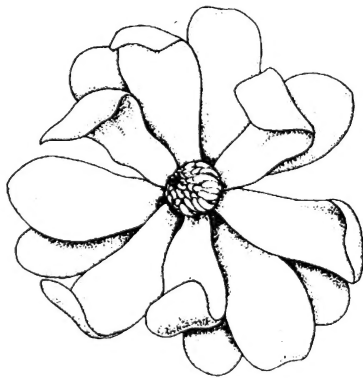




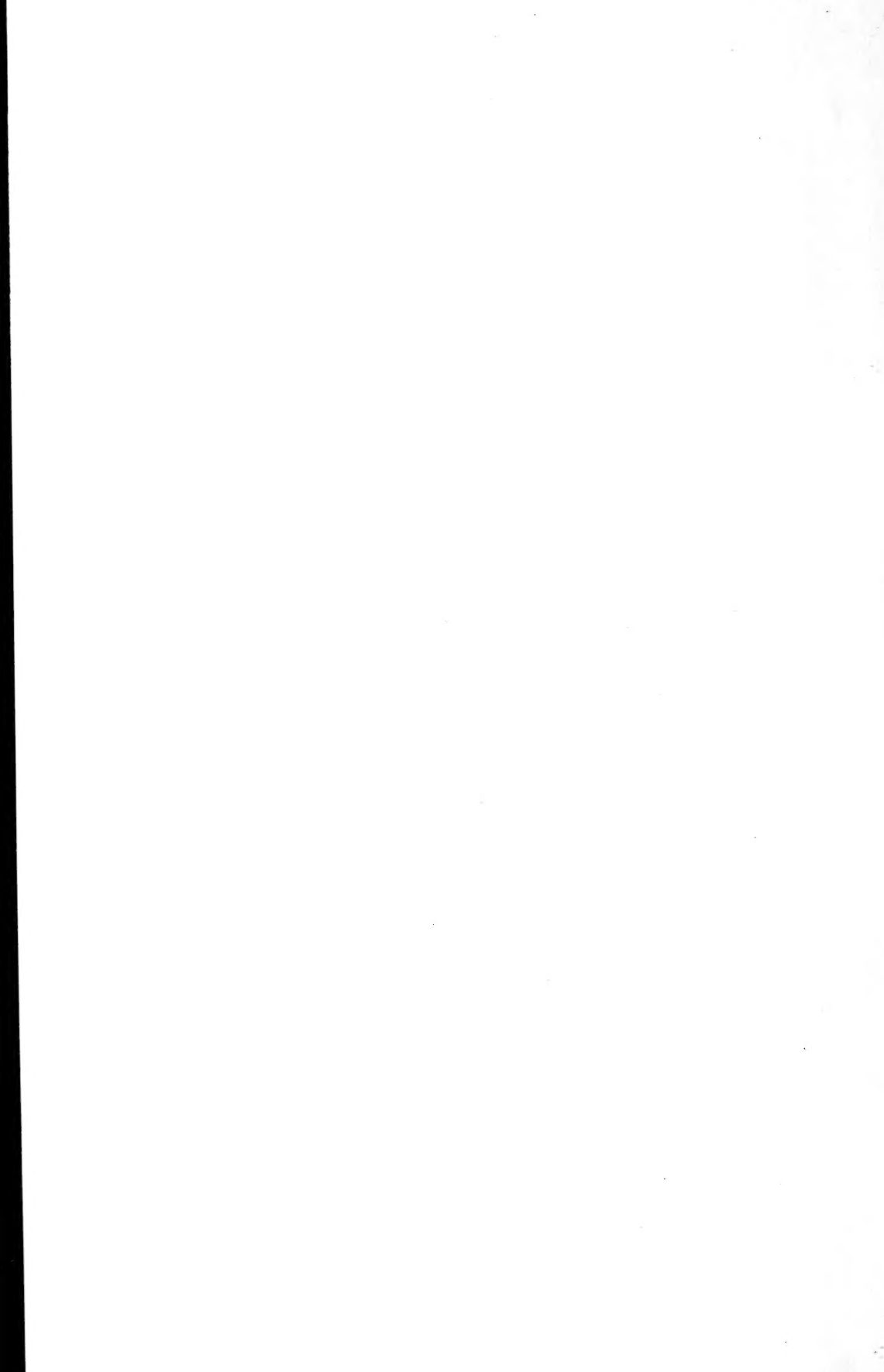


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Singapore's First Spice Plantation and Botanic Garden 1819–1859

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Abstract

The history of the spice plantation and Botanic Garden conceived by Sir Stamford Raffles (1781–1826) for Government Hill (now Fort Canning Hill) in Singapore is documented from its inception in 1819 using archival sources, contemporary accounts, as well as previously published and unpublished maps. After Raffles's departure from Singapore in 1823 and under pressure for retrenchment, the patronage of economic botany shifted from the government to entrepreneurs who revived Raffles's original nutmeg (*Myristica fragrans* Houtt.) plantation in the 1830's, subsequently leading to frenzied nutmeg cultivation around the settlement. A combination of competitive pressure, inadequate husbandry and an insect pest brought nutmeg cultivation on Government Hill and elsewhere in Singapore to an end in 1859. Not only was the spice plantation envisioned by Raffles in existence longer and at times more extensive than previously thought, it also exerted a significant impact on land development in and around the settlement. A map of Government Hill and the surrounding area is shown to illustrate the extent of the Botanic Garden as originally planned, its approximate location in 1827 and the gradual encroachment of other buildings and facilities over time.

Introduction

The powerful combination of George III (1738–1820) and Sir Joseph Banks (1743–1820) created in late eighteenth-century Britain a spirit of agricultural 'improvement' that extended its reaches well beyond domestic agrarian reform. The West Indies, after 1783 deprived of their connection to the American mainland, saw the revival (e.g. St. Vincent) or founding (e.g. Grenada) of Botanic Gardens to prepare for the acclimatization of new Asian plants as

much needed staple foods or crops. In Asia itself, the East India Company was faced with millions of pounds of debt and needed to seek new measures to finance its China trade. Economic botany, in particular the cultivation of commodities of value in Europe or China, it was hoped, would come to the rescue of the East India Company's trade balance (Drayton, 2000, pp. 85–128).

When in 1786 Lieutenant-Colonel Robert Kyd (1746–1793) first approached the Board of Directors with the suggestion for a Company plantation in Calcutta in order to transfer novel food plants to Bengal as a measure against a future famine, his arguments were of a moral and political nature (Kyd to Board of Dir., 15 April 1786, in Biswas, 1950). Subsequently, he withdrew to more traditional mercantile reasoning and detailed the financial benefits the Company could derive from undermining the profitable Dutch monopoly for spices. He envisioned a Botanic Garden 'not for the purpose of collecting rare plants ... as things of mere curiosity', but rather to provide a depository for plants that would 'tend to the extension of the national Commerce and Riches' (Kyd to Board of Dir., 1 June 1786, in Biswas, 1950; Chatterjee, 1948, p. 362; Shukla, 1994, pp. 28–30). As the cultivation of the 'finer spices', nutmeg (*Myristica fragrans* Houtt.) and its derivative mace, cloves (*Syzygium aromaticum* (L.) Merr. & Perry) and cinnamon (*Cinnamomum verum* Presl), had so far and contrary to French successes, eluded the East India Company, the Court of Directors seized upon this opportunity by endorsing Kyd's plan in July 1787. On a site of 310 acres along the Hooghly river, Kyd then introduced about 300 species of commercially significant plants into the new Calcutta Botanic Garden.

Early Spice Cultivation in Penang and Bencoolen

The British occupation of the Moluccas from 1796 to 1803 for the first time allowed unhindered access to the spice gardens of the Banda islands and Ambon (Wright, 1958, p. 27–47), and Kyd's successor, Dr William Roxburgh (1751–1815), immediately sent the botanist Christopher Smith (d. 1807) to organise the transportation of large amounts of nutmeg and clove plants to areas under the Company's control. In the years 1800–1801 over 30,000 nutmeg seedlings and plants and 31,000 clove seeds and plants were dispatched to Penang. The larger spice plants, some as tall as 14 ft and over 15 years old, typically perished during the journey, but not so the younger plant material (Leith to Government (Gov.), 16 July 1800, in Braddell, 1851; Penang to Calcutta, 21 April 1802, in Braddell, 1851; Hunter to Sec. to Gov., 1 July 1802, in Braddell, 1851; Warburg, 1897a, pp. 244–246). The spice plants were cultivated in an extensive government-run spice plantation at Ayer Hitam, where, however, due to the

excessive inventory and ill-guided care the survival rate was low. When in 1805 the annual expenses for the plantations in Penang reached \$11,909, the Calcutta government ordered that they be disposed of, and Lieutenant-Governor Robert Townsend Farquhar (1776-1830) did so by selling the surviving 7,800 spice plants to European individuals for a total of \$9,656 (Farquhar to incoming Gov., 1805, in Braddell, 1851; Penang to Gov., 12 November 1805, in Braddell, 1852). Spanish dollars (\$) were worth about 5 shillings sterling in the early 19th century. Except for a feeble and ultimately abortive attempt at establishing another Company Garden between 1822 and 1834, the further development of the spice industry of Penang was left entirely to private initiative (Low, 1836, p. 20; Warburg, 1897a, p. 246; Jackson, 1968, table 7, p. 105).

In Bencoolen, the British settlement in West Sumatra, fruitless attempts had been made since the early 1770's to procure spice plants, until in 1798 a first shipment of about 850 nutmeg and 70 clove plants arrived (Warburg, 1897a, pp. 226–228; Bastin, 1965, pp. xxxii–xxxiii). Since the initial progress of the nutmeg plants was encouraging, a much larger shipment from the Moluccas followed in 1803, and, despite the Court of Directors' fiscal concerns, the local authorities at Fort Marlborough in Bencoolen decided to cultivate spices in a significant Company-owned nursery, where by 1809 about 3,200 nutmeg trees and 200 clove trees thrived (Fort Marlborough to Court of Dir., 7 March 1804, in Bastin, 1965). However, the second British occupation of the Moluccas from 1810–1817 and the ensuing excessive imports brought about a glut of spices on the London market, and when Sir Stamford Raffles (1781–1826) was dispatched to his post as Lieutenant-Governor of Fort Marlborough in October 1817, he had clear instructions to dispose of the Company's spice plantation there. Unlike Robert Farquhar, who had been criticized for his fire sale of the government plantation in Penang, Raffles resisted the immediate execution of his order and only gradually sold off the stock in the government plantation to locals planters whose spice cultivation he steadfastly encouraged (Remarks on Farquhar's Report by Governor in Council, 20 February 1806, in Braddell, 1851; Raffles to Court of Dir., 18 April 1818, in Bastin, 1965).

In late 1818, Raffles stayed in Calcutta in order to lobby for his plan of permanently securing the British trade route through the Straits of Malacca and thus had the opportunity to explore the Calcutta Botanic Garden where he became acquainted with the Danish surgeon and botanist Dr Nathaniel Wallich (1786–1854). In 1809, Roxburgh's support had helped Wallich to be employed by the East India Company as a collector 'to travel about in search of the unknown objects of natural history' (Roxburgh to Gov., 24 February 1809, in Bastin, 1981), and in 1817 Wallich was appointed permanent Superintendent of the Calcutta Garden. Wallich introduced Raffles to Dr William Jack (1795–1822), a physician and outstanding systematic botanist, staying at the Garden to pursue his botanical interests. Raffles immediately engaged Jack as his

naturalist. Jack was to replace Raffles's previous naturalist Dr Joseph Arnold (1782-1818) who had died in July 1818, shortly after discovering with Raffles and Lady Raffles the parasitic plant that would be named *Rafflesia arnoldii* R.Br. (Burkill, 1916, p. 149; van Steenis-Kruseman, 1950, pp. 23-24; Bastin, 1990, p. 12).

First Spice Plantation in Singapore, 1819–1822

When in January 1819, Raffles and Major William Farquhar (1770–1839) settled on Singapore island for a new British trading post, they found a Malay fishing village surrounded by lush primary forest with ample fresh water supplies. Even during those first days spent on Singapore island, Raffles took time to study the vegetation and engage in some botanising (Raffles to Marsden, 31 January 1819, in Raffles, 1830). Raffles returned to Singapore a second time in May 1819 for about three weeks to instruct the new Resident Farquhar on numerous administrative issues, and this time he brought along a group of naturalists comprised of Jack and two Frenchmen, Alfred Duvaucel (1793–1863) and Pierre Diard (1795–1863) who later became Director of the Botanic Garden at Buitenzorg (now Bogor) in Java (Treub, 1893, p. 34; van Steenis-Kruseman, 1950, p. 136). After exploring the island, Jack was overwhelmed with the abundance of the vegetation, reporting to Wallich:

‘Flora here luxuriates in endless varieties, where she finds soil, climate and everything congenial. I find many, or most of my Penang acquaintances with others surpassing them in magnificence’ (Jack to Wallich, 8 June 1819, in Burkill, 1916).

If the luxuriant growth of tropical vegetation was not enough to raise Raffles's hopes for successful plantations on the island, there was also evidence of past and ongoing agriculture around what was known to the local Malays as *Bukit Larangan* (Forbidden Hill). This cone-shaped eminence, located between the Singapore River and a fresh water stream (Bras Basah River), in March 1819 had undergone some clearing (Hill, 1970, p. 146; *ibid.*, p. 168) whereby workers came upon an abandoned orchard on the apparently fertile hillside. A few years later this orchard was still being recognized as a remnant of Singapore's past:

‘It is remarkable, that many of the fruit-trees cultivated by the ancient inhabitants of Singapore are still existing, on the eastern side of the hill, after a supposed lapse of near six hundred years. Here we find the durian, the rambutan, the duku, the shaddock, and other fruit-trees of great size’ (4 February 1822; Crawford, 1828, p. 47).

Lacking other historical or physical evidence, the actual age and origin of the trees cannot now be ascertained, but the presence of fruit trees was rightly taken as evidence of previous arboriculture on the hillside. Early British

observers also found established plantations in the hills surrounding the mouth of the Singapore River where, in exchange for rent, Temenggong Abdul Rahman (d. 1825) had allowed various Malays and Chinese to establish about 20 gambier (*Uncaria gambier* Roxb.) plantations prior to the arrival of the British (Jack to Wallich, 8 June 1819, in Burkill, 1916; *Singapore Straits Records* (SSR, National Archives, Singapore) L11, pp. 139–141, Farquhar to Sec. to Lieutenant Governor, 23 December 1822; Bartley, 1933, p. 117; Jackson, 1968, pp. 7–8). This was recognized in the treaty of 26 June 1819 between the British and the Temenggong, in which he, as the proprietor of the soil, was given continuing and exclusive control over the disposal of land for gardens and plantations, while the boundaries of the land under British control were restricted to a stretch of sea front of about six miles long and landwards to the range of a cannon shot (SSR, L17, p. 57A, Sec. to Lieutenant Governor to Farquhar, 4 February 1823; Buckley, 1902, pp. 58–59; Wake, 1975, pp. 60–61). Before his departure, Raffles decreed as part of his instructions for the town planning that the whole of the hill, subsequently known as ‘Government Hill’, should be reserved for the ‘exclusive accomodation of the Chief Authority’ and that a bungalow later be added on top as a residence (SSR, L10, pp. 71–75, Raffles to Farquhar, 25 June 1819). No written orders to Farquhar were included for the location of the planned spice plantation, though he would have received at least oral directions from Raffles. Cross-referencing later documents allows us to place the first spice plantation on the more gradual lower eastern slopes of the hill, close to the later Government House, and not too far from the site of previous awricultural activities. This particular location would prove well-suited to the cultivation of nutmegs (Wallich to Raffles, 21 November 1822, in Hanitsch, 1913; Pearson, 1953, pp. 200–204).

After 1818, the nurseries of the private and public spice plantations near Fort Marlborough in Bencoolen contained such a tremendous supply that many plants perished from neglect (Lumsdaine, 1821). Upon returning to Bencoolen in July 1819, Raffles was therefore quickly able to assemble a collection of 1000 nutmeg and 350 clove seeds as well as 100 seedlings and 25 large plant specimens each of both species, and on 18 August this shipment was dispatched to Singapore on the *Indiana* (Captain J. Pearl). Raffles explained to his superiors that the purpose of the endeavour was ‘to extend the cultivation of the nutmeg and clove tree as much as possible’ advising Farquhar ‘to exert [his] utmost endeavours to establish the cultivation under [his] immediate authority’ (SSR, L10, p. 125, Raffles to Farquhar, 18 August 1819; Raffles to Gov., 26 August 1819, in Bastin, 1965). The plant material arrived in Singapore on 27 September 1819 in the care of M.W. Dunn. The latter was apparently not so much a gardener, but a long-time employee of the Company in Batavia (today’s Jakarta) and Bangka sent by Raffles for general assistance to the administration in Singapore where Dunn can be traced till July 1821 as an occupant of land

(SSR, L10, p. 179, Farquhar to Raffles, 27 October 1819; Braddell, 1855, p. 451; Kathirithamby-Wells, 1969, p. 51).

Farquhar himself was known to have a long-standing interest in botany. During his tenure as Resident of Malacca, 1803–1818, he collected plants on Mount Ophir and had Chinese artists prepare a large collection of botanical drawings (Jack to Wallich, 14 January 1819, in Hanitsch, 1916; Goh, 1999). Farquhar soon reported back from Singapore that the larger plants had been established in their permanent location and that seeds and seedlings were in a nursery, all 'in a thriving state' (SSR, L10, pp. 182–183, Farquhar to Raffles, 28 October 1819). Farquhar's initiative to employ Mr Brooks, a European gardener, at \$40 a month as Botanist and Superintendent for the spice plantation on Government Hill, drew an immediate rebuke from Raffles. Raffles cited orders of the Supreme Government to prune expenses in Singapore and abolished the post of Brooks in December 1819 (SSR, L10, pp. 239–243, Raffles to Farquhar, 29 December 1819, enclosing letter from Governor General, 15 October 1819; Kathirithamby-Wells, 1969, p. 51). The spice plantation was thereafter under the direction of Farquhar with no further guidance from Raffles until he eventually returned to Singapore.

Raffles's extreme disdain for the Dutch helped motivate his own zealous pursuit of spices. He resented the return of the 'fertile and important Islands of Java and the Moluccas' to the Dutch, and one of his declared objectives in founding Singapore was to 'eventually destroy the spell of Dutch monopoly' (Raffles to Col. Addenbrooke, 10 June 1819, in Willians, 1878). Fostering the cultivation of spices to this end was, however, at least a ten-year project and reveals Raffles's long-term hopes for the British foothold at a time when the future of Singapore was still caught up in a 'paper war' (Wurtzburg, 1954, pp. 525–542). Besides sending spice plants to Singapore, Raffles continued to entice planters in Bencoolen to increase nutmeg production. In Penang in 1818, 79,000 nutmeg and 104,000 clove trees had been counted, and harvests were beginning to swell during the 1820's (Penang Consultations, 7 October 1818, in Jackson, 1968). Raffles grossly overestimated both the future demand for spices in Great Britain and the price they would command. In 1822, the Company's London warehouses had about 1,000,000 lbs of nutmeg and 200,000 lbs of mace in stock, and further imports of spices from Bencoolen could only be sold, if at all, at great losses (Bastin, 1960, p. xxxvii). Hence, Raffles agricultural endeavours in Bencoolen proved financially disastrous for the Company and did little to inspire official support for Raffles's new agricultural experiments in Singapore.

In 1819, Raffles himself also imported to Singapore cotton (*Gossypium* sp.) seeds of the *pernambuco* variety, probably from Penang, and the plants were successfully raised on Government Hill. While claims of cacao trees (*Theobroma cacao* L.) and cultivated orchids thriving nearby are apocryphal

(Ridley, 1905, p. 296; *ibid.*, p. 303; Knecht, 2000, p. 194), there is evidence that tea (*Camellia sinensis* (L.) Kuntze) was flourishing in the Garden by 1822, though nutmeg and clove trees would remain its dominant features (Wallich to Raffles, 2 November 1822, in Hanitsch, 1913; Jack to Wallich, 15 March 1819, in Burkill, 1916).

By May 1821, access to the spice plantation was improved with small roads over the top and around Government Hill, and an additional \$80 had been spent on a bungalow, presumably a small structure to house a caretaker and tools (Buckley, 1902, pp. 68–69; Bastin, 1960, pp. 146–147). During the same time period, Chinese gambier and pepper (*Piper nigrum* L.) plantations continued to slowly expand inland (Finlayson, 1826, pp. 61–62), but the unclear future of Singapore and uncertain land rights caused most of the 22 Europeans that occupied land in 1821 to abstain from engaging in agricultural ventures (Braddell, 1855, p. 451; Miller, 1941, p. 194). A notable exception and case in point regarding the issue of land tenure was Farquhar himself who started a 'Garden & Plantation' at his own expense on a hill north of the settlement. Despite his insistence that he had received sanction from the Temenggong according to the treaty of June 1819, his claim on the land was later denied by Raffles (*SSR*, L11, pp. 139–141, Farquhar to Sec. to Lieutenant Governor, 23 December 1822).

Plans for a Botanic and Experimental Garden, 1822–1823

Raffles returned from Bencoolen to Singapore on 10 October 1822 and, out of concern about the haphazard growth of the settlement, he mounted a final effort to shape its design and character to match his vision for a 'civilized' society. By coincidence, in early September 1822 Wallich had arrived in Singapore from Calcutta on his way to China to recover from malaria. He decided to remain on the island for the rest of his leave, ultimately taking with him 'a curious and extensive botanical collection' as the result of his botanising in Singapore (Crawford, 1828, p. 297; Wallich to Secretary to Gov., 19 July 1822, in Hanitsch, 1913).

Wallich's friendship with Raffles and Lady Sophia Raffles (1786–1858) led to frequent social meetings and shared excursions over the course of six weeks. They agreed to significantly expand the existing 'Government Garden' into a larger 'Botanic and Experimental Garden'. The timing of their plan was not accidental: Under the guidance of Raffles, a 'Land Allotment Committee', in which Wallich participated, and a 'Town Planning Committee' were formed to advise on developing a detailed masterplan for the settlement. Dr John Lumsdaine, Superintendent of the Company's Spice Plantation at Fort Marlborough and an expert in the cultivation of spices, had accompanied Raffles to Singapore and joined Wallich on the first committee. The actual map of the

town was to be drawn up by Lieutenant Philip Jackson (1802–1879), the Assistant Settlement Engineer (Report of the Committee to Raffles, 23 October 1822, in Hanitsch, 1913; Pearson, 1953, pp. 200–204; Wurtzburg, 1954, pp. 608–610; Bastin, 1981, p. 49). In the course of this town planning process, and no doubt with much input from Raffles himself, on 2 November 1822 Wallich formally suggested to Raffles to include an extended garden into the redesigned town plan:

‘... I beg leave to recommend that a suitable piece of ground may be appropriated in the neighbourhood of the European town for the purposes of a botanic garden and for the experimental cultivation of the indigenous plants of Singapore and the adjacent Islands, as well as of such others of foreign growth, as it might be desirable to submit to a skilful trial, previous to encouraging their general introduction’.

In Wallich’s opinion Singapore’s location was ideal for such an institution: ‘... the most favourable for indigenous as well as foreign vegetation and forming part of the richest archipelago in the world - its soil yielding to none in fertility, its climate not exceeded by any in uniformity, mildness and salubrity’ (Wallich to Raffles, 2 November 1822, in Hanitsch, 1913; SSR, L9, pp. 91–100, 1822).

As an indication of the commercial promise of Singapore’s agriculture, Wallich pointed to a number of wild nutmeg species found in the surrounding forests, Farquhar’s successful experiments with spices and *pernambuco* cotton in the existing garden, as well as the local pepper and gambier production. He closed by expressing his hopes of becoming the Superintendent of this Garden, which he planned to staff with a number of apprentices and experienced gardeners from Calcutta. Raffles’s and Wallich’s letter was carefully designed to aid their bid for financial support from the East India Company, hence it overstated the bright prospects of economic botany in Singapore. Wallich had, indeed, collected at least six species of wild nutmegs on the island, one of which he named in Farquhar’s honour *Myristica farquhariana* (now known as *Gymnacranthera farquhariana* (Wall. ex Hook. f. & Thomson) Warb. var. *farquhariana*; Warburg 1897b: p. 367; de Wilde, 2000, pp. 44–46), but none of those species had the slightest aromatic quality. Over the years, some other of Wallich’s supporting arguments also proved to be spurious, for example, the lack of seasonality had a deleterious effect on some crops, like cotton, and made the cultivation of others, like coffee (*Coffea arabica* L.), costly by extending the harvest over a long period (Thomson, 1850, p. 141; Crane, 1851, p. 122).

The planning for the Botanic Garden was cut short when suddenly an opportunity arose for Wallich to catch a return passage to Calcutta (Wurtzburg, 1954, p. 614). On 21 November, one day before his embarkation, Wallich outlined to Raffles a plot for the Garden, which was soon after surveyed by Jackson, the planner. An area of 48 acres on the northeastern side of

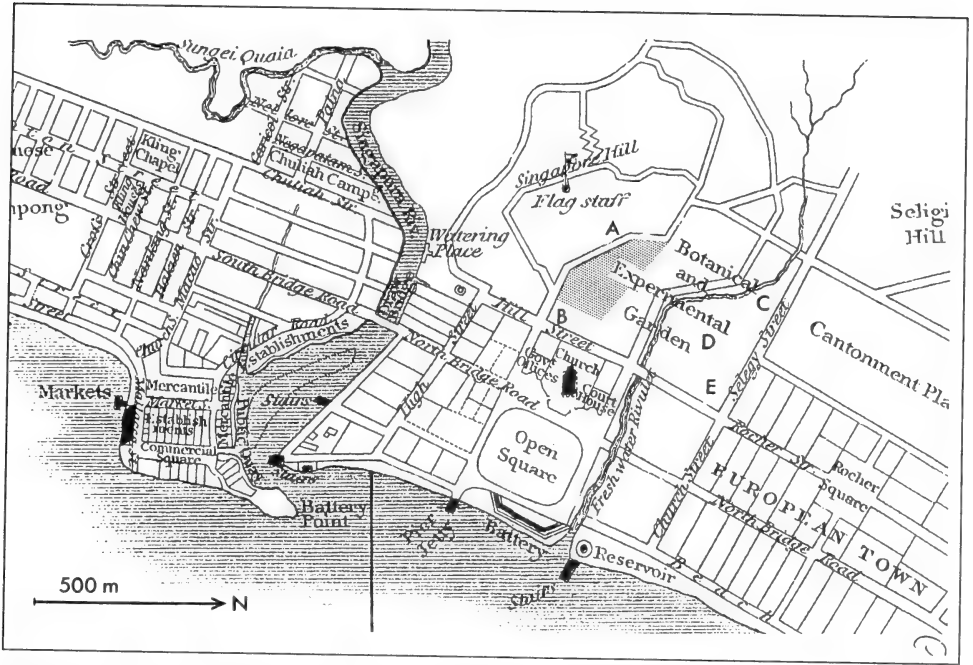


Figure 1. This ‘*Plan of the Town of Singapore by Lieut. Jackson*’ represents the proposed lay-out of the town as of December 1822 (Crawford, 1828, opposite p. 529; Pearson, 1953, pp. 200-204) with a revised scale added.

The road along the ‘Fresh water Rivulet’ (Bras Basah River) corresponds to Hospital Street, now Stamford Road, and Selegie Road was soon renamed Brass Bassa Road (now Bras Basah Road). The area east of Hill Street, originally reserved for church, government offices and court house as shown in this layout, accommodated the convict lines after 1825. The total area of the planned ‘Botanical and Experimental Garden’ within the borders of the roads as shown here is 48 acres. The dotted area of eight acres marks the approximate extent of the Government Garden under Montgomerie’s superintendency in 1827 and includes the original plantings by Farquhar. The calculation of the planted area is conservatively based on a distance of thirty feet between trees, equivalent to fifty trees per acre (Low, 1836, pp. 28-30; Ridley, 1912, p. 445).

- (A) The cemetery opened in 1822 and was extended across the road from town in the late 1840’s.
- (B) The Armenian Church was erected in 1835 in proximity to the location of the first home of the merchant A. L. Johnston. By 1840 Armenian Street ran parallel to Hill Street on the lower slopes of Government Hill with houses encroaching on the spice plantation.
- (C) After 1830 the area (between the current Bencoolen and Waterloo Streets) was used for different hospitals, hence the early name Hospital Street for Stamford Road.
- (D) A new convict jail was erected by convicts in 1841 and expanded considerably between Hospital and Brass Bassa Road over the next fifteen years.
- (E) The location of the Catholic Church of the Good Shepherd since 1845.

Government Hill including the Fresh Water Stream and some low ground were to be enclosed appropriately as the new 'Singapore botanic and experimental institution' (Fig. 1). Furthermore, Wallich sweepingly proposed that *all* of Government Hill should be landscaped with indigenous and non-indigenous ornamental trees and shrubs by the Superintendent of the Garden so as to complement the Botanic Garden (Wallich to Raffles, 21 November 1822, in Hanitsch, 1913). Raffles, not one to let financial considerations stand between him and his wishes (Hill, 1970, p. 78), donated \$1,000 for the layout and enclosure of the Garden. He also ordered an initial public subsidy of \$60 a month, less than 2% of the total budget for Singapore at the time and just sufficient for about ten workers and some tools and materials (Braddell, 1853, p. 347; Raffles to Wallich, 15 November 1822, in Bastin, 1981). In addition, Raffles sent a formal letter, complete with supporting enclosures by Wallich, to the Supreme Government in Calcutta to garner recognition and funding for his project (Raffles to Wallich, November 1822, in Bastin, 1981; Raffles to Wallich, 17 April 1823, in Bastin, 1981).

By early January 1823, Raffles and his wife had moved into a new bungalow at the top of Government Hill overlooking the settlement. Despite his serious and recurrent health problems, he was now anxious to begin the design of his 'future Superstructure' by expanding the existing Botanic Garden and turning the remainder of the Hill into a 'very pretty Park'. He even planned for an enclosure with 200 Spotted Deer (*Axis axis* Erxleben), though he soon scaled back and abandoned the idea, recognizing that his successor would not look favourably upon it (Raffles to Wallich, 5 January 1823, in Bastin, 1981; Raffles to Marsden, 21 January 1823, in Raffles, 1830). Without official approval from Calcutta for the project, Raffles prepared for the start of construction: He gave orders to evict locals residing within the area of the planned Botanic Garden and to compensate them for their dwellings and surrounding cultivated areas (SSR, L13, p. 14, Farquhar to Asst. to Police Dept. Bernard, 11 January 1823). Engineer Jackson began building a wall made from a combination of brick and wood around the part of the Botanic Garden facing the town, and workers began cutting a number of 'noble' walks through the grounds (SSR, L13, p. 3, Farquhar to Jackson, 6 January 1823; SSR, N1, p. 103, Montgomerie to Prince, 8 February 1827). Raffles's grand vision of Government House overlooking a magnificently landscaped park and Botanic Garden appears modelled after the private estates of the influential and wealthy members of Penang's British community, such as Governor William Edward Phillips's (b. 1769) Suffolk House or David Brown's (d. 1825) Glugor House (Crawfurd, 1828, p. 10; Stevens, 1929, pp. 405-411). For Singapore, Raffles's plan for his Garden was way out of proportion with the simple Government Residence it was to surround, and, more importantly, would have required substantial public financing.

Montgomerie's Superintendency of the Garden, 1823–1827

Initially, Wallich had planned to return to Singapore soon and was anxious to secure a land grant from Raffles for a future home on what would be known as Mount Wallich (Raffles to Wallich, 17 April 1823, in Bastin, 1981). But before committing any resources to the development of the Garden, Wallich awaited the Supreme Government's decision on the project including his confirmation as Superintendent in Singapore. As the endorsement failed to materialise, he completely withdrew his support and, despite Raffles's pleas for help ('- pray send down something like a Gardener or Head Man'), no personnel from Calcutta ever arrived (Raffles to Wallich, 8 March 1823, in Bastin, 1981). Thus, when Raffles made his final departure from Singapore in June 1823, the nascent Garden lost its most ardent and, by then, only supporter.

