Singapore Botanic Gardens (Singapore), the Royal Botanic Garden Edinburgh (UK) and the Agricultural Park at Tenom (Sabah, Malaysia). Voucher specimens are deposited in the herbaria at Singapore Botanic Gardens and Royal Botanic Garden Edinburgh.

Leaf tissue was used for AFLP analysis. The leaves were surface sterilised using a procedure from Zhang *et al.* (1997). The leaves collected were swirled in 95% ethanol for 1 min, 5% bleach (NaOCl) for 5 min, and then re-immersed in fresh 95% ethanol for 30 sec, after which they were blotted dry and stored in sealed plastic bags at –80°C until needed for DNA extraction.

DNA extraction

Plant DNA was extracted using the CTAB method according to Reichardt and Rogers (1993). Briefly, leaf tissue was pulverised using liquid nitrogen prior to the addition of 4 ml of Solution I (2% w/v CTAB (Sigma), 100 mM Tris-HCl, 20 mM EDTA, 1.4 M NaCl, pH 8.0) per gram of leaf tissue

Table 1. Species of *Musa* studied

Taxon	Accession No.	Source
Section undetermined		
M. beccarii Simmonds	AL 1	Agricultural Park, Tenom
M. monticola [Hotta ex] Argent	19891874 / AL 4	Royal Botanic Garden Edinburgh / Agricultural Park, Tenom
M. suratii Argent	AL 6	Agricultural Park, Tenom
Musa sect. *Musa*		
M. acuminata Colla spp. *truncata* Ridl.	RK4718 / RK4889	Cameron Highlands / Fraser's Hill (Peninsular Malaysia)
M. acuminata Colla spp. *malaccensis* (Ridl.) Simmonds	RK 4890 / CW1-5	Kuala Kubu Baru / Tapah (Peninsular Malaysia)
M. balbisiana Colla	Ar s.n. / G.A s.n.	Royal Botanic Garden Edinburgh / Camiguin Island, Philippines
M. nagensium Prain	19991679A	Royal Botanic Garden Edinburgh
Musa sect. *Rhodochlamys*		
M. ornata Roxb.	19961732 / AL 5	Royal Botanic Garden Edinburgh / Agricultural Park, Tenom
M. velutina H. Wendl & Drude	19702121 / 19980690	Royal Botanic Garden Edinburgh / Singapore Botanic Gardens
Musa sect. *Callimusa*		
M. borneensis Becc.	AL 2	Agricultural Park, Tenom
M. campestris Becc.	19773441 / AL 3	Royal Botanic Garden Edinburgh / Agricultural Park, Tenom
M. coccinea Andr.	AR213	Royal Botanic Garden Edinburgh
M. violascens Ridl.	RK 4876	Fraser's Hill, Peninsular Malaysia
Musa sect. *Australimusa*		
M. textilis Née	AL 7	Agricultural Park, Tenom
M. jackeyi Hill	19990218	Singapore Botanic Gardens

and incubated for 60 min at 65°C. The homogenate was then extracted with an equal volume of chloroform isoamyl alcohol (24:1) and centrifuged at 12,000 rpm for 5 min. The upper aqueous phase was recovered and incubated with 1/10 volume of Solution II (10% w/v CTAB, 0.7 M NaCl), prewarmed to 65°C. The aqueous phase was then extracted with 1 volume of chloroform isoamyl alcohol (24:1) and recovered as before. To the recovered aqueous phase, 1 volume of Solution III (1% w/v CTAB, 50 mM Tris-HCl, 10 mM EDTA, pH 8.0) was added and incubated overnight at 37°C. The mixture was then centrifuged for 5 min at 3,500 rpm and supernatant removed. The DNA pellet was then re-dissolved in Solution IV (10 mM Tris-HCl, 0.1 mM EDTA, 1 M NaCl, pH 8.0) at 0.5 to 1 ml per gram starting material, followed by ethanol precipitation of the DNA. It was then washed with 70% ethanol, dried and re-suspended in minimal volume of TE buffer at 0.1 to 0.5 ml per gram starting material.

AFLP analysis

AFLP analysis was carried out according to Vos *et al.* (1995) with minor modifications. Restriction digests of genomic DNA with *Eco*RI and *Mse*I were carried out at 37°C for 1 h. Following heat inactivation of the restriction endonucleases, the genomic DNA fragments were ligated to *Eco*RI and *Mse*I adapters overnight at 16°C to generate template DNA for amplification. PCR was performed in two consecutive reactions. The template DNA generated was first pre-amplified using AFLP primers each having one selective nucleotide. The PCR products of the pre-amplification reaction were then used as template after 5-fold dilution in sterile water, for selective amplification using two AFLP primers, each containing three selective nucleotides. A total of eight primer combinations were used in this study (Table 2). The final PCR products were run on a 6% denaturing polyacrylamide gel in 1X TBE buffer. The *Eco*RI primers used were not radioactively labelled as in the original protocol. Instead, a modified silver staining method was used (Loh *et al.*, 1999).

Data analysis

For the diversity analysis, bands were scored as present (1) or absent (0) to form a raw data matrix. A square symmetric matrix of similarity was then obtained using Jaccard's Similarity Coefficient [x / (y-z)], where x is the number of fragments in common between two taxa, y is the total number of fragments scored, z is the number of fragments absent in both taxa, from the raw data matrix. Genetic diversity estimates (GDEs) were then calculated as 1 minus Jaccard's Similarity Coefficient and used for cluster analysis using the Unweighted Pair Group Method with Arithmetic mean

(UPGMA) technique of the NEIGHBOR program in PHYLIP version 3.5c (Felsenstein, 1993).

Table 2. Sequences of the primers and adapters used for AFLP analysis

Name / Abbreviation	Enzyme	Type	Sequence (5'-3')
GYY 101/ EA+	*Eco*RI	Adapter +	CTCGTAGACTGCGTACC
GYY 102/ EA-	*Eco*RI	Adapter -	AATTGGTACGCAGTCTAC
GYY 103/ MA+	*Mse*I	Adapter +	GACGATGAGTCCTGAG
GYY 104/ MA-	*Mse*I	Adapter -	TACTCAGGACTCAT
GYY 105/ E-A	*Eco*RI	Primer +1	GACTGCGTACCAATTCA
GYY 107/ E-AAC	*Eco*RI	Primer +3	GACTGCGTACCAATTCAAC
GYY 108/ E-AAG	*Eco*RI	Primer +3	GACTGCGTACCAATTCAAG
GYY 109/ E-ACA	*Eco*RI	Primer +3	GACTGCGTACCAATTCACA
GYY 110/ E-ACT	*Eco*RI	Primer +3	GACTGCGTACCAATTCACT
GYY 111/ E-ACC	*Eco*RI	Primer +3	GACTGCGTACCAATTCACC
GYY 112/ E-ACG	*Eco*RI	Primer +3	GACTGCGTACCAATTCACG
GYY 113/ E-AGC	*Eco*RI	Primer +3	GACTGCGTACCAATTCAGC
GYY 114/ E-AGG	*Eco*RI	Primer +3	GACTGCGTACCAATTCAGG
GYY 106/ M-C	*Mse*I	Primer +1	GATGAGTCCTGAGTAAC
GYY 115/ M-CAA	*Mse*I	Primer +3	GATGAGTCCTGAGTAACAA
GYY 116/ M-CAC	*Mse*I	Primer +3	GATGAGTCCTGAGTAACAC
GYY 117/ M-CAG	*Mse*I	Primer +3	GATGAGTCCTGAGTAACAG
GYY 118/ M-CAT	*Mse*I	Primer +3	GATGAGTCCTGAGTAACAT
GYY 119/ M-CTA	*Mse*I	Primer +3	GATGAGTCCTGAGTAACTA
GYY 120/ M-CTC	*Mse*I	Primer +3	GATGAGTCCTGAGTAACTC
GYY 121/ M-CTG	*Mse*I	Primer +3	GATGAGTCCTGAGTAACTG
GYY 122/ M-CTT	*Mse*I	Primer +3	GATGAGTCCTGAGTAACTT

Results

Identification of species using AFLP markers

AFLP fingerprinting of 15 species of *Musa* with eight primer combinations (Table 2) yielded a total of 276 unambiguous bands of size 50—500 base pairs. Of these, 262 (95%) are polymorphic across all samples, while the number of polymorphic loci generated per primer combination is 33. Figure 1 illustrates an AFLP profile generated using primer pair 1 (E-AAC, M-CAA).