The incoming Resident, John Crawford (1783–1868), drew his own conclusions on Singapore's agricultural capabilities from his study of 'agricultural geology' (Khuo, 1996, pp. 61–70). The absence of 'alluvial plains' and sufficient 'rich black mold' on the one hand and the presence of the 'poor red soil of the hills' on the other hand made Singapore ill-suited for raising most tropical crops of commercial importance (Crawford, 1828, p. 534; Crawford, 1849, pp. 508–509). The relatively poor soil of Singapore island had been noticed as early as the 1330's by the travelling Chinese trader Wang Ta Yuan in his *Tao-i Chih-lioh* who remarked about the settlement surrounding Government Hill: 'The soil is poor and grain scarce' (Wheatley, 1961, p. 83).

Crawford's dire predictions for the cultivation of the finer spices were based on his calculations of the inherent value versus the actual price obtained for spices. He became convinced that competitive pressure from the Moluccas would eventually erode profits for the British planters if ever the Dutch restored free culture and the artificially high prices were to disappear (Crawford, 1820, vol. III, p. 409). Declining prices did, indeed, become a challenging issues for the spice planters around the middle of the nineteenth century, and Crawford's cautious assessment of the island's agricultural potential would turn out to be more accurate than Raffles's and Wallich's glowing endorsements. To make matters worse for the future of the Garden, in February 1823, Crawford had bitterly fallen out with Wallich while both were in Calcutta, at the time when Raffles was lobbying the authorities for support of the project (Raffles to Wallich, 8 March 1823, in Bastin, 1981). It was no surprise then that Crawford gave no further support to the Garden than the stipulated monthly allowance and polite appreciation for the work of the new Superintendent of the Gardens, Dr William Montgomerie (1797–1856; Crawford, 1828, p. 534).

Montgomerie had been in Singapore since May 1819 as Assistant Surgeon in general medical charge of the troops and from January 1823, after the dismissal of his colleague Dr Thomas Prendergast, was alone in medical charge of the settlement (Makepeace *et al.*, 1921, vol. I, p. 517; Pearson, 1955, pp.

41–46). In the course of his own rushed departure, Wallich had suggested that Montgomerie, known for his interest in natural history, should temporarily oversee the Garden - though without any addition in pay 'as the thing was upon a small scale' (Braddell, 1855, p. 62). Montgomerie, initially reluctant, was put to work willy nilly '*nolens volens*' under Raffles's direct supervision, but after Raffles's departure, Montgomerie found himself left entirely to his own devices since Wallich never contacted him again nor sent the promised botanical expert (Raffles to Wallich, 5 January 1823, in Bastin, 1981).

This mirrors the experience of the botanist George Porter (d. 1833) who in 1822 on Wallich's recommendation was put in charge of the new Government Botanic Garden in Penang, but he, too, waited in vain for the expected support from Calcutta (SSR, A19, p. 386, Establishment of a Botanic Garden at Penang, 1823; Bastin, 1981, pp. 43-44). In fact, during the period between Wallich's departure from Singapore and 1830, not a single botanical collector brought his expertise to the settlement (van Steenis-Kruseman, 1950, p. LXXXIV). Hence Montgomerie lacked the inspiration and means to establish a botanical collection, but instead concentrated on the development of the experimental spice plantation, marking the start of his enthusiastic involvement in plantation agriculture.

Montgomerie completed the enclosure of this plantation with a bamboo fence on the hill side and improved the roads in the area. He also attempted in vain to drain some of the low ground along the Bras Basah River which was prone to flooding and remained unsuitable for the cultivation of spices. As late as 1841, when a permanent convict jail was erected on the northern side of the Bras Basah River, the marsh had to be reclaimed by raising the site by 2–4 ft with soil from Government Hill (McNair, 1899, pp. 147-148). In addition to the nutmeg and clove trees already planted by Farquhar, he continued to procure seeds, raise them in a nursery and set out seedlings on 18 foot-wide terraces on the lower eastern slopes of Government Hill. When in April 1825, the first 200 Indian convicts were transferred from Bencoolen to Singapore and accommodated in sheds built between Hill Street and North Bridge Road, i.e., just south-east of the spice plantation, Montgomerie was able to supplement his small work force with a few extra convict labourers, some even with working experience from the spice plantations of Bencoolen (Jannings et al., 1821; Raffles, 1830, fold-in plate, facing p. 525; McNair, 1899, pp. 38–39).

The new Resident Councillor Prince, in charge of the town from 1826 to 1828, was far more sympathetic towards the cause of botany than Crawford: Prince himself made botanical collections and re-established communications with Wallich by sending him living specimens to Calcutta (van Steenis-Kruseman, 1950, pp. 416–417; Wurtzburg, 1950, p. 141). In February 1827, Montgomerie reported to Prince that a total of about 300 nutmeg and 100 clove trees were growing on the slope of Government Hill. The first small crop of nutmegs had been harvested in 1826 and from selected fruits 200

seedlings were being propagated in a nursery that held a total of 300 nutmeg and 200 clove plantlets (*SSR*, N1, pp. 101–106, Montgomerie to Prince, Report upon the present State of the Honorable Company's Botanical and Experimental Garden at Singapore, 8 February 1827). An estimated eight acres plus the nursery, i.e. a fraction of the plot originally allocated in 1822, was being cultivated with nutmegs and cloves (Fig. 1, dotted area). Despite Montgomerie's claim that the spices 'appeared to thrive uncommonly well' (*SSR*, N1, p. 102, Montgomerie to Prince, 8 February 1827), this was only true for the nutmeg trees, since the clove trees, some in their ninth year, still showed no sign of bearing (Ridley, 1912, p. 176; Bastin, 1960, p. 192). Still, Montgomerie suggested that the government would eventually profit if it developed spice plantations with convict labour and leased them out once they approached bearing - a plan that was both ill-timed and unrealistic.

The Anglo-Dutch treaty of London of March 1824 that had ceded Bencoolen and upheld the Dutch trade monopoly in the Moluccas, raised largely unwarranted fears that the Dutch hold on the spice trade would tighten again. While the treaty caused ruin to the British nutmeg farmers in Bencoolen, giving up the costly dependency was a financial blessing for the Company. In parliament, Foreign Secretary George Canning (1770–1827) used the news about successful experiments with spices in Singapore to assure critics of the treaty that Britain's spice supply would not be endangered in the future (Wright, 1958, p. 101; Newbold, 1839, p. 271). This promise, however, had no bearing on any further investment into spice cultivation by the Company whose prime concern for the United Presidency Administration of Penang, Malakka and Singapore was retrenchment (Kathirithamby-Wells, 1969, p. 53). Lacking sufficient funding, Resident Councillor Prince could do little more to encourage private involvement in spice cultivation than to offer the limited supply of nutmeg and clove seedlings available in Singapore. In 1827 he directed Montgomerie to increase production of seedlings in the nursery and also approached the Governor in Penang with a request for the shipment of young plants or even just germinating seeds since 'many of the European Land holders ... [were] now preparing their Lands for the reception of spices' (*SSR*, N1, p. 107, Resident's diary, 9/10 February 1827; Prince to Sec. Gov. Penang, 15 February 1827, in Cowan, 1950).

During the same year a period of decline began for the Garden as Montgomerie left Singapore with the Bengal troops for India and financial support of the Garden was limited to a staff allowance of 20 rupees (Makepeace *et al.*, 1921, vol. I, p. 490; *ibid.*, vol. I, p. 517). A Sicca rupee was worth about 2 shillings sterling. The supervision was first put into the hands of a professional English gardener turned artilleryman with the newly arrived Madras troops, later taken on by a Mr Caswall in charge of Medical Garrison Staff (*SSR*, V2, pp. 307–308, Fullerton and Prince to Court of Dir., June 1828). Upon receiving a report that the Garden was 'by no means in good order and very confined'

the Governor-General ordered that the establishment be discontinued. Effective 30 June 1829, all financial support was cut, and the grounds from then on left under the exclusive care of ten convicts (*SSR*, N6, p. 160, Act. Resident Presgrave to Supt. of Convicts Bonham, 30 June 1829).

Despite its limited scale, the government plantation had in principle demonstrated the possibility of growing nutmegs on the island by bringing the first nutmeg trees to fruiting, and thus inspired other residents to slowly follow suit with nutmeg cultivation. However, soil analyses performed by Major James Low (1791–1852) during his time as Assistant Resident in 1840–1841, revealed that the soil on the slopes of Government Hill was particularly fertile and suited to the cultivation of nutmegs (*Singapore Free Press*, 25 November 1841). Therefore the initial success had exaggerated the commercial opportunities for nutmegs growing in other locations in Singapore on inferior soils.

The government plantation also presented a ready source for young plantlets. As the viability of nutmeg seeds falls rapidly within a week, but they self-seed easily, young plants could be dug up around the existing trees and transplanted from there. In this respect, the plantation fulfilled a continuing role by providing propagation material, at times supplemented from Penang, for most of the other planters in Singapore (Buckley, 1902, p. 198). Even the less successful cloves in the government plantation continued to attract attention until about 1840, when it was eventually recognized that their best use in Singapore was as an ornamental tree (Belcher, 1848, vol. II, p. 381; Thomson, 1850, pp. 102–103).

Montgomerie had started out as an amateur, unfamiliar with agriculture under equatorial conditions and drew on the experience of the British spice planters from Bencoolen and Penang. He had at his disposal Lumsdaine's often reprinted '*Report on the Cultivation of Spices at Bencoolen, 1819–20*' that became the standard manual for British nutmeg planters for years to come (Lumsdaine, 1821; *Singapore Chronicle* 15 May 1834; Low, 1836, pp. 28–30; Lumsdaine, 1851, pp. 78–84; Ferguson, 1889, pp. 102–108). Montgomerie also had the opportunity to receive direct advice from Lumsdaine when the latter visited Singapore with Raffles in 1822–1823. Consequently, Montgomerie adopted in Singapore Lumsdaine's practice of growing nutmeg trees without the permanent shelter of shade trees. While on the Banda Islands trees were grown in alleys beneath tall *kanari* trees (*Canarium vulgare* Leenh.), in the British plantations only newly-planted trees were protected with individual shade structures made of *atap* (fronds of the mangrove palm, *Nypa fruticans* Wurmb.). The slow growth of the shade trees, the terraced hill sides of the plantations and the scarcity of fertile soil prevented protective shade trees from being considered a useful practice in the British plantations. In the long-run this decision had crucial consequences for Singapore's nutmeg cultivation: Not only did the open design of plantations promote excessive

growth of invasive *alang* grass (*Imperata cylindrica* (L.) Raensch.), thus requiring frequent expensive weeding, it also made the trees more susceptible to the insect pest that later devastated the spice plantations.

Land Development around the Botanic Garden, 1830s to 1840s

Parts of the large area that had originally been designated for the Botanic Garden gradually began to be utilized for other purposes. A new Christian cemetery had been opened in 1822 on the upper slopes of Government Hill to take the place of the very first cemetery that was located inappropriately close to Government House. This new cemetery gradually expanded downhill towards the Spice Garden, but did not approach planted areas until the late 1840s (Fig. 1, A; Stallwood, 1912, plate I). In the direction of town, the spice plantation early on bordered the gardens of the houses along Hill Street on the lower slopes of Government Hill (Pearson, 1955, frontispiece; *ibid.*, p. 67). In April 1833, the Armenian community petitioned the Resident Councillor for a grant of land from the Botanic Garden facing Hill Street to build a church (Fig. 1, B). A subsequent enquiry with the government in Calcutta led to Raffles's original land grant for the Botanic Garden being cancelled in July 1834. The desired parcel was then assigned to the Armenian community which completed the Armenian Church in January 1835 and had it consecrated in March 1836 (SSR, Z8, pp. 175-176, Act. Governor to Resident Councillor, Aug. 1834, with enclosing letter to Sec. Gov. to Act. Governor, 28 July 1834).

Records for the early land grants in the area of the original Botanic Garden failed to turn up in a search at the Singapore Land Authority. Some had apparently been reissued only in recent years. A school operated by the Rev Darrah from August 1834 to December 1837 at the bottom of Government Hill opposite the top of High Street, apparently was close to, but did not encroach on the original Garden (Buckley, 1902, p. 128). On the north side of the Bras Basah River, a simple Pauper Hospital was built between Bencoolen (now Bencoolen) and Church (now Waterloo) Street in 1830 (Fig. 1, C). Three years later a larger brick building was erected nearby as a permanent hospital for convicts, paupers and European seamen. This building was located approximately at the corner of Hospital Street (later Stamford Road) and Bencoolen Street, i.e. across the street from where the Singapore History Museum now is (Makepeace *et al.*, 1921, vol. I, pp. 493-494). Beginning in 1841 a convict jail and other convict facilities began spreading out in the area to the east of the hospital (Fig. 1, D; McNair, 1899, 54; *ibid.*, plate X, facing p. 77), and, yet further towards the sea, the new Roman Catholic Church (Church of the Good Shepherd) was erected between 1843 and 1846 (Fig. 1, E; Buckley, 1902, p. 248).

Through the early 1830's parts of the original Garden survived insufficient maintenance, weeds and depredation by cattle (Bennett, 1834, vol. II, p. 174; Earl, 1837, p. 350). A drive to the top of Government Hill, past what was still known as the Botanic and Experimental Garden, became a popular evening outing:

'The drive up to this spot is exceedingly romantic - A spiral carriage road winds up the hill, and, at each progressive step, fresh beauties attract the eye. Eminences, undulating above each other, display broad patches either cleared for cultivation, or shining in the bright green livery of clove plantations' (Begbie, 1834, p. 353).

The area provided the closest to a park-like 'recreational' space Singapore had to offer and a respite from what was perceived as 'the gloomy mass of forest scenery' (Bennett, 1834, vol. II, p. 139). Within the confines of the former Garden visitors encountered a variety of ornamental and fragrant trees, some indigenous like Kedah Gardenia (*Gardenia carinata* Wall.), others imported such as Yellow Bauhinia (*Bauhinia tomentosa* L.) and Champaca (*Michelia champaca* L.). There were also common medicinal plants, Purging Croton (*Croton tiglium* L.) and the native *gelam* tree (*Melaleuca cajuputi* Powell) that lent its name to Muslim quarter Kampong Glam, as well as the introduced Borneo Camphor tree, *Dryobalanops aromatica* C.F.Gaertn. (Burkill, 1935, vol. I, pp. 862–863). Many of the older nutmeg and clove trees continued to produce fruit, and even some of the cotton plants from Raffles's days survived so that in 1836 their seeds could be collected to conduct a trial for larger scale, private cotton plantations (Bennett, 1834, vol. II, pp. 174–176; Thomson, 1850, p. 142; Crane, 1851, p. 121). This was part of broader surge in agricultural interest that began to accelerate during the 1830s.

Singapore Agricultural and Horticultural Society, 1836 to c. 1845

Despite some initial interest shown by Europeans, development of plantation agriculture had been hampered by a number of issues. During the 1820s access to cultivatable areas further away from town was difficult, as well as dangerous, so that the interior of the island remained almost unknown to Europeans (Earl, 1837, p. 353). The reluctance of the government to sell land in perpetuity combined with the long maturation period of spice trees also made the shorter term leases offered unattractive to planters (Thomson, 1850, pp. 210–219; Makepeace *et al.*, 1921, vol. I, pp. 301–311). Until about 1835 the cultivation of spices was therefore restricted to about a dozen merchants with 'small *amateur* plantations of spice-trees near their residences', close to town (*Singapore Chronicle*, 15 May 1834; Earl, 1837, p. 410). Gradually some long-term residents of Singapore accumulated enough free capital to explore local investment options besides trade, and the relative success of the existing

nutmeg plantations and other potential crops caught their attention (Little, 1849, p. 678; Cameron, 1865, p. 168). Renewed interest in spices was helped when locally the price of nutmegs spiked after 1835, aided by the rapidly declining output of Bencoolen's neglected plantations and diminished production of the Banda spice gardens that were recovering from the impact of volcanic eruptions in the 1820s (Warburg, 1897a, pp. 155–157; *ibid.*, pp. 262–263; Jackson, 1968, table 11, p. 123).

Montgomerie, who had returned to Singapore in December 1834 as Senior Surgeon, was one of the Europeans who rapidly developed spice plantations. In 1836, he purchased Ryan's Hill, a ten-year-old 16 acre nutmeg plantation and developed it in conjunction with the neighbouring Craig Hill into a large estate (Makepeace *et al.*, 1921, vol. I, p. 517; Gibson-Hill, 1958, pp. 147–148). His medical colleague and later successor as Senior Surgeon, Dr Thomas Oxley (1805–1886), had an equally strong interest in economic plants and botany. He dispatched plant specimens to Calcutta and Kew as well as contributing 'a large number of peculiar plants' to the Buitenzorg Garden (now Kebun Raya, Bogor) in Java (Treub, 1893, p. 48; Burkill, 1927, p. 129). His nutmeg plantation on the slopes of 'Oxley Hill' became renowned for its beauty, and his residence on top of the hill was surrounded by a considerable collection of rare ornamental plants (Jagor, 1866, pp. 18–20; Buckley, 1902, p. 405). Montgomerie's and Oxley's enthusiasm for nutmeg cultivation interfered sufficiently with their medical duties that after 1857 medical officers were forbidden to engage in any agricultural or commercial pursuits (Turnbull, 1972, p. 217).

In May 1836, a number of influential European residents, Montgomerie and Oxley amongst the leadership, organized the Singapore Agricultural and Horticultural Society to represent their interest as planters. Their ultimate goal was that 'this island should all be cleared and cultivated; in fact become a large Garden' (*Singapore Free Press*, 9 June 1836; *Singapore Free Press*, 6 April 1837; Earl, 1837, p. 409; Buckley, 1902, pp. 305–306). The members soon addressed their most pressing issue by petitioning the Governor-General to review the restrictive land rights, although it took until 1845 that, with the approval of the Court of Directors, large areas of land could be sold in perpetuity (*Singapore Chronicle*, 15 October 1836; Makepeace *et al.*, 1921, vol. I, pp. 310–311). As a means of funding its activities, on 19 November 1836 the Agricultural and Horticultural Society received a land grant for seven acres on Government Hill and access to convict labour so that it could resuscitate the neglected nutmeg plantation (Makepeace *et al.*, 1921, vol. II, p. 70). Fortunately a significant number, by one estimate in excess of 200 nutmeg trees, had survived in the original Garden from the early 1820 (*Singapore Free Press*, 25 November 1841) and in 1837 the Society was already able to earn \$270 from the sale of about 325 lb of nutmegs. Among their other activities was the mutual exchange of seeds with similar Societies in Calcutta and Bombay. It also tried

encouraging the Chinese population to cultivate a broader range of crops and vegetables by distributing pamphlets and seeds, though apparently with little success (*Singapore Free Press*, 6 April 1837; *Singapore Free Press*, 6 July 1837; Buckley, 1902, p. 361). The Society continued to formally operate for about ten years but with increasingly less visibility, and, as its members became absorbed with their own agricultural endeavours, the nutmeg plantation on Government Hill reverted back to the government.

‘Nutmeg Mania’

For this was the time when first many European, then Chinese and Malay inhabitants, were swept away in ‘nutmeg mania’, frantically buying up land and expanding their plantations (Belcher, 1848, vol. II, p. 381; Cameron, 1865, p. 168). Consequently the town’s surroundings to a distance of about five miles underwent a dramatic transformation during the 1840’s:

‘A few years ago it was a dense jungle: On every hill may now be seen the residence of some hospitable merchant, surrounded by plantations of nutmeg or other spice trees’ (Keppel, 1853, vol. I, p. 409).

Corresponding developments took place around Government Hill and can be traced with early maps of Singapore. The first map to show land use patterns was prepared in 1835 by George Drumgoole Coleman (1795-1844) based on his surveys of the early 1830’s. At the time only a few scattered spice plantations existed around Singapore and therefore, unlike other crops, nutmeg and cloves were not yet specifically identified on his map. A strip along Stamford Road, across from the Chinese Hospital, appears to have some agricultural use, but it is impossible to clearly identify the remnants of the government spice plantation as such on Coleman’s map (Tassin, 1836; Tassin, 1839; Goh, 1990, pp. 60-64).

In 1841, John Turnbull Thomson (1821–1884) was appointed Government Surveyor of Singapore to help clarify the issue of land rights. His *Plan of Singapore Town and Adjoining Districts*, based on surveys conducted in 1842, represented the first map of Singapore to establish accurate property boundaries. His maps clearly delineated a significant nutmeg plantation in an area labelled ‘Botanical Garden’ on the north-eastern side of Government Hill, indicating the renewed agricultural use after the Agricultural and Horticultural Society had taken over the management of the site (Thomson, 1846; Thomson, 1854). By the end of 1848 this plantation contained 778 nutmeg trees, of which less than 50 were ‘of the old stock, most having been planted since 1836’, and it had expanded well beyond the boundaries of Montgomerie’s previous plantation to over 13 acres (Oxley, 1848, p. 657). A total of 350 trees were bearing in 1848, the rest being too young or unproductive, and yielded the government an income of \$1134, while expenses were kept

low due to the use of free convict labour (Oxley, 1848, p. 659; Thomson, 1850, p. 31). This was about the height of Singapore's nutmeg craze when a total of 1,190 acres around town were planted with over 71,000 nutmeg trees (Thomson, 1850, fold-out tables, facing p. 219).

Demise of Nutmeg Cultivation, 1859

As nutmeg production in the British and Dutch possessions gradually expanded, demand proved to be inelastic, and prices on the saturated world markets continued their long-term downward trend between 1840 and 1860 (Warburg, 1897a, pp. 518–519; Jackson, 1968, table 11, p. 123). Nutmeg planters in Singapore and Penang incurred significantly higher expenses for labour and fertilizer than their competitors in the Moluccas, and hence found it more and more difficult to compete. What promised to be a profitable undertaking when the nutmeg trees were planted, no longer was so when the first harvests were reaped five to ten years later.

British planters were put at a further disadvantage when fungal and insect-borne diseases began to spread through their plantations in the late 1840's. The most significant disease was 'nutmeg canker', which caused premature dehiscence and became quite prevalent in Penang, but also took effect in Singapore (Little, 1849, pp. 678–681; *Singapore Free Press*, 12 July 1855; Ridley, 1912, pp. 135–138; Flach & Tjeenk Willink, 1999, p. 147). Over the course of the 1850s the first European planters began abandoning their ventures, but the final demise of nutmeg cultivation in Singapore began in 1859 when a mysterious disease ravaged the plantations (*Singapore Free Press*, 7 June 1860; Cameron, 1865, pp. 168–170; Jagor, 1866, pp. 21–22), sending trees into rapid decay:

'In the night a tree would be attacked, and the morning light would show its topmost branches withered; the leaves fell off; the disease slowly spread downwards, chiefly on one side of the tree; and, in spite of every attempt to check it (the lower portion often being for a long time green and bushy), the tree became an unsightly mass of bare and whitened twigs' (Collingwood, 1867, p. 47).

The pest was later identified as a small bark boring scolytid beetle (*Hyledius cribratus* Blandf., previously *Phloeosinus cribratus* Blandf.), which killed off the trees by attacking the cambium layer (Ridley, 1896, p. 92; Ridley, 1912, pp. 125–130; Flach & Tjeenk Willink, 1999, p. 147). By 1864 all but one nutmeg plantation in Singapore and most in Penang had been destroyed. Nutmeg mania in Singapore ended with large tracts of abandoned land surrounding the town overgrown by secondary vegetation and financial devastation for private planters who had speculated on their crops as much as on real estate values.

In 1851, the Kew-trained botanical collector Berthold Carl Seemann (1825-1871), stopping over in Singapore on a voyage around the world still had cause to admire the slopes of Government Hill as 'clothed with numerous Nutmeg-Trees, and a turf of brilliant green' (Seeman, 1852, p. 82).

Even an updated map of 1857 shows a significant nutmeg plantation between Armenian Street and the by-now expanded cemetery on the Hill, though it is unclear to what degree the trees were actively maintained (Narayanan, 1857). In November 1859 some 'enterprising citizens' formed a second Singapore Agri-Horticultural Society to stimulate the culture of flowers and vegetables with the ultimate goal of creating a pleasure garden (*Straits Times*, 12 November 1859; Burkill, 1918, p. 55). The government was quick to offer the defunct plantation on Government Hill as well as the labour of convicts, but the Society wisely declined the land and settled a few weeks later for a larger plot of 56 acres at Tanglin, which has remained the site of the current Botanic Gardens (*Straits Times*, 24 December 1859; Makepeace *et al.*, 1921, vol. II, p. 73). As no further agricultural or horticultural use could be found for the eastern side of Government Hill, now overlooked by the newly-built Fort Canning, the land was gradually allocated to a handful of ecclesiastical and public buildings that sparsely filled some of the area originally reserved for Singapore's first Botanic Garden.

Although there are now no remnants of the original Garden, Raffles's overall design for Government Hill left an enduring legacy: Initial exclusion of the Garden area from commercial and residential use allowed its partial preservation and enhancement as a green space after the Botanic Garden was discontinued. Despite continued encroachment over the past 180 years, a significant 'green island' on Fort Canning Hill has survived as a consequence of Raffles's original plan.

The Failure of Raffles's Programme of 'Cultivation'

Taking a broader perspective, it becomes apparent that Raffles's agenda as an advocate for a Botanic Garden extended well beyond his passion for natural history or the hope for the ultimately elusive financial rewards of spices. True to the Georgian ideology that the advance of agriculture lay at the heart of creating an 'improved' society, Raffles had previously proclaimed for Bencoolen: 'I am endeavouring to cultivate the soil, and to civilize the people' (Raffles to ?, 14 July 1820, in Raffles, 1830). When he, through Wallich, pleaded with the government to support the Garden in Singapore, he not only promised rewards of a commercial nature but also an ameliorating influence on the public at large (Wallich to Raffles, 2 November 1822, in Bastin, 1981). In the spirit of enlightened imperialism, Raffles considered the Botanic Garden an instrument of development:

'I am laying out a botanic and experimental garden, and it would delight you to see how rapidly the whole country is coming under cultivation' (Raffles to Marsden, 21 January 1823, in Raffles, 1830).

His broader programme of 'cultivation' was to be complemented by another grandiose idea, the Singapore Institution, combining a new Malay College and the Anglo-Chinese College of Malacca to create 'the means of civilizing and bettering the condition of millions' (Raffles to Wallich, 17 April 1823, in Bastin, 1981). The idea of moving the Malacca College to Singapore arose in January 1823 during a visit to Singapore of Rev Dr Robert Morrison (1782–1834), the founder of the Anglo-Chinese College in Malacca. Morrison was a 'devoted friend' to botany (Broomhall, 1924, pp. 105–107; Harrison, 1979, figure 5; *ibid.*, p. 60) and therefore shared another vision with Raffles, namely to establish a botany department and extend the garden attached to his Malacca College:

'A botanical garden was originally projected, but has failed, from mismanagement. The object of it was to collect, under one view, all the tropical plants of the Eastern Archipelago' (Newbold, 1839, p. 183).

Despite his initial enthusiasm, in 1826 Morrison finally had to abandon the plan of moving his Anglo-Chinese College to Singapore and blamed Crawford, 'the infidel doctor-civilian', for it (Harrison, 1979, p. 75). Raffles's Singapore Institution was formally founded in April 1823 and amongst the numerous provisional appointments was Montgomerie as Professor of Natural Philosophy. But upon Raffles's departure this project did not fare much better than the Botanic Garden: By the early 1830s the poorly constructed building of the Institution had turned into a landmark eye-sore (Earl, 1837, p. 351).

Raffles's aspirations for a botanical enterprise collided with a broader shift in British policy triggered by the death of both George III and Banks in 1820. The loss of the great sponsor and defender of the usefulness of science and, in particular, botany, eventually sent many of the Banksian public initiatives into retreat. As early as 1821 the War Office cut funding for the Botanic Garden in St. Vincent (Guilding, 1825, pp. 22–23), while Kew Garden's plant collectors began to be recalled from abroad. This official pressure for retrenchment in the pursuit of natural history increasingly also pervaded the East India Company where the practical value of the existing Botanic Gardens was being questioned (Drayton, 2000, pp. 130–131). Raffles's plans for his Botanic and Experimental Garden with a focus on spice cultivation not only violated basic economic considerations, when London's storehouses were still overflowing with spices, but were also based on an outdated paradigm of public funding for his ventures. In the age of retrenchment, the initiative and burden was shifting to private support by local amateurs interested in botanical pursuits, often with an eye to investment opportunities. This is exemplified by Montgomerie, a member of the East India Company's medical service, whose passion for economic botany eventually eclipsed his dedication to medicine. Not only did he emerge in

Singapore as a key supporter of private spice growers, he was also one of the first two Europeans to attempt large scale sugar cultivation and claimed priority for introducing the uses of Gutta Percha (*Palaquium gutta* (Hook.) Baill.) to Europeans (Oxley, 1847, p. 22; Thomson, 1848, pp. 138–140).

After 1820, both domestically and abroad, Agri-Horticultural Societies organized efforts to substitute government patronage of Botanic Gardens and botanical exploration in general (McCracken, 1997, pp. 7–8; Drayton, 2000, pp. 132–133). In Singapore, the first local Society operated Raffles's Botanic Garden primarily to fund its main objective of supporting the planters' interests. On the botanical front, their efforts fell short, since amateurish enthusiasm could not make up for proper training or systematic experimentation. H.N. Ridley, the first Director of the current Singapore Botanic Gardens, later claimed that the 'apathy of Government' caused the disastrous decline of spice cultivation in Singapore and Penang, because nutmegs were grown 'only empirically and without the aid of any scientific botanist' (Ridley, 1905, p. 297; Ridley, 1910, p. 103), but this criticism would apply to both public and private efforts. Indeed, pursuit of a more rigorous 'Experimental Garden' as originally envisaged by Raffles might have revealed much sooner that nutmeg culture on a larger scale was not viable in Singapore.

Conclusions

Raffles's vision of spice cultivation in Singapore was embedded in the Georgian philosophy of improvement, but was also based on flawed economic and agronomic premises, and as such was doomed to failure from the onset. Nonetheless, Raffles's Botanic and Experimental Garden was far more than a 'false start' for the current Botanic Garden (McCracken, 1997, p. 8; Tinsley, 1989, pp. 14–17). Characteristic for the changing patronage for botany at the time, it spawned a group of 'botanic entrepreneurs' who for a period of time organized an Agricultural and Horticultural Society. In their pursuit of nutmegs and other crops, they brought large areas of forest around Singapore town under cultivation, thus leaving an indelible imprint on the environment. The 'nutmeg mania' that ultimately ensued was not only a speculation on future nutmeg prices but also bore the signs of an 'asset bubble' in real estate that quickly collapsed when nutmeg cultivation finally failed. The nutmeg plantation on Government Hill survived in its original location until the late 1850s, much longer than previously thought, reaching its greatest extent around 1848 during the peak of frantic spice cultivation in Singapore. It exerted a significant influence on land development in the vicinity of the settlement, as well as helped to preserve 'green space' near the centre of town.

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New Grass (Poaceae) Records for Singapore, Including *Panicum laxum* New for Asia

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Abstract

Working on a field guide to the grasses of Singapore, 15 records not included in *The Concise Flora of Singapore* were discovered. Eight species and a variety are either recorded for the first time for Singapore, or their presence, which was doubted before, is confirmed. They are: *Cyrtococcum patens* (L.) A. Camus, *Dichanthium annulatum* (Forssk.) Stapf, *Eragrostis cilianensis* (Bellardi) Vignolo ex Janch., *Panicum paludosum* Roxb., *Panicum laxum* Sw., *Paspalum plicatulum* Michx., *Rottboellia cochinchinensis* (Lour.) W.D. Clayton, and *Sporobolus indicus* (L.) R.Br var. *pyramidalis* (Beauv.) Veldt. and *S. tenuissimus* (Schrank) Kuntze. *Panicum laxum* is a new record for Asia. The occurrence of six more species already known from Singapore but not reported in local floras is noted: *Cenchrus echinatus* L., *Digitaria bicornis* (Lam.) Roem. & Schult., *D. mollicoma* (Kunth) Henrard, *Eragrostis brownii* (Kunth.) Nees (including *E. cumingii* Steud. var. *cumingii*), *Panicum trichocladum* Hack. ex K. Schum., and *Urochloa piligera* (F. Muell. ex Benth.) R.D. Webster. For the sake of completeness, they are included with a short discussion.