A total of 17 genetic markers unique to each species were observed for nine species of *Musa* (Table 3), including *M. monticola* and *M. suratii*. No unique bands distinguished *M. beccarii* from the rest of the *Musa* species. *M. suratii* is distinct due to two unique bands, while another unique marker

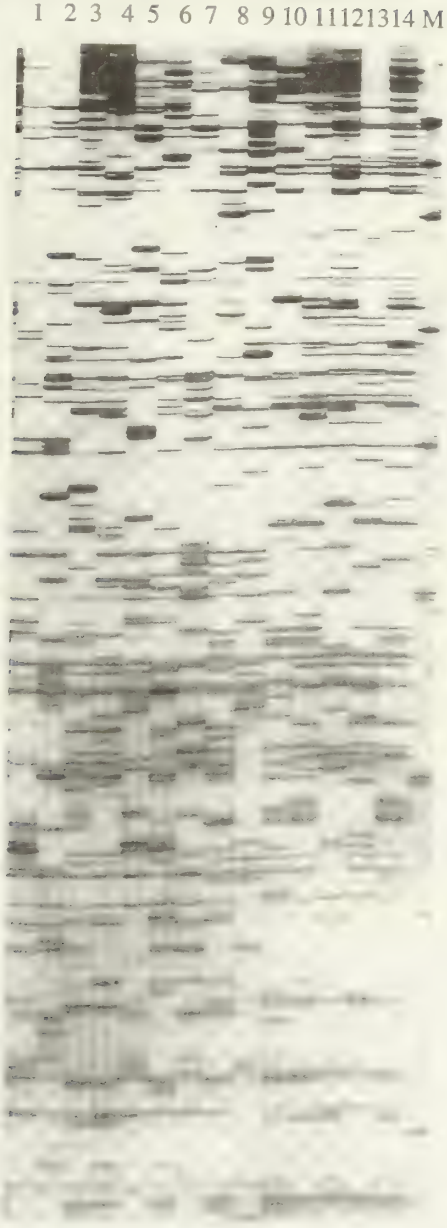

Figure 1. AFLP profile obtained with primer pair 1 (E-AAC, M-CAA) illustrating banding patterns for some species examined in this study. Lane 1: *M. acuminata* ssp. *truncata*, Lane 2: *M. balbisiana*, Lane 3: *M. textilis*, Lane 4: *M. violascens*, Lane 5: *M. ornata*, Lane 6: *M. coccinea*, Lane 7: *M. nagensium*, Lane 8: *M. campestris*, Lane 9: *M. velutina*, Lane 10: *M. jackeyi*, Lane 11: *M. beccarii*, Lane 12: *M. suratii*, Lane 13: *M. monticola*, Lane 14: *M. borneensis*, Lane M: pUC19/*Hpa*II molecular weight marker.

Table 3. Genetic markers observed for nine species of *Musa*

Primer Pair	*Eco*RI	*Mse*I	*M. acuminata ssp. truncata*	*M. monticola*	*M. suratii*	*M. jackeyi*	*M. balbisiana*	*M. borneensis*	*M. textilis*	*M. violascens*	*M. nagensium*	Total number of unique markers per primer pair
1	AAC*	CAA**	-	-	-	-	-	-	-	-	-	0
10	AAG	CAC	-	-	-	-	1	-	-	-	-	1
19	ACA	CAG	-	-	-	-	-	2	-	-	-	2
28	ACC	CAT	-	-	-	-	-	-	1	-	-	1
37	ACG	CTA	1	-	-	1	1	-	-	-	-	3
46	ACT	CTC	-	-	1	-	1	-	-	-	1	3
55	AGC	CTG	-	1	1	2	1	-	-	-	1	6
64	AGG	CTT	-	-	-	-	-	-	-	1	-	1
Total			1	1	2	3	4	2	1	1	2	17

**Eco*RI : *Eco*RI-adapter based primer; the selective nucleotides added at the 3' end are indicated

***Mse*I : *Mse*I-adapter based primer; the selective nucleotides added at the 3' end are indicated

was observed for *M. monticola*. The unique bands support the distinctiveness of both *M. suratii* and *M. monticola* as separate species. The number of unique bands observed for the remaining species of *Musa* ranged from one to four.

Genetic relationships between species of Musa

The cluster analysis using values of GDEs (Table 4) generated a phenogram (Fig. 2) depicting genetic relationships between species of *Musa*. Two main clusters were observed, each made up of the traditional sectional alliance of *Musa-Rhodochlamys* and *Callimusa-Australimusa* respectively. The cluster of the *Musa-Rhodochlamys* alliance revealed both subspecies of *M. acuminata*, ssp. *truncata* and ssp. *malaccensis*, to be closely related as anticipated. *M. velutina* H. Wendl. & Drude and *M. ornata* of sect. *Rhodochlamys* clustered closely with *M. acuminata*, while *M. nagensium* Prain and *M. balbisiana* in sect. *Musa* formed the remaining members of this cluster.

The cluster of the *Callimusa-Australimusa* alliance showed *M. violascens* Ridl., *M. borneensis* Becc. and *M. coccinea*, which all belong to sect. *Callimusa*, separated from the other species in this cluster. The cluster was further divided into a sub-cluster consisting of *M. textilis*, *M. beccarii*,

Table 4. Mean genetic diversity estimates (GDEs) of eight primer combinations (*M. acuminata* is abbreviated to *M. acu*)

	M. acuminata ssp. *truncata*	*M. acuminata* ssp. *malaccensis*	*M. balbisiana*	*M. textilis*	*M. violascens*	*M. coccinea*	*M. nagensium*	*M. ornata*	*M. velutina*	*M. beccarii*	*M. monticola*	*M. campestris*	*M. borneensis*	*M. suratii*	*M. jackeyi*
M. acu ssp. *truncata*		0.224	0.509	0.530	0.649	0.474	0.515	0.362	0.428	0.524	0.561	0.550	0.581	0.581	0.581
M. acu ssp. *malaccensis*			0.487	0.512	0.644	0.452	0.478	0.235	0.338	0.530	0.533	0.554	0.596	0.540	0.588
M. balbisiana			-	0.546	0.565	0.490	0.563	0.546	0.455	0.545	0.527	0.563	0.547	0.599	0.588
M. textilis				-	0.353	0.474	0.670	0.536	0.544	0.249	0.276	0.349	0.431	0.358	0.357
M. violascens					-	0.540	0.722	0.639	0.614	0.446	0.442	0.421	0.434	0.429	0.453
M. coccinea						-	0.607	0.453	0.463	0.434	0.491	0.430	0.529	0.440	0.477
M. nagensium							-	0.416	0.466	0.689	0.662	0.712	0.706	0.677	0.641
M. ornata								-	0.321	0.531	0.476	0.579	0.583	0.550	0.560
M. velutina									-	0.494	0.542	0.527	0.564	0.505	0.558
M. beccarii										-	0.327	0.336	0.351	0.417	0.391
M. monticola											-	0.410	0.415	0.437	0.462
M. campestris												-	0.423	0.357	0.453
M. borneensis													-	0.526	0.525
M. suratii														-	0.405
M. jackeyi															-

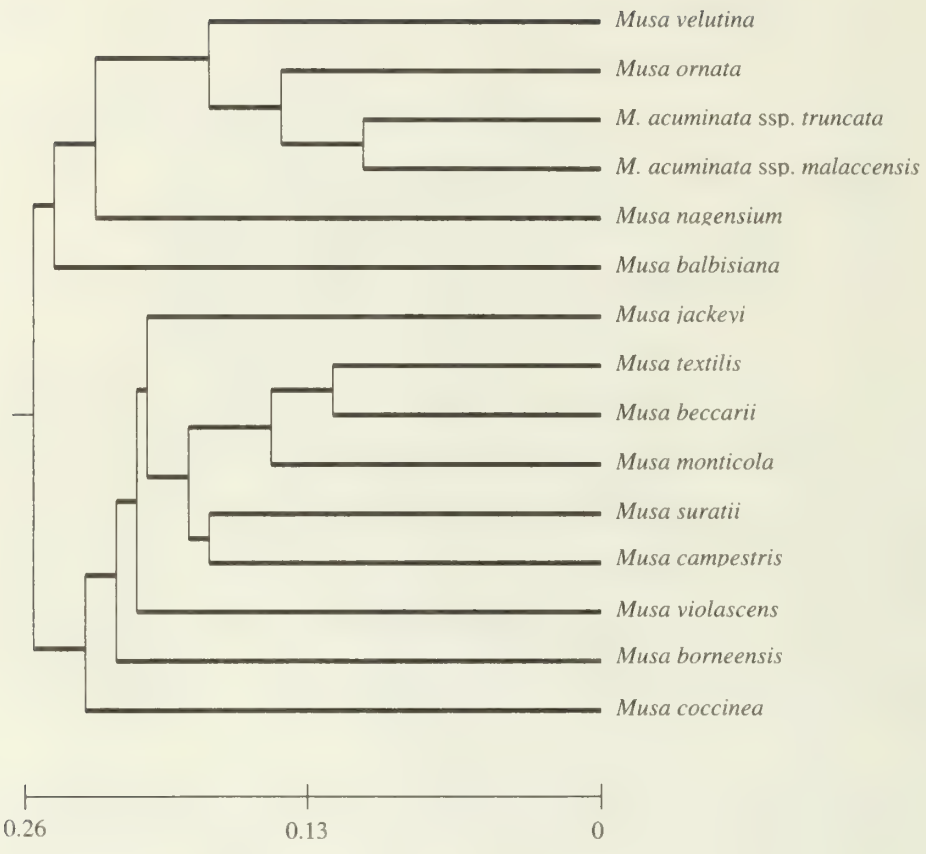

Figure 2. Genetic relationships of 15 species of *Musa* by UPGMA cluster analysis. Scale depicts genetic diversity estimates (GDEs).

M. monticola, *M. suratii* and *M. campestris* Becc., while *M. jackeyi* Hill in sect. *Australimusa* was distant from this subcluster.

Based on the phenogram, *M. beccarii* is closest to *M. textilis* of sect. *Australimusa*. GDE values between *M. beccarii* and both species of sect. *Australimusa* examined ranged from 0.249 (between *M. beccarii* and *M. textilis*) to 0.391 (between *M. beccarii* and *M. jackeyi*), as compared with species of sect. *Callimusa* where values ranged from 0.336 (between *M. beccarii* and *M. campestris*) to 0.446 (between *M. beccarii* and *M. violascens*). These data suggest *M. beccarii* to be closer genetically to species of sect. *Australimusa* than to those of sect. *Callimusa*.

Musa monticola showed a similar pattern in that it was also genetically most similar to *M. textilis*. GDE values between *M. monticola* and species

of sect. *Australimusa* ranged from 0.276 (between *M. monticola* and *M. textilis*) to 0.462 (between *M. monticola* and *M. jackeyi*), while values for species of sect. *Callimusa* ranged from 0.410 (between *M. monticola* and *M. campestris*) to 0.491 (between *M. monticola* and *M. coccinea*). This, too, suggests a higher similarity between *M. monticola* and members of sect. *Australimusa* than between *M. monticola* and members of sect. *Callimusa*.

Musa suratii clustered closely with *M. campestris*, which belongs to sect. *Callimusa* and had GDE values ranging from 0.357 (between *M. suratii* and *M. campestris*) to 0.526 (between *M. suratii* and *M. borneensis*) when compared with species in sect. *Callimusa*. On the other hand, species of sect. *Australimusa* possessed GDE values of between 0.358 (between *M. suratii* and *M. textilis*) to 0.405 (between *M. suratii* and *M. jackeyi*). GDEs between *M. suratii* and *M. textilis*, and *M. suratii* and *M. campestris* are highly similar, giving no indication of whether *M. suratii* is genetically closer to members of sect. *Callimusa* or sect. *Australimusa*.

Discussion

AFLP is highly informative and reliable in providing valuable insight into genetic similarities between species. In addition, it is useful in generating unique molecular markers for identification purposes and the development of these is important in the improvement of banana breeding programmes. In assessing unique bands, results confirm both *M. monticola* and *M. suratii* to be distinct species as described by Argent (2000).

The separation of the *Rhodochlamys-Musa* and *Callimusa-Australimusa* taxa in this molecular result is in agreement with previous morphological data and supports the traditional chromosomal grouping of *Musa* species into the n = 11 group and n = 10 group respectively.

Musa beccarii falls within a cluster comprising *M. textilis* and *M. monticola*. Simmonds and Weatherup (1990) suggested that *M. beccarii* belonged in sect. *Callimusa* based on morphological characters. Our results disagree with that placement as genetically its alliance with sect. *Australimusa* is much stronger.

In addition, the chromosome numbers reported for *M. beccarii* are n = 9 and n = 10, this latter number being due to multivalent formation in meiosis (Shepherd, 1959) and which supports the inclusion of *M. beccarii* in sect. *Australimusa*. The subglobose seed of *M. beccarii* resembles that of sect. *Australimusa* and is unlike the cylindrical seed found in sect. *Callimusa*. Based on its seed structure, chromosome number and the AFLP results obtained, *M. beccarii* is confidently placed within sect. *Australimusa*.

Argent (2000) suggested the inclusion of *M. monticola* in sect. *Australimusa* based on morphological characters. AFLP results are in agreement with this placement, as *M. monticola* clusters closely with *M. textilis* and *M. beccarii*. Values of GDEs support the inclusion of *M. monticola* in sect. *Australimusa*, rather than in sect. *Callimusa*. Although *M. monticola* is distinct from *M. textilis* morphologically, e.g. in pseudostem height, the length of the male peduncle, imbrication of the male bud, and characteristics of the basal flower and seeds (Argent, 2000), they are genetically the most closely related.

Interestingly, *M. suratii* clustered closely with *M. campestris* of sect. *Callimusa*, but GDEs indicate high genetic similarity with *M. textilis* suggesting *M. suratii* to be intermediate between sect. *Callimusa* and sect. *Australimusa*. Argent (2000) noted that its unique tiny seeds provide no clue as to its sectional alliance. Jong and Argent (2001) determined its chromosome number as n = 10, which further supports its position within the *Callimusa-Australimusa* group. AFLP results show *M. suratii* falling between sect. *Callimusa* and sect. *Australimusa* suggesting that the two sections can no longer be maintained as distinct.

Conclusion

AFLP has shown *M. monticola* and *M. suratii* to be distinct species as described by Argent (2000). In addition, results unambiguously show that these three species fall within the *Callimusa-Australimusa* alliance of *Musa*, thus disproving any notion of them belonging to the *Musa-Rhodochlamys* alliance. Their chromosome numbers also support this placement. *M. beccarii* and *M. monticola* possess high genetic similarities with *M. textilis* in sect. *Australimusa*, while *M. suratii* is intermediate between *M. campestris* in sect. *Callimusa* and *M. textilis* in sect. *Australimusa*.

UPGMA cluster analysis illustrates why the problem has arisen as the three species in question, *M. beccarii*, *M. monticola* and *M. suratii*, in fact cluster between taxa in sect. *Australimusa* (with *M. jackeyi* being most distant) and taxa in sect. *Callimusa* (with *M. coccinea*, *M. borneensis* and *M. violascens* being most distant) and are intermediate between *M. campestris* in sect. *Callimusa* and *M. textilis* in sect. *Australimusa*. While *M. beccarii* is definitely closer to *M. textilis* and can therefore be said to fall within sect. *Australimusa*, *M. monticola* and *M. suratii* are intermediate and could equally belong to either section. The single character that separates the two sections is the seed type and, while that of *M. monticola* is more like that of sect. *Australimusa*, that of *M. suratii* is unique and conforms to neither section. This calls into question the validity of keeping

sections *Australimusa* and *Callimusa* distinct. This problem is dealt with in a later study.

Acknowledgements

This research was funded by the Academic Research Fund, National Institute of Education, Nanyang Technological University, Singapore, RP 12/98/GYY. We thank the Director of Singapore Botanic Gardens for permission to collect leaf samples, George Argent (Royal Botanic Garden Edinburgh, UK) for providing plant materials and useful comments on the manuscript and Kwiton Jong (University of Aberdeen, Scotland, UK) for making available his data on cytology.

References

Aggarwal, R.K., D.S. Brar, S. Nandi, N. Huang and G.S. Khush. 1999. Phylogenetic relationships among *Oryza* species revealed by AFLP markers. *Theoretical and Applied Genetics*. **98**: 1320—1328.

Argent, G.C.G. 1976. The wild bananas of Papua New Guinea. *Notes Royal Botanic Garden Edinburgh*. **35**: 77—114.

Argent, G. 2000. Two interesting wild *Musa* species (Musaceae) from Sabah, Malaysia. *Gardens' Bulletin Singapore*. **52**: 203—210.

Beismann, H., J.H.A. Barker, A. Karp and T. Speck. 1997. AFLP analysis sheds light on distribution of two *Salix* species and their hybrid along a natural gradient. *Molecular Ecology*. **6**: 989—993.

Bhat, K.V., S.R. Bhat and K.P.S. Chandel. 1992. Survey of isozyme polymorphism for clonal identification in *Musa*. II. Peroxidase, superoxide dismutase, shikimate dehydrogenase and malate dehydrogenase. *Journal Horticultural Science*. **67**: 737—743.

Cheesman, E.E. 1947. Classification of the bananas. II. The Genus *Musa* L. *Kew Bulletin*. **2**: 106—117.

Crouch, J.H., H.K. Crouch, H. Constandt, A. Van Gysel, P. Breyne, M. Van Montagu, R.L. Jarret and R. Ortiz. 1999. Comparison of PCR-based molecular marker analyses of *Musa* breeding populations. *Molecular Breeding*. **5**: 233—244.

Felsenstein, J. 1993. *PHYLIP (Phylogeny Inference Package)* version 3.5c.

Distributed by the author. Department of Genetics, University of Washington, Seattle, U.S.A.

Hotta, M. 1987. Distribution of the genus *Musa* in Malesia. *Acta Phytotaxonomica et Geobotanica.* **38**: 292—302.

Jong, K. and G. Argent. 2001. Cytology of two new species of *Musa* (Musaceae) from Borneo and their sectional relationship. *Gardens' Bulletin Singapore.* **53**: 185—189

Kaemmer, D., R. Afza, K. Weising, G. Kahl and F.J. Novak. 1992. Oligonucleotide and amplification fingerprinting of wild species and cultivars of banana (*Musa* spp.). *Bio/technology.* **10**: 1030—1035.

Loh, J.P, R. Kiew, A. Kee, L.H. Gan and Y.Y. Gan. 1999. Amplified fragment length polymorphism (AFLP) provides molecular markers for the identification of *Caladium bicolor* cultivars. *Annals Botany.* **84**: 155—161.

Novak, F.J. 1992. *Musa* (Bananas and Plantains). *In*: F.A. Hammerschlag and R.E. Litz (eds.). *Biotechnology of Perennial Fruit Crops.* CAB International.

Paul, S., F.N. Wachira, W. Powell and R. Waugh. 1997. Diversity and genetic differentiation among populations of Indian and Kenyan tea (*Camellia sinensis* (L.) O. Kuntze) revealed by AFLP markers. *Theoretical and Applied Genetics.* **94**: 255—263.

Powell, W., M. Morgante, C. Andre, M. Hanafey, J. Vogel, S. Tingey and A. Rafalski. 1996. The comparison of RFLP, RAPD, AFLP and SSR (microsatellite) markers for germplasm analysis. *Molecular Breeding.* **2**: 225—238.

Reichardt, M.J. and S.J. Rogers. 1993. Plant DNA isolation using CTAB. *In*: F.M. Ausubel, R. Brent, R.E. Kingston, D.D. Moore, J.G. Seidman, J.A. Smith and K. Struhl (eds.). *Current Protocols in Molecular Biology*, supplement 22, John Wiley and Sons, USA.

Shepherd, K. 1959. Two new basic chromosome numbers in Musaceae. *Nature.* **183**: 1539.

Simmonds, N.W. 1960. Notes on banana taxonomy. *Kew Bulletin.* **14**: 198—212.

Simmonds, N.W. 1962. *The Evolution of the Bananas.* Longmans, London, U.K.

Simmonds, N.W. and K. Shephard. 1955. The taxonomy and origin of the cultivated banana. *Journal Linnean Society (Botany)*. **55**: 302—312.