Introduction

Ridley (1907) provided the first account of the grass family (Poaceae) for Malaya (including Singapore), followed much later by Gilliland (1971). Recently, Keng *et al.* (1998) summarised the family for Singapore. The keys provided in all works (in the latter unfortunately not to the species level) are very technical. Also, some quite common species rarely seem to flower in Singapore. They cannot be identified with the available literature. To tackle the diverse identification problems that exist, I am working on a field guide to the grasses of Singapore (excluding the woody bamboos). During the course of this project, I came across 15 new records, not mentioned or accepted in Keng *et al.* (1998). The species belong to the genera *Cenchrus*, *Cyrtococcum*, *Dichanthium*, *Digitaria*, *Eragrostis*, *Panicum*, *Paspalum*, *Rottboellia*, *Sporobolus* and *Urochloa*. The presence in Singapore of some of them had already been mentioned by others, but for the sake of completeness they are included here. The species are discussed in alphabetical order.

Cenchrus

In Keng *et al.* (1998), *Cenchrus brownii* Roem. & Schult. was considered in the wider sense, including *C. echinatus* L. Veldkamp (1999) accepts both

species, and confirms the latter for Singapore. Both species are weeds of ruderal places, native to America. Although *Cenchrus brownii* was first recorded for Singapore (Sinclair SFN 38881, 1950), it is now more rare than the more recently introduced *C. echinatus* (first collected in 1994). Both have spikelets in groups (or burs) surrounded by a dentate involucre, with the burs arranged on a single common axis.

Key to the *Cenchrus* species of Singapore

- 1a. Burs 1–2 mm apart, spines at base slender, 0.1–0.2 mm wide, erect, 2–4 (–7) mm long, apical lobes at margin with hairs up to 0.5 mm long. Spikelet 4–5 mm long. *C. brownii*
- 1b. Burs 1.5–4.0 mm apart, spines at base stout, 0.3–0.5 mm wide, recurved, up to 4 mm long, apical lobes at margin with at least few hairs 1.0–1.5 mm long. Spikelet 5–6.2 mm long. *C. echinatus*

Cenchrus echinatus L.

Singapore collections (in SING unless indicated otherwise): *Ali Ibrahim & Chin* AI223 (1994) Armenian Street; *Ali Ibrahim* AI224 (1994) Bedok Road, Bedok Corner; *Tan et al.* 2043a (1996) Pulau Tekong (SINU). *Teo* TM11 (2000) Tanah Merah (SINU). *Samsuri, A. et al.* 290 (2002) Pulau Tekong; *Duistermaat* S120 (2003) Pulau Ubin, near Jetty, ruderal place on sandy soil, unshaded; S149 (2003) Orchard Road, next to Specialist Shopping Centre, ruderal open place, shaded; S224 (2003) Cluny Road, recently replanted flowerbed with fertile, humus-rich soil, partly shaded; S230 (2003) Labrador Villa Road, edge of field, unshaded.

Cyrtococcum

Keng et al. (1998) mentioned two species of *Cyrtococcum* for Singapore, *C. accrescens* (Trin.) Stapf and *C. oxyphyllum* (Steud.) Stapf. A third species, *C. patens* (L.) A. Camus, was mentioned for Malaysia, in shady places, but not for Singapore (Gilliland, 1971). I found collections from 1993 onwards of *C. patens* in the herbaria of both SING and SINU, and collected it in secondary to primary forest in Singapore.

Key to the *Cyrtococcum* species of Singapore (Veldkamp, pers. comm.).

- 1a. Longest pedicel of the pair shorter than spikelet. Inflorescence contracted. *C. oxyphyllum*
- 1b. Longest pedicel of the pair longer than spikelet. Inflorescence more open.

2a. Erect part of culms 30–100 cm long. Sheath usually pilose all over. Panicle 20–50 by 6–30 cm. Spikelets usually 1.35–1.5 mm long.

C. accrescens

2b. Erect part of culms 10–30 cm long. Sheath usually pilose along margins only. Panicle 3–18 by 0.8–2.3 cm. Spikelets usually 1.5–1.8 mm long.

C. patens

***Cyrtococcum patens* (L.) A. Camus**

Culm with erect part 10–30 cm tall. Nodes hairy on one side. Sheath with hairy margins only. Ligule 0.4–0.8 mm long, membranous. Blade 4–7 cm long, 5–8 mm wide, base at margin with up to 4 mm-long bulbous-based hairs. Mature inflorescence 4–9 by 1–2.3 cm. Longest pedicel of the pair 2.5–4.0 mm long. Spikelet 1.5–1.8 mm long, 0.9–1.0 mm wide.

Singapore collections: Chua *et al.* H135 (1993) Pulau Hantu (SINU). Lai & Saifudin LJ549 (1999) Loyang Avenue, back mangrove (SINU). Duistermaat S176 (2003) Pulau Ubin, E of Kampong Melayu, abundant along paths and open patches in old rubber plantation with remnants of old forest on top of the hill; S219 (2003) Bukit Timah Nature Reserve, Senapang Road, shaded roadside in secondary forest; S226 (2003) Pulau Ubin, Jalan Ubin, secondary forest (SING).

Another specimen, Wong *P.W. s.n.* (1959; SINU) is intermediate between *C. accrescens* (sheath sparsely hairy all over, panicle 20–35 cm long) and *C. patens* (spikelet 1.6–1.7 mm long). It could either be a hybrid, or a form of *C. accrescens* with unusually small spikelets.

Dichanthium

Although Gilliland (1971) mentioned *Dichanthium annulatum* (Forssk.) Stapf for Singapore, Keng *et al.* (1998) did not include it, because they had not seen any Singapore material. The species is different from both *D. caricosum* (L.) A. Camus and *D. mucronulatum* Jansen in having an inflorescence with 3–5 racemes (only 1 raceme in the other two). Superficially, it resembles a poorly developed *Bothriochloa bladonii*, the inflorescence of which as a rule has more than 10 racemes. Moreover, the racemes and pedicels are furrowed in the latter, not so in *D. annulatum*. I was able to identify collections as *D. annulatum* both in SING and SINU, and made three collections (all from one area) in Singapore.

This species of Palearctic origin is mainly a roadside ruderal. Because of its tufted habit with rather long and tough decumbent culms, it can be a nasty weed in lawns.

Dichanthium annulatum (Forssk.) Stapf

50–200 cm tall. Tufted, decumbent. Nodes hairy. Sheath 3–7 cm long, glabrous, slightly compressed, not keeled, margin glabrous. Ligule 1.5 mm long, hairy, membranous. Blade 7–17 cm long, 3–6 mm wide, hairy at least on upper side, base rounded, with a few up to 5 mm-long hairs. Inflorescence with 3–5 simple racemes, 3.5–7 cm long, axils hairy. Spikelets in pairs, one sessile, one pedicelled. Pedicel 1.8–2.0 mm long, somewhat flattened but not furrowed, hairy on one margin. Sessile spikelet 3.5–3.9 mm long, 1.0–1.2 mm wide, dorsiventrally flattened, 2-flowered, awned; both lowest bracts (glumes) as long as the spikelet. Awn 2–2.5 cm long. Pedicelled spikelet reduced to 2 glumes.

Singapore collections: Teruya 2012 (1932) Newton (SING). Sinclair SFN 39429 (1951) Tanjong Pagar Docks (SING). Wong P.W. s.n. (1959) General Hospital grounds (SINU). Sinclair SFN 10784 (1965) Tanjong Pagar, Nelson Road (SING). Ali Ibrahim AI337 (1998) Upper East Coast Road (SING). Lai LJ498 (1999) Tanglin, Dempsey Road, Civil Service Club (SINU). Duistermaat S16 (2002) Mount Sinai Drive, shaded grassy roadside; S25 (2002) Mount Sinai Drive, grassy roadside, partly shaded, frequently mown; S118 (2003) Mount Sinai Drive, on 300 cm high stone wall in backyard, unshaded (SING).

Digitaria

The genus *Digitaria* comprises worldwide *c.* 170 species, the delimitation of which has long been a problem. For the 27 Malesian species, there is the revision by Veldkamp (1973). The treatment of the genus in Keng *et al.* (1998) obviously follows this revision. However, they did not include *D. bicornis* (Lamk.) Roem. & Schult. and *D. mollicoma* (Kunth) Henr., although in the revision the first was recorded as ‘throughout Malesia’ and the latter as ‘Singapore [among others]’. Material of both species is present in both SING and/or SINU, and I collected them recently as well. Veldkamp (*pers. comm.*) provided a separately distributed identification list of the specimens he had examined, including those from SING. An updated list is given here.

Digitaria bicornis is a species from waste places, often on sand, also along the shore. Its recorded presence on the island dates back to the 19th century. The paired spikelets are heteromorphous, i.e. sterile lemma of the sessile spikelet glabrous with nerves equidistant to slightly pubescent with nerves not equidistant, that of the pedicelled spikelet always more pubescent to bristled, nerves not equidistant; if basal spikelets homomorphous, then completely glabrous. In Singapore there is only one other taxon with heteromorphous spikelets, *D. setigera* Roem. & Schult. var. *calliblepharata*

(Henr.) Veldk. The two can be separated by the absolute and relative length of the upper glume: 1–2.75 mm long and 0.35–0.8 times as long as the spikelet in *D. bicornis*, versus 0.3–1 mm long and 0.15–0.3 times as long as the spikelet in *D. setigera* var. *calliblepharata* (Veldkamp, 1973, *pers. comm.*). *Singapore collections* (all in SING): Ridley *s.n.* (1890) Changi. Burkill 4669 (1919) Tanah Merah Besar. Teruya 2221 (1932) Newton. Corner *s.n.* (1941) Yio Chu Kang (Veldkamp det. as *D. nuda*). Duistermaat S142 (2003) Gim Moh, raised flowerbed, unshaded; S184 (2003) Pulau Ubin, Chek Jawa, house no 1, 'The English House', on rock facing the sea; S217 (2003) East Coast Park; S253 (2003) Sarimbun, Jalan Bahtera, grassy roadside, under trees, in shade.

Digitaria mollicoma, like *D. longiflora* (Retz.) Pers., is a stoloniferous, mat-forming grass with spikelets in groups of three. Both grow on open, shaded to unshaded, humid, sandy to rocky soil. Both species seem to be fairly recent introductions to Singapore, the oldest record is from 1955 for the first, 1958 for the latter (*H.B. Gilliland* 1782). The two differ in the length of the spikelets, relative length of the upper glume, and the positioning of the veins on the sterile lemma (Veldkamp, 1973, *pers. comm.*):

- 1a. Spikelets 1.8–2.5 mm long. Upper glume 0.7–1 times as long as the spikelet. Sterile lemma with 7 more or less equidistant veins. *D. mollicoma*
 1b. Spikelets 1.3–1.7(–1.9) mm long. Upper glume as long as the spikelet. Sterile lemma with 5–7 more or less inequidistant veins. *D. longiflora*

Singapore collections: Abu Kassim *s.n.* (1955) Bedok roadside (SINU); 1754 (1958) University grounds. Jumali K994 (1964) Botanic Gardens, near the pond (SINU). Chan *s.n.* (1984) NUS, Kent Ridge Campus, waste ground (SINU). Lai LJ493 (1999) junction of Sembawang Road and Gambas Ave, open waste ground (SINU). Duistermaat S31 (2002) Holland Road, inclined verge with grass vegetation, shaded; S160 (2003) Upper Pierce Reservoir, dirt road through forest, in low vegetation on wet soil along free running streamlet; S240 (2003) Pulau Subar Laut (Big Sisters Island), sandy soil just above high water-line, underneath coconut trees (SING).

Eragrostis

The delimitation of the species of *Eragrostis* (c. 350 species worldwide) is troublesome. However, for the Malesian region they were recently revised by Veldkamp (2002), who clarified many problems. Most of the names he mentions for Singapore are included in Keng *et al.* (1998), although the delimitation is different in a few cases. Most dramatic is the change in the *E. atrovirens-elongata* complex. The name *E. elongata* (Willd.) J.Jacq., now to be regarded as a synonym for the E. Malesian-Australian *E. diandra* (R.Br.) Steud., appears

to have been widely used for other taxa in Singapore including *E. atrovirens* (Desf.) Trin. ex Steud., *E. brownii* (Kunth.) Nees and *E. cumingii* Steud. var. *cumingii*. The last two, not mentioned in Keng *et al.* (1990), are not easily distinguished. The discriminating character is in the length and shape of the anthers, and to a lesser extent also in the colour of the pericarp (Veldkamp, 2002): anthers 0.1–0.2 mm long, globose, and pericarp cinnamon-coloured in *E. cumingii* var. *cumingii*, versus anthers 0.3–0.4 mm long, ellipsoid, and pericarp dark tea-coloured, rarely cinnamon-coloured as in *E. brownii*. However, in the Singapore material the anthers are never globose (1.6 to 3.0 times as long as wide), the length of the anthers ranges continuously between 0.15 and 0.34 mm, and differences in the colour of the pericarp do not correspond with this. I have therefore decided to treat the Singapore material as one species, *E. brownii* in the wider sense (*s.l.*). It is distinguished from the other Singapore species by the persistent paleas and the jointed rachilla that will ultimately break up from above downward. It was collected for the first time in 1930, and is today rather common, also in the urban environment.

Eragrostis brownii s.l.

Singapore collections (not already cited in Veldkamp, 2002; herbarium only mentioned if not SING): *Teruya* 1299 (1930) Geylang, *Teruya* 2023 (1932) Newton. *Teo* TM30 (2000) Tanah Merah (SINU). *Samsuri et al.* 44 (2001) Pulau Tekong. *Duistermaat* S4 (2002) Mount Sinai Drive, road side and between pavement; S24 (2002) Holland Road area, Mount Sinai Rise, bank of terrace house, with grass vegetation; S53 (2002) Sungei Kadut area, Mandai Quarry, off Woodlands Road, waterlogged soil; S68 (2002) Sungei Buloh, on gravel path, unshaded, low density vegetation; S145 (2003) Holland Road area, Mount Sinai Drive, bank of terrace house, with grass vegetation, unshaded; S185 (2003) Pulau Ubin, Chek Jawa, house no 1, 'The English House', between cracks of staircase leading to private jetty; S213 (2003), N-side of Sultan's Land, off Gallop Road, steep slope with seepage water, low and dense vegetation, unshaded; S256 (2003) Sarimbun, Bahtera Track, sunny roadside on sandy clay.

Furthermore, the collections in SING revealed, rather surprisingly, an old collection of *E. cilianensis* (Bellardi) Vignolo ex Janch. (*Corner s.n.*, 1941, Yio Chu Kang; Veldkamp det. as *E. uniolooides*, but lemmas lack the granular structure that is typical for this species). The species is recognised by its persistent paleas and the presence of obvious glands on leaf sheath and blade. In Malesia, it is recorded as a weed of waste places, especially in regions with a distinct dry season, from the Philippines, Java, Lesser Sunda Islands, Moluccas, and introduced in New Guinea (Veldkamp, 2002). However, the species does not seem to be part of the present day flora of Singapore.

Panicum

With 450 species worldwide, the genus *Panicum* is one of the largest within the grass family (Poaceae). Only 26 species occur in the Malesian region (Veldkamp, 1996, 1999). According to Aliscioni *et al.* (2003, and references therein), *Panicum* is a polyphyletic group. They propose a new generic delimitation and divide *Panicum* into various genera (with a number of sections still as *incertae sedis*). Because many of the Malesian species were not included in the analysis, I prefer to consider their results as preliminary. I therefore retain *Panicum* with its traditional delimitation (Aliscioni *et al.*, 2003). The genus is recognized by a lax to dense panicle with rounded to triquetrous branches. The spikelets are 2-flowered and unawned with the upper glume as long as the spikelet.

Six species of *Panicum* were confirmed by Keng *et al.* (1998) based on Veldkamp (1996). *Panicum trichocladum* Hack. ex K.Schum. was confirmed by Veldkamp (1999), whereas material of one more *Panicum* species was found in the herbarium, and a third species was collected in the field. *Panicum* is now represented by nine species in Singapore.

Panicum trichocladum, when present, is often abundant, scrambling through shrubs up to 3 m high. Its diagnostic features include ligule membranous, ciliolate, panicle branches at base without spikelets, lower glume 0.3–0.6 mm long and 0.1–0.2 times as long as the spikelet, and 2nd lemma apiculate and incurved. It has been collected from three localities in 1998 (specimens cited in Veldkamp, 1999), and more recently in the secondary forest between Holland Road and Tyersall Avenue (*Duistermaat* S200, 2003; SING), and inside Bukit Timah Nature Reserve, Senapang Link (*Duistermaat* S220, 2003; SING).

In the collections of SINU, I found two specimens of *Panicum paludosum* Roxb. This species is similar to *P. repens* L. in having a collar-shaped lower glume, but differs in having an entirely glabrous sheath and blade, and the sterile lower floret without a palea or, when present, up to 0.7 times as long as the lemma, while *P. repens* has a male lower flower with the palea more than 0.8 times as long as the lower lemma. It also has larger spikelets (3.3–4.5 mm long against 2.6–3.25 mm; see Veldkamp, 1996). *Panicum paludosum* is an aquatic species, favouring shallow waters, whereas *P. repens* usually grows in terrestrial conditions and is only able to survive inundation temporarily (Gilliland, 1971). Its presence in Singapore is a little surprising, as in Malaysia *P. paludosum* is known only from the northern and central states of Kedah (including Langkawi), Pahang and Penang. In Indonesia, the nearest localities are in Sumatra and Borneo. The oldest Singapore collection is from 1959 (Wong P.W. *s.n.*, Tampines, floating in water). The second and newest collection is from 1965 (Keng *et al. s.n.*, unfortunately without locality). Although I have not seen the species on my collecting trips, it could still be present in shallow waters.

In 2002, I found a delicate, c. 20 cm high grass with minute spikelets c. 1.3 mm long. It grew on a shaded roadside with rather dense, lawn-like vegetation. At the time I could only identify it to *Panicum*. Later, on a field trip with Tan Kai Xin (NUS) on Coney Island (Pulau Serangoon), I found a similar plant growing near the coast on the reclaimed part of the island, on coarse sand in rather open, unshaded vegetation. Finally, I discovered along Clementi Road a third population of over a hundred plants in an open field with clayey, waterlogged soil, and a fourth of some tens of plants on the shaded roadside along Seletar West Farmway 1 (off Jalan Kayu). Bor (1960) and Veldkamp (1996, 1999) do not list the species, and even the World Grass Species Database at the Kew website (<http://www.rbgkew.org.uk/data/grasses/grasses.ink>) yielded only a single, but not identical species. Finally, Hitchcock & Chase (1910, 1915) and Hepper (1972) lead beyond doubt to *P. laxum* Sw. A recent revision of section *Laxa* (Zuloaga *et al.*, 1992) resulted in the same positive identification.

The species is widely distributed in America from Mexico to Argentina, where it is common in wet and open, disturbed places, margins of roads, swamps and rivers, at altitudes of 0–1500 m. During the early 20th century, the species was introduced to West Africa (first collected in 1927) and is there now naturalized on roadsides and in clearings, particularly on damp soil. Later, it was also found in Australia (Simon, 1992, as *Cliffordiochloa parvispiculata* and Simon, 2003, as *Steinchisma laxa*), confined to water channels (Queensland). As far as I know, this is the first time *Panicum laxum* is recorded for Asia. Its habitat in Singapore is comparable to where it is found in Africa, but the Singapore plants seem to be smaller. *Duistermaat* S37 is different from the other two collections in being single and prostrate, rather than tufted and geniculate. It could be the *cv.* 'Shadegro', a form with a potential as a turf grass for shaded conditions, which is established in the Brisbane Botanic Gardens (Simon, 2003).

Panicum laxum is more closely related to the Asian *P. auritum* (also occurring in Singapore, and the only two species of section *Laxa* occurring in Malesia) than to any of the other species occurring in Malesia. The two can be separated as follows:

- 1a. Plant 80–120 cm tall. Leaf sheath and blade without transverse veinlets. Spikelet 2.0–3.0 mm long. Upper glume and 1st lemma with (faint) transverse veinlets. 1st palea up to 0.75 times as long as 1st lemma.
P. auritum
- 1b. Plant 20–45 cm tall. Leaf sheath and blade with minute transverse veinlets. Spikelet 1.3–1.4 mm long. Upper glume and 1st lemma without transverse veinlets. 1st palea as long as 1st lemma.
P. laxum

Panicum laxum Sw.*(Steinchisma laxa* (Sw.) Zuloaga)

Culms 20–45 cm tall. Single or tufted, geniculate to prostrate. Nodes glabrous. Sheath glabrous, with minute transverse veins, margin hairy at apex or upper half only. Ligule 0.3–0.4 mm long, membranous, fimbriate. Blade 4–7 cm long, 2–5 mm wide, glabrous. Inflorescence 5–13 cm long, 3–10 branches scattered along rachis, patent, longest branch 2.5–6.0 cm long, branchlets appressed to 1st order branch. Pedicel 0.5–1.0 mm long. Spikelet 1.3–1.4 mm long, 0.7 mm wide, obtuse. Lower glume 0.5–0.6 mm long, 0.5 times as long as the spikelet, glabrous, 3 veins. Upper glume 1.2 mm long, glabrous, 5 veins. 1st lemma as upper glume, 1.2–1.3 mm long, 3 veins, obtuse to acute. 1st palea 1.2–1.3 mm long.

Habitat in Singapore: Open to shaded roadside or field, on clayey or sandy soil.

Singapore specimens: *Duistermaat* S37 (2002) Holland Grove Road, Henry Park Apartments, roadside lawn, shaded (SING, L). *Duistermaat* NUS 1269 (2003) Coney Island, raised bank of reclaimed area near the coast, on coarse sand in rather open and unshaded vegetation. (SINU, L). *Duistermaat* S285 (2004) Clementi Road, at junction with Dover Road, open field on waterlogged, clayey soil, more than 100 plants; S287 (2004) Seletar West Farmway 1, on shaded roadside on clayey soil, some tens of plants.

Paspalum

The collections in SINU include one specimen of *Paspalum plicatulum* Michx. (*Teo* L3 (2000) Lazarus Island). The species is readily recognised by a conspicuous dark centre on the oblong to (ob-)ovate, paired spikelets. It is native to America, and has been found several times in northern Australia (Mallett & Orchard, 2002: p. 348). It was found in Malesia only once, in a cultivation plot in Papua New Guinea (De Koning & Sosef, 1985: p. 313, and included in their key to the Malesian species). Plants are cultivated for their high palatability to cattle in (sub-)tropical America (known as Brownseed *Paspalum*), the Chinese province of Gansu (Chen & Phillips, undated), and Papua New Guinea (De Koning & Sosef, 1985). It remains to be seen if this species will establish itself in Singapore.

Rottboellia

In the collections of SINU, I found a specimen (*Chua et al.* 1074) that, with its 80 cm-long culms growing in tufts and with several spike-like racemes from a single culm, superficially resembles *Mnesithea glandulosa*. With this species it also shares the sessile spikelets with winged lower glumes, and the sterile pedicelled spikelets (Veldkamp *et al.*, 1986), but the gland-like warts on the margins of the lower glumes of the sessile spikelets, which are characteristic for this species, are lacking. Moreover, the male 1st floret of the sessile spikelet,

and the sheaths with bulbous-based hairs speak more for *Rottboellia cochinchinensis* (Lour.) W.D. Clayton (Veldkamp *et al.*, 1986). Thus, the specimen is intermediate between the genus *Mnesithea* and *R. cochinchinensis*. In SING, I found a second intermediate specimen (*Samsuri et al.* 315), but this one has unwinged lower glumes, a less inflated rachis, and sterile pedicelled spikelets of only 2 glumes. Earlier, an intermediate specimen from the Philippines was described as *Rottboellia paradoxa* Koning & Sosef (Veldkamp *et al.*, 1986), but here the pedicels are only partly fused with the rachis; they are completely fused in the Singapore material. All intermediate specimens are different from each other. Study of the Malesian collections of *R. cochinchinensis* in SING revealed that this species is probably much more variable than earlier thought. I therefore keep both Singapore specimens under this name. Because both were collected on recently reclaimed land, it remains to be seen whether the species will become established in Singapore.

Rottboellia cochinchinensis (Lour.) W.D. Clayton

R. exaltata L.f. (see Clayton, 1981)

Culms up to 80 cm tall, tufted. Nodes glabrous. Sheath 6–7 cm long, with bulbous-based hairs, rounded, margin hairy. Ligule 1.5 mm long. Blade 21–45 cm long, 11 mm wide. Inflorescence spike-like raceme, 5–7 cm long, several from 1 stem, basal part internode flattened, 2–3.8 mm wide, upper part rounded, 2–4.5 mm wide. Spikelets in pairs, 1 sessile, 1 pedicelled; pedicel glabrous, one side completely fused with rachis; sessile spikelet 4.5–5.0 mm long, 1.7–4 mm wide, 1st floret male. Lower glume granulate, margin smooth, apex unwinged or with indurated wings. Pedicelled spikelet c. 4.5 mm long, of two reduced, herbaceous, flat glumes, 0–2 smaller hyaline bracts inside.

Habitat in Singapore: Open wasteland on sand near the coast, waterlogged, unshaded.

Singapore specimens: *Chua et al.* 1074 (1995) Marina East, reclaimed land (SINU). *Samsuri et al.* 315 (2002) Pulau Tekong, reclaimed land (SING).

Sporobolus

In mid-2003, a small-tufted grass with lax panicles attracted my attention. I have found it several times in Singapore, on roadsides, in flower beds and flower pots. The species is not mentioned in Gilliland (1971) or Keng *et al.* (1998). The keys in Bor (1960), however, lead to *Sporobolus tenuissimus*, a species native to tropical Africa, America, and India. Introduction of the species with potting mix or garden material is obvious.

Baaijens and Veldkamp (1991) already noticed that this species had been introduced into other regions in Asia (Vietnam, Indonesia: Java). It seems to be spreading (rapidly) in India (Sreekumar, 1994), Indonesia (Veldkamp, 1997) and Thailand (Veldkamp, 2003). We should therefore expect to see more of this species in Singapore and Malaysia; it could even spread to everyone's highrise garden!

The plant superficially resembles *Eragrostis amabilis* (L.) Wight & Arn. ex Nees, with which it was found growing, in the panicle shape and in the hyaline parts of the spikelet. It immediately stood out because of the strictly erect stems (prostrate to ascending in *E. amabilis*) and the 1-flowered spikelets (vs. 3–6-flowered).

During fieldwork with H.T.W. Tan *et al.*, I found a few plants of *Sporobolus indicus* (L.) R.Br. that seemed particularly tall. For that reason I collected them, and checking with Baaijens and Veldkamp (1991) they appeared to be *S. indicus* var. *pyramidalis* (Beauv.) Veldk., a taxon from Africa and S. America. Because it had been reported for Australia and the Pacific they suggested it might turn up in Malesia. Veldkamp (*pers. comm.*) was able to confirm this identification and that it is the first record of the variety for Malesia.

Key to the *Sporobolus* species and varieties in Singapore

(after Baaijens and Veldkamp, 1991)

- 1a. Stoloniferous plants. Lower glume 0.55–0.9 times as long as spikelet, upper glume 0.75–1 times as long. *S. virginicus*
- 1b. Tufted plants. Lower glume 0.2–0.5 times as long as spikelet, upper glume up to 0.67 times as long. 2
- 2a. Spikelet 0.9–1.25 mm long; pedicel 2–6 mm long. Lemma and palea hyaline. *S. tenuissimus*
- 2b. Spikelet longer than 1.25 mm; pedicel less than 1 mm long. Lemma and palea herbaceous. 3
- 3a. Upper glume truncate, less than half as long as the spikelet, slightly longer than the lower glume. (Spikelets 1.7–2.2 mm long. Anthers 3). *S. indicus* var. *pyramidalis*
- 3b. Upper glume more or less acute, 0.4–0.67 times as long as spikelet, distinctly longer than the lower glume. 4
- 4a. Panicle usually somewhat lax and branches with loose spikelets. Spikelets usually 1.4–1.6 mm long. Anthers usually 2, 0.5–0.8 mm long. Seed 0.6–0.9 mm long. *S. indicus* var. *flaccidus*
- 4b. Panicle usually contracted and branches with dense spikelets. Spikelets usually 1.8–1.9 mm long. Anthers usually 3, 0.7–1 mm long. Seed 0.9–1.1 mm long. *S. indicus* var. *major*

Sporobolus indicus (L.) R.Br. var. *pyramidalis* (Beauv.) Veldk.

Plant 1.55 m high, tufted. Culm erect. Spikelet 1.9 mm long. Lower glume 0.3 mm long, truncate. Upper glume 0.6 mm long, truncate. Anthers 3, 0.9 mm long. *Habitat in Singapore*: Unshaded, open vegetation, sandy soil.

Singapore specimens: Duistermaat and Tan *et al.* S304 (2004) 38x39 Neo Tiew Crescent, open field of private company (SING, duplicated in L, living collection in SINU).

Sporobolus tenuissimus (Schrank) Kuntze

Plant 20–70 cm high, single or in small tufts. Culm erect. Nodes glabrous. Sheath and blade glabrous. Ligule 0.2 mm long, fimbriate. Blade up to 14 cm long, 2 mm wide. Inflorescence a lax panicle, 15–36 by 4–6 cm, longest branches 4 cm long, glabrous, very thin, with secondary branchlets. Spikelets well-spaced, pedicelled, single, 1-flowered, 1.3 mm long, hyaline. Both glumes much shorter than spikelet. Anthers 0.3–0.4 mm long.

Habitat in Singapore: In flowerbeds and on roadsides, open vegetation, unshaded. Seems to be associated with *Eragrostis amabilis*.

Singapore specimens (all in SING, duplicated in L): *Duistermaat* S131 (2003) as a weed in potted plant at 56 Mt. Sinai Drive; S223 (2003) Bukit Timah campus of Singapore Management University, flowerbed with fertile humus-rich soil, unshaded; S259 (2003) Waterloo Street, near the church of St Peter & St Paul, on sandy roadside with cement and brick debris, unshaded; S260 (2004) Cluny Road, in unshaded flowerbed with clayey sand.

Urochloa

Veldkamp (1999) noticed that besides the three *Urochloa* species mentioned in Keng *et al.* (1998), a fourth, *U. piligera* (F. Muell. *ex* Benth.) R.D. Webster, is present in Singapore. Like *U. subquadripara* (Trin.) R.D. Webster, spikelets are solitary, and the lower glume has overlapping margins (Veldkamp, 1996). It is immediately recognised as different, however, because of the hairy upper glumes (glabrous in the latter). It is native to Australia and east Malesia (Sulawesi to New Guinea), where it grows in open sandy places near the seashore, and in dry rice fields. The first records for Singapore (1959, specimens in SINU, cited in Veldkamp, 1999), were found inland, in swampy places, on the bank of a canal and on a roadside. It was not collected again, until in 2002 I found the species in Sungei Buloh (*Duistermaat* S72), and in 2003 in Sarimbun (*Duistermaat* S243; collections in SING). In both places it grew on dry to damp roadsides on sandy clay in coastal areas on the northwest of the island, a habitat comparable to its native one.

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Added in press: Three more new records need to be added.