Simmonds, N.W. and S.T.C. Weatherup. 1990. Numerical taxonomy of the wild bananas (*Musa*). *New Phytologist*. **115**: 567—571.

Tohme, J., D.O. Gonzalez, S. Beebe and M.C. Duque. 1996. AFLP analysis of gene pools of a wild bean core collection. *Crop Science*. **36**: 1375—1384.

Travis, S.E., J. Maschinski and P. Keim. 1996. An analysis of genetic variation in *Astragalus cremnophylax* var. *cremnophylax*, a critically endangered plant, using AFLP markers. *Molecular Ecology*. **5**: 735—745.

Vos, P., R. Hogers, M. Bleeker, M. Reijans, T. van de Lee, M. Hornes, A. Frijters, J. Pot, J. Peleman, M. Kupier and M. Zabeau. 1995. AFLP: a new technique for DNA fingerprinting. *Nucleic Acids Research*. **23**: 4407—4414.

Zhang, W.P., J.F. Wendel and L.G. Clark. 1997. Bamboozled again! Inadvertent isolation of fungal rDNA sequences from bamboos (Poaceae: Bambusoideae). *Molecular Phylogenetics and Evolution*. **8**: 205—217.

Gardens' Bulletin Singapore **53** *(2001) 343–356.*

New Combinations, New Names and New Species of *Madhuca* (Sapotaceae) from Sabah and Sarawak, Borneo

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Abstract

Five new species of *Madhuca*, *M. engkikiana*, *M. markleeana*, *M. multinervia*, *M. ochracea*, and *M. silamensis*, are described and two new combinations, *M. daemonica* and *M. prolixa*, and two new names, *M. cheongiana* and *M. kuchingensis*, are proposed as a consequence of the reduction of *Ganua* to *Madhuca*.

Introduction

In revising the family Sapotaceae for the Tree Flora of Sabah and Sarawak, we accepted Pennington's reduction (1991) of *Ganua* Dubard (1908) to *Madhuca* Buch.–Ham. *ex* J.F. Gmelin (1791). The enlarged genus *Madhuca* comprises 47 species and one variety in Sabah and Sarawak out of a total of 50 species found in Borneo.

The Sabah and Sarawak account includes two new combinations (*M. daemonica* and *M. prolixa*), two new names (*M. cheongiana* and *M. kuchingensis*), and five new species (*M. engkikiana*, *M. markleeana*, *M. multinervia*, *M. ochracea*, and *M. silamensis*) here described.

New Combinations and New Names

1. ***Madhuca cheongiana*** Yii & P. Chai, **nom. nov.**

Synonyms: *Ganua sarawakensis* Pierre *ex* Dubard, Bull. Mus. Hist. Nat. Paris 14 (1908) 409. **Type:** *Beccari PB 3105*, Borneo, Sarawak, Kuching (holotype FI, *n.v.*); Van den Assem, Blumea 7 (1953) 375; *Ganua attenuata* Griffioen & H.J. Lam, *nom. ined.*, Anderson, A Checklist of the Trees of Sarawak (1980) 314, *nom. nud.*

Notes: In transferring *Ganua sarawakensis* to the genus *Madhuca*, the species name "*sarawakensis*" cannot be used because it is already preoccupied by *Madhuca sarawakensis* (Pierre *ex* Dubard) H.J. Lam, Bull. Jard. Bot. Buitenz., 3, 7 (1925) 180, based on *Kakosmanthus sarawakensis* Pierre *ex*

Dubard, Bull. Mus. Hist. Nat. Paris 14 (1908) 407, and typified by *Beccari PB 423*, Borneo, Sarawak, Kuching (holotype P, *n.v.*; isotypes FI, L, *n.v.*).

The species is endemic to Borneo (Brunei Darussalam, Kalimantan, Sabah, and Sarawak). In Sabah and Sarawak, it is uncommon and scattered in a few localities (*SAN 29561*, *SAN 33601*, *SAN 36601A*, *SAN 86191*, *SAN 126691*; *S 2162*, *S 2222*, *S 7559*, *S 15043*, *S 15437*, *S 29477*, and *S 32947*), and occurs mainly in lowland kerangas and mixed dipterocarp forests below 200 m altitude.

The species is named in honour of Mr. Cheong Ek Choon, the Director of the Sarawak Forestry Department, for his interest and continuous support in the study of the diversity, conservation and sustainable management of forest tree resources in Sarawak.

2. ***Madhuca daemonica*** (Van den Assem) Yii & P. Chai, **comb. nov.**

Basionym: *Ganua daemonica* Van den Assem, Blumea 7 (1953) 394. **Type:** *Egar A 0932*, Borneo, Sarawak, Setapok FR (holotype KEP!).

Notes: A species endemic to Borneo and found in a few localities in Sabah (*SAN 17437*, *SAN 17448*), and more commonly in Sarawak (*Egar A 0932*, *S 2618*, *S 2722*, *S 2768*, *S 4423*, *S 4666*, *S 5866*, *S 7088*, *S 12393*, *S 12965*, *S 14462*, *S 30039*, and *S 36452*). Its habitats include peatswamp, kerangas and mixed dipterocarp forests at altitudes up to 700 m.

3. ***Madhuca kuchingensis*** Yii & P. Chai, **nom. nov.**

Based on *Ganua beccarii* Pierre *ex* Dubard, Bull. Mus. Hist. Nat. Paris 14 (1908) 408. **Type:** *Beccari PB 2241*, Borneo, Sarawak (holotype FI, *n.v.*).

Notes: In the genus *Madhuca*, there exists *M. beccarii* (Engl.) H.J. Lam, Bull. Jard. Bot. Buitenz., 3, 7 (1925) 177, based on *Payena beccarii* Engl., Bot. Jahrb. 12 (1890) 508, and typified by *Beccari PB 1598*, Borneo, Sarawak, Kuching (holotype FI, *n.v.*; isotypes K, P, *n.v.*). The new name *Madhuca kuchingensis* Yii & P. Chai is, therefore, proposed.

The species is endemic to Borneo and confined to the central and western parts of Sarawak (*S 3356*, *S 4307*, *S 14846*, *S 24344*, *S 24514*, *S 24516*, *S 24545*, *S 24602*, *S 27064*, *S 32394*, *S 32472*, *S 37044*, and *S 37861*), and found mainly in lowland kerangas and mixed dipterocarp forests at altitudes up to 100 m.

4. ***Madhuca prolixa*** (Pierre *ex* Dubard) Yii & P. Chai, **comb. nov.**

Basionym: *Ganua prolixa* Pierre *ex* Dubard, Bull. Mus. Hist. Nat. Paris 14 (1908) 409. **Type:** *Beccari PB 2446*, Borneo, Sarawak, Kuching (holotype FI, *n.v.*; isotype L, *n.v.*).

Notes: A species occurring in Peninsular Malaysia and Borneo. Scattered throughout Sarawak in lowland mixed dipterocarp forest at altitudes up to 200 m (*S 4099*, *S 18771*, *S 25258*, and *S 29249*). It also occurs in Brunei (*BRUN 2476* and *BRUN 3317*).

New Species

1. ***Madhuca engkikiana*** Yii & P. Chai, **sp. nov.**
(Engkik Soepadmo, Coordinator and Chief Editor of the Tree Flora of Sabah & Sarawak project)

Madhucae kuchingensi arcte similis, sed in ramulis glabris foliis bene dispositis, venatione intercostali reticulata supra non impressa, venis paucis e costa enascentibus venis lateralibus parallelis differt. **Typus:** *Kodoh Tarodop SAN 83612*, Borneo, Sabah, Sandakan, Telupid (holotypus SAR!; isotypi AA, K, KEP!, L, SAN!, SING!).

Figure 1

Tree up to 25 m tall, 42 cm diameter. *Bark* reddish grey; inner bark yellowish red. Sapwood yellow. *Twigs* slender, terete, glabrous. *Terminal buds* c. 3 mm long, puberulous. *Stipules* triangular, c. 1 x 0.4 mm. *Leaves* spirally arranged, scattered and well-spaced along the twigs, coriaceous, glabrous on both surfaces; blade elliptic to elliptic-obovate, 9–13 x 3.5–4.8 cm, base cuneate, slightly decurrent and oblique, margin entire and plane, apex short-acuminate; midrib raised on both surfaces; lateral veins 11–15 pairs, ascending at an angle of c. 80° from the midrib, distinctly connected by the thickened intercostal veins to form intramarginal vein-loops, prominent on both surfaces; intercostal venation reticulate, with a few veins arising from the midrib and parallel to the lateral veins; petioles 2–3.5 cm long, flat to slightly raised on the adaxial side, thickened, black and puberulous at the base. *Inflorescences* axillary, 6–8-flowered; pedicels up to 0.3 cm long, yellowish appressed hairy. *Flowers:* calyx biseriate, consisting of two whorls of two sepals; sepals suborbicular, c. 3 x 2.5 mm, tufted hairy at the apex; corolla c. 2 mm long, tube c. 0.75 mm long, lobes 7, oblanceolate, densely pubescent with tufted yellowish hairs at the apex; stamens 16, in two whorls,

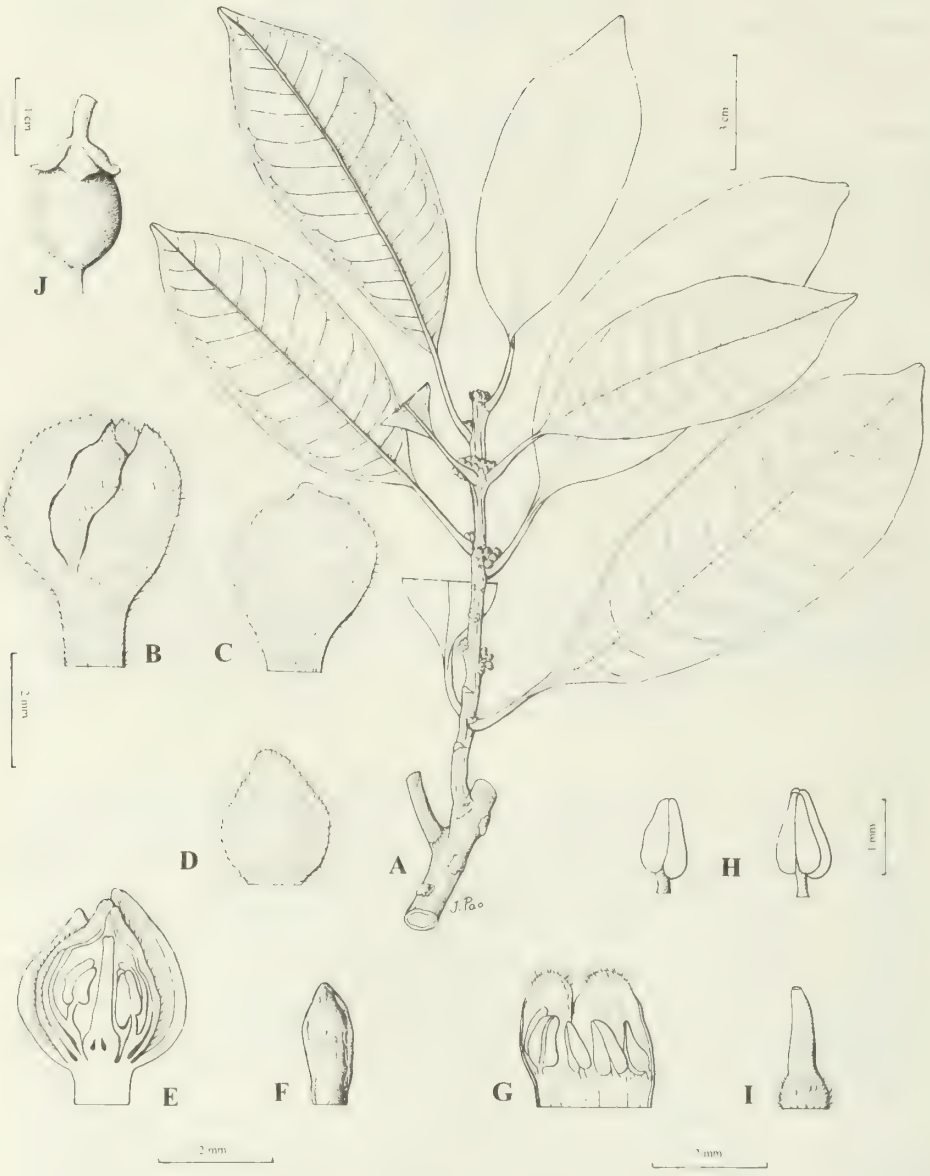

Figure 1. *Madhuca engkikiana*. A, leafy flowering twig; B, flower bud; C, outer sepal; D, inner sepal; E, longitudinal section of flower bud; F, petal; G, petals and stamens; H, stamens in different views; I, gynoecium; J, fruit. (A–I from *SAN 83612*, J from *SAN 131963*.)

filaments very short, anthers lanceolate, c. 1 x 0.5 mm, slightly hairy; ovary subconical, c. 2 mm long, hairy, 6–7-loculed, style stout, c. 1.5 mm long. *Fruits* (young) ellipsoid, laterally compressed, 1.5 x 0.6–1.2 cm, densely brownish tomentose. *Seeds* laterally compressed, pointed at both ends; testa thin, smooth; scar linear.

Distribution: Endemic to Borneo. Known only from four collections from Sabah (*SAN 53982*, *SAN 54205*, *SAN 131963*, and the type).

Ecology: In lowland mixed dipterocarp forest, up to 250 m altitude.

Notes: Similar to *Madhuca kuchingensis* but differs by its glabrous twigs, leaves well-spaced along the twigs, and reticulate intercostal venation that is not impressed above and with a few shorter veins arising from midrib and parallel to lateral veins.

2. ***Madhuca markleeana*** Yii & P. Chai, **sp. nov.**
(Mark Lee Hua Seng, Deputy Director, Forestry Department, Sarawak)

Madhucae borneensi et M. sarawakensi in characteribus vegetativis similis, sed in ramulis laminisque foliorum glabris, stipulis orbicularibus, sepalis exterioribus magnis suborbicularibus et recurvatis, pedicello fructifero longiore (7–8 cm longo) differt. **Typus:** *Yii S 72728*, Borneo, Sarawak, Bukit Meluku (holotypus SAR!; isotypi K, KEP!, L, SAN!).

Figure 2

Tree up to 15 m tall, 25 cm diameter, with very low buttresses. *Bark* chocolate brown with greyish green mottles, smooth to finely fissured; inner bark c. 4 mm thick, dull orange, granular. *Twigs* terete, rusty-brown velvety hairy at the tips, glabrescent. *Terminal buds* up to 8 mm long; bud-scales elliptic, 10–14 x 9–11 mm. *Stipules* lanceolate, c. 10 x 3 mm, velvety hairy, caducous. *Leaves* spirally arranged, scattered and well-spaced along the twigs, coriaceous, glabrous on both surfaces; blade lanceolate or oblong, 25–35 x 7–8 cm, base broadly cuneate and slightly oblique, margin entire and plane, apex obtuse or acuminate with a sharp tip; midrib broadly crested above, prominent below; lateral veins 28–35 pairs, ascending at an angle of 75–85° from the midrib, straight at first and then curving and joining at their tips to form vein-loops rather far from the leaf margin, impressed above, prominent below; intercostal venation slender, scalariform, with at least one vein descending from the margin and parallel to the lateral veins, faint above, distinct below; petioles 1.5–2.5 cm long, flat on

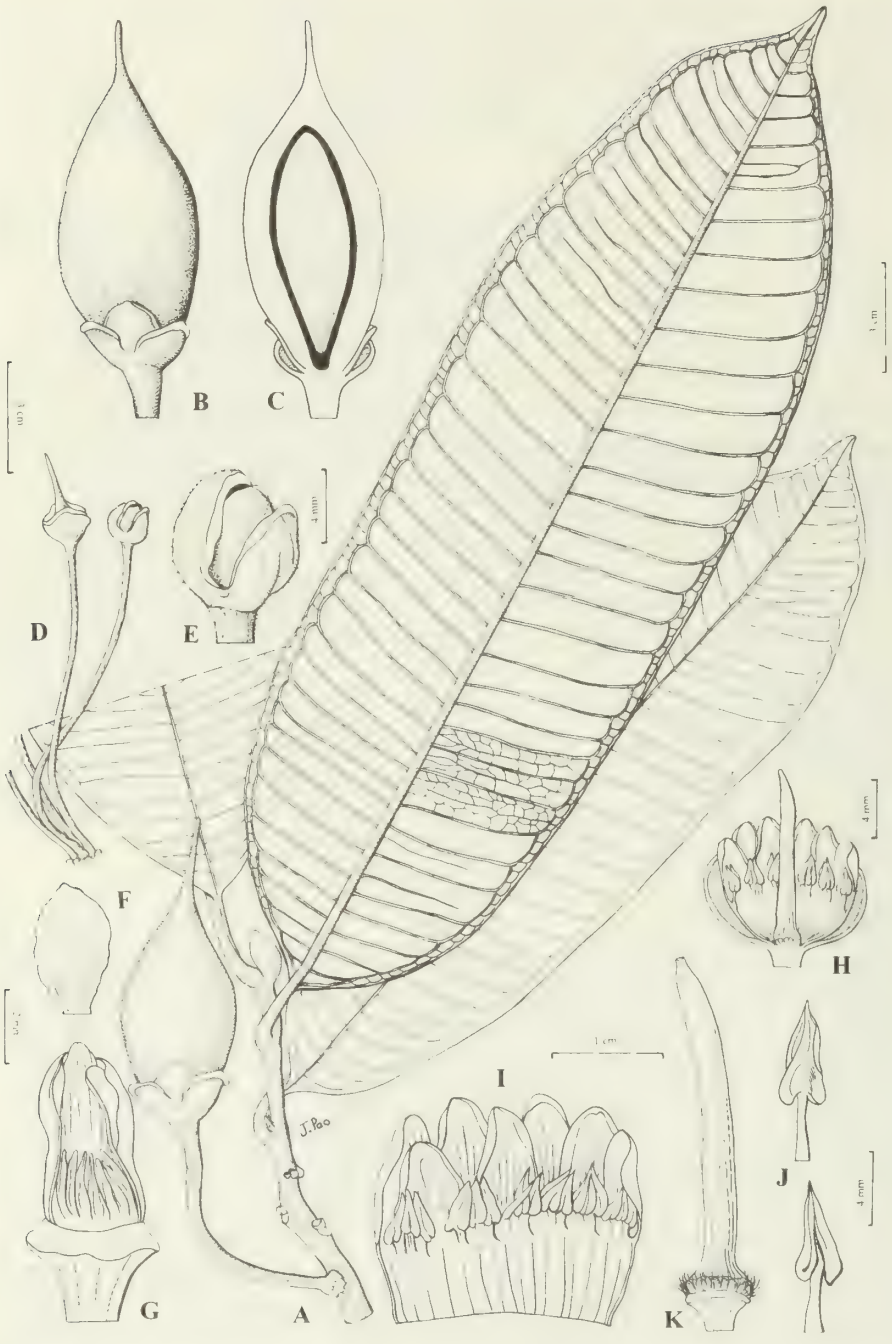

Figure 2. *Madhuca markleeana.* A, fruiting leafy twig; B, fruit; C, longitudinal section of fruit; D, part of inflorescence; E, flower bud; F, petal; G, flower bud with sepals and a few petals removed; H, longitudinal section of flower bud; I, petals and stamens; J, stamens in different views; K, gynoecium. (A–C from *S 72729*, D–K from *S 72728.*)