Neyraudia

Veldkamp (1999) reported *Neyraudia arundinacea* (L.) Henr. var. *zollinger* (Buse) Henr. as a new record for Singapore (Wong W.P. s.n., August 1959, Bartley Road, SINU). It has not been found since. This grass with a reed-like habit and silky-hairy panicles is distinguished from *Phragmites* by the hairy lemmas. It also grows in drier places than the latter (Gilliland 1971).

Oplismenus

Oplismenus is characterized by awned glumes and ovate to lanceolate leaf blades (Gilliland 1971). The presence in Singapore of *O. burmanni* (Retz.) P. Beauv. and *O. compositus* (L.) P. Beauv. was mentioned by Veldkamp (1999). Besides the specimens cited by him, I have seen the first in Nee Soon forest (*Duistermaat* S166, 2003, SING). The two are best distinguished by the type of awn: antrosely scaberulous and filiform in *O. burmanni* vs. smooth and rather thick in *O. compositus*.

***Curcuma mutabilis* (Zingiberaceae): a New Species from South India**

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Abstract

Curcuma mutabilis Skornickova, M.Sabu & M.G.Prasanthkumar, *sp. nov.* is described from Northern Kerala, South India, including illustrations and notes.

Introduction

The genus *Curcuma* L. is of great economic and ornamental importance and several species such as *C. longa* L., *C. aromatica* Salisb., *C. zanthorrhiza* Roxb., *C. alismatifolia* Gagnep., etc., can be found all over the tropics introduced, cultivated and sometimes naturalized. The genus is distributed mostly in tropical Asia with a few species extending to Australia and the South Pacific. Larsen *et al.* (1998) stated there are about 80 species, Sirirugsa (1996) estimated the number at around 100. Presently there are 103 validly published names (excluding those that have been transferred to other genera) and another 6 species were published only as *nomen nudum*. Without a doubt, a number of names will turn out to be synonyms, but as recent field exploration in India and SE Asia proceeds, the number of species will probably reach 120. Three new species were recently described from SE Asia (Sirirugsa & Newman, 2000; Mood & Larsen, 2001). In India, the genus is represented by 29 species (Karthikeyan *et al.*, 1989; Jain and Prakash, 1995) and has been revised for South India by Mangaly and Sabu (1993). Since then exploration of remote areas in India has brought to light another three new species (Tripathi, 2001; Skornickova *et al.*, 2003a, b).

While working for the project 'Revision of Indian Zingiberaceae', the authors encountered an interesting seed-setting *Curcuma* species from Nilambur, North Kerala. At the beginning of the monsoon season, the plant resembled *C. oligantha* Trimen in lacking an obvious coma, by the inflorescence appearing before the first leaf expands, the flowers being exerted from the bracts, and in rhizome shape. However, critical studies of the plants observed at different times in relation to the monsoon season revealed that the species is different from *C. oligantha*, especially in its general habit and size, shape and coloration of the bracts, and size and shape of flower parts.

Subsequently, we discovered that Velayudhan *et al.* (1999) had described this species as *C. nilamburensis* based on a collection from the same locality.

Unfortunately, this name is not validly published according to the St Louis Code (Greuter *et al.*, 2000) because the description lacked a Latin diagnosis and a type was not designated. In addition, the publication by Velayudhan *et al.* (1999) is of limited circulation, consequently, the species is described appropriately below.

Curcuma mutabilis Skornickova, M. Sabu & M.G. Prasanthkumar *sp. nov.* (Fig. 1, Plate 1.)

C. nilamburensis in Velayudhan K.C., V.K. Muralidharan, V.A. Amalraj, P.L. Gautham, S. Mandal & D. Kumar, Curcuma Genetic Resources. 1999. p. 42. *nom. illegit.*

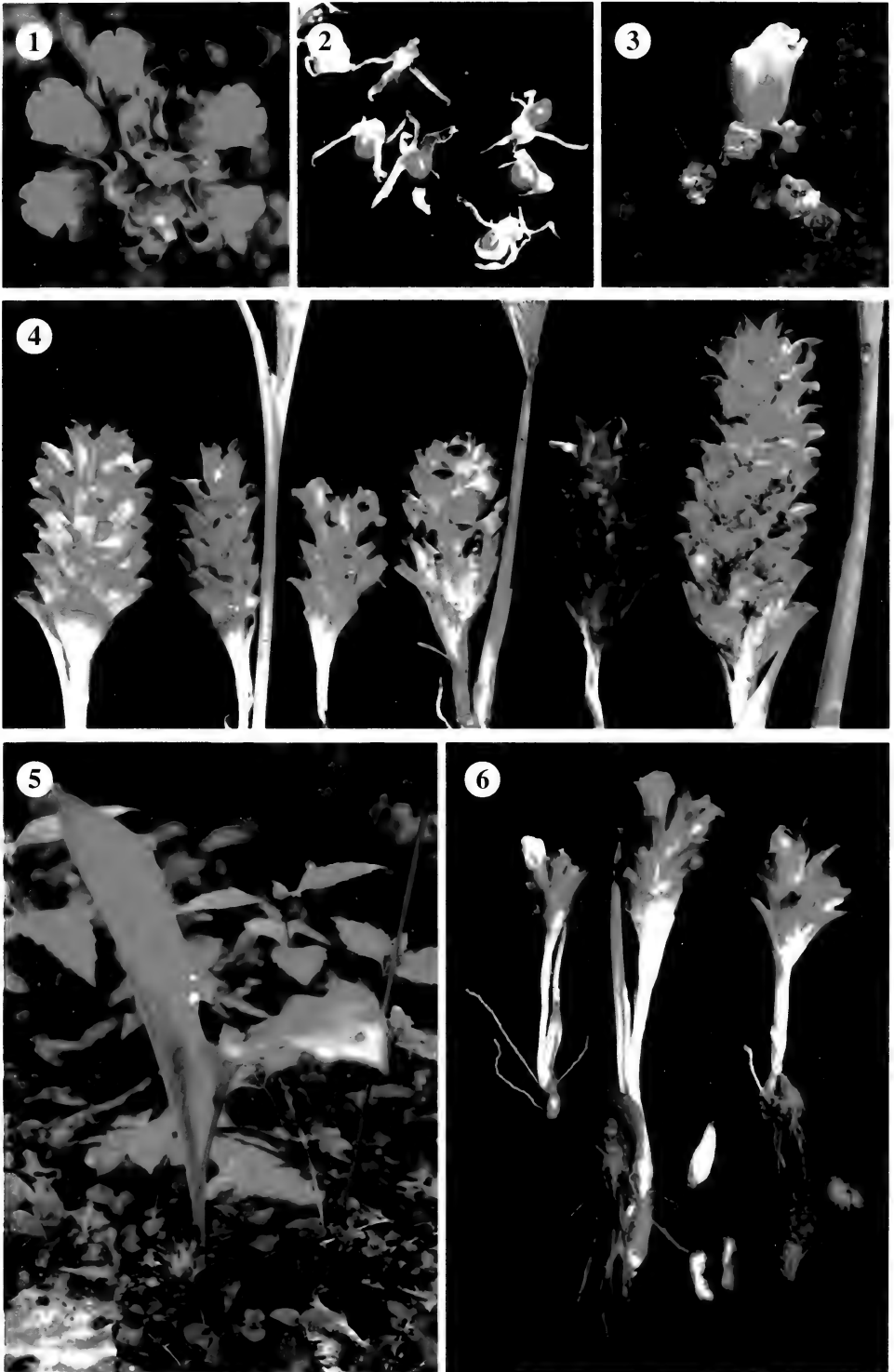
C. neilgherrensis auct. non Wt.: Sivar. & P. Matthew, Fl. Nilambur. 1996. p. 708.

Curcumae oliganthae Trimen in coma inconspicua rhizomatis figura magnitudo colorque similis, habitu maiore robustiore (60 cm longo), bracteis fertilibus ovato-ellipticis in dimidio inferiore connatis apice rodundato macula fusce brunneo-violacea proviso, floribus bracteis minus exsertis, labello minore (14–16 mm longo), staminodiis lateralibus brevioribus (13–16 mm longis) corollae lobo dorsali non multo excedentibus, antherarum calcaribus sursum versis differt. *Typus*: India, Kerala, Malappuram District, Nilambur, *Skornickova & Prasanthkumar 84145* (holo MH; iso K, CALI, SING).

Rhizomatous herb, 10–60 cm tall. *Rhizome* ovoid without branches, cylindrical to conical, up to 5 x 2.5 cm, deeply buried in the ground, light brown externally, glabrous, sheathed by papery brown scales and bases of the leaf sheaths, which leave vertical scars after decaying, creamy yellowish internally, faintly aromatic. *Roots* fleshy ending in ovoid root tubers 2–4 x 1–2 cm distanced 2–15 cm from the main rhizome, externally light brown, glabrous, pearly white inside, non-aromatic. *Pseudostem* 5–30 cm long, deeply buried in the soil, formed by leaf sheaths and 3–4 sheathing bracts, green or with a red tinge, drying towards the end of season and becoming brown and papery, *ligule* 3–4 mm, bilobed, translucent greenish, hairy outside and on the margin, hairs 0.2–0.3 mm; *leafy shoot* 15–60 cm long. *Leaves* at the beginning of the season 1–2 with a short petiole or even almost sessile, later with up to 7 leaves, gradually with longer petioles up to 20 cm long, petiole green or with a red tinge, glabrous or shortly

Plate 1. *Curcuma mutabilis*

1. Inflorescence of a yellow-flowered plant (seen from above); 2. Detail of arillate seeds; 3. Inflorescence of a white-flowered plant; 4. Variability of inflorescences; 5. Habit at type locality; 6. The whole plant including rhizome. All photographs are of the type material *Skornickova & Prasanthkumar 84145* with lateral inflorescences at the beginning of season. *Photos J. Skornickova.*



hairy; *lamina* ovate-elliptic, 14–35 x 7–11 cm, adaxially deep green, prominently veined, prominent veins quite closely arranged c. 5 mm apart, sulcate in between, hairy on the prominent raised veins and towards the margin especially in the upper half of the lamina, hairs c. 0.3 mm long (rarely almost glabrous on the upper surface), abaxially paler green, usually glabrous, rarely densely velvety pubescent; margin hyaline, translucent white, c. 0.2 mm wide, hairy in the apical part and glabrous in the distal part of lamina, tip c. 0.5 cm long, acuminate, densely hairy, base attenuate to slightly cordate, oblique, midrib green, glabrous. *Inflorescence* lateral at the start of the season, central later in the season. Peduncle 4–20 cm long, 2.5–8 mm diam., glabrous, whitish, light green or with a red tinge, peduncle of the vernal inflorescence sheathed by bracts, central one hidden within the pseudostem. *Spike* 3.5–15 x 2.5–5 cm, consisting of 6–70 bracts. *Coma* inconspicuous, usually only the uppermost 2 or 3 bracts are sterile and more linear than the fertile ones, 2.5–3.5 x 0.7–1.5 cm, light green or with a red tinge (sometimes deep red), upper side sparsely hairy, lower side glabrous, tips rounded with a deep violet brown patch. *Fertile bracts* ovate-elliptic with visible parallel veinlets, tip obtuse or slightly acuminate, both sides glabrous, connate in the lower half, 2.5–3.5 x 1.5–2.7 cm, whitish, light green, green or with a red tinge verging to brown red, but all bracts (including uppermost sterile ones) always with a dark violet mauve tip, which is usually larger in the upper bracts and less conspicuous in the lower ones. *Cincinni* with 2–4 flowers. *Bracteoles* one per flower, 5–7 x 2–4 mm, hyaline, translucent white or with a pink or a red tinge, almost glabrous or puberulus with a few hairs 0.2–0.3 mm long on the tip. *Flowers* 4.5–5 cm long, exerted from bracts. *Calyx* 8–11 mm long, 3-toothed, unilaterally split 3–4.5 mm deep, translucent white or tinged with pink or dark violet, quite glabrous, but with sparsely hairy teeth and sometimes along the upper part of the vein leading from teeth to the base. *Corolla tube* c. 2.5–3 cm, at the base white, yellowish or yellow, towards the lobes sometimes tinged with pink, red or violet, glabrous; *dorsal corolla lobe* c. 1.4–1.8 x 1–1.4 cm, triangular-ovate, concave, apex mucronate, mucro 1–2 mm long, glabrous, varying from white, yellowish or yellow, sometimes tinged pink red or deep violet-bluish, *lateral corolla lobes* 1.4–1.7 x 0.6–0.8 cm, triangular with rounded, slightly concave tip, glabrous, with the same coloration as the dorsal lobe but less intensive, usually overlapping in the tip portion on the ventral side of the flower. *Lateral staminodes* obovate-rhomboid, 1.3–1.6 x 1–1.2 cm, usually yellow or yellow with a reddish base, less frequently white or white with a yellow or reddish base, glandular hairs present on the raised middle portion. *Labellum* 1.4–1.6 x 1.5–1.9 cm, emarginate, split 3–6 mm long (opening wider as the flowers age and wilt), yellow or less frequently white, centre deep yellow or yellow, rarely also white, base of labellum usually yellowish, rarely with a deep red patch or tinge. *Anther* spurred, glandular hairs present on the sides and back part, anther

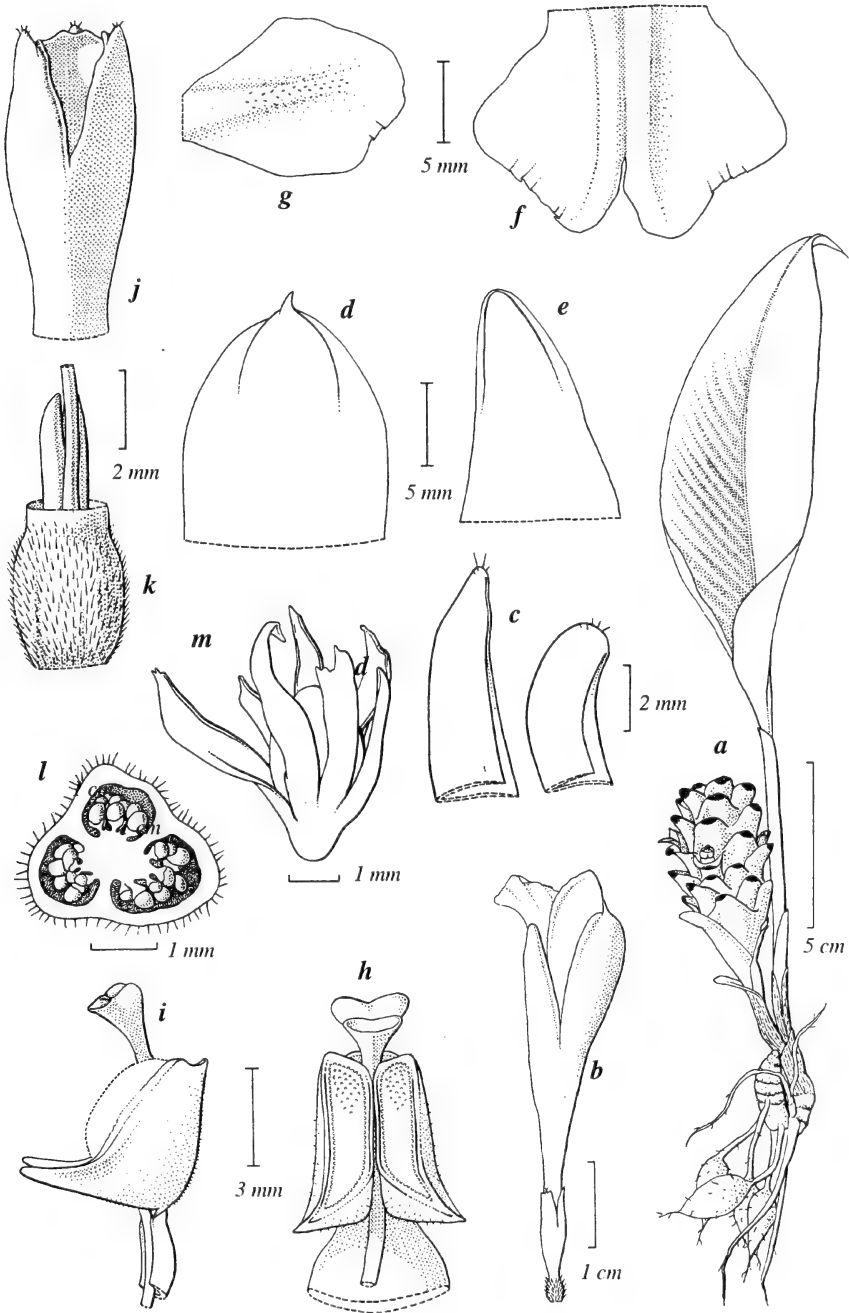


Figure 1. *Curcuma mutabilis*

a. Habit; b. Flower (side view); c. Bracteoles; d. Dorsal corolla lobe; e. Lateral corolla lobe; f. Labellum; g. Lateral staminode; h. Anther (front); i. Anther (side); j. Calyx; k. Ovary and epigynous glands; l. Ovary (cross section); m. Seed. Based on the type material Skornickova & Prasanthkumar 84145. Del. J. Skornickova.

thecae whitish, 3.5–4 mm long; filament 3–4 mm, light yellow, yellow or with deep red tinge, constricted, 3 mm broad at base, 2 mm broad at upper part. *Anther spurs* 2–2.5 mm long, white or creamy yellowish, pointing upwards. *Anther crest* present, roundish to slightly truncate, c. 1.5 mm broad and 0.5 mm long. *Ovary* trilocular, 3–3.5 x 2.5–3 mm, hairy, white pubescent, hairs 0.3–0.4 mm long, ovules many. *Stigma* 1–1.4 x 0.9–1.1 mm, white, ciliate, exserted 1–2.5 mm. *Epigynous glands* 2, creamy yellow, 3–5 mm long, 0.5–0.6 mm diam. *Fruit* a dehiscent capsule, spherical, c. 1 x 1 cm. *Seeds* 3 x 2 mm, light brown, shiny glabrous, non-aromatic, aril translucent white, laciniate, lobes up to 6 x 0.7–1.5 mm.

Distribution: India: Nilambur in Kerala, so far known only from the type locality and adjacent areas.

Habitat: In lowland areas c. 50–100 m asl, in the undergrowth of teak plantations, secondary forests and shrubby vegetation on dry lateritic soil.

Flowering and fruiting: Lateral inflorescences appear in May to June just before or simultaneously with the leaves. Terminal (central) spikes are produced in September provided the monsoon was sufficient. Fruiting occurs about 3–4 weeks after flowering.

Etymology: The specific epithet refers to the extremely variable colour of floral parts (corolla lobes, labellum and lateral staminodes) and size of the plants.

Notes: *Curcuma mutabilis* appears to be closely related to *C. oligantha* Trimen in having an inconspicuous coma and in its ovoid rhizome internally creamy yellow and without branches, but it differs in the following salient characters. Most remarkable is the more robust habit (up to 60 cm tall), the ovate-elliptic lamina and the size of inflorescence that consists of 6–70 bracts. The ovate-elliptic bracts and prominent dark violet brownish patch at their rounded tips as well as the fact they are connate in the lower half make this species readily recognizable from *C. oligantha*, which rarely exceeds 15–20 cm in height, has ovate-lanceolate laminas and its inflorescences consist of 5–10 (rarely up to 15) lanceolate bracts, which are connate in the lower quarter or even less and have no prominent coloration at the tips that are acuminate. Even though *C. mutabilis* is more robust in its vegetative parts, the flowers are overall smaller (up to 5 cm long with the calyx 8–11 mm long, lateral staminodes up to 1.6 x 1.2 cm and which do not protrude much beyond dorsal corolla lobe) compared with those of *C. oligantha* (5–7 cm long, calyx 15–21 mm long, lateral staminodes up to 3 x 1.4 cm prominently protruding beyond the dorsal corolla

lobe, which make flowers of *C. oligantha* much more exserted out of the fertile bracts than those of *C. mutabilis*). Notable also is the difference in anther spurs, which point upwards in *C. mutabilis*, but downwards more or less following the anther thecae direction in *C. oligantha*. Further details in morphological characters and measurements of *C. mutabilis* and *C. oligantha* are compared in detail in Table 1. More details on *C. oligantha* were published, for example, by Trimen (1885, 1898a), Burt and Smith (1983) and Bhat (1987). There is a colour plate of *C. oligantha* in Trimen's *Handbook to the Flora of Ceylon* (1898b).

Great variability in several *Curcuma* species have already been observed by others, for example, *C. pseudomontana* Graham (Santapau 1945, 1952), *C. aurantiaca* Zijp (Valeton, 1918), and during the past several years we have observed the same feature in several other species (*C. oligantha* Trimen, *C. inodora* Blatt., *C. neilgherrensis* Wt.). All these species share in common propagation by seed. Most of such species have ovoid rhizomes without branches (usually referred as sessile or palmate tubers), and thus there is no provision for vegetative propagation.

Many *Curcuma* species do not set seed and reproduce vegetatively by the rhizome branches (e.g., *C. aeruginosa* Roxb., *C. amada* Roxb., *C. longa* L., *C. zanthorrhiza* Roxb.). Very rarely in some of these species formation of fruit can be observed and, even more rarely, the presence of developed seeds. These species are morphologically quite uniform not only within population, but also between remote populations. Root tubers, which are present in both seed-setting and non-seed-setting *Curcuma* species, are not capable of sprouting and functioning to sustain the plant during periods without rain, when the leafy shoot dries up.

Like other seed-setting species, *C. mutabilis* possesses high variability within populations as already mentioned by Sivarajan and Matthew (1996). In fact, *C. mutabilis* is one of the most variable species we have encountered in the genus. Most remarkable is the difference in flower colour. Corolla lobes can vary from whitish pink, pink-red, reddish orange, dark pink to dark violet; labellum and lateral staminodes can be pure white, white with a yellow or reddish tinge in the throat of the labellum or base of the lateral staminodes or different shades ranging from creamy, light yellow to deep yellow. The colour of the corolla and staminodes varies independently and in fact hardly any two individuals look identical. The leaves are also highly variable regarding pubescence. All these differences can be observed within a few square metres. Also remarkable is the difference in size of the plants, which ranges from a few centimetres to about 60 cm tall, as well as in the number of the bracts, which can vary from 6–70. Size and number of bracts seems to be correlated with the age of the plant, which is a feature we have observed in some other seed-setting *Curcuma* species.

This great variability might suggest that hybridisation has occurred. However, it can be ruled out in the case of *C. mutabilis* because the pollen is fully formed (although it has not been tested yet for viability), seed is viable and readily germinates, and many seedlings are observed in wild populations, the range of variation is similar in the separate populations and there are no species within this area that could be putative parents.

The species that appeared under the name *Curcuma neilgherrensis* Wt. in the *Flora of Nilambur* (Sivarajan & Matthew, 1996) is *C. mutabilis* and not *C. neilgherrensis*, which is a completely different species that grows in high altitude grasslands (700–1200 m) and which is common on southwest slopes of the southern range of Neilgherries. Even though *C. neilgherrensis* is also seed-setting and quite a variable species, especially in size of the plant and inflorescence, coma colour (pinkish to deep pink) and indumentum of leaves, it can easily be distinguished from *C. mutabilis* by its lanceolate and firm leaves, spikes with a prominent coma, green fertile bracts with no dark violet patch and yellow flowers, which are not exerted out of the fertile bracts. In contrast, *C. mutabilis* is lowland species (growing at 50–100 m altitude) found in the undergrowth in shady places and it has rather thin, ovate-elliptic leaves, with prominent sulcate venation, an inconspicuous coma, bracts tipped by dark violet brown patch and the flowers (highly variable in colour) are exerted out of the fertile bracts. We have so far not observed such colour variability of flower parts in the *C. neilgherrensis*.

Table 1. Comparison of morphological characters of *Curcuma mutabilis* and its closest ally, *C. oligantha* Trim. Diagnostic characters are in bold.

	<i>C. mutabilis</i>	<i>C. oligantha</i>
Rhizome	<p><i>Main rhizome</i> ovoid, unbranched, up to 5 x 2.5 cm. Inwardly creamy-yellowish colour, faintly aromatic.</p> <p><i>Root tubers</i> 2–4 x 1–2 cm, pearly white inside.</p>	<p><i>Main rhizome</i> ovate-conical, unbranched, up to 5 x 1.5 cm. Inwardly creamy white-yellowish colour, no obvious aroma.</p> <p><i>Root tubers</i> 1.5–4 x 0.8–1.5 cm, pearly white inside.</p>
Leafy shoot	<p><i>Leafy shoot</i> to 60 cm tall with 2–7 leaves.</p> <p><i>Pseudostem</i> and peduncle sheathed by green or reddish green bracts.</p>	<p><i>Leafy shoot</i> to 20 cm tall with 2–6 leaves.</p> <p><i>Pseudostem</i> and peduncle sheathed by green or reddish green bracts.</p>

Table 1. Continued:-

<p>Leafy shoot</p>	<p><i>Ligule</i> 3–4 mm, 2-lobed, hairy along the margin, hairs 0.2-0.3 mm long.</p>	<p><i>Ligule</i> 1–1.5 mm, obscurely 2-lobed, glabrous.</p>
<p>Lamina</p>	<p><i>Lamina</i> ovate-elliptic, 14–35 x 7–11 cm, base attenuate-slightly cordate, oblique. Adaxially deep green, prominently sulcate, hairy along the main veins especially at the distal half of the lamina and near margins (rarely some individuals almost glabrous), abaxially pale green, usually glabrous, rarely individuals densely velvety hairy.</p>	<p><i>Lamina</i> ovate-lanceolate, 7–19 x 3.2–7 cm, base attenuate-slightly cordate, oblique. Adaxially green, glabrous or sparsely hairy, always hairy along the main veins especially at the distal half of the lamina and near margins, abaxially pale green, glabrous.</p>
<p>Inflorescences</p>	<p>Vernal, lateral, later in season central. <i>Peduncle</i> 4–20 cm, spike c. 3.5–15 x 2.5–5 cm, comprised of 6–70 bracts. <i>Coma</i> inconspicuous, few uppermost bracts sterile and more linear. <i>Bracts</i> ovate-elliptic with rounded tip, light green, green or with red tinge with dark brownish-violet patch at the tips, c.2.5–3.5 x 1.5–2.7 cm, connate in lower half. <i>Cincinni</i> with 2–4 flowers.</p>	<p>Vernal, lateral, later in season central. <i>Peduncle</i> 4–11 cm, spike c. 3–6 x 2–4 cm, comprised of 4–10 (rarely 15) bracts. <i>Coma</i> inconspicuous. <i>Bracts</i> lanceolate, erect with acuminate tip, light green or green, rarely with reddish tinge, no obvious patch at the tips, c.2.5–4 x 1–2 cm, connate in lower quarter or even less. <i>Cincinni</i> with 2–3 flowers.</p>
<p>Flowers</p>	<p><i>Flower</i> 4.5–5 cm long, exserted from the fertile bracts. <i>Bracteoles</i> 5–7 x 2–4 mm, hyaline, translucent white or pinkish with red tinge, almost glabrous.</p>	<p><i>Flower</i> 5–7 cm long, highly exserted from the fertile bracts. <i>Bracteoles</i> 5–9 x 3.5–4 mm, hyaline, whitish translucent, usually hairy at the tip.</p>

Table 1. Continued:-

Flowers		
	<p>Calyx 8–11 mm long, 3-toothed, unilaterally split 3–4.5 mm, translucent white or tinged with pink or tinged with dark violet, sparsely hairy.</p> <p><i>Corolla tube</i> 2.5–3 cm, glabrous, white or yellow at base, towards lobes sometimes tinged with red.</p> <p><i>Labellum</i> 1.4–1.6 x 1.5–1.9 cm, emarginate, yellow. white with yellow center or white, with or without red tinge at the base.</p> <p><i>Lateral staminodes</i> 1.3–1.6 x 1–1.2 cm, yellow, white with yellow or white with or without red tinge at the base.</p> <p><i>Anther thecae</i> 3.5–4 mm long, anther spurs 2–2.5 mm white or creamy, pointing upwards.</p> <p><i>Ovary</i> 3–3.5 x 2.5–3 mm, hairy.</p> <p><i>Seeds</i> brown, glossy with lacinate aril.</p> <p><i>Epigynous glands</i>, c. 3–5 mm long, 0.5–0.6 mm diam., creamy yellow</p>	<p>Calyx 15–21 mm long, 3-toothed, unilaterally split 6–10 mm, translucent greenish-white or tinged with pink, shortly hairy.</p> <p><i>Corolla tube</i> 1.7–3.5 cm, shortly hairy, hairs 0.1–0.2 mm, appressed, yellow or white, with or without red tinge.</p> <p><i>Labellum</i> 1.8–1.2 x 1.5–2.2 cm, emarginate, yellow. white with yellow center or pure white.</p> <p><i>Lateral staminodes</i> 2.2–3 x 1–1.4 cm, yellow or white greatly exceeding beyond dorsal corolla lobe.</p> <p><i>Anther thecae</i> 4–5 mm long, anther spurs c. 3mm white or yellow, pointing downwards following more or less anther thecae direction.</p> <p><i>Ovary</i> 3–3.5 x 2–3 mm, hairy.</p> <p><i>Seeds</i> brown, glossy with lacinate aril.</p> <p><i>Epigynous glands</i>, c. 2.5–4 mm long, c. 0.4 in diam., yellow or creamy.</p>

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A Tropical Seasonal Rain Forest at its Altitudinal and Latitudinal Limits in Southern Yunnan, SW China

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Abstract

The tropical seasonal rain forest (semi-evergreen rain forest) in Caiyanghe Nature Reserve, Simao, Yunnan, China, is at the northern and altitudinal limits of tropical rain forest in Asia. It shares the main physiognomic characteristics of tropical rain forest. Compared with lowland rain forests in China and equatorial regions in Asia, it has lower species diversity with more micro- and nano-phanerophytes and herbaceous phanerophytes in the life form spectra, more microphyllous plants and more plants with non-entire leaves. In floristic composition, it is dominated by tropical Asian elements and characterized by the Indo-Malayan tropical flora. It is suggested that the occurrence of tropical rain forest in southern Yunnan is more influenced by topography and local habitats than the regional climate.

Introduction

Tropical rain forests occur mainly in those wet tropical areas between the Tropics of Cancer and Capricorn with a mean annual temperature above 24°C and the mean monthly temperature above 18°C in the coldest month; and an annual rainfall of at least 1700 mm and usually above 2000 mm (Richards 1996). However, the northern and southern borders of tropical rain forests do not coincide exactly with any latitudinal limits and in some places they extend somewhat beyond the Tropics of Cancer and Capricorn. For example, the Indo-Malayan rain forests extend beyond the Tropic of Cancer at 27° 31' N in northeastern India (Proctor *et al.*, 1998), Myanmar (Kingdon-Ward 1945) and southern Yunnan, China (Zhu 1997), where they occur as small patches forming mosaics within the monsoon forests (Whitmore 1990; Richards 1996; Morley 2000). These Indo-Malayan tropical rain forests north of the Tropic of Cancer are little known apart from some descriptive accounts (Kingdon-Ward 1945; Proctor *et al.* 1998).

Southernmost Yunnan, i.e. Xishuangbanna, which borders Myanmar and Laos, is a mountainous area on the northern margin of tropical Southeast Asia. Tropical rain forest in this region was first mentioned by Wang (1939). Between 1955 and 1960, these forests in southern Yunnan were investigated in detail by

Sino-Russian expeditions and Yunnan University. It was then suggested that biogeographically tropical rain forests existed in southern Yunnan, but these were considered to be a type different from the ones in Indo-Malaysia because of the lack of representatives of Dipterocarpaceae, which dominates the rain forests of tropical SE Asia (Fedorov 1958; Qu 1960; Wang 1961). Since the tropical rain forest in Xishuangbanna occurs at the climatic limits of rain forest (lower mean annual temperature and annual precipitation than usual) and has a clear change of physiognomy between different seasons, Chinese botanists prefer the term 'tropical seasonal rain forest' (Wu 1987; Zhu 1992; Cao 1996; Jin 1997), although it conforms to the semi-evergreen rain forests of SE Asia as defined by Whitmore (1984, 1990) and to a lowland rain forest (Zhu 1997).

Although several studies on the tropical rain forests in southern Yunnan have been carried out (Wu 1987; Xu *et al.* 1987; Jin 1997; Zhu *et al.* 1998a, 2002), little has been published in English (Cao & Zhang 1997; Zhu 1997; Zhu *et al.* 1998b) and most of these focused on the tropical seasonal rain forest in Xishuangbanna where they occur only in areas below 900 m asl.

Recently, tropical seasonal rain forest was found in the Caiyanghe Nature Reserve, Simao County, just north of Xishuangbanna at an altitude of 1300 m and for which Zhu *et al.* (2000) provided a descriptive report. However, the occurrence of tropical seasonal rain forest here is unusual more for its high altitude than its northerly latitude. Its floristic composition and physiognomy are presented in this paper.

The Caiyanghe Nature Reserve

Location and topography

The Nature Reserve is in southeast Simao County, Yunnan, 101°7'~101°15' E 22°30'~22°38' N (Fig. 1). It has a mountainous topography with its main range running east to west with the highest elevation (1698 m) in the north and the lowest elevation (980 m) on the Caiyanghe River on the southwest slope of the mountain.

Climate and Soil

There are no meteorological records for Caiyanghe, but from the records from Simao county climate station c. 20 km away, the region has a monsoon climate with a mean annual temperature of 17.7°C, a mean for the coldest month of 11.4°C, annual temperature accumulation (the sum of daily temperature means of > 10°C) of 6253°C and mean annual precipitation of 1547.6 mm, of which more than 80% falls during the rainy season between May and the end of October.

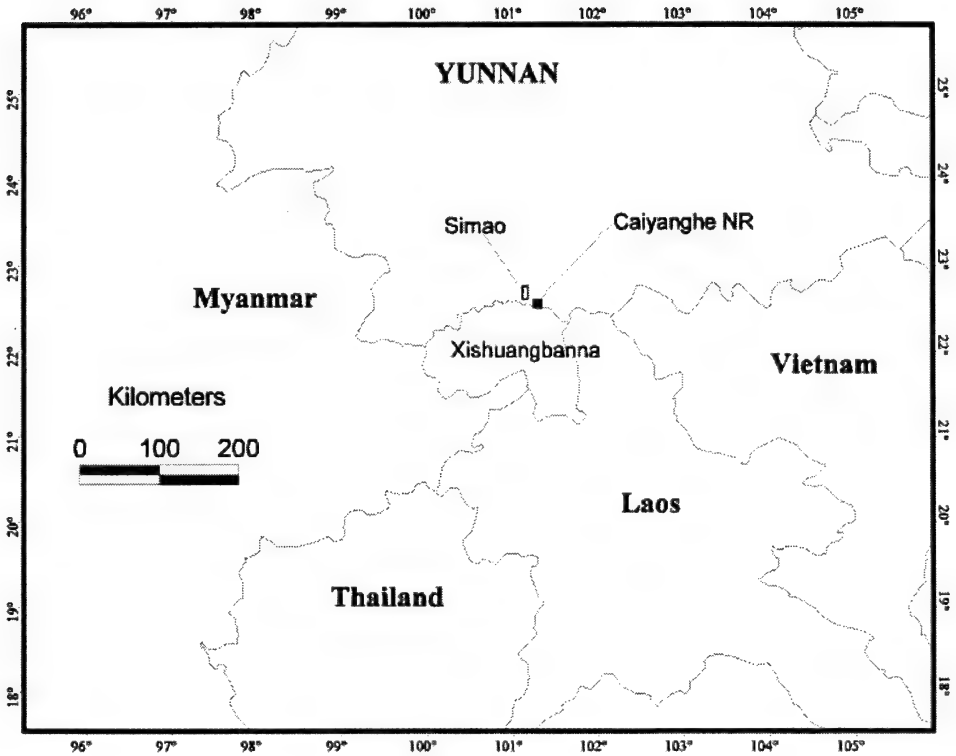


Figure 1. The location of Caiyanghe Nature Reserve in Simao, southern Yunnan, Southwestern China

The soil is oxisol with a deep solum but a thin humus horizon. The oxisol was derived from sandstone (above 1200 m asl) and from muddy shale (below 1300 m asl).

Vegetation types

The main vegetation formation at Caiyanghe is a montane evergreen broad-leaved forest in terms of physiognomy and habitat, which was called monsoon evergreen broad-leaved forest in Chinese literature (Wu 1987). It occurs on mountain slopes and summits above 1200 m asl and in valleys at 1300~1500 m altitude, and makes up 92% of the natural forest cover in the Nature Reserve (Cao, 2003).

The focus of this study was on the tropical seasonal rain forest in Caiyanghe, which makes up less than 2% of the natural forest cover in the Nature Reserve and which is dominated by *Pometia tomentosa* (Sapindaceae) and *Garuga floribunda* var. *gamblei* (Burseraceae). It occurs only in valleys below 1300 m altitude and usually on south-facing slopes. The tropical seasonal rain forest in Caiyanghe is an extension of the ones in Xishuangbanna.

Methods

Several small patches of tropical seasonal rain forest occur in the Nature Reserve. A representative stand in a valley was selected for a plot study. The plot size was 25 m x 100 m (with the plot length along the valley). All trees in the plot were identified and their dbh (minimum 5 cm), height and crown cover were measured. The plot was divided into five subplots (25 m x 20 m each) so that frequency of tree species could be calculated. The forest profile was drawn from a strip stand of 50 m x 10 m in the plot. Five small plots of 5 m x 5 m each were set up for a floristic survey of the understorey. In these small plots, saplings, shrubs and herbaceous plants were counted. Epiphytes and lianas in the plot were identified and their abundance estimated visually. Importance value indices (IVI) for tree species were calculated (Curtis & McIntosh 1951). A rank/abundance diagram (Magurran 1988) of species in the plot was plotted. Shannon-Wiener's indexes for species diversity (Shannon and Wiener 1949) were calculated from the plot data. Physiognomy (life forms and leaf size) was analyzed using Raunkiaer's criteria (1934). Specimens were collected and identified. Species authorities follow Flora Reipublicae Popularis Sinicae (Flora of China). Specimens are deposited in the herbarium of Xishuangbanna Tropical Botanical Garden, Chinese Academy of Science.

Results

Species composition

The tropical seasonal rain forest in the Nature Reserve can be recognized as a *Garuga floribunda* var. *gamblei*-*Pometia tomentosa* formation based on the dominant species. It occurs in the valleys below 1300 m altitude. It is c. 35 m tall with three tree layers (Fig. 2). The top tree layer, composed of emergent trees with buttresses, is 25~35 m tall and has a crown cover of 40~50%. The most dominant tree species in this layer is *Pometia tomentosa*. The second tree layer is 10~25 m tall with a crown cover of 50-60%. The most dominant tree is *Alphonsea monogyna* (Annonaceae). The third tree layer is 3~10 m tall with a crown cover of 50% and *Cleidion spiciflorum* (Euphorbiaceae) is the most dominant species. Some species in the tree layer are cauliflorous and many have leaves with a drip tip. The sapling-shrub layer is 1~3 m tall with a cover of 30~40%. It is composed mainly of juvenile trees. The commonest shrub species is *Mycetia glandulosa* (Rubiaceae). The herb layer is 1 m tall with a cover of c. 25%. The woody lianas are abundant, but there are relatively few epiphytes.

Evergreen trees both in species and individuals dominate the forest. Only two deciduous species were recorded from the forest plot. *Garuga floribunda*

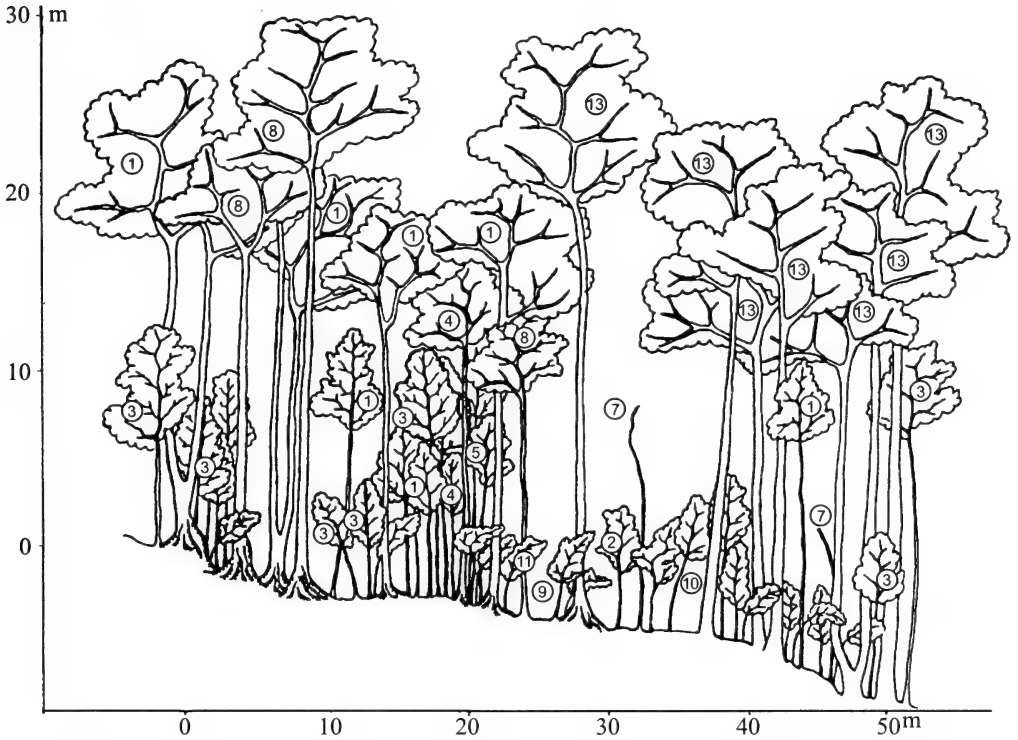


Figure 2. Profile diagram of the tropical seasonal rain forest in Caiyanghe
 1 *Pometia tomentosa*, 2 *Cleidion spiciflorum*, 3 *Alphonsea monogyna*,
 4 *Cinnamomun bejolghota*, 5 *Phoebe lanceolata*, 6 *Elaeocarpus sikkimensis*,
 7 Dead tree, 8 *Garuga floribunda* var. *gamblei*, 9 *Saurauia macrotricha*,
 10 *Baccaurea ramiflora*, 11 *Macropanax dispermus*, 12 *Flacourtia rukam*,
 13 *Duabanga grandiflora*, 14 *Phoebe puwenensis*

var. *gamblei*, although not dominant in individuals, is the largest deciduous tree in canopy layer, and *Radermachera igneum* (Bignoniaceae) in the second tree layer.

The species composition and their phytosociological importance are given in the Appendix.

Physiognomy

The forest in Caiyanghe is characterized by phanerophytes, of which woody phanerophytes contribute the most (Table 1). Among 52 woody plant species from the plot, ones with mesophyllous leaves contribute 69.2% of the total, ones with microphyllous leaves 17.3% and ones with macrophyllous leaves 13.5%.

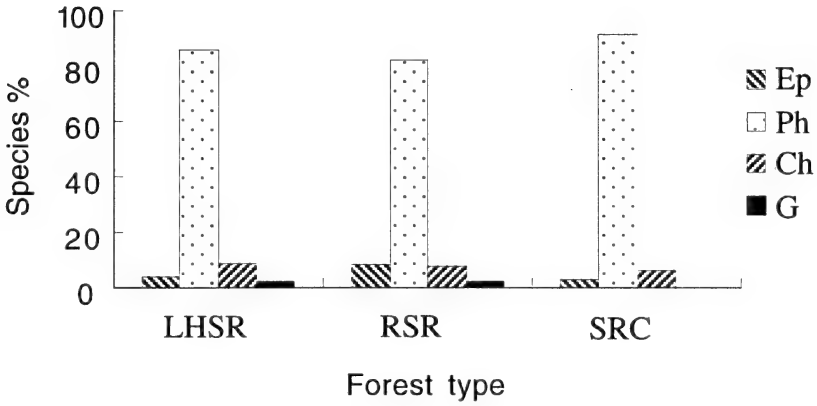
Compared with tropical seasonal rain forests at lower elevations in Mengla and Mengyang of Xishuangbanna (Zhu *et al.* 1998b), the forest in

Table 1. Life form spectrum of the plants from the tropical season rain forest in Caiyanghe.

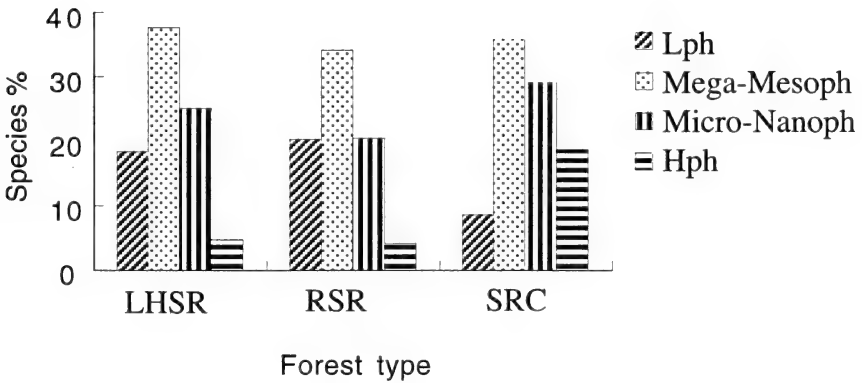
Life form	Epiphyte	Liana	Woody plants				Herb plants		Total
			Megaph.	Mesoph.	Microph.	Nanoph.	Hph.	Ch	
No. of species	2	7	9	20	18	5	15	5	81
%	2.5	8.6	11.1	24.7	22.2	6.2	18.5	6.2	100

Megaph.: Megaphanerophytes; Mesoph.: Mesophanerophytes; Microph.: Microphanerophytes; Nanoph.: Nanophanerophytes; Hph.: Herbaceous phanerophytes; Ch: Chamaephytes

Caiyanghe has fewer liana species, but more micro- and nano-phanerophytes, and herbaceous phanerophytes (Fig. 3), Caiyanghe rain forest has a similar leaf size spectrum to seasonal rain forests in Xishuangbanna and lowland evergreen rain forest in northeastern India, which show a higher percentage of microphyllous plants than those of equatorial lowland rain forests in Borneo and the Philippines (Fig. 4). Like the lowland evergreen rain forest in northeastern India, the rain forest in Caiyanghe also has a higher percentage of species with simple leaves and non-entire leaves (Table 2). A relatively high proportion of plants with non-entire leaf margins could be a character of the rain forest either at latitudinal or altitudinal limits because a higher proportion of non-entire leaved species is usually present in subtropical evergreen broad-leaved forest in eastern Asia and in tropical montane forest in southeastern Asia.



a. For all plant species



b. For phanerophytes

Figure 3. Comparison of life form spectra from the tropical seasonal rain forest in Caiyanghe and the tropical seasonal rain forests at lower altitude in southern Yunnan In Caiyanghe - SRC: Seasonal rain forest. In southern Yunnan (Zhu *et al.*, 1998b) - LHSR: Lower hill seasonal rain forest; RSR: Ravine seasonal rain forest. Ep=Epiphyte; Ph=Phanerophyte; Ch=Chamaephytes; G=Geophyte; Lph=Liana-phanerophyte Hph=Herbaceous phanerophyte; Mega-Mesoph=Megaphanerophyte + Mesophanerophyte; Micro-Nanoph=Microphanerophyte + Nanophanerophyte

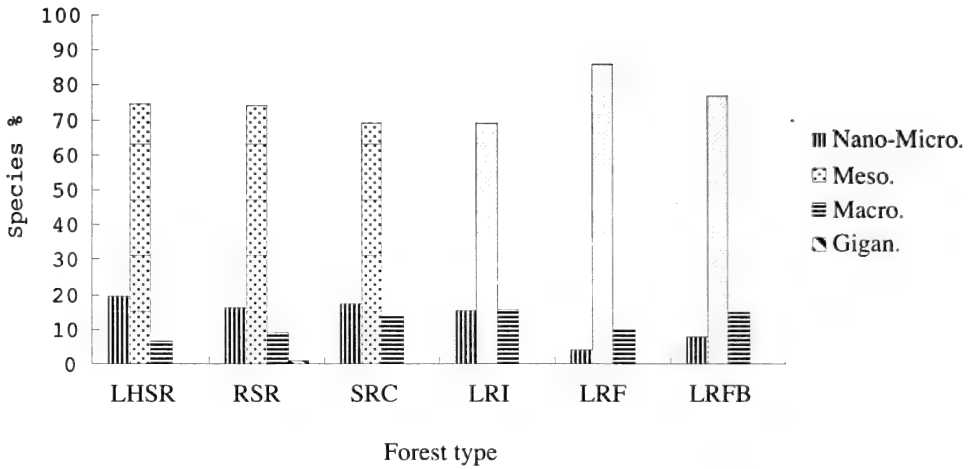


Figure 4. Comparison of leaf size spectra from tropical rain forests in Caiyanghe, southern Yunnan, India and equatorial lowlands
Caiyanghe - SRC; Southern Yunnan - LHSR: Lower hill seasonal rain forest (Zhu, 2000); RSR: Ravine seasonal rain forest (Zhu et al., 1998b); India - LRI: Lowland evergreen rain forest (Proctor et al., 1998); Equatorial lowlands - LRF: Lowland rain forest in the Philippines (Brown, 1919); LRFB: Lowland rain forest in Borneo (Vareschi, 1980). Nano-Micro.: Nanophyll + Microphyll; Meso.: Mesophyll; Macro.: Macrophyll; Gigan.: Gigantophyll

Table 2. Comparison of leaf type and leaf margin spectra for phanerophytes from the tropical rain forest in Caiyanghe, the rain forest in southern Yunnan, the rain forest in northeastern India and the equatorial tropical rain forest in New Guinea.

Forest type	Leaf type		Leaf margin	
	Simple	Compound	Entire	Non-entire
Tropical seasonal rain forest in Caiyanghe	78.9	21.1	76.9	23.1
Tropical seasonal rain forest in Xishuangbanna, southern Yunnan ³	78.6	21.4	80	20
Lowland evergreen rain forest in northeastern India ¹	80.5	19.5	72.9	27.1
Tropical rain forest in New Guinea ²	77	23	85	15

¹Proctor *et al.* (1998); ²Pajmans (1970); ³Zhu (1997).

Table 3. Comparison of species diversity among different tropical rain forest in southern Yunnan.

Forest type	Plot code	Area (m ²)	Alt (m)	Slope (°)	N.S.	N.I.	H'
Tropical seasonal rain forest in Caiyanghe	CYH	2500	1200	25	29	154	2.528
Ravine seasonal rain forest ¹ in Menglun, Xishuangbanna	940102	2500	650	5-10	49	108	3.586
	940103	2500	675	30	57	194	3.573
	940101	2500	700	25	48	96	3.599
Lower hill seasonal rain forest ¹ in Menglun, Xishuangbanna	931206	2500	650	10	52	182	3.377
	9201	2500	680	30	46	207	3.159
Seasonal rain forest dominated by dipterocarp ² in Mengla, Xishuangbanna	Dipt-I	2500	700	20	57	284	3.356
	Dipt-II	2500	800	30	56	186	3.116

H': Shannon-Wiener's diversity indexes; Base:2.718283; N.S.: Number of species; N.I.: Number of individuals. ¹data from Zhu *et al.* (1998b) ²data from Zhu (2000)

Tree population patterns and diversity

A comparison of the rank/abundance diagram of species based on 0.25 ha plot each between the tropical rain forest in Caiyanghe and other tropical rain forest types in southern Yunnan was made to show tree population patterns (Fig. 5). The graph for the rain forest in Caiyanghe has a shorter tail in the species sequence curve, which indicates fewer species with only one or two individuals than for the other rain forests.

A total of 29 tree species > 5 cm d.b.h. was obtained from a plot of 0.25 ha in tropical seasonal rain forest at Caiyanghe. Comparable sites in seasonal rain forests in valleys and on lower hills, and the seasonal rain forest dominated by dipterocarps at lower altitudes in Xishuangbanna yielded 51, 49 and 56 tree species respectively (Table 3). The Shannon-Wiener's diversity index is lower for the forest in Caiyanghe. This indicates that the tropical rain forest in Caiyanghe at both of the altitudinal and latitudinal limits has lower species diversity than the other rain forests at the latitudinal limit in southern Yunnan.

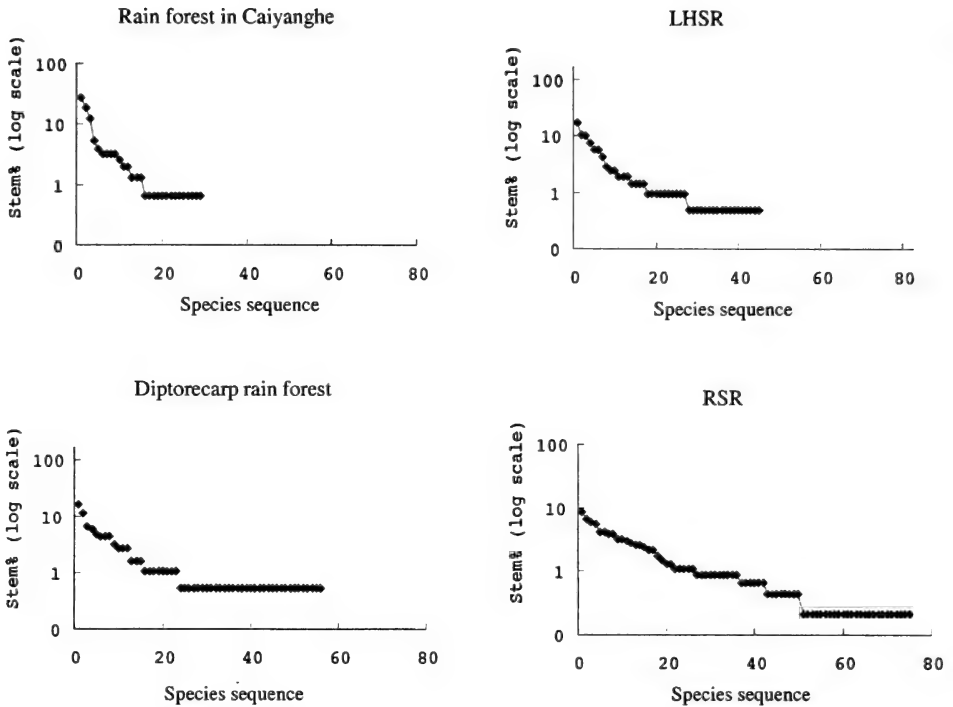


Figure 5. Comparison of rank/abundance diagram of tree species between the tropical seasonal rain forest in Caiyanghe and other tropical rain forest types in southern Yunnan

LHSR*: Lower hill seasonal rain forest; RSR*: Ravine seasonal rain forest; Dipterocarp rain forest*: Seasonal rain forest dominated by dipterocarps.

* Zhu (2000).

Discussion

The tropical rain forest in southern Yunnan is considered to be a type of Indo-Malayan rain forest at the northern margin of tropical Asia as judged by its similarity to the Indo-Malayan forests in forest profile, physiognomy and floristic composition (Zhu 1997). Occurring at the area with a seasonal dry period, the tropical rain forest in southern Yunnan is a semi-evergreen rain forest with deciduous trees making up 5 – 30% of the number of canopy species or individuals (Zhu *et al.* 1998a). Interestingly, tropical seasonal rain forests in Yunnan have a profile similar to those of lowland rain forests although it occurs in mountain habitats with higher altitude (Zhu, 1997). In terms of physiognomy, the tropical rain forest in Yunnan is similar to the lowland semi-

Table 4. Temperature and rainfall distribution recorded at different sites in southern Yunnan.

Locality	Lat.	Alt. (m)	AT	≥10°C TC	MTH	MTC	AR	RD	RR	RD/RR	RH
							(mm)	(Nov.—Apr.) (May—Oct.)			
Mengla, Xishuangbanna	N21°49	634	21.0	7639	24.6	15.2	1531.9	281.6	1250.3	0.23	86%
Mengyang, Xishuangbanna	N22°06	740	20.8	7592	24.6	14.7	1193.7	176.0	1017.9	0.15	80%
Simao	N22°47	1302	17.7	6253	21.7	11.6	1547.6	202.9	1311.3	0.15	82%

AT: annual mean temperature; ≥10°C TC: Annual temperature accumulation; MTH: monthly mean temperature of the hottest month; MTC: monthly mean temperature of the coldest month; AR: Annual rainfall; RD: Rainfall during dry season; RR: Rainfall during rainy season; RH: Relative humidity. (Data for Simao from Cao, 2003; data for Mengla and Mengyang from Xu *et al.*, 1987)

evergreen rain forests in SE Asia as defined by Whitmore (1984, 1990). The rain forest in Caiyanghe, although occurring further north and at higher elevations with annual mean temperatures and annual temperature accumulation lower than those Xishuangbanna of southern Yunnan (Table 4) is up to 35 – 40 m tall with three tree layers. It has the main physiognomic characteristics of tropical rain forest, such as the upper layer trees with huge buttresses, the lower layer trees with cauliflory, leaves with drip tips, and the relative abundance of woody lianas and some epiphytes. Like the seasonal rain forest in Xishuangbanna, the rain forest in Caiyanghe is also semi-evergreen due to some deciduous trees in the canopy layer. The rain forest in Caiyanghe is the extension of seasonal rain forest in Xishuangbanna. It is not only one of the northern-most types of the Indo-Malayan rain forests, but it is also the northern-most and the highest altitudinal type of tropical seasonal rain forest in Yunnan. Beyond the northern watershed line of the mountain of Caiyanghe, tropical rain forest is not seen, although there are still some tropical floristic elements. It is possible that the tropical rain forest in southern Yunnan never extended beyond the mountains of Caiyanghe in the north.

The tropical seasonal forest at Caiyanghe has also lower species diversity than the seasonal rain forests at lower altitude in Xishuangbanna of southern Yunnan. However, the differences in physiognomy and species diversity observed from the seasonal rain forest in Caiyanghe do not surpass the differences observed in other locations in the climatic and geographic zone categorized as tropical.

In floristic composition, the seasonal rain forest in Caiyanghe is dominated by tropical Asian elements that characterize the Indo-Malayan flora, as do the other tropical rain forests in southern Yunnan. However, the dominant tree species, such as *Pometia tomentosa*, *Alphonsea monogyna*, *Duabanga grandiflora* (Sonneratiaceae), *Garuga floribunda* var. *gamblei* and *Terminalia myriocarpa* (Combretaceae), are all near the northern limits of their tropical Asian distributions. Some strictly tropical Asian species, such as *Barringtonia macrostachya* (Lecythidaceae), *Myristica yunnanensis* and *Knema furfuracea* (Myristicaceae), and *Pouteria grandiflora* (Sapotaceae), which are the climax species in the tropical seasonal rain forest in the lowlands of southern Yunnan, are not seen in the rain forest in Caiyanghe. This shows that the tropical seasonal rain forest in Caiyanghe is really at the altitudinal and latitudinal limits in southern Yunnan.

Compared with equatorial lowland rain forest in southeast Asia, the seasonal rain forest in Caiyanghe has more microphyllous plants and more plants with non-entire leaves, which may be a result of the fact that it occurs at both latitudinal and altitudinal limits and shows some similarities with subtropical evergreen broad-leaved forest in eastern Asia and montane rain forests in southeastern Asia.

Although the tropical rain forest in Caiyanghe is composed mainly of tropical floristic elements, the ones of strictly tropical distribution are still under-represented compared with the Malesian flora. Many Malesian elements reach to their northern limits here. This indicates that the tropical rain forest is floristically transitional to the subtropical forests of SW China.

According to the climatic classification for tropical rain forest regions (Richards 1996), the Caiyanghe Nature Reserve falls outside it because it has a mean annual temperature of just 17.7°C and a coldest monthly mean of 11.4°C. The tropical seasonal rain forest in Caiyanghe therefore occurs at the climatic limits of tropical rain forest. Its occurrence is unusual more for its high altitude than its northerly latitude.

The tropical seasonal rain forest in Caiyanghe occurs quite locally in limited habitats in valleys. Its occurrence therefore seems to correspond more with topography than with regional climate. The tropical seasonal rain forest, which occurs locally in wet valleys and on lower slopes, forms a mosaic with montane evergreen broad-leaved forests and monsoon forests in southern Yunnan. This implies that the distribution of tropical rain forest in southern Yunnan is more influenced by local habitats and microclimates than regional climate.