the adaxial side, round on the abaxial side, velvety hairy, glabrescent. *Inflorescences* axillary, 3–5-flowered; pedicels subangular, 5–6 cm long, pale green, sparsely pubescent. *Flowers:* calyx biseriate, consisting of two whorls of two sepals; sepals suborbicular, c. 10 x 14 mm, outer pair with recurved margin, inner pair smaller, margin not recurved, pubescent; corolla white, c. 12 mm long, lobes 8, lanceolate, 7–8 mm long, apex acute, tube c. 4 mm long, slightly pubescent at the throat; stamens 19, in two whorls, filaments subulate, c. 5 mm long, anthers sagittate, yellowish, c. 5 mm long; ovary disciform, c. 3 x 5 mm, 8-loculed, pilose, style filiform, pale green, tapering towards stigma. *Fruits* ellipsoid, c. 7 x 4 cm, 1-seeded, tapering at both ends; pericarp thick and fleshy, green, densely brown tomentose; stalk 7–8 cm long. *Seeds* ellipsoid, 4.5 x 1.2–2 cm, pointed at both ends; testa thin; scar narrowly linear, c. 43 x 3 mm.

Vernacular name: Sarawak—*nyatoh gasing* (Malay).

Distribution: Endemic to Sarawak; known only from two collections, the type and *Yii S 72729*, Borneo, Sarawak, Bukit Meluku (K, KEP!, L, MO, SAN!, SAR!, SING!).

Ecology: Understorey tree on steep slopes of lowland mixed dipterocarp forest, up to 400 m altitude.

Notes: Resembles *Madhuca borneensis* and *M. sarawakensis* in vegetative characters but differs in having glabrous twigs and leaves, orbicular stipules, large suborbicular and recurved outer sepals, and longer fruit stalk (7–8 cm long).

3. ***Madhuca multinervia*** Yii & P. Chai, **sp. nov.**
(Latin, *multi* = many, *nervis* = nerves; alluding to the many, closely parallel lateral veins of the leaves)

Madhucae elmeri arcte similis in characteribus vegetativis, sed in ramulis novellis foliis petiolisque glabris, venis lateralibus 28–45 paribus arcte approximatis ascendentibus distinguenda. **Typus:** *Dewol SAN 97008*, Borneo, Sabah, Tongod district, Bt. Pantagaluang (holotypus SAR!; isotypi AA, BO!, K, KEP!, L, OX, SAN!, SING!).

Figure 3

Tree up to 20 m tall, 40 cm diameter. *Bark* pale brown with greyish mottles, smooth; inner bark pale reddish, with sticky white latex. Sapwood whitish.

Twigs slender, solid, 2–4 mm diameter, subangular with distinct stipular scars, rusty-brown velvety hairy at the tips, quickly glabrescent and becoming blackish. *Terminal buds* c. 5 mm long. *Stipules* broadly ovate, c. 6 x 4 mm, truncate, rusty-brown velvety. *Leaves* spirally arranged and scattered along ends of twigs, papyraceous to subcoriaceous, glabrous or with appressed silvery hairs on the midrib above, glabrous or with remnants of appressed silvery hairs and subappressed ferrugineus hairs on the midrib below; blade oblong-elliptic, 16.5–19 x 5–12 cm, base obliquely cuneate to rounded, margin entire and plane, apex obtuse; midrib impressed and slightly crested above, strongly prominent and rounded below; lateral veins 28–45 pairs, ascending at an angle of 65–85° from the midrib, straight or slightly curved, arching and joining into vein-loops at 1–2 mm from the leaf margin, impressed above, prominent below; intercostal venation scalariform, faint; petioles 2–4 cm long, thickened, narrowly grooved on the adaxial side, rounded on the abaxial side, rugose and black at the base, glabrous. *Inflorescences* axillary, 3–10-flowered; pedicels 1–2 cm long, slender, velvety hairy. *Flowers:* calyx biseriate, consisting of two whorls of two sepals; sepals free, imbricate, orbicular, c. 6 mm across, velvety hairy, inner pair thinner, crested and hairy; corolla 7–10 mm long, 8-lobed, lobes elliptic or ovate, c. 3.5 x 1.5 mm, apex acute, densely hairy at the throat; stamens 16–24, in two or three whorls, filaments very short, anthers sagittate, c. 3.5 mm long; ovary subconical, c. 1 mm across, 8-loculed, glabrous, style c. 8 mm long, glabrous. *Fruits* ellipsoid, up to 2.1 x 1.2 cm, 1-seeded; pericarp thin, glabrous; stalk up to 2 cm long. *Seeds* laterally compressed, ellipsoid to obovoid, 1.7 x 1.1 x 0.8 cm, obtuse at both ends; scar as long as seed, c. 5 mm wide.

Distribution: Endemic to Borneo. Scattered throughout the eastern parts of Sabah (*SAN 88312*, *SAN 93874*, *SAN 96918*, *SAN 97008*, *SAN 99692*, *SAN 99726*, *SAN 111764*, *SAN 124566*, and *SAN 133478*).

Ecology: Usually on hillsides and ridges in primary lowland mixed dipterocarp forest.

Notes: Closely allied to *Madhuca elmeri* in vegetative characters but can be distinguished by its glabrous young twigs, leaves and petioles, and 28–45 pairs of closely set ascending lateral veins.

4. ***Madhuca ochracea*** Yii & P. Chai, **sp. nov.**
(Latin, *ochraceus* = pale yellowish brown; referring to the indumentum)

Figure 3. *Madhuca multinervia*. A, flowering leafy twig; B, flower bud; C, longitudinal section of flower bud; D, outer sepal; E, inner sepal; F, petals; G, part of flower with petals and stamens; H, stamen; I, gynoecium. (All from *SAN 97008*.)

Madhucae dubardii similis in foliis infra persistentiter pallide flavido-brunneo tomentosis, sed in folii margine recurvata, apice caudato, nervis intercostalibus a margine descendentibus venis lateralibus parallellis differt. **Typus:** *Wright S 29130*, Borneo, Sarawak, Niah National Park (holotypus SAR!; isotypi K, L, SAN!, SING!).

Figure 4

Tree up to 25 m tall, 70 cm diameter. *Bark* greyish brown, scaly; inner bark dull orange. *Twigs* angular, glabrous. *Terminal buds* c. 5 mm long. *Stipules* broadly ovate, c. 5 x 4 mm, glabrous, persistent. *Leaves* spirally arranged and crowded at the ends of twigs, coriaceous, glabrous above, covered with persistent pale yellowish brown tomentum below; blade elliptic or elliptic-obovate, 8.5–19 x 3.5–8.2 cm, base cuneate, margin recurved, apex caudate or acuminate, acumen c. 1 cm long; midrib shallowly grooved and crested above, rounded and prominent below; lateral veins slender, 26–34 pairs, ascending at an angle of 80–85° from the midrib, curved, diminishing and becoming inconspicuous toward the leaf margin, faint and impressed above, distinct below; intercostal venation slender, descending from the margin and parallel to the lateral veins, laxly reticulate towards the leaf margin, indistinct above, faint below; petioles 2–4.8 cm long, narrowly grooved on the adaxial side, thickened and rugose at the base. *Inflorescences* axillary, 2–7-flowered; pedicels c. 1.2 cm long, glabrous, angular and enlarged at the apex. *Flowers:* calyx biseriate, consisting of two whorls of two sepals; sepals orbicular, c. 6 mm across, apex rounded, velvety hairy; corolla c. 8 mm long, 10-lobed, lobes obovate, c. 4 x 3 mm, apex rounded and ciliate; stamens 16, in two whorls, filaments c. 2.5 mm long, anthers sagittate, c. 2.5 mm long; ovary subconical, c. 2 mm across, 6–8-loculed, velvety hairy, style c. 7 mm long, subangular, glabrous. *Fruits* (immature) ovoid, c. 1 cm across, base rounded, apex flattened and topped by stout remnant of style, pale yellowish brown hairy. *Seeds* unknown.

Vernacular name: Sarawak—*nyatoh kelabu* (Iban).

Distribution: Endemic to Borneo. Known from only two collections from Sarawak, the type and *S 23100* from the Mentagai Hills, Marudi, Miri Division.

Ecology: In primary lowland mixed dipterocarp forest on clay loam soils, up to 100 m altitude.