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Appendix. Plot table of the tropical rain forest in Caiyanghe Nature Reserve, Simao, Yunnan

Plot information:

Plot size: 25 x 100 m	Altitude: 1200 m	Slope aspect: SW
Height of forest: 40 m	Coverage: >95%	Slope: 25°

Trees

Name of trees	Stem%	Base area%	Frequency%	IVI ¹
<i>Pometia tomentosa</i>	12.34	28.10	8.47	48.91
<i>Alphonsea monogyna</i>	27.27	5.52	8.47	41.27
<i>Duabanga grandiflora</i>	5.19	22.47	3.39	31.05
<i>Cleidion spiciflorum</i>	18.83	2.05	8.47	29.36
* <i>Garuga floribunda</i> var. <i>gamblei</i>	3.25	13.52	6.78	23.55
<i>Terminalia myriocarpa</i>	0.65	14.82	1.69	17.16
<i>Homalium laoticum</i>	3.90	6.34	6.78	17.02
<i>Garcinia cowa</i>	3.25	1.09	5.08	9.42
<i>Ostodes paniculata</i>	3.25	0.43	5.08	8.76
<i>Phoebe puwenensis</i>	3.25	0.38	5.08	8.72
<i>Cinnamomum bejolgota</i>	2.60	1.05	3.39	7.04
<i>Baccaurea ramiflora</i>	1.95	0.24	3.39	5.58
<i>Syzygium szemaoense</i>	1.30	0.48	3.39	5.16
<i>Mitrephora maingayi</i>	1.30	0.38	3.39	5.07
<i>Randia wallichii</i>	1.30	0.08	3.39	4.76
<i>Flacourtia rukam</i>	1.95	0.97	1.69	4.61
<i>Elaeocarpus sikkimensis</i>	0.65	0.82	1.69	3.16
<i>Amoora tetrapetala</i>	0.65	0.53	1.69	2.87
<i>Horsfieldia kingii</i>	0.65	0.21	1.69	2.55
* <i>Radermachera igneum</i>	0.65	0.17	1.69	2.51
<i>Caryota monostachys</i>	0.65	0.12	1.69	2.46
<i>Phoebe lanceolata</i>	0.65	0.12	1.69	2.46
<i>Drypetes indica</i>	0.65	0.03	1.69	2.38
<i>Saurauia macrotricha</i>	0.65	0.03	1.69	2.37
<i>Dichapetalum gelonioides</i>	0.65	0.02	1.69	2.36
<i>Syzygium cathayensis</i>	0.65	0.02	1.69	2.36
<i>Magnolia henryi</i>	0.65	0.01	1.69	2.36
<i>Trigonostemon thyrsoideum</i>	0.65	0.01	1.69	2.36
<i>Glycosmis pentaphylla</i>	0.65	0.01	1.69	2.36
Total: 29 species	100	100	100	300

¹Importance Value Indices; *Deciduous trees

Sapling and shrub (from 5 subplots of 5 x 5 m)

Species	Individual	Frequency %	Life form
<i>Mycetia glandulosa</i>	10	60	shrub
<i>Cleidion spiciflorum</i>	7	40	sapling
<i>Alphonsea monogyna</i>	4	40	sapling
<i>Trigonostemon thyrsoideum</i>	3	40	sapling
<i>Garuga floribunda</i> var. <i>gamblei</i>	3	20	sapling
<i>Pandanus furcatus</i>	3	40	shrub
<i>Magnolia henryi</i>	2	40	sapling
<i>Desmos dumosus</i>	2	20	shrub
<i>Baccaurea ramiflora</i>	2	40	sapling
<i>Leea compactiflora</i>	2	40	shrub
<i>Mitrephora maingayi</i>	2	20	sapling
<i>Litsea monopetala</i>	2	40	sapling
<i>Mallotus philippinensis</i>	1	20	sapling
<i>Semecarpus reticulatus</i>	1	20	sapling
<i>Ficus tinctoria</i> ssp. <i>gibbosa</i>	1	20	sapling
<i>Caryota urens</i>	1	20	sapling
<i>Flacourtia rukam</i>	1	20	sapling
<i>Clausena dunniana</i>	1	20	sapling
<i>Horsfieldia amygdalia</i>	1	20	sapling
<i>Ardisia arborescens</i>	1	20	sapling
<i>Sarcosperma kachinensis</i>	1	20	sapling
<i>Pometia tomentosa</i>	1	20	sapling
<i>Nephelium lappaceum</i> var. <i>pallens</i>	1	20	sapling
<i>Listea pierrei</i> var. <i>szemaois</i>	1	20	sapling
<i>Phoebe puwenensis</i>	1	20	sapling
<i>Glycosmis pentaphylla</i>	1	20	sapling
<i>Reevesia pubescens</i>	1	20	sapling
<i>Ficus collosa</i>	1	20	sapling
<i>Sapium baccatum</i>	1	20	sapling
<i>Ficus cyrtophylla</i>	1	20	sapling
<i>Maesa permollis</i>	1	20	shrub
<i>Litsea dilleniifolia</i>	1	20	sapling
<i>Bischoffia javanica</i>	1	20	sapling
<i>Calophyllum polyanthum</i>	1	20	sapling
<i>Randia wallichii</i>	1	20	sapling
Total: 35 species			

Herbaceous plants (from 5 subplots of 5 x 5 m)

Species	Individual	Frequency %
<i>Costus speciosus</i>	2	20
<i>Alocasia macrorrhiza</i>	1	20
<i>Pseudoranthemum malaccense</i>	2	20
<i>Aglaonema pierreanum</i>	2	20
<i>Alpinia bracteata</i>	2	20
<i>Piper bavinum</i>	2	20
<i>Mananthus patentiflora</i>	5	20
<i>Phrynium capitatum</i>	5	20
<i>Rhynchoetechum obovatum</i>	15	40
<i>Chloranthus spicatus</i>	2	20
<i>Elatostema megacephalum</i>	8	20
<i>Steudnera colocasiasaeolia</i>	3	20
<i>Musa acuminata</i>	2	20
<i>Elatostema macintyreii</i>	3	20
<i>Ophiopogon griffithii</i>	2	20
<i>Ophiopogon sarmentosus</i>	10	20
<i>Senecio densiflorum</i>	2	20
<i>Amischotolype hookeri</i>	3	20
<i>Globba racemosa</i>	1	20
<i>Boehmeria siamensis</i>	1	20
Total: 20 species		

Lianas and epiphytes

Species	Dominance	
<i>Combretum latifolium</i>	rare	liana
<i>Milletia dorwardii</i>	rare	liana
<i>Heterostemma wallichii</i>	rare	liana
<i>Gymnostemma pentaphylla</i>	rare	liana
<i>Tetrastigma crucistum</i>	frequent	liana
<i>Byttneria grandifolia</i>	frequent	liana
<i>Toxocarpus villosus</i>	frequent	liana
<i>Piper flaviflorum</i>	frequent	epiphyte
<i>Rhaphidophora hongkongensis</i>	abundant	epiphyte
Total: 9 species		

***Begonia sabahensis* Kiew & J.H.Tan (Begoniaceae), a New Yellow-flowered Begonia from Borneo**

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AND

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Abstract

Begonia sabahensis Kiew & J.H.Tan, (Begoniaceae) is described from Sabah, Malaysia. It belongs to sect. *Diploclinium* and is most remarkable for its pure yellow flowers.

Introduction

In 2000, Recin Sapau collected a yellow-flowered begonia from the hills behind Kampung Katabelangan, about 40 km south of Tenom, Sabah. It was planted in the Tenom Agricultural Park but never flowered so its flower colour could not be confirmed. As far as we know, this is the first record of a yellow-flowered begonia in Borneo. Most Bornean begonias have white or pink or, occasionally, orange to red flowers, the closest they come to yellow is a greenish cream colour.

To re-find this species and verify its flower colour, one of us (TJH) returned to the original site with Recin Sapau and there found a few plants. The fact that it is known only from one small population in just one locality suggests it is not a common begonia.

Begonia sabahensis* Kiew & J.H. Tan, *sp. nov.

A *Begonia calcarea* Ridl. floriis canarinis (nec tangerinis vel rubis) et majoribus differt. **Typus:** *Recin Sapau & Tan JH. AL 727/2004* 11 Feb 2004 Sungai Telekosen, Tenom, Sabah, Malaysia (holo SAN).

Plant rhizomatous, hairy, hairs straight, unbranched; *c.* 2–3 mm long and dense on the young stems, stipules, petioles and veins on the lower lamina surface; on the lamina *c.* 1 mm long, very scattered on the upper surface, sparse beneath; *c.* 1 mm long and dense on the veins on the upper lamina surface; brown on the

stem; red on the young petiole and lamina, transparent on older leaves. *Stem* creeping and rooting at nodes, up to 30 cm long, *c.* 5 mm thick when dried, green, succulent, unbranched, nodes slightly swollen; without a tuber. Stipules ovate, 10–15 x *c.* 5 mm, margin entire, apex acuminate, soon falling. *Leaves* distant, 3–7 cm apart; petiole pink, 8–17 cm long, succulent and up to 9 mm thick in life, *c.* 3 mm thick when dried; lamina oblique, plain dark green, glossy above, succulent in life, thinly leathery when dried, broadly ovate, strongly asymmetric, 9–10.5 x (9–)10–12 cm, broad side 5.7–6.7 cm wide, base cordate, slightly unequal, basal lobes rounded, 2–4 cm long, margin entire, fringed with hairs 1–3 mm long, apex acuminate 5–8 mm long; veins palmate-pinnate, 2–3 pairs of secondary veins at the base with another 1–2 pairs along the midrib branching *c.* halfway to the margin, and 3 veins in each of the basal lobes, slightly impressed above, beneath prominent and green.

Inflorescences axillary, pink, erect, shorter than the leaves, male and female flowers on separate inflorescences. Male inflorescences *c.* 3.3 cm long, umbellate with 2 or 3 flowers; bracts pink, ovate, *c.* 4 x 3 mm, margin entire, apex setose, persistent. Bracteoles white and transparent, ovate, 2–3 mm long. Female inflorescences *c.* 1.5 cm long with a single flower; bracts pink, ovate, 2–3 mm long, margin entire, persistent; bracteoles white and transparent, ovate, *c.* 1.5 mm long. *Male flowers* with a white pedicel 15–25 mm long; tepals 4, isomorphic, canary yellow, glabrous, broadly oval, slightly narrowed to the base, margin entire, apex rounded, outer two tepals 12–14 x 9–11 mm, inner two tepals slightly smaller, 11–13 x 8–13 cm; stamens 20–23, in a lax, sessile cluster, filaments 1.5–2 mm long, anthers deep yellow, narrowly oblong, 1.5–2 mm long, apex rounded, opening by lateral slits. *Female flowers* with a pink pedicel 2–3 mm long; ovary white becoming pale yellow, 12–13 x 10–15 mm, turbinate, wings 3, equal, rounded *c.* 7 mm wide, locules 3, placentas bifid; tepals 5, canary yellow, glabrous, isomorphic, oval slightly narrowed to base, margin entire, apex slightly acute, 12–13 x 8–11 mm; styles 3, free, styles and stigma deep yellow, 6–8 mm long, stigmas forming a papillose spiral band. *Fruits* not known.

Distribution: Endemic in Sabah, Malaysia, known only from the type locality near the Sungai Telekosen, Tenom.

Habitat: Growing in deep shade on thick leaf litter on a steep hill slope in forest in the transition zone between hill forest and lower montane forest at 1,115 m altitude.

Notes: This new species is very distinctive, not only in its pure yellow flowers, but also in producing male and female flowers on separate, short inflorescences from the prostrate rhizome, often from the old stem from which the leaves have already fallen. The male inflorescences are umbellate, while the female

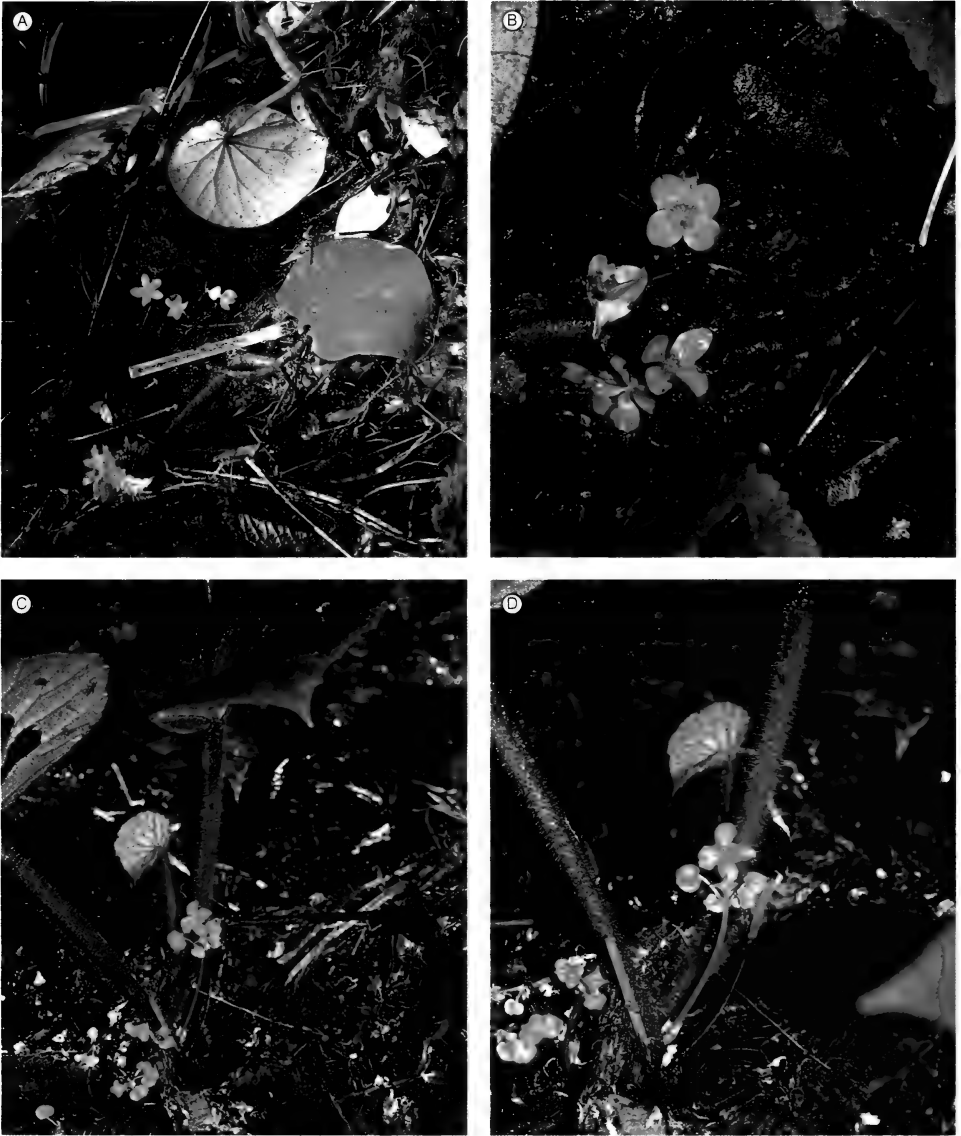


Plate 1. *Begonia sabahensis* Kiew & J.H.Tan and *Begonia calcarea* Ridl.

Begonia sabahensis. A. The plant showing the red-haired young petiole and the pure yellow flowers produced from the old stem. B. The female flowers have five tepals and the male four isomorphic tepals. *Tan J.H.*

Begonia calcarea. C. The plant showing the tufted habit, red veins on the young leaves and bristles on the upper leaf surface. D. The peachy orangey-red flowers. *R. Kiew*

inflorescences apparently produce a single flower. The leaves are broadly rounded and wider than long. The succulent petioles with dense, long red hairs are also striking. The male flowers have four isomorphic tepals. In all these characters it resembles *Begonia calcarea* Ridl., which grows on a few limestone hills around Bau, Sarawak (Ridley, 1906; Kiew and Geri, 2003). In addition, they both have brightly coloured flowers, rather than the usual white or pale pink ones.

However, *Begonia sabahensis* is distinct from *B. calcarea* in a number of characters (Table 1), the most conspicuous being flower colour. The flowers of *B. calcarea* are orangey red, in male flowers becoming deeper red toward the margin. The male and female flowers of *B. sabahensis* are pure yellow without a tinge of red, a unique feature among Bornean begonias.

Both *Begonia calcarea* and *B. sabahensis* belong to section *Diploclinium* in possessing rhizomes, male flowers with 4 tepals and ovaries with three locules each with a bifid placenta.

This fine begonia is so named because it is endemic in Sabah, Malaysia. It is apparently a rare and local begonia and, because the area is currently being logged, there is concern for its long-term survival.

Table 1. Differences between *Begonia sabahensis* and *B. calcarea*

Character	<i>Begonia sabahensis</i>	<i>Begonia calcarea</i>
Leaves	distant on the stem	tufted
Lamina width (cm)	9–12	c. 15
Lamina	not bristly above	bristly above
Vein colour on the lower surface of young leaves	green	red
Flower colour	pure yellow	orangey red
Male tepals (mm)	11–14 x 8–13	7–11 x 4–9
Stamen number	20–23	25–35
Female tepals (mm)	12–13 x 8–11	c. 6 x 7
Style length (mm)	6–8	4

Acknowledgements

We thank Recin Sapau for guiding TJH to the site, the Manager and Botanist of the Sabah Agricultural Park for permission for Aninguh (Andy) Surat to accompany TJH in the field, Anthony Lamb for detailed colour notes of the living plant, and the Curator of the Sabah Forest Department Herbarium (SAN) for permission to borrow the specimen.

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New Species and Comments on *Rhododendron* (Ericaceae) from the Island of Palawan, Philippines

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Abstract

Three new species of *Rhododendron* section *Vireya* are described: *R. mendumiae*; *R. reynoso* and *R. wilkiei*, together with a new subspecies of *R. javanicum* ssp. *palawanense* and new records of *R. edanoi*, which is shown to be the same species as *R. pneumonanthum* of Borneo although differing at the sub-specific level. Keys are given to all the *Rhododendron* species currently known from the island of Palawan.

Introduction

The island of Palawan (Fig. 1) has high biodiversity (Anon., 1997). It has a distinctive Bornean element in its flora resulting from the fact that it is the only part of the Philippines lying on the Sunda Shelf (Whitmore, 1975) so that it has been connected with land bridges to the west in recent periods of low sea level. It has been, and still is, in many respects poorly investigated and Sleumer (1966) in his *Flora Malesiana* account of *Rhododendron* only reported three species specifically from the island, two endemics (*R. acrophilum* Merr. & Quisumb. and *R. edanoi* Merr. & Quisumb.) and one more widespread species (*R. javanicum* (Blume) Benn. var. *schadenbergii* (Warb.) Sleumer). Both endemics were known only from single collections at the time of his publication. Joint National Museum (Manila) and Royal Botanic Garden Edinburgh expeditions in 1992, 1997, 1998 and 1999 have added significantly to our knowledge of the flora of the island. *R. madulidii* Argent was described as a new endemic (Argent 1998) and *R. acrophilum* was rediscovered and the description amended after being introduced to cultivation and successfully flowered (Argent & Madulid, 1995). In this account, three new species are described from Cleopatra Needle and Thumb Peak (Fig. 1) together with new subspecies of *R. javanicum* (Blume) Benn. and *R. edanoi*. Of these subspecies, *R. javanicum* shows great similarity to the Mt. Kinabalu populations of this species and *R. edanoi* is shown to be insufficiently distinct from *R. pneumonanthum* Sleumer of Borneo to maintain this as a separate species. *Rhododendron bagobonum* H.F.Copel. was recorded from Mt Mantalingjahan in the south of the island (Argent RBGE Acc.No. 19922777). Originally described from the island of Mindanao in the Philippines, this record is an

extension of its known range in the Philippines and is yet another link to the Bornean flora where this species is widespread (Sleumer 1966, Argent 2003).

Vegetative Key to *Rhododendron* from Palawan

- | | | |
|---|--|-------------------|
| 1 | Largest leaves more than 5 cm wide,
petioles more than 2 cm long | <i>javanicum</i> |
| | Largest leaves up to 3 cm wide, petioles up to 1.5 cm long | 2 |
| 2 | Leaves less than 1 cm wide | <i>bagobonum</i> |
| | Leaves more than 1 cm wide | 3 |
| 3 | Stems minutely puberulent (and with scales),
leaves narrowly but distinctly revolute | <i>madulidii</i> |
| | Stems with scales only, leaf margin flat
(or only very indistinctly revolute in <i>R. mendumiae</i>) | 4 |
| 4 | Leaf apex rounded (except sometimes with a mucronate point) | <i>edanoi</i> |
| | Leaf apex obtusely or acutely pointed | 5 |
| 5 | Leaves mostly, or at least commonly, broadest in the upper half | 6 |
| | Leaves broadest in the middle, only rarely broader in the upper half | 7 |
| 6 | Leaves in tight pseudowhorls spread over c. 6 mm of stem,
leaf blades up to 4 cm long | <i>acrophilum</i> |
| | Leaves in loose pseudowhorls spread over c. 20 mm of stem,
leaf blades often more than 5 cm long | <i>mendumiae</i> |
| 7 | Largest leaf blades more than 5 cm long,
lateral veins more than 6 per side | <i>reynosoi</i> |
| | Largest leaf blades up to 4 cm long,
lateral veins 3 or 4 per side | <i>wilkiei</i> |

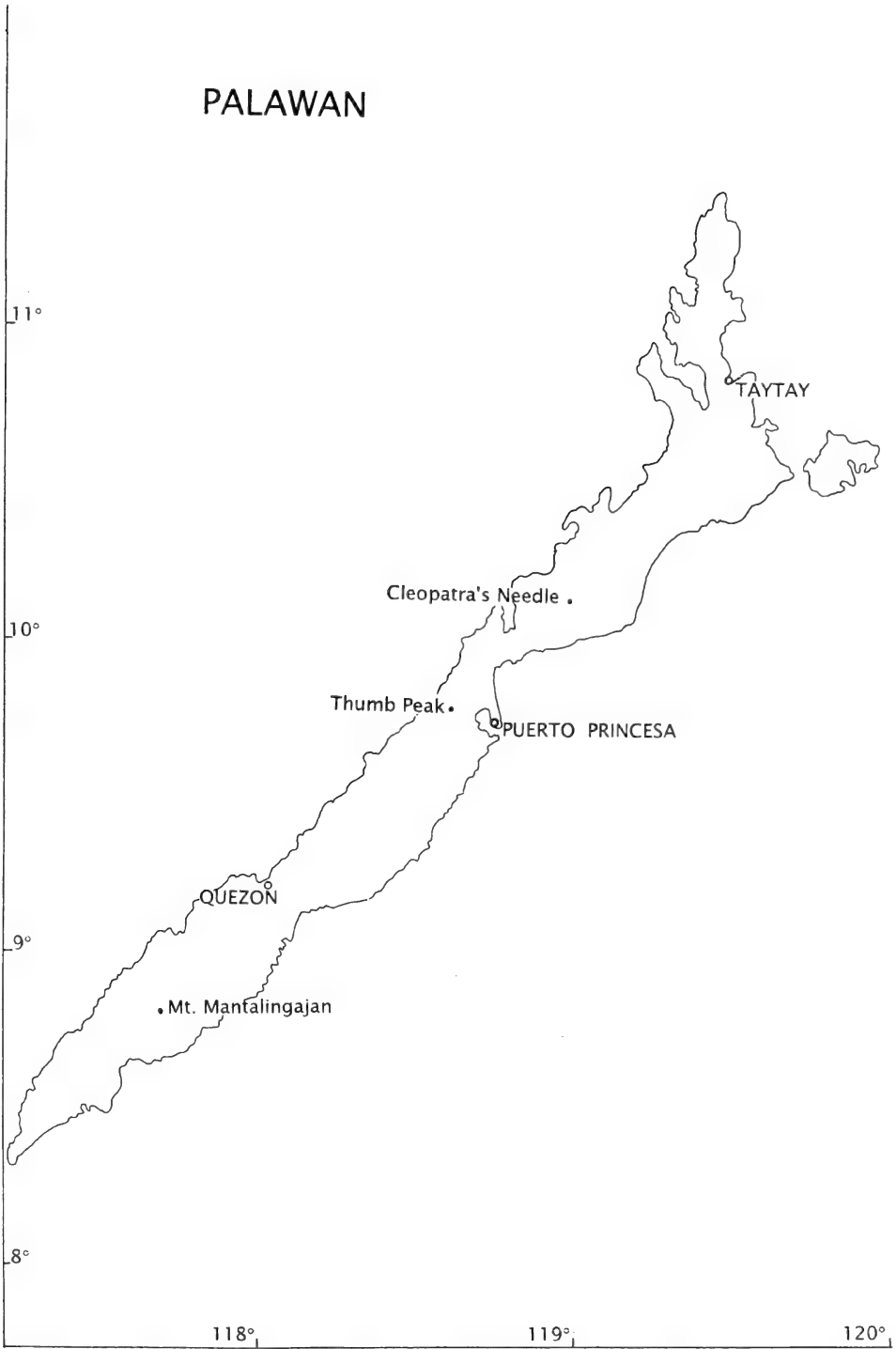


Figure 1. The island of Palawan, Philippines.

Key to flowering specimens of *Rhododendron* from Palawan

- | | | |
|---|---|--|
| 1 | Flowers white or very pale pink | 2 |
| | Flowers coloured, red orange or yellow and orange | 4 |
| 2 | Flowers hypocrateraeform, the tube up to 6 mm in diameter | <i>edanoi</i> |
| | Flowers funnel-shaped, the tube more than 15 mm in diameter | 3 |
| 3 | Flowers up to 3 per umbel, bract tips reflexed, stems and pedicels without a fine puberulence | <i>mendumiae</i> |
| | Flowers more than 3 per umbel, bract tips erect, stems and pedicels with a fine puberulence | <i>madulidii</i> |
| 4 | Flowers longer than broad, up to 1 cm wide | <i>bagobonum</i> |
| | Flowers broader than long or more than 2 cm wide | 5 |
| 5 | Flowers more than 6 cm long | <i>javanicum</i> ssp. <i>palawanense</i> |
| | Flowers less than 4 cm long | 6 |
| 6 | Filaments and inside of the corolla tube glabrous
corolla lobes red | <i>wilkiei</i> |
| | Filaments and inside of the corolla tube hairy, corolla lobes orange | 7 |
| 7 | More than 5 flowers in each umbel,
the flowers bright orange with a red star in the throat | <i>reynosoi</i> |
| | Less than 4 flowers in each umbel,
the flower bicoloured with a yellow tube and orange lobes | <i>acrophilum</i> |

1. *Rhododendron mendumiae* Argent *sp. nov.*

Named in memory of Mary Mendum [1945–2004] who was on the expedition which collected this species. A tireless enthusiast for SE Asian botany and respected research worker.

R. madulidii simillima sed floribus majoribus fragrantibus per inflorescentiam uno duobus tantum, caulibus pedicellisque sine pilis simplicibus, et disco glabro differt.

Typus: Philippines, Palawan, Cleopatra Needle. 1600 m. *Argent, Chavez, Cronk, Fuentes, Mendum, Middleton & Wilkie 53*. Original collection 22 January 1998. Cultivated collection: 20 Sept. 2003. *Ac. No. 19981815*, (holo PNH; iso E).

Figure 2

Shrub to *c.* 1 m. *Stems* pale green, terete, *c.* 3 mm diam., moderately densely covered in brown stellate scales. *Leaves* in rather loose pseudowhorls 3–8 cm apart. *Petiole* 4–7 x 2–3 mm, faintly grooved above, pale green or pale pink with brown scales. *Leaf blade* narrowly oblanceolate, occasionally elliptic, 40–75 x 17–30 mm, at first scaly with silvery or brown scales above, quickly glabrescent, below brown scaly, the scales rounded to weakly lobed with darker centres which are often as broad in diameter as the flanges, distributed 1–2 diameters apart in the mature leaves. Leaf base cuneate, often slightly decurrent into the petiole; the margin entire, flat or slightly and narrowly recurved; the apex obtuse, with a somewhat obscure, white, non-protruding, gland-like structure at the point, midrib narrowly impressed above, distinctly prominent in the proximal half to two-thirds beneath, pink in colour especially towards the base, lateral veins plane, rather indistinct, 5–8 per side, the basal arising at an acute angle, the upper ones wide-spreading, all disappearing before the edge of the leaf.

Flower buds green, up to 40 x 22 mm, conical but contracted near the base, imbricate with the tips of the bracts reflexed. *Bracts* minutely hairy and with a few small, scattered scales outside and scales along the margins, inner ones often shortly emarginate. *Pedicels* 18–22 x 2–3 mm, green, laxly scaly but without simple hairs. *Flowers* one or two together, terminal, held more or less horizontally, white with a cream throat, very strongly and sweetly scented, 52–60 x 102–105 mm; *calyx* a lobed disk, densely scaly below, less so near the perimeter; *corolla tube* 26–30 x *c.* 15 x 17–24 mm, glabrous outside but with retrorse white hairs in the basal half inside, the lobes *c.* 46 x 35–46 mm, spreading more or less horizontally, overlapping to about half their length, with a rather irregular ‘frilled’ margin. *Stamens* clustered on the lower side of the flower, exerted 20–25 mm from the mouth, the filaments white, slightly dimorphic, 38–43 x 0.2 mm wide expanded suddenly for the basal 2.5 mm to *c.* 1.4 mm wide, glabrous but densely white hairy in the basal expanded portion, anthers brown, *c.* 7 mm long, shortly but distinctly apiculate at the base. *Disc* green with dense short, white, erect hairs. *Ovary* *c.* 6 x 5 mm, broadly trapezoid in outline, densely silvery scaly and with rather sparse short patent hairs mostly towards the top. Style cream, lying on the lower side of the corolla tube but curving upwards when the stigma becomes receptive, *c.* 50 mm, rather densely patent-hairy and sparsely scaly in the basal third, the scales arising on low papillae. Stigma white, 4–7 mm in diam., somewhat crown-shaped, exerted up to 15 mm beyond the anthers. *Fruit* 25 x 12 mm, pale green with a covering of dense brown scales, the pericarp only weakly separating from the valves which curve outwards on opening without twisting, the placentae separating from the central column. *Seeds* *c.* 2.3 mm long, without tails 1.0 mm, the longest tail 0.8 mm.

Notes: *Rhododendron mendumiae* is somewhat reminiscent of *R. madulidii* from Mt Mantalingajan near the southern tip of Palawan but that species has many more flowers in the inflorescence, puberulous stems and pedicels, and very different flower bud morphology with erect not reflexed tips to the bracts. Vegetatively, it looks very similar to *R. jasminiflorum* Hook. var. *copelandii* (Merr.) Sleumer, but the massive flowers of this new species are totally different to the slender flowers with very small lobes of that species and the bud morphology again is also very different.

This very distinctive species should be associated with Sleumer's (1966) subsection *Euvireya* on the basis of its short broad corolla tube relative to the enormous lobes and the well spaced, stellate scales on the leaves. It is slightly anomalous in that, from the single observation of fruit dehiscence, the pericarp remains closely attached to the valves, only weakly separating near the tips but it clearly does not belong in the groups with adherent pericarps from the scale morphology. On the basis of leaf size it could be placed in either series *Buxifolia* or series *Javanica*. In series *Buxifolia*, it clearly does not key out having a very distinct combination of characters. In series *Javanica*, it would key out with the Indonesian species: *R. lompohense* J.J.Sm., *R. bloemberginii* Sleumer, from Sulawesi or *R. buruense* J.J.Sm. from Maluku, all rather unlikely geographical alliances. All three of these species have many more flowers in the inflorescence, much smaller corolla lobes and ovaries that are much longer than broad. When this species flowered in cultivation for the first time in 2002 with a single flower, it was thought this must be an anomalous peloric form but the following year two-flowered inflorescences were produced on several plants and it was concluded that these large flowers are normal. The seeds are rather unusual in having such short tails, these are characteristic of vireyas which occur in open situations on mountain peaks. *R. retusum* (Blume) Benn., *R. adinophyllum* Merr. and *R. abietifolium* Sleumer have similar seeds with very reduced tails. Since this species was collected near the summit of Cleopatra Needle where the vegetation was dense, mossy forest, this is a surprising character. Plants have been raised from both seed and cuttings collected in the wild and from the isolation of the peak it seems virtually impossible that these are hybrids. Given the isolation of the habitat and the very restricted area of mossy forest on the mountain, the population of this species is very small and must be vulnerable to any kind of habitat disturbance.

Additional specimens: All from the type locality with the same collecting details as the type: 19981798; 19981800; and 20031269.

2. *Rhododendron reynosoii* Argent *sp. nov.*

Named in memory of Ernesto Reynoso who was a wonderful companion on several expeditions and made a considerable contribution to Philippine botany working for the National Museum, Manila.

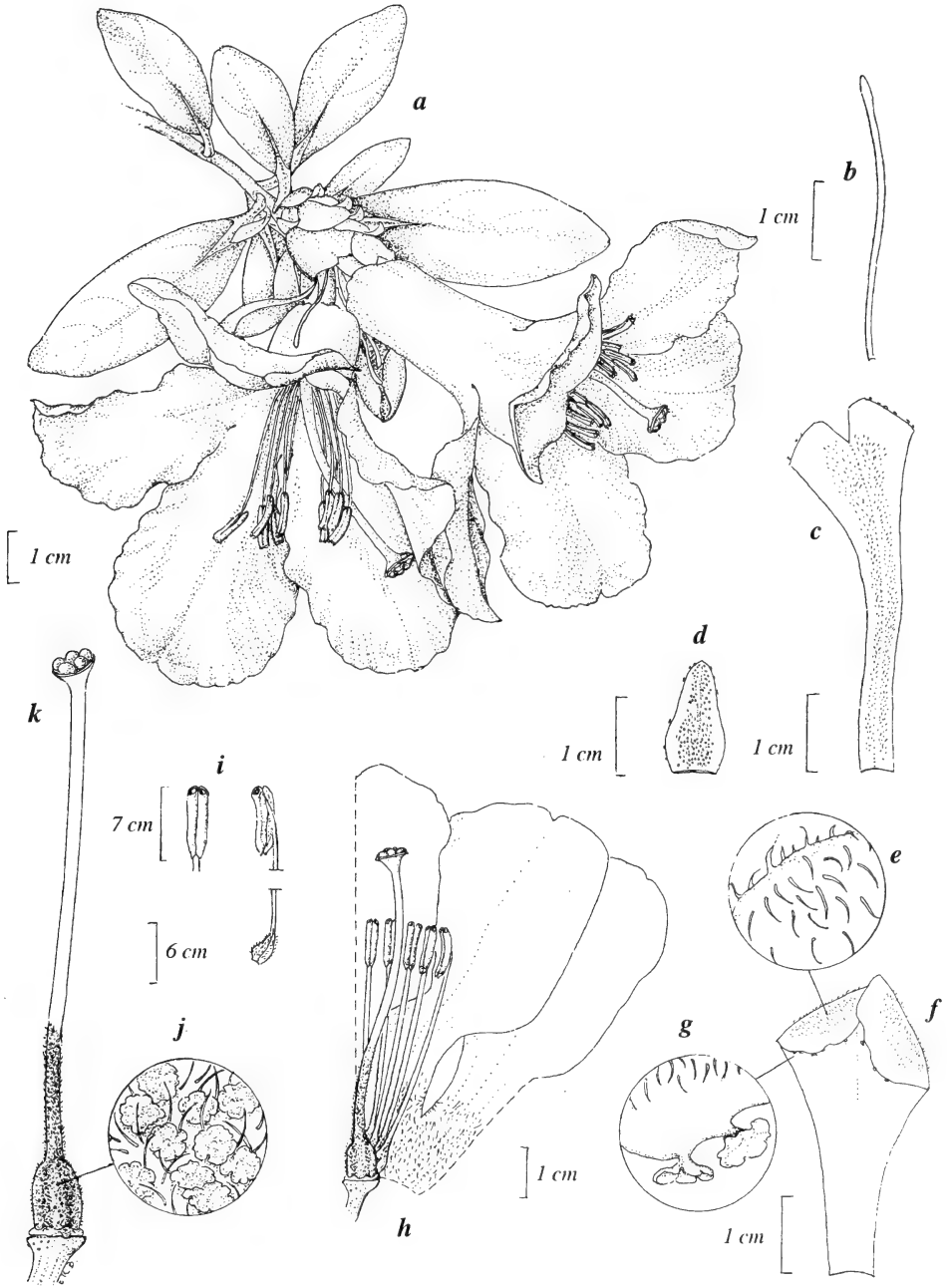


Figure 2. *Rhododendron mendumiae*

a Branch with inflorescence; **b** bracteole; **c**, **d**, **f** bracts; **e** enlargement of indumentum on abaxial surface of bract; **g** enlargement to show scales on bract margins; **h** part flower, opened; **i** anthers; **j** enlargement to show ovary indumentum; **k** pistil.

Umbella erecta florum clare aurantiacorum, foliis comparate parvis et foliis foliaceis bracteis sensim transientibus distincta. **Typus:** Philippines, Palawan, Cleopatra Needle, 22 January 1998, just below summit, moss forest, 1600m. *Argent, Chavez, Cronk, Fuentes, Mendum, Middleton & Wilkie 44A.* Original collection 22 Jan. 1998. Cultivated collection: 29 August 2002, Ac. No. 19981806 (holo PNH; iso E).

Figure 3

Shrub to *c.* 80 cm. *Stems* green, terete, *c.* 3 mm diam., moderately densely covered in brown stellate scales. *Leaves* in close pseudowhorls 1–2 cm apart, consisting mostly of 6–7 leaves. *Petiole* 6–10 x 1.5–2 mm, not grooved above, pale green with brown stellate scales. *Leafblade* elliptic to slightly oblanceolate 50–80 x 15–30 mm, with some sparse silvery, sub-circular scales at first above but quickly glabrescent here, below moderately brown scaly, the scales rounded or weakly lobed slightly impressed, the centres small 1–3 diameters apart in the mature leaves. Leaf base broadly cuneate; the margin entire, flat, narrowly cartilaginous; the apex acute to broadly acute, sometimes shortly acuminate or apiculate, midrib narrowly impressed above although slightly prominent just above the petiole where it is also faintly grooved; beneath broadly raised for about three-quarters of the length proximally, lateral veins plane, 6–10 per side, spreading broadly but then curving upwards to link with the vein above before the margin, distinct above but obscure below.

Flower buds green, up to 40 x 20 mm, ovoid, sharply pointed with a gradual transition from foliage leaves to bracts these transitional forms having a smaller but distinct foliar blade with broad translucent decurrent margins instead of a petiole, the inner bracts narrowly lanceolate to subulate with spreading points. *Bracts* glabrous or with a few, scattered scales outside and along the margins but no simple hairs. *Pedicels* 9–15 x 1–2 mm, orange, moderately scaly but without simple hairs. *Flowers* terminal, 6–10 in an umbel, held erect or semi-erect, bright orange with a red star in the throat the points extended as lines along the lobes, without scent, 32–40 x 30–40 mm; *calyx* a low scaly disc. *Corolla tube* *c.* 15 x 6 x 13 mm, glabrous outside, white hairy in the proximal half inside, the lobes 15–30 x 12–22 mm, semi-erect, overlapping half to three quarters of their length, rounded or weakly emarginate at the apex. *Stamens* regularly arranged around the mouth of the flower, exerted to *c.* 5 mm, distinctly dimorphic, filaments pale orange, with white shaggy hairs in the basal third glabrous above, the anthers dark purple *c.* 3 x 1.5 mm. *Disc* green almost glabrous but with a few short hairs on the upper margin. *Ovary* *c.* 6.5 x 3 mm, ellipsoid, silvery-scaly and densely white hairy. *Style* orange, at first lying on the lower side of the corolla tube, rising to a central position as the flower ages, *c.* 14 x 0.8 mm, glabrous. *Stigma* purplish-red, hardly expanded from the style, *c.* 3 mm in diam. *Fruits* sub-cylindrical, tapering distally to the

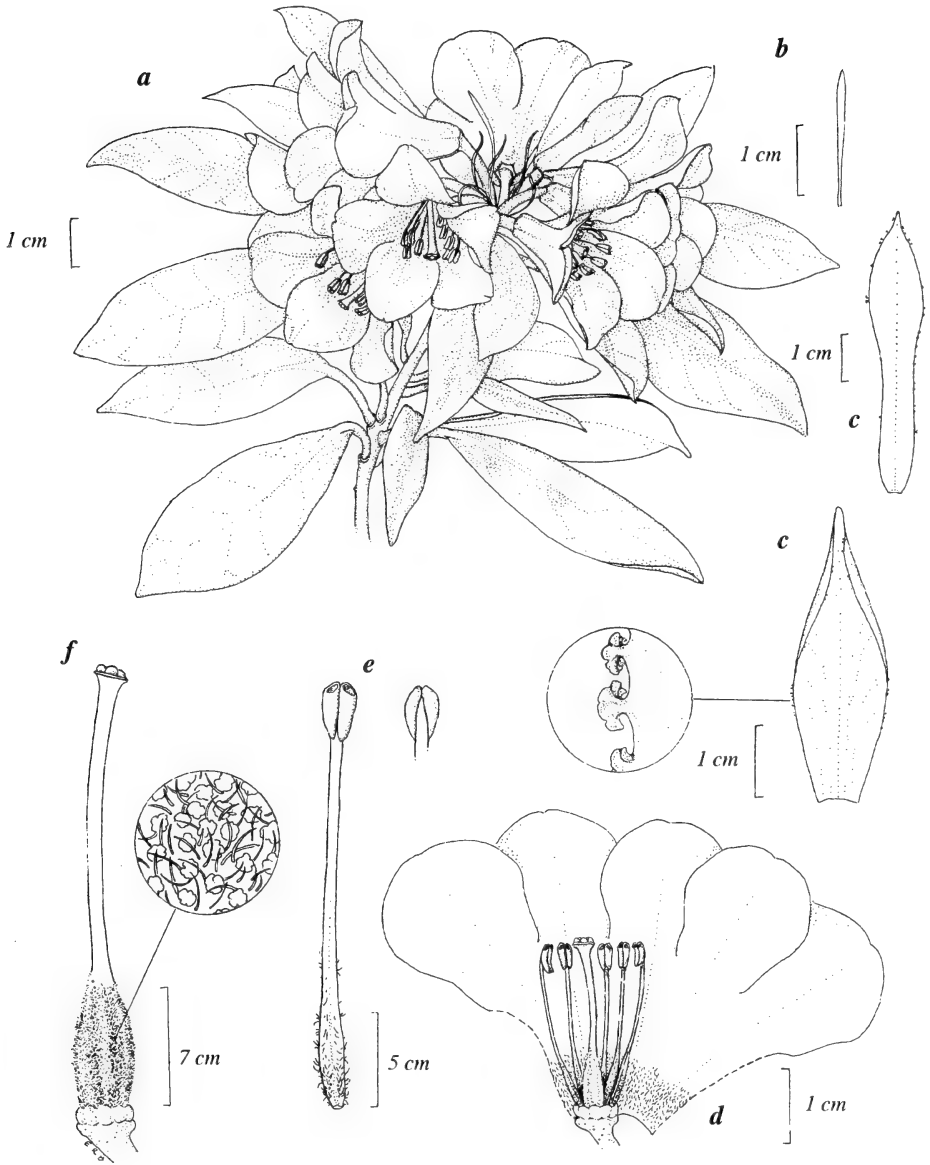


Figure 3. *Rhododendron reynosoi*
a branch with inflorescence; **b** bracteole; **c** bract with enlargement to show scales on the margin; **d** flower cut open; **e** stamen with anther back view; **f** pistil with enlargement of ovary indumentum.

style, grooved longitudinally in the proximal two thirds, 20–25 x c. 6 mm, the calyx slightly accrescent. On splitting the outer layer peeling back irregularly, the valves spreading to c. 45°, the placentae remaining more or less adherent to the central column. *Seeds* c. 3.7 mm long, with tails c. 0.8 mm, the longest tail 1.5 mm.

Notes: This species keys out in Sleumer (1966) to *Rhododendron leytense* Merr. differing, however, not only in the colour of the flowers, which is recorded as yellow in *R. leytense* but in the non-puberulous pedicels and it has more flowers in the inflorescence than that species. A unique feature, at least amongst the Philippine rhododendrons, is the gradual transition from foliage leaves to bracts, the intermediates are longer than the bracts, have broad sheathing bases but progressively smaller blades than the foliage leaves.

This species is very distinct with its bright vibrant orange flowers in a tight, erect umbel. This alone distinguishes it from all other Philippine species as those with several flowered umbels either have very differently sized flowers or have a totally different disposition. It is much smaller leaved than *R. javanicum* (Blume) Benn. var. *schadenbergii* (Warb.) Sleumer as conceived by Sleumer (1966).

3. *Rhododendron wilkiei* Argent *sp. nov.*

Named after Peter Wilkie, botanist and explorer in SE. Asia, who nearly died of a malarial attack helping to collect this species.

R. acrophilo similis a qua flore intense rubro haud bicolori et filamentis ac corollae parte interiore glabris (haud pilosis) differt. **Typus:** Philippines, Palawan, Thumb Peak. *Argent, Chavez, Cronk, Mendum, Middleton & Wilkie* 48. Original collection 30 January 1998; Cultivated collection *Ac.No.19981810* 11 July 2003. (holo PNH; iso E).

Figure 4

Weak shrub to c. 30 cm. *Stems* pale green, terete, c. 1.5 mm diam., moderately densely covered in brown stellate scales. *Leaves* in pseudowhorls 1–2 cm apart, consisting of 3–4 larger and 2–3 smaller leaves, mostly only possessing leaves at the terminal pseudowhorl. *Petiole* 2–3 x c. 1.5 mm, not distinctly grooved above but with a central line, pale green with brown stellate scales. *Leaf blade* elliptic 25–40 x 10–15 mm, with some sparse silvery, stellate scales at first but quickly glabrescent above, below moderately brown scaly, the scales rounded, lobed to sub-stellate, impressed into small pits the centres small and indistinct distributed 2–4 diameters apart in the mature leaves. *Leaf base* broadly cuneate; the margin entire, flat; the apex broadly acute to obtuse, sometimes with an

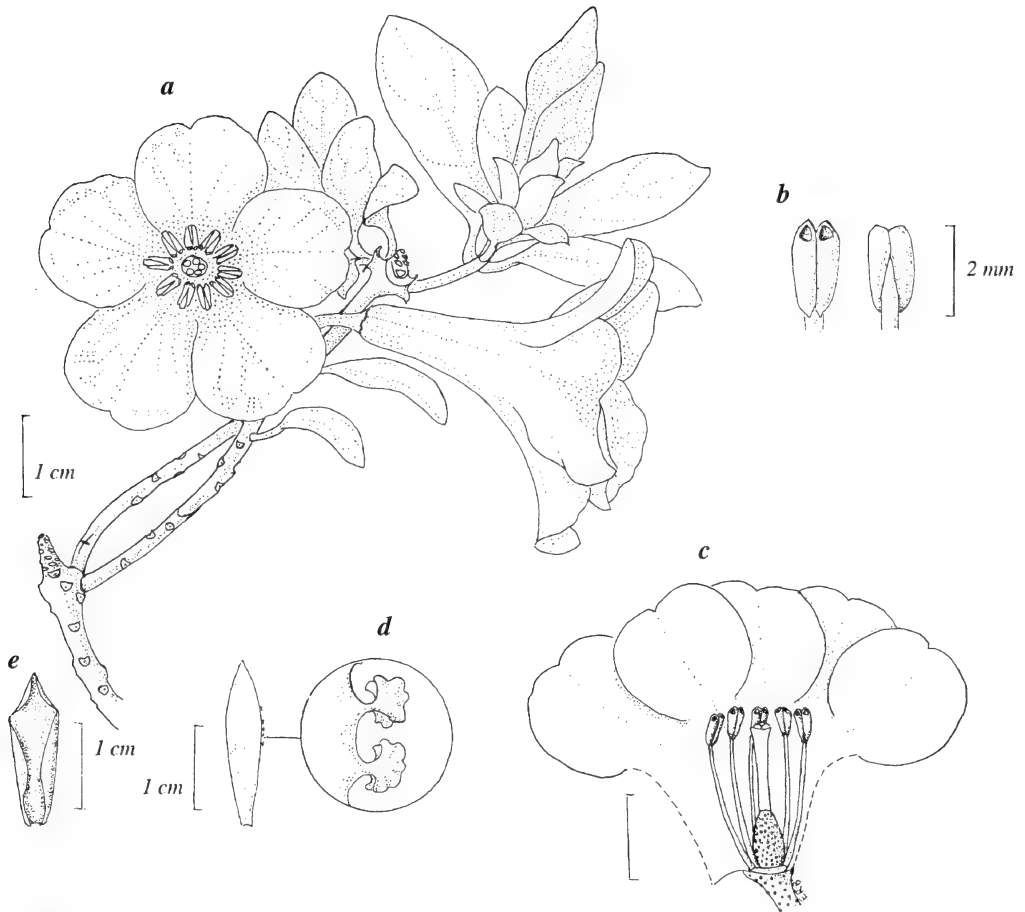


Figure 4. *Rhododendron wilkei*

a branch with inflorescence and opening bud; **b** anthers face and back view; **c** flower cut open; **d** inner bract with enlargement to show marginal scales; **e** bract.

obscure, white, non-protruding, gland-like structure at the point, midrib narrowly impressed above, slightly prominent just above the petiole but then somewhat impressed distally beneath, translucent green especially towards the base, lateral veins plane, 2–4 per side, spreading broadly but disappearing before the margin, distinct above but obscure below.

Flower buds green, up to 18 x 8 mm, narrowly conical but contracted near the base, sharply pointed with the basal bracts spreading, the upper (inner) bracts mostly appressed. *Bracts* glabrous or with a few small, scattered scales outside and with scales along the margins. *Pedicels* 10–15 x 1–2 mm, red, moderately

scaly but without simple hairs. *Flowers* terminal, solitary or paired, held half-hanging, red, without scent, *c.* 27 x 44 mm; *calyx* a low scaly disc or with two irregular longer lobes up to 2 mm long. *Corolla* tube *c.* 15 x 4 x 10 mm, glabrous outside and inside, the lobes *c.* 19 x 21 mm, spreading horizontally, overlapping to about half to two thirds of their length, emarginate at the apex. *Stamens* regularly arranged around the mouth of the flower, filaments pale pink, glabrous, the anthers dark purple 2–2.5 x *c.* 1.25 mm. *Disc* green glabrous. *Ovary* *c.* 6 x 2.5 mm, ellipsoid, rather sparsely brown-scaly, without simple hairs. *Style* pink, at first lying on the lower side of the corolla tube, rising to a central position as the flower ages, *c.* 20 mm, glabrous. *Stigma* purplish-red, hardly expanded from the style, *c.* 1.25 mm diam. *Fruits* not seen.

Notes: This keys out in Sleumer (1966) to *Rhododendron porphyranthes* Sleumer, known from only a single collection from the Arfak Mountains in New Guinea. Apart from being a most unlikely distribution pattern, *R. porphyranthes* differs in its rounded to emarginate leaves, in having much smaller corolla lobes, a smaller ovary and a style only half as long as in this new species. It is probably most similar to *R. acrophilum*, which is at least from the same island, but differs in the flower colour, which is bicoloured with a yellow tube and orange lobes in that species (Argent & Madulid, 1995) and that the filaments and the inside of the corolla are glabrous in *R. wilkiei*, not hairy. This new species also lacks the white waxy substance associated with the flower buds of *R. acrophilum* and is much less vigorous in its growth habit.

Additional specimen with the same collecting details as the type: 55, *Ac.No.19981817* (PNH, E).

Rhododendron javanicum (Blume) Benn. ssp. ***palawanense*** Argent ssp. **nov.**
Named from the island of Palawan from where it was collected.

Folia spiraliter disposita laevia. Gemmae anguste ovoideae apice acuto bracteisque adpressis. Flores *c.* 10 cm longi, aurantiaci fauce luteo, lobis circiter duplo longioribus quam latioribus. **Typus:** Philippines, Palawan, Mt. Mantalingajan. Argent & Romero *Ac. 19922770* Cultivated specimen collected 16 January 1998. (holo PNH, iso E).

Shrub to 1.5 m. *Leaves* spirally arranged, smooth. *Flower buds* green, narrowly ovoid with an acute apex and appressed bracts. *Pedicels* glabrous or sparsely scaly. *Flowers* *c.* 10 x 9 cm, bicoloured, with a yellow tube, hairy inside near the base and forming a yellow 'star' in the mouth, lobes orange, *c.* 5 x 2.5 cm. *Stamens* with hairs in the basal quarter of the filaments, anthers *c.* 5 mm with grey pollen. *Ovary* glabrous, (in the type), or variably hairy and scaly.

Notes: Following Argent *et al.* (1988) and Argent (2003), *Rhododendron javanicum* is presently treated in a broad sense including *R. brookeanum* H.Low *ex* Lindl. and *R. moultonii* Ridl. This complex of mainly low altitude forest epiphytes is characterised by large, more or less elliptic, acutely pointed leaves and large funnel-shaped flowers in a range of colours. As conceived here, it is widespread occurring through Sumatra, Peninsular Malaysia, the Philippines, Borneo, Java, Bali to Sulawesi. It is highly variable in its leaf arrangement and ovary indumentum even within some populations and is difficult to deal with satisfactorily although various populations are distinct. This new subspecies is very similar to the Mt. Kinabalu populations: *R. javanicum* ssp. *brookeanum* (H.Low *ex* Lindl.) Argent & Phillipps var. *kinabaluense* Argent, A.L.Lamb & Phillipps, which is similarly a high altitude form with large, conspicuously bicoloured flowers, broad flower buds with appressed bracts that are often emarginate and rugose leaves arranged in regular spirals. The Palawan plants differ, however, in having smooth leaves, more slender flower buds with acutely pointed bracts and longer flowers, with longer and narrower lobes to the corolla, and grey pollen. The significance of pollen colour is not yet known but it was considered important as a specific character in *Aeschynanthus* (Gesneriaceae) by Mary Mendum (*pers. comm.*). Within the Philippines, all plants of *Rhododendron javanicum* were included in var. *schadenbergii* (Warb.) Sleumer (Sleumer, 1966). However, these recent collections from Mt. Mantalingajan are very different from the majority of Philippine collections, mostly from the island of Mindanao. These have much shorter, uniformly red flowers and cream pollen. The ovary indumentum in ssp. *palawanense* varies from completely glabrous to hairy and scaly in the proximal two thirds. Thus this Palawan population appears to be similar but not identical to the Kinabalu one and very different to at least that on Mindanao. It seems best to give these plants subspecies status at present which draws attention to their unique character and distribution. Further collections of this species complex from other islands in the Philippines are badly needed to satisfactorily understand the variation.

Additional collections that are very similar are from Cleopatra Needle, *Ac. No.* 19981796, and from Thumb Peak, *Ac. Nos.* 19981802, 19981812. A vegetative herbarium specimen in PNH from Victoria Peak is probably the same taxon.

New Records of *Rhododendron edanoi* Merr. & Quisumb.

Philippines, Palawan, Thumb Peak, near summit c.1200 m Argent, Chavez, Cronk, Mendum, Middleton & Wilkie 46, *Ac.* 19981808 Original collection 30 Jan.1998; Philippines, Palawan, Cleopatra Needle, just below summit c.1500 m, in mossy forest Argent *et al.* *Ac.*19981819. Original collection 15 January 1998. (All preserved in PNH. and E).

Notes: This species was previously only known from the type collection made on Mt. Mantalingajan near the southern tip of the island of Palawan on 13th May 1947 by G.E. Edaño. The materials collected in 1998 on the tiny isolated area of mossy forest on the summit of Cleopatra Needle and from Thumb Peak, a similar isolated area of mossy forest a little further to the south, were both seed and cuttings of what was designated in the field as the 'round leafed' rhododendron. None of these rhododendrons was in flower at the time of collection and identification had to await flowering in cultivation. This occurred first for the cutting material in March 2000 and for the seed in 2003. The interest in these collections is not just that this extends the range of this otherwise point endemic to most of the length of the island of Palawan but that it shows this species to be conspecific with that of *Rhododendron pneumonanthum* Sleumer of Borneo. Sleumer (1966) distinguished these two species at couplet '31' on the characters "Corolla tube more or less manifestly and gradually narrowed from the base upwards. Leaves sub-sessile (*R. pneumonanthum*) vs. Corolla tube equally wide all over or slightly and gradually widened from the base upwards. Leaves distinctly petioled. (*R. edanoi*).

From examination of isotypes of the original collection of *Rhododendron edanoi* from BM, K and L, the first character is not a valid difference. Several corolla tubes show a quite definite narrowing from the proximal to the distal ends. The corollas from cultivated plants from both Palawan and Borneo, in the fresh state all quite clearly taper from base to mouth. After pressing, the tube can appear to at least look parallel-sided. There does appear to be a difference in petiole length between Bornean and Philippine materials but again there is a lot of variation even on one plant and this alone would not support maintaining these plants as different species. There is a very small difference in the scales on the leaves from the two islands, those from Bornean materials are darker and more variable in size but both have essentially the same sub-stellate shape, are rather tall and set on pronounced epidermal tubercles. The vegetative habit of the plants in cultivation from the different islands is certainly very different. Both Philippine collections are slow and low growing compared to the tall 'leggy' and much more vigorous Bornean plants. It is tempting to imply that the Philippine plants growing in such small isolated populations are suffering from inbreeding depression compared with the much larger populations of *R. pneumonanthum* in northern Sarawak where it is reported to be common over large areas close to Bario on the slopes of Mt. Murud (A. Lamb *pers. comm.*). Differences in habit between different populations of the same species are known elsewhere in section *Vireya*. *R. burttii* P.Woods varies on different mountain ranges (Argent *et al.*, 1988) and *R. leptanthum* F.Muell. (*pers. obs.*). The clinching factor in regarding the Bornean *R. pneumonanthum* to be, at best, a subspecies and not specifically distinct from *R. edanoi* is the fact that the flower bud morphology is identical and very distinctive from both

island populations. The flower buds are broadly oval with reflexed points to the tips of the bracts (perulae of Sleumer, 1966).

Thus the Bornean populations are reduced to the status of subspecies which reflects the relationship between Philippine and Bornean plants more accurately:

R. edanoi* ssp. *pneumonanthum (Sleumer) Argent *comb. nov.*

Basionym: *R. pneumonanthum* Sleumer, *Reinwardtia* 5 (1960) 132.

Key to the subspecies

Small spreading plants, mostly less than 30 cm,
petioles mostly more than 5 mm long,
distinctly longer than wide, scales pale brown ssp. *edanoi*

Tall erect plants, often more than 1 m, petioles up to
3 mm long, hardly longer than wide, scales
blackish-brown when mature ssp. *pneumonanthum*

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***Begonia sizemoreae* Kiew (Begoniaceae), a Handsome New Begonia from Vietnam**

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Abstract

Begonia sizemoreae Kiew (sect. *Platycentrum*) is described from the Ba Vi National Park in North Vietnam. Closely related to *B. rex* Putzeys and with similarly fine variegated leaves, it is striking for the crimson reticulation of veins in the central and marginal parts of the leaves.

Introduction

This attractive begonia was first discovered by Mary Sizemore on 6th November 1996 in Ba Vi National Park. c. 80 km west of Hanoi, Vietnam. It was listed in the American Begonia Society's *Unidentified Species List* as *Begonia* U388 and, because of its beautiful leaves, was quite widely circulated among the Society's members (Keepin, 2003). Naming such a striking plant, which is a significant addition to the foliage begonias already in cultivation, is long overdue. It is here described and illustrated and is named in honour of Mary Sizemore.

Begonia sizemoreae* Kiew, *sp. nov.

A *Begonia rege* Putzeys petiolis quam laminis subduplo longioribus, venis tertiariis foliorum rubris et cymis 3-floris statim dignoscenda. **Typus:** Vietnam, Ba Vi National Park, Ha Tay Province, c. 80 km west of Hanoi, Accession No. 20020399 cult. in Singapore Botanic Gardens *ex* Palm Hammock Orchid Estate, Miami, U.S.A. *R. Kiew 5304* (holo SING, iso HN).

Plate 1

Begonia rhizomatous. *Stem* creeping, not branched, succulent, c. 2.5 cm long and c. 5 mm thick; reddish brown or purplish; without a tuber. Indumentum of white, c. 10 mm long, uniseriate hairs, scattered on the upper lamina surface (not on the veins), these c. 5 mm long and dense on the stem, stipules and petiole, 2–4 mm long and dense on the lamina margin and on the undersurface

of the midrib, secondary and tertiary veins. *Stipules* persistent, broadly triangular tapering to a setose point, 8–12 x 4–9 mm, reddish when young, becoming pale yellowish green with a reddish band along the midrib, margin entire. *Leaves* alternate, tufted; *petiole* terete, (4.5–)10.5–19 cm long, pale red or purplish; *lamina* oblique, asymmetric, broadly ovate, 6.5–11.5 x 5.5–10.5 cm, broad side 4–6.5 cm wide, base unequally cordate, larger basal lobe 2.25–3.5 cm long, margin entire, slightly undulate, apex slightly acute, sometimes rounded, lamina slightly velvety above and thinly succulent in life, papery when dried, variegated on the upper surface with the basal part (less than half the lamina width) and a band c. 10–15 mm wide around the margin jade green sometimes with a blackish hue and with the middle part pale silvery grey-green, secondary veins green in the basal part, white in the middle part and deep crimson in the marginal band, tertiary veins deep crimson in the basal and marginal parts and white in the middle part, on the lower lamina surface green with secondary veins greenish brown, tertiary veins deep crimson; venation palmate-pinnate with 2 pairs of secondary veins at the base and 2 pairs along the midrib with another vein in the basal lobe, secondary veins branching c. halfway to the margin, impressed above, prominent beneath.

Inflorescences axillary, monochasial cymes, protandrous with two male flowers and one female flower, glabrous, 7.25–19.5 cm tall with two branches 2–3 mm long, rosy red, greenish distally. *Bracts* narrowly ovate, 11–15 x 4–5 mm, glabrous, pale green, almost transparent, reddish along the midrib and towards the tip, apex acutely pointed, margin entire, caducous. *Male flower*: pedicel 18–20 mm long, pale pink or white; *tepals* 4, glabrous, margin entire, apex rounded, outer two tepals ovate, 18–25 x 13–14 mm, deep pink paler towards base, longitudinal veins slightly impressed; inner two tepals oval, 16–25 x 9–11 mm, pale pink, veins not impressed; *stamens* many, joined into a more or less globose cluster, 5–7 x 5 mm; filaments joined into a column for 1–3.5 mm and free for c. 1.25 mm, white; anthers narrowly oblong, c. 2.5 mm long, deep yellow, apex strongly apiculate, c. 1 mm long, thecae dehiscing through lateral slits. *Female flower*: pedicel 15–25 mm long, slightly reddish; *ovary* pale green, 7–8 x 20–23 mm, wings 3, unequal, long wing 12–17 mm wide, two shorter wings 3–5 mm wide, locules 2, placentas bifid; *tepals* 5, obovate tapered to an acute apex, more or less isomorphic, 19–21 x 10–12 mm, deep pink at the tip, paler at the base, margin entire and undulate; styles and stigma golden yellow or yellowish green, *styles* 2, 8–9 mm long, joined for c. 2 mm at the base, bifurcating in the upper third; *stigmas* a spiral papillose band. *Fruit and seed* not known.

Distribution: Endemic in N. Vietnam (Ba Vi National Park).

Habitat: Locally common on earth banks beside the road in medium shade at c. 800 m altitude.



Plate 1. *Begonia sizemoreae* Kiew.

A. The plant. B. Monochasial cyme with two male flowers and the developing female flower. C, D. Male flower. E, F. Female flower. *Serena Lee*

Other specimen examined: U.S.A., Palm Hammock Orchid Estate, Miami, Kiew s.n. 10 Feb 2002 (SING).

Notes: *Begonia sizemoreae* belongs to sect. *Platycentrum* in being rhizomatous, protandrous, and having a male flower with four tepals and a female flower with an ovary with one wing much longer than the other two, two styles, and two locules each with a bifid placenta.

This new species is very similar to *Begonia rex* Putzeys from Assam, India, in its leaf shape, the silvery band around the middle of the leaf and in flower structure. However, *B. sizemoreae* is distinct in its petioles being much longer (over 1.5 times longer) than the lamina and densely hairy, whereas in *B. rex* the petioles are shorter than the lamina and are less hairy. The lamina of *B. rex* is distinctly bullate, while that of *B. sizemoreae* is not. The details of the variegation are significantly different: in *B. sizemoreae* the basal and marginal parts of the lamina are jade green with striking deep crimson venation, while in *B. rex* the basal and marginal parts are dark green to bronzy green and the venation is concolorous. In addition, the leaf base is never overlapping, as is seen in wild collections of *B. rex* (e.g. *Griffith 2588*, K). In *B. sizemoreae*, the inflorescence is a three-flowered, monochasial cyme with a single female flower, while in *B. rex* it is a dichasial cyme with four female flowers.

The introduction of *Begonia rex* is well documented—it was inadvertently introduced from Assam together with a consignment of orchids and was bought by J. Linden for 10,000 francs (Thompson & Thompson, 1981). The original French publication described it as ‘ce merveille Begonia’ (Hooker, 1859). Since then it has been hybridized with a wide range of species, both closely and distantly related, to produce an amazing variety of leaf shapes (some even spiral!), colours, patterns and leaf textures but most with the characteristic silvery sheen. It is doubtful now whether any ‘pure’ *B. rex* plants exist in cultivation considering the ease with which it hybridizes. As Krempin (1993) records, the hybrids of *B. rex* are ‘never ending’ and there are probably more than a thousand named and unnamed. *Begonia rex* is not recorded wild from Vietnam. Hô (1991, 1999) included it in his account of Vietnamese begonias as a cultivated species.

Golding (2004) recently identified *Begonia* U388, which is here described as *Begonia sizemoreae*, as *B. longiciliata* C.Y. Wu, a begonia from Guizhou, China. However, *B. sizemoreae* is different from this species in its variegated leaves, the larger basal lobe (one third as long as the midrib) and the entire margin; the inflorescence is a monochasial cyme with two much larger male flowers. In contrast, the lamina of *B. longiciliata* is plain deep green above and green beneath, the larger basal lobe is only one fifth to one sixth as long as the midrib, and the margins are denticulate; the outer tepals of the male flowers are 13 by 8 mm and the inner ones 9 by 3.5 mm. Although Wu in Wu

& Ku (1995) described the inflorescence as monochasial with two flowers, the illustration shows it to be dichasial with potentially six male flower and four fruits. In this latter character, it resembles *B. rex*.

Apart from its stunning foliage, *Begonia sizemoreae* has the advantage that it is easy to grow in cultivation unlike many other wild species in Asia. In cultivation, its leaves can grow up to 26 by 16.5 cm (M. Sizemore, *pers. comm.*). It flowers freely and, in Singapore, it is not seasonal. It propagates easily from the leaves. Keepin (2003) reports that it is self compatible and produces viable seed. This new species is therefore an important addition to the stable of cultivated begonias. Its charm lies in the deep crimson tracery of the fine network of veins—a feature not seen in *B. rex*. No doubt, it too will prove easy to hybridise, but it is important to keep a pure line so that its identity is not lost.