Notes: Similar to *Madhuca dubardii* in the persistently pale yellowish brown tomentose leaf undersurface but differs by its recurved leaf margin, caudate

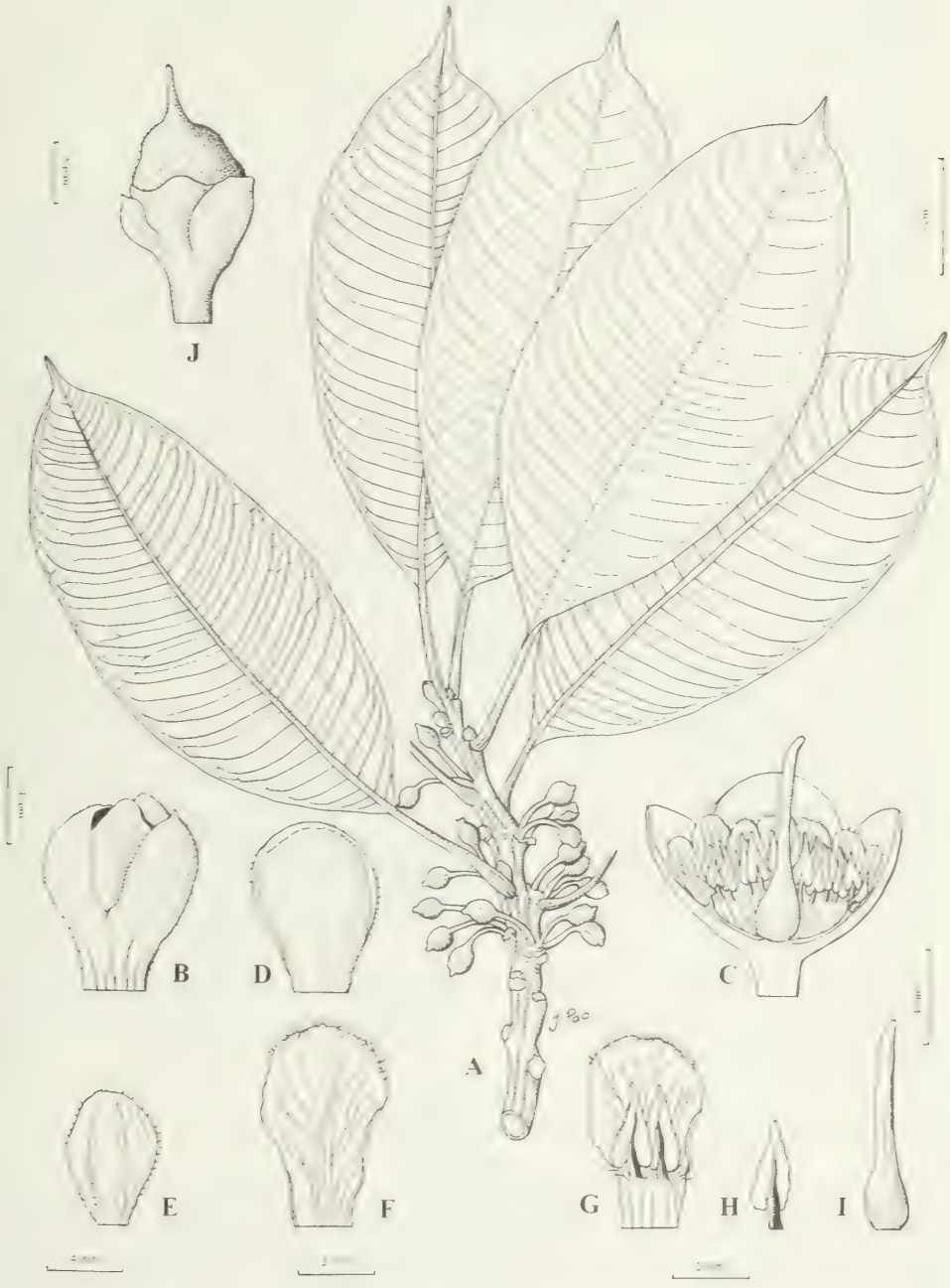

Figure 4. *Madhuca ochracea*. A, flowering leafy twig; B, flower bud; C, longitudinal section of flower bud; D, outer sepal; E, inner sepal; F, petal; G, petal and stamens; H, stamen; I, gynoecium; J, young fruit. (A–I from *S 29130*, J from *S 23100*.)

leaf apex and intercostal veins descending from the margin and parallel to the lateral veins.

5. ***Madhuca silamensis*** Yii & P. Chai, **sp. nov.**
(of Mt. Silam, Sabah)

Ab ullis speciebus borneensibus cognitis in foliis crasse coriaceis argenteo-brunneo tomentosis secus ramos crassos subangulares dispersis distincta. **Typus:** *Mujin SAN 37849*, Borneo, Sabah, Mt. Silam (holotypus SAR!; isotypus SAN!).

Figure 5

Tree up to 9 m tall, 15 cm diameter. *Bark* shallowly fissured or scaly, greyish brown; inner bark brittle, with white latex. *Twigs* stout, subangular, glabrous. *Terminal buds* up to 8 mm long. *Stipules* triangular, c. 4 x 4 mm, crested, glabrous. *Leaves* spirally arranged, scattered and well-spaced along the twigs, thickly coriaceous, silvery brown tomentose on both sides; blade elliptic to oblong-elliptic, 16–25 x 6–8 cm, base narrowly cuneate, margin entire and plane, apex blunt or rounded; midrib raised on both sides, stronger below; lateralveins 15–19 pairs, ascending at an angle of 70–80° from the midrib, curved, diminishing and becoming inconspicuous near the leaf margin, distinctly raised on both surfaces; intercostal venation laxly reticulate; petioles 3–4 cm long, grooved on the adaxial side, thickened at the base, glabrous. *Inflorescence* axillary, 2–3-flowered; pedicels 1–1.5 cm long, angular and slightly enlarged at both ends. *Flowers:* calyx biseriate, consisting of two whorls of two sepals; sepals broadly ovate, 6 x 4 mm, rusty-brown tomentose (mature flowers not seen). *Fruits* unknown.

Distribution: Endemic to Sabah; known only from the type collection from Mt. Silam, Lahad Datu district and *SAN 51742* from Bt. Tawai, Kinabatangan district.

Ecology: In forest on ultrabasic soils, up to 850 m altitude.

Notes: The spirally arranged leaves and the calyx comprising two whorls of two sepals confirm that the specimens belong to *Madhuca*. The species is distinct from any known species of *Madhuca* from Borneo in having thickly coriaceous, silvery-brown tomentose leaves that are scattered along the subangular and stout glabrous twigs.

Figure 5. *Madhuca silamensis*. A, flowering leafy twig; B, flower bud; C, longitudinal section of flower bud; D, gynoecium. (All from *SAN 37849*.)

Acknowledgements

The work was supported financially by the Tree Flora of Sabah and Sarawak project jointly executed by the Forest Research Institute Malaysia (FRIM), Sabah Forestry Department and Sarawak Forestry Department. We are deeply indebted to the Director General and Directors of these institutions for their support and encouragement. Grateful acknowledgements are also due to the Directors/Curators of the Herbarium Bogoriense (BO), and the herbaria of the Forest Research Institute Malaysia (KEP), Sabah Forestry Department (SAN), Sarawak Forestry Department (SAR), Royal Botanic Gardens, Kew (K), National Herbarium of Netherlands, Leiden Branch (L), and Singapore Botanic Gardens (SING) for the loan of specimens and/or hospitality accorded to us during our visit to their institutions. We are extremely grateful to Dr. J.F. Veldkamp for his kind help in providing Latin translations for the diagnoses of the new species. Finally we would like to express our thanks to Mr. Joseph Pao of the Sarawak Forestry Department for diligently preparing the illustrations, and to Dr. E. Soepadmo, Dr. Francis S.P. Ng, and Dr. W. Vink for their constructive criticisms and comments on the manuscript.

References

Dubard, M.M.M. 1908. Les Sapotacées du groupe des Illipées. *Revue Génerale Botanique*. **20**: 201.

Gmelin, J.F. 1791. *Systema Naturae*. **2**, 1: 772 & 799.

Pennington, T.D. 1991. *The Genera of Sapotaceae*. Royal Botanic Gardens, Kew, U.K.

Corrigenda

Gardens' Bulletin Singapore **52** *(2000) 261–271.*

The Significance of Pollen Morphology in the Taxonomy of the Genus *Durio* (Bombacaceae)

I. SALMA

replace page 269 with the following:

graveolens, *D. kutejensis*, *D. oxleyanus*, were reported as oblate spheroidal. Sharma (1970) showed *D. lowianus* and *D. pinangianus* had a similar pollen shape, but that pollen of *D. griffithii* and *D. singaporensis* were oblate and that of *D. carinatus* oblate spheroidal.

Generally, in the majority of species the thickness of the pollen wall varied from 2—4 μm. However, the pollen wall of *D. griffithii* and *D. excelsus* was thin (less than 2 μm) while that of *D. testudinarum* was thick (greater than 4 μm).

Size varied from 46 to 145 μm for the polar diameter (P) and 50 to 120 μm for the equatorial diameter (E) (Table 2). According to the classification of the pollen size by Erdtman (1952), *Durio* pollen can be divided into three groups, i.e. medium (25—50 μm), large (50—100 μm) and very large (100—200 μm). Most *Durio* species fell within the large group except for *D. griffithii*, which had medium to large pollen, and *D. affinis*, *D. oxleyanus*, *D. pinangianus*, *D. testudinarum* and *D. zibethinus*, which possessed large to very large pollen (Table 2). Similar results were obtained by Abang Mokhtar (1991), except that pollen of his sample of *D. griffithii* and *D. acutifolius* fell within the medium-sized group and *D. graveolens* in the very large group. This difference in size was probably due to whether herbarium or fresh specimens were used. Since there was variation in pollen size within a species and variation between species was not distinct, pollen size is therefore not a good character for distinguishing the species.

Conclusions

Only in *D. testudinarum* are pollen characters species-specific (Table 3) and the pollen of this species can clearly be distinguished by a combination of its large size, thick wall and verrucose exine. Although there are differences in pollen morphological characters between the species, intraspecific variation also occurs. A combination of pollen characters, such as the exine sculpture, size and shape, can, in some cases (Table 3), provide supplementary information, which should, however, be used together with other characters for the identification of *Durio* species.

Gardens' Bulletin Singapore **53** *(2001) 359–361.*

Book Review: Paul Kessler (Ed) 2000. **Secondary Forest Trees of Kalimantan, Indonesia. A Manual to 300 Selected Species.** 404 pp. MOFEC Tropenbos, PO Box 319, Balikpapan, Indonesia. ISBN 90-5113-044-9. Paperback. Price US$35, available from The National Herbarium Netherlands, University of Leiden Branch, PO Box 9514, 2300 RA, Leiden, The Netherlands.

This book is a welcome addition to the slowly growing botanical literature on Borneo. The work now being undertaken on the Tree Flora of Sabah and Sarawak (the Malaysian part of Borneo) has shown that the floristic congruence between Indonesian Borneo (Kalimantan) and Malaysian Borneo (Sabah and Sarawak) is over 80%. Any book on the flora of Kalimantan is useful to Sabah and Sarawak and *vice versa*.

About half of the book (p 23–198) is taken up by descriptions of the trees, in alphabetical order by family and species. Each description is followed by concise notes on habitat and ecology, distribution and uses. For each family, there is an identification key to the genera treated, and under each genus, there is an identification key to the species. The other half of the book (p 204–403) is taken up by line drawings, one page per species, illustrating about two-thirds of the 300 species.

There is no overall key to families or to the whole secondary forest flora. Instead, the book offers a comprehensive list of spot characters under which genera are listed where applicable. For example, under spot character 4: armed plants, are listed *Cratoxylum*, *Flacourtia*, *Gmelina*, *Leea*, *Oxyceros* and *Ziziphus*. Under spot character 7: white sap, are listed *Alstonia*, *Artocarpus*, *Cerbera*, *Dyera*, *Ficus*, *Homalanthus*, *Parartocarpus*, *Prainea* and *Tabernaemontana*. Altogether 58 spot characters are compiled. I find spot characters very useful, in fact, more useful than the keys. The keys work only for the selection of species recognised in this manual, whereas spot characters, working at the genus level, tend to cover all species of the listed genera. One can query the list at any point instead of proceeding along the pre-set path of a key. With slight changes, this spot character list can be used anywhere in SE Asia.

The descriptions and illustrations are of a high professional standard. Floral dissections, tertiary venation and indumentum details have been omitted by the artists, but the form and habit of each plant are effectively depicted. From my own experience, I know that getting the drawings done for a flora can be a real hassle. This approach sacrifices the fine details, but saves a lot of time. Otherwise, it would have been very difficult to get such a high proportion of the species illustrated.

The plant identified as *Phyllanthus emblica* is actually *Phyllanthus*

pectinatus, as indicated by the position of the fruits towards the ends of the leafy twigs. In *P. emblica*, the fruits would be close to the base. *P. emblica* ranges across mainland Asia from India to South China but stops at Perlis in north Peninsular Malaysia. *P. pectinatus* replaces it in Sumatra and Peninsular Malaysia south of Perlis (Ng, F.S.P. 2000. *Malaysian Naturalist* **53**(3): 32—35). All Bornean plants previously identified as *P. emblica* are likely to be *P. pectinatus*.

I expected a discussion of the nature and origin of secondary forests in Kalimantan, but the authors, P.J.A. Kessler, P.B. Pelser, C.E. Risdale and K. Sediyasa have carefully avoided this topic. Instead, they offer this cryptic introduction: "After the completion of our manual 'Trees of the Balikpapan – Samarinda area, East Kalimantan, Indonesia' the production of a manual to selected tree species of the secondary forest was considered an urgent necessity. Deforestation in Kalimantan was proceeding at an alarming rate and had led to millions of hectares of more or less severely degraded forest. The recent immense forest fires (1997-1998) added to the loss and made a publication even more urgent." In this way, the authors try to convey a sense of urgency, but do not explain how deforestation and burning impact upon forests, primary and secondary, in Kalimantan. A discussion might have been politically difficult in a book sponsored by the Indonesian Ministry of Forestry and Estate Crops.

I think that what is happening in Kalimantan is too important to ignore. When I went to South Kalimantan recently, I found that the forests there had been replaced by *Imperata* grassland. The sheer scale of grasslands, in the absence of a cattle industry, took me by surprise. In the humid tropics, it needs work to convert woody vegetation to grassland. Logging alone does not result in grasslands. In 1994, I was in West Kalimantan and was shocked to see that for hundreds of kilometres, fires were burning all over the countryside. These were individually small fires that did not obstruct road traffic, but the smoke and haze filled the skies. It was obvious that these fires were the work of the people of the countryside. Their little houses were spaced out so that each could lay claim to many hectares of land – far more land than the settlers could farm manually. To maintain their claims, the settlers had to keep their lands cleared of natural vegetation. Annual burning during the dry season was the only way to do this. Eventually, the woody vegetation would give way to grassland. Why do the settlers clear more land than they can cultivate? They were hoping that plantation companies would eventually acquire the land for oil palm, pulpwood or other industrial crops, and pay compensation. The loggers had indeed opened the way into the forests, but the settlers did the rest. In this scheme of things, secondary forests in Kalimantan are

not forests gradually recovering from logging, but a brief transient phase between forest and *Imperata* grassland. West Kalimantan will soon look like South Kalimantan and the rest of Kalimantan is not far behind.

Francis S.P. Ng
Kepong, Malaysia

Gardens' Bulletin Singapore **53** *(2001) 363.*

Obituary

DR GUNNAR SEIDENFADEN

To our great sadness we learned that Dr Gunnar Seidenfaden passed away in February 2001 at the respectable age of 92. His career as an orchid taxonomist has been a long and extremely fruitful one. He continued to be productive right up to his death, leaving several unfinished manuscripts.

His impact on the taxonomy of the orchids in the Indo-Chinese to Malaysian region has been enormous. The core of his orchidological oeuvre is his revision of the orchids of Thailand. In order to have at least a chance of completing this project he developed his own, slightly unusual but certainly concise style: full bibliography, full citation of specimens, good illustrations but no descriptions. Making use of the information gathered for this project, he produced a checklist for the orchids of Indo-China, and, together with Jeffrey Wood, he revised R.E. Holttum's *Orchids of Malaya*. For the latter project he visited Singapore on several occasions to consult the Singapore Botanic Gardens' herbarium.

Seidenfaden can be ranked among the greatest in the field of South East Asian orchidology, on par with Smith, Schlechter and Holttum. While all these persons were professional plant taxonomists; for Seidenfaden, however, orchid taxonomy was only one of his many fields of interest. One could say that he 'did' the orchids of Thailand as a hobby, which makes his achievements all the more impressive.

Gunnar Seidenfaden has left an admirable scientific legacy. His death is much regretted.

Reference

Seidenfaden, G and J.J. Wood. 1992. *The Orchids of Peninsular Malaysia and Singapore*. Olsen & Olsen, Denmark.

Jaap J. Vermeulen
Singapore Botanic Gardens
Singapore

INSTRUCTIONS TO AUTHORS

Manuscripts: The Gardens' Bulletin publishes original findings and reviews of progress in the field of plant taxonomy, horticulture, and allied subjects. Contributions must be original and the material must not have been submitted for publication elsewhere.

Two copies of the manuscript should be submitted, typed or type printed, and if typed, then the top copy must be one of the two. Type or print on one side only, with double-line spacing and a margin of at least 4 cm. Do not type all the letters of any word in capitals. Underline only in pencil: with a straight line for italic type face and wavy line for bold type face. Authors should see the layout of other papers recently published in this journal to ensure that papers submitted conform as closely as possible to the accepted pattern. Numerical data should only be included if it is essential to the argument and this can be presented either in the form of tables or diagrams. Once the papaer is accepted, a diskette with the final version is required.

Titles and authors: The title should give a concise description of the content of the paper. The name(s) and affiliation(s) of author(s) must be given below the title. Lengthy papers and those of a complex nature must have the contents listed at the beginning of the paper.

Scientific names: The complete scientific name - genus, species, authority, and cultivar where appropriate - must be cited for every organism at time of first mention. The generic name may be abbreviated to the initial thereafter except where intervening references to other genera with the same initial could cause confusion.

Tables: All tables should be numbered and carry headings describing their content. These should be comprehensive without reference to the text.

Abbreviations: Standard chemical symbols may be used in text (e.g. IAA, IBA, ATP), but the full term should be given on the first mention. Dates should be cited as: 3 May 1976. Units of measurement should be spelled out except when preceded by a numeral where they should be abbreviated in standard form: g, mg, ml, etc. and not followed by stops.

Literature citations: Citations in the text should take the form: King and Chan (1964). If several papers by the same author in the same year are cited, they should be lettered in sequence (1964a), (1964b), etc. When papers are by three or more authors they should be cited as e.g., Geesink *et al.* (1981). All references must be placed in alphabetic order according to the surname of the (first) author and the journal title be given in full, as in the following example:

> Stone, B.C. 1994. Additional notes on the genus *Glycosmis* Correa (Rutaceae). *Gardens' Bulletin Singapore. 46: 113-119.*

References to books and monographs should be cited according to the following form:

> Ridley, H.N. 1930. *The Dispersal of Plants Throughout the World.* L.Reeve, Ashford, Kent.

For literature citations in taxonomic papers the following style is required:

> *Medinilla alternifolia* Blume, Mus. Bot. Lugd.-Bat. I:2 (1849) 19.
> *Sterculia acuminatissima* Merr., Philip. J. Sci. 21 (1922) 524.

Illustrations: Drawings should be done in indian ink. Authors should indicate where individual illustrations receive first mention in the text.

Offprints: Authors will be given 50 offprints *gratis*. Additional copies must be ordered and paid for, prior to publication.

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