Acknowledgements

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Note added in press: A begonia called ‘Vietnamese hairy *Begonia*’ was illustrated in *The Garden* (2004) Volume 129 (7): 515, after it had been exhibited at the Chelsea Flower Show. From the photograph, it looks very like *Begonia sizemoreae*, which suggests that this species is beginning to enter the horticultural trade.

The Vegetation and Plants of Niah National Park, Borneo

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Abstract

Based on survey work and specimen collection carried out during 2001 to 2003, vegetation types that occur in Niah National Park (the various facies of limestone vegetation—the Subis limestone is the most prominent feature of the Park—mixed dipterocarp forest, seasonal swamp forest on clayey marls and on peat soils, riparian forest, and regenerating forest developing after shifting cultivation) are described. A provisional checklist of species includes more than 300 species. Ferns, Acanthaceae, Annonaceae, Araceae, Begoniaceae, Euphorbiaceae, Gesneriaceae, Moraceae, Rubiaceae and Urticaceae are well represented, while orchids and palms appear to be under-collected. A number of fruit tree species and other useful plants occur in the Park. The Park is home to at least 12 endemics found nowhere else, and 5 possible new species.

Introduction

The following account of the plants of Niah National Park (Niah NP) grew out of work done to map and describe the vegetation types at Niah NP under the Sarawak Forest Department/DANIDA Project *Support to Wild Life Master Plan Implementation through the Improved Management of Totally Protected Areas, Sarawak, Malaysia* (SWMPI) completed in 2003. An understanding of the Park's vegetation and flora is, of course, a *sine qua non* for effective park management.

Niah NP lies close to the north coast of Sarawak in the lower reaches of Sungai (Sg) Niah catchment. The Park's most prominent feature, located almost entirely within the Park, is the striking Subis limestone massif (the remains of an ancient coral reef), which rises vertically out of the Sg Niah floodplain. The Park area has a unique history of human interaction dating from prehistoric times to the present. Constituted in 1974 (with the inclusion of the Niah Great Cave and Historical Monument in 1994), Niah NP covers 3,139 ha. Local people formerly farmed and planted fruit trees in the area and some local inhabitants have been accorded a range of gazetted rights within the Park, such as the right to collect fruit and forest products.

Although the first plant collections were made at Subis in 1894, the Gunung Subis limestone outcrop, until this study, was somewhat neglected by plant collectors (Pearce, 2003). Particularly for some of the earlier collections

from non-limestone habitats that give the locality as 'Niah', it cannot be ascertained whether the collections were made within what is now the Niah NP area.

Methodology

This account is based on fieldwork at Niah NP during the period 2001 to 2003 and an examination of available literature. Field work included observations, an investigation of the use of gazetted rights and forest products and local botanical knowledge at Niah NP and recording plants in verification plots in seven vegetation types. The botanical expedition teams collected 303 fertile specimens of trees, shrubs and herbs and covered most of the vegetation types represented in the Park including some less well-collected areas, such as the summit of Gunung Subis, and areas to the Park's east.

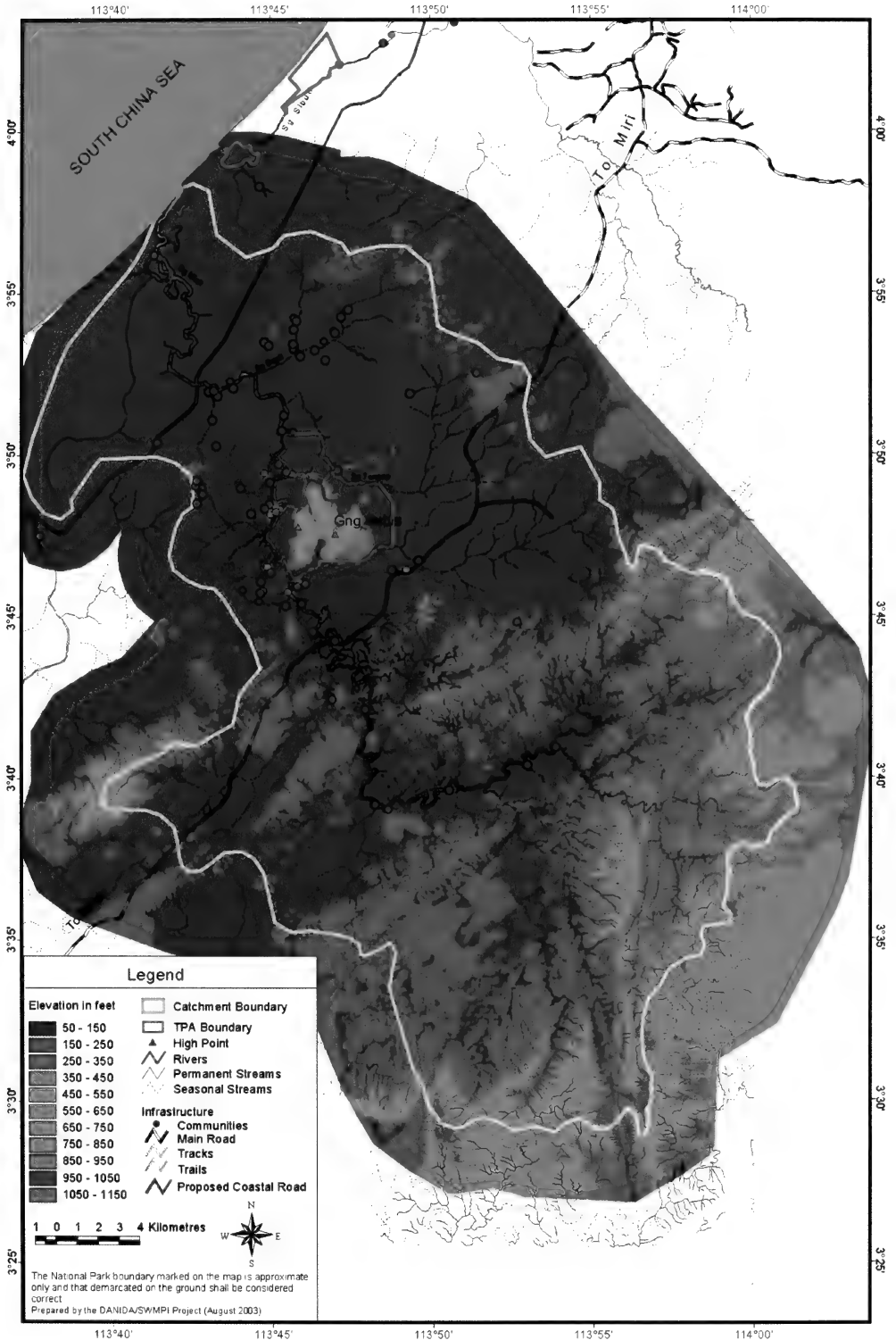
The specimens were subsequently identified by reference to the literature and comparison with specimens in the Herbarium, Sarawak Forest Department (SAR) and, for the Araceae, *Macaranga* species, Orchidaceae, Sterculiaceae and Zingiberaceae, with the help of experts. The identification of species of *Piper*, *Syzygium*, Lauraceae and Urticaceae posed problems as up-to-date revisions and/or well-annotated SAR herbarium specimens were not available.

The checklist includes specimens collected, recorded or observed during the DANIDA/SWMPI Project period, some mentioned in the literature and some SAR collections reliably identified by specialists. Fern classification is according to Parris and Latiff (1997).

Vegetation Types in the Park

Though small, the Park includes six distinct vegetation types, namely:

- **Limestone vegetation on karst** (rough limestone country with underground drainage) covers approximately 16 km² or *c.* 40% of the Park's area). It includes both the massif and surrounding scattered limestone fragments, large and small, which provide habitats for a variety of limestone plants; Sg Subis drains forest west of the limestone massif and flows over limestone bedrock in places
- **Mixed Dipterocarp Forest (MDF)** covering *c.* 16% of the Park chiefly on gentle to steep slopes to the Park's southwest where weathering has exposed the sandstone that underlies the limestone (Sg Trusan drains part of this MDF) and also a patch traversed by the Plank Walk from the Park Head Quarters to the Great Cave and also, south of this, a patch of MDF-Kerangas forest traversed by the Jalan Madu Trail



Map 1. Topography of Niah National Park and Surrounding Areas. (reproduced with permission of the Sarawak Forest Department).

- **Seasonal Swamp Forest on clayey marl soils** covers *c.* 10% of the Park on the Sg Niah and Sg Tangap floodplains, which are periodically inundated, sometimes to a depth of 3 m (the height of stranded debris), when, after intense rainfall, the rivers flood their banks and rainwater is slow to drain
- **Seasonal Swamp Forest on peat soils** covers *c.* 5% of the Park and is found in a patch of low-lying and periodically inundated land that lies between the levees of Sg Niah and Sg Tangap at the north of the Park and which has a different forest type from seasonal swamp forest on clayey marl soils
- **Riparian Forest** fringes the tidal and navigable Sg Niah and its slow-moving tributaries, Sg Tangap and Sg Sekaloh, the three rivers that bound the Park to the west, northeast and south, respectively
- **Regenerating Forest** covers *c.* 29% of the Park in areas that have been disturbed.

Limestone vegetation on karst

Karst hills provide a variety of microhabitats (Kiew 1991). Niah National Park's karst landscape includes summits, steep to vertical cliffs rising to more than 100 m, narrow gorges, broad valleys, complexes of extensive and spectacular caves and a pool, 'Telaga Kumang', located at the base of a karst wall.

The Subis massif summits are of jagged karst rocks with pockets of humus and soil in crevices (acidic where litter has accumulated) and surrounding skeletal (< 25 cm deep) mineral soils with rock particles. The massif's high point, Gunung Subis at 394 m, does not match altitudes reached by karst at Mulu and few collections mention the existence of a summit peat or 'mor' layer such as occurs on even quite low hills in the Kuching Division (Kiew *et al.* 2004).

Summit vegetation is characterized by a few species of trees. *Gymnostoma nobile* (ru ronang), with its characteristic rounded, soft-looking crowns of fine needle-twigs, is typical and abundant on undisturbed summits and there are also shrubs, numerous herbs and epiphytes. Orchids and ferns are well represented and *Paraboea speluncarum*^E, with its distinctive rosettes of pale leaves, is abundant.

Vegetation may differ from summit to summit. Exposed karst rocks and surrounding humus soil at the summit of Gunung Subis (partly disturbed by the setting up of a camp) support *Ficus deltoidea* and *F. sumatrana*; *Schefflera burkillii* and *Schefflera* species, *Medinilla botryocarpa*^E, a species each of

^E

Endemic to Borneo

Cayratia, *Mussaenda* and *Fagraea* and orchid species while just below the summit were *Pandanus calcinactus*^E, *Podocarpus confertus*, the jewel orchid *Dossinia marmorata*^E, species of *Hemigraphis* and *Justicia* and the fern *Paragramma longifolia*. These species were not noted on the only accessible portion of Bukit Kasut summit (220 m, burnt in the past and suffering high visitor pressure). Altitude may be a factor restricting the distribution of *Pandanus calcinactus* and *Schefflera burkillii* to the summit of Gunung Subis since SAR specimens of the former species have (with one exception) only been collected from an altitude of at least 400 m and specimens of the latter from at least 780 m. However, SAR specimens of *Podocarpus confertus* have been collected from as low as 100–133 m altitude.

Species found at the summit of Bukit Kasut included *Macaranga endertii*^E, the ferns *Antrophyum parvulum*, *Drynaria quercifolia*, *Phymatosorus scolopendria*, and species of *Asplenium*, *Pyrrosia* and *Loxogramme*; as well as *Dischidia albida* (Asclepiadaceae) and the legume *Ormosia sumatrana*, none of which were noted on the summit of Gunung Subis.

Burning has clearly modified summit vegetation. Distinct differences between the vegetation of burnt and un-burnt areas are apparent on Bukit Kasut, said to have been burnt c. 1997, and on summits opposite the West Mouth of the Great Cave, burnt in 1988 due to a lightning strike. There is much exposed limestone both at the summit and on slopes of the burnt area of Bukit Kasut and vegetation comprises scattered trees and shrubs to c. 4 m tall, with no *Gymnostoma nobile*, and a herb layer that includes drought resistant plants, such as *Paraboea speluncarum* and *Phymatosorus* sp. By comparison, a peak immediately to the southeast, separated by a ravine and thus inaccessible, is dominated by well-developed specimens of *G. nobile* to at least 10 m tall, with an understorey of shorter trees and bare limestone visible only on sheer vertical slopes. Similarly, the skyline of the cliff facing the Great Cave West Mouth, viewed from the West Mouth, has sparse *G. nobile* to the left (south) but a well-developed canopy of *G. nobile* and other species to the right (north).

Visitor pressure on steep, open parts of the trail leading to Bukit Kasut (the only trail to a limestone summit easily accessible to park visitors and also the habitat of the endemic *Begonia kasutensis*) has loosened the friable soil in places.

Exposed limestone faces, including cliffs and the sides of shady sinkholes, are typically dry and support little growth besides ferns and scattered clinging shrubs and herbs. On the other hand, limestone slopes can be comparatively well vegetated with scattered trees, some to 30 m tall, and an open canopy. This habitat supports some large dipterocarps including species of *Shorea* (lun or damar hitam and selangan batu), *Dipterocarpus* and *Dryobalanops* including *D. lanceolata* (kapur paji) and *D. beccarii* (kapur bukit), *Koompassia excelsa* (tapang), *Hopea andersonii* (luis somit), *Artocarpus* sp., *Popowia* spp., *Ficus* spp. and *Eusideroxylon zwageri* (belian) are present. Herbs include aroids and ferns.

Exposed limestone hills and cliffs may support scattered large trees and smaller trees, such as *Mallotus miquelianus*, *Streblus macrophyllus*^E and *Hydnocarpus gracilis*. Herbs include gingers, *Costus*, aroids and ferns, such as *Asplenium nidus* (bird's nest fern) that may reach a very large size, *A. salignum* and *Antrophyum parvulum*.

Shaded limestone outcrops occur in the seasonal swamp forest. They vary in size and shape and provide a range of niches differing in exposure and thus light, humidity and moisture availability, surface features (presence or absence and tilt of eroded bedding planes, which give the appearance of worn brickwork), aspect, inclination and presence of soil pockets in crevices and associated sinkholes and small ravines. Large strangling fig trees rooting into these outcrops are conspicuous and abundant. Lithophytes include aroids, orchids, ferns (e.g. *Cyclopeltis presliana*), begonias and the limestone specialists *Elatostema acuminata*, *Epithema sarawakensis*, and *Monophyllaea merrilliana*. Caves at Niah provide a continuum of plant microhabitats differing in substrate (combinations of bare rock/guano/soil), light and moisture availability (rock surfaces may be dry, damp or wet), inclination, aspect, altitude, etc. In the deepest shade algae and patches of liverwort cover the rocks. Ferns (*Tectaria devexa*, *Tectaria* sp., *Asplenium* spp.) occupy shaded areas, as do *Cyrtandra spelaea*^E, *Clerodendrum* sp. and *Elatostema acuminata*.

At the Great Cave entrance, karst specialist species include the ferns *Heterogonium pinnatum* and *Cyclopeltis presliana*, *Epithema sarawakensis* and two *Begonia* species. On exposed karst rocks and dry, soil-covered slopes in the same area six *Ficus* (fig) species, *Alstonia scholaris* (pelai) and *Piper* (wild pepper) occur. On slopes just outside the mouth of the Great Cave, cultivated/exotic species that have been planted or have escaped include *Sauropus androgynus* (cankok manis - a local vegetable, also recorded from Gua Pangomah in the Park), *Capsicum* sp. (chilli), *Areca catechu* (pinang), *Alocasia macrorrhizos* (keladi), *Carica papaya* (papaya) and an ornamental *Codiaeum*. Weeds (*Mikania cordata*, *Ageratum conyzoides* and *Oxalis corniculata*) also occur in this habitat.

Aroid species in limestone habitats at Niah NP included *Amorphophallus brachyphyllus*, *A. hewittii*, *Arisaema filiforme*, *Homalomena humilis*, *Raphidophora lobbii* and *Schizmatoglottis elegans*, *S. niahensis* and *Schizmatoglottis* sp. (the last is possibly a new species - A. Hay, pers. comm.).

Many limestone plants have very exacting niche requirements. For example, four of Niah's five *Begonia* species and *Monophyllaea merrilliana* each occupied highly localized limestone microhabitats.

Mixed Dipterocarp Forest

The mixed dipterocarp forest (MDF) in the Niah comprises impressive, mature trees, including emergents. Trees exceeding 100 cm dbh (exceptionally 200

cm dbh) were observed. The understorey comprised numerous saplings and seedlings, woody climbers and a few herbs. The MDF is likely to be of the humult ultisol type typically found on sandy soils with a surface horizon of loosely matted and densely rooted raw humus, low nutrient status and low water retention capacity (Ashton 1995). *Dryobalanops lanceolata*, *Shorea superba* and *Dipterocarpus caudiferus*, which can indicate this type of MDF, occur at Niah (*D. lanceolata* was observed in the Park). According to Ashton, humult ultisol MDF 'appears to be the richest in species of all forest types in Malaysia, because of its remarkable endemism'.

Large trees north of Sg Sekaloh and along Sg Trusan include *Shorea* spp. (meranti, selangan batu), *Dipterocarpus* spp. (keruing), *Sindora leiocarpa* (tampar hantu), Anacardiaceae sp. (rengas) and Chrysobalanaceae sp. (merbatu). The MDF on the sandstone slopes at the Park's southwest included *Dryobalanops* spp. (kapur), *Dipterocarpus confertus* (keruing kobis) and *Shorea quadrinervis* (meranti sudu). In this area, belian has been extracted and *Antiaris toxicaria* (ipoh) tapped. The ground flora includes aroids.

Seasonal Swamp Forest on Clayey Marls

Seasonal swamp forest in Niah NP occurs on somewhat acid clayey marls, has a broken canopy, no emergents (some trees reach 20 m but the majority are shorter), and a dense understorey with herbs chiefly represented by climbers. There is low tree species diversity but high levels of gregariousness. *Octomeles sumatrana* (benuang), *Pterospermum subpeltatum* (bayur) and *Pandanus basilocularis* (a stilted screw-pine that reaches 10 m and is abundant beside the plank walk to the Painted Cave) are gregarious in this forest. *Dracontomelum dao* (sengkuang), *Pometia pinnata* (kasai) and *Anthocephalus cadamba* (kelampayan) also occur in this habitat. Much of the seasonal swamp forest at Niah has been disturbed. There are large belian stumps and the canopy is generally broken.

In seasonal swamp forest below the West Mouth of the Great Cave, belian, *Diospyros euphlebica*^E, *Ficus* spp. and *Saurauia* sp. (mata ikan) predominate. Aroids carpet the ground and some, e.g. *Pothos scandens*, climb.

Forest transitional between riverine and seasonal swamp forest occurs between Kuala Sg Subis and the foot of Bukit Kasut. Here are large fig trees, *Mallotus floribundus* (buantik), *Macaranga* (benuang), sengkuang, gregarious *Schoutenia glomerata* and *Lithocarpus blumeanus* (empili). Rattans (*Calamus* sp., *Daemonorops sparsiflora*, *Korthalsia* sp.) and *Caryota* sp., erect and creeping aroids, *Nepenthes* (pitcher plants), wild *Piper* species (including the locally abundant *P. sarmentosum*), *Costus speciosus*, ginger (*Boesenbergia* sp. and *Globba* sp.) and urticaceous herbs, as well as a number of woody and herbaceous climbers, occur here. At the base of Bukit Kasut and on the way to Telaga Kumang, mosses grow on rocks beside small channels.

Seasonal Swamp Forest on Peat Soils

At the north of the Park, a small area between the levees of Sg Niah and Sg Tangap had, where sampled, an organic horizon >150 cm deep and peat soil with 76% loss on ignition (peat soil has >65% loss on ignition). Small channels and pools of standing water occur. This forest had a broken canopy (extraction was reported to have occurred in the past), some emergents to 25 m and shorter trees to 20 m or less, a dense understorey with abundant saplings and seedlings of primary forest species, herbs, woody climbers and abundant bryophytes on tree roots.

Peat swamp timber species that occur in this forest include *Copaifera palustris* (sepetir paya), *Dactyloclados stenostachys* (jongkong), *Gonystylus* sp. (ramin), *Shorea* sp. (meranti), *Dryobalanops rappa* (kapur paya) and *Combretocarpus rotundatus* (keruntum) as well as large trees of *Parishia* sp. (upi). There are also seedlings of *Parishia maingayi* (upi paya) and *Vatica mangachapoi* (resak paya).

Other trees include the riverine kasai, *Elaeocarpus stipularis* (sengkurat) and *Vatica umbonata*, the swamp species *Quassia indica*, and other trees including figs, *Stemonurus secundiflorus* var. *lanceolatus* (semburok), *Blumeodendron tokbrai* (merbulan), *Diospyros pilosanthera* (kayu malam), *Syzygium* spp. (ubah), *Memecylon* sp. (nipis kulit) and *Santiria laevigata*. The swamp palm *Eleiodoxa conferta* (asam paya) and the aroids *Raphidophora korthalsii* and *R. lobbii* occur here.

Riparian Forest

The banks of Sg Niah, where it bounds the Park, are occasionally flooded and are occasionally under saline influence as the river is tidal at this point. A well-developed riparian fringe includes abundant *Lithocarpus blumeanus*, frequent sengkurat and buantik and frequent, large specimens of sengkuang. The climber *Willughbeia* sp. (akar kubal) is moderately frequent and kasai scattered. *Dipterocarpus oblongifolius* (ensurai) was recorded. Fruit trees that have been planted behind the riverbanks include *Durio zibethinus* (the cultivated durian), two wild *Durio* species with edible fruits (nyakak and isu), *Mangifera pajang* (embang) and *Artocarpus odoratissimus* (terap).

Sungai Sekaloh appears to have lost most of its original riparian vegetation. Sungai Subis, a muddy, slow flowing river with muddy banks, flows through seasonal swamp forest at the north and west of the Subis massif. No macrophytes were noted either in the water or on the banks in this moderately to deeply shaded habitat. To the west of the Subis massif, towards Kuala Subis, the stream is bigger and the riverside trees sengkuang, kasai and benuang are common while fig trees are abundant.

Regenerating Forest

About 29% of the Park is now in various stages of regeneration after having been disturbed. Some of the area was formerly used for shifting cultivation. Some timber extraction has taken place. Regeneration, occurring over different time intervals, on different soil types and presumably after different types and degrees of disturbance, is by no means uniform. A plot set in old secondary forest, where a charcoal layer in the clay loam to sandy loam soil suggested past clearance for agriculture, had emergents reaching 30 m and 110 cm dbh, though most trees were 25 m or less. In this 20 x 20 m plot there was a dense understorey of numerous saplings of primary forest species, a few herbs, some woody climbers and almost no ferns or palms. The mix of primary forest species in this plot included only one individual belonging to the Dipterocarpaceae.

The Park's Flora

The flora of Niah NP is as yet incompletely known. To date, more than 800 plant specimens from Niah NP are deposited at SAR. This includes more than 300 specimens collected during the SWMPI project botanical field investigations. Orchids and palms appear to be under-collected. New species of aroid (A. Hay, P. Boyce, *pers. comm.*) *Paraboea*, *Schumannianthus* and *Boesenbergia* (A. Poulsen, *pers. comm.*) are still to be described from specimens collected in the park.

Orchid species reported with certainty from the Park to date are surprisingly few. Beaman *et al.* (2001) list nine genera and species (*Agrostophyllum* sp., *Bulbophyllum minutulum*, *B. vaginatum*, *Calanthe triplicata*, *Coelogyne verrucosa*, *C. pandurata*, *Didymoplexiella borneensis*^E, *Dossinia marmorata*^E and *Plocoglottis borneensis*). However, they mention 31 orchid species as originating from 'Niah' (six terrestrial, one lithophytic and two saprophytic) and at least some of these are likely to be found in the Park as all but four are noted as occurring at least occasionally on karst. The SWMPI study has added *Agrostophyllum glumaceum*, *Liparis elegans* and *Thecostele alata* while *Anoectochilus* sp. was photographed and *Claderia viridiflora* observed just off park trails.

Dossinia marmorata is an attractive jewel orchid of karst found also at Bau and Mulu. *Adenoncos triloba*^E, an epiphytic orchid of lowland karst hills described in 1935, is known only from the type specimen from Niah. Beaman *et al.* (2001), applying IUCN Red List Categories to orchid taxa known only from Sarawak, consider *Adenoncos triloba* to be Critically Endangered and both *Malaxis andersonii* (a terrestrial karst species) and *Didymoplexiella borneensis* (a saprophyte of hill forest sometimes found on karst) as Endangered. There are unconfirmed reports that a slipper orchid (*Paphiopedilum* sp.) occurs near the karst summits at Niah.

Orchids not associated with karst include two attractive terrestrial species, *Plocoglottis borneensis* and *Calanthe triplicata*.

Palms observed, reported or recorded from in and around the Park include *Caryota no.*, *Areca andersonii*^E, which is known only from the type specimen from Niah (Dransfield 1984) and from Brunei, *Licuala borneensis*^E (previously collected in 1867 in Tubau but no longer there (Saw Leng Guan pers. comm.) and at Niah collected in secondary forest), and rattans including *Calamus myriacanthus*^E, *C. caesius* and *C. scipionum*, *Daemonorops microstachys*^E and *D. sparsiflora*^E.

Well-represented groups at the Park include:

ferns and fern allies - 31 species including *Taenitis trilobata* (Holttum 1968) described from Niah and known from only two localities in Sarawak; possibly two new records for Sarawak (*Adiantum* cf. *malesianum* and *Asplenium subnormale*), *Mesophlebion oligodictyon* (originally described as *Dryopteris oligodictia* from Niah) and five species (*Syngramma wallichii*, *Lindsaea borneensis*, *Tectaria aurita*, *Leptochilus macrophyllus* and *Monogramma paradoxa*) collected by H. Schneider (pers. comm.),

Acanthaceae with 9 species including *Cosmianthemum dido*, described from within the Park,

Annonaceae with 15 species,

Araceae with 19 species includes *Schizmatoglottis niahensis* and *Alocasia venusta*, which are both endemic to Niah NP,

Begoniaceae with five *Begonia* species, all new to science and endemic to Gunung Subis (Pearce 2003),

Euphorbiaceae with 13 species,

Gesneriaceae includes *Cyrtandra cretacea*^E (Burt 1970) and *C. spelaea*^E (Burt 1978), both described from Niah and the latter endemic to the Park; *Monophyllaea merrilliana* (*Monophyllaea* had not previously been reported from Niah), and *Paraboea speluncarum* and *Paraboea* sp. nov. endemic to the Park,

Moraceae - *Ficus* is especially diverse with eight species and *Streblus macrophyllus* is a new record for Sarawak,

Rubiaceae with 14 species,

Urticaceae is represented by 11 species, and

Vitaceae includes *Ampelocissus capillaris* and a *Cayratia* from the summit of Gunung Subis that could not be matched at SAR.

This array of plant groups largely mirrors those Anderson (1965) reported as being well represented on limestone in Sarawak (Annonaceae, Begoniaceae, Euphorbiaceae, Gesneriaceae and Moraceae).

The Park is reported to be rich in both **wild and cultivated fruit tree species**. Informants interviewed regarding gazetted rights to collect fruits, etc., in the Park mentioned a total of more than 30 fruit tree species. These include species of *Mangifera* (Anacardiaceae), *Willughbeia* (Apocynaceae), *Durio*

(Bombacaceae), *Lansium* (Meliaceae), *Artocarpus* (Moraceae) and *Nephelium* (Sapindaceae). Other species include *Gnetum gnemon* (meninjau), *Pangium edule* (kepayang) and *Dialium indum* (keranji).

Useful species in the Park include *Eurycoma longifolia* (tongkat ali), locally well-known owing to its reputed aphrodisiac properties; *Dyera polyphylla* (jelutong paya) formerly tapped for latex for export to make chewing gum (a tree showing tapping scars is just beside the plank walk to the Great Cave and jelutong is said to have been harvested for timber in the Park); *Goniothalamus velutinus* (kayu hujan panas, lim panas)—a treelet common on sandy soil and *kerangas* forest that is locally highly valued based on its supposed magical powers to protect against evil forces; *Antiaris toxicaria* (ipoh) - a tree tapped for its cardiac-glycoside-containing latex, an ingredient of blowpipe dart poison; palms with edible cabbages; rattan canes (*Calamus caesius* (sega) and other species) for tying scaffolding used to collect edible birds' nests in caves, for handicrafts and for weaving; and *Pandanus andersonii* (kerupok) and *P. ?vinaceus* - (akas or akah) whose leaves are collected for making mats.

Endemicity

Little information on endemicity is available for most plant groups in Sarawak. Wong (1998) listed endemic species of selected taxa in Borneo, which indicated endemicities ranging from 8% (*Aglaia*) to 92% (*Vaccinium*).

Limestone forest in Borneo is rich in endemics particularly among herbaceous species (Ashton 1995). Wong (1998) noted that nearly all of the 15 *Paraboea* species in Borneo are locally endemic to karst and 16 of the 17 species of *Monophyllaea* are specifically confined to it. Wong mentioned *Cyrtandra* species and *Pandanus calcinactus* as Sarawak karst plants and notes that the 'inselberg' (island mountain) nature of the majority of the karst outcrops in Borneo appears to have promoted speciation among such groups as the gesneriads, balsams and begonias. Likewise, Kiew (1991), with reference to the limestone flora in Peninsular Malaysia, states that for some herbaceous groups such as the *Paraboeas*, recent speciation appears to have occurred as a result of isolation, so that many species are confined to a particular hill or group of hills.

The Subis massif is indeed well isolated from other Sarawak karst formations (Bau and Padawan-Serian in the southwest; Bukit Sarang southeast of Bintulu; Mulu to the northeast, and the Upper Baram limestone in the interior). So far, the following endemics from the Subis massif have been reported: *Alocasia venusta* and *Schismatoglottis niahensis* (Araceae), *Begonia kachak*, *B. kasutensis*, *B. niahensis*, *B. stichochaete* and *B. subisensis* (Begoniaceae), *Tectaria andersonii* and *T. subdigitata* (Dryopteridaceae) (Holttum 1991) both known only from the type specimens, *Cyrtandra spelaea*

Table 1. List of species endemic to Borneo reported from Niah National Park
*endemic to the Niah National Park, excluding new species

Adiantaceae	<i>Adiantum malesianum</i> Ghatak
Annonaceae	<i>Goniothalamus calcareus</i> Mat Salleh <i>Goniothalamus velutinus</i> Airy Shaw <i>Orophea sarawakensis</i> Kessler
Araceae	* <i>Alocasia venusta</i> A. Hay * <i>Schismatoglottis niahensis</i> A. Hay
Arecaceae	<i>Areca andersonii</i> J.Dransf. <i>Calamus myriacanthus</i> Becc. <i>Daemonorops microstachys</i> Becc. <i>Licuala borneensis</i> Becc.
Aspleniaceae	<i>Asplenium subnormale</i> Copel.
Begoniaceae	* <i>Begonia kachak</i> K. G. Pearce * <i>B. kasutensis</i> K. G. Pearce * <i>B. niahensis</i> K. G. Pearce * <i>B. stichochaete</i> K. G. Pearce * <i>B. subisensis</i> K. G. Pearce
Dryopteridaceae	* <i>Tectaria andersonii</i> Holttum * <i>T. subdigitata</i> (Baker) Copel.
Ebenaceae	<i>Diospyros euphlebica</i> Merr.
Euphorbiaceae	<i>Macaranga endertii</i> Whitmore
Gesneriaceae	<i>Cyrtandra cretacea</i> Kraenzlin * <i>C. spelaea</i> B. L. Burtt * <i>Paraboea speluncarum</i> (Burtt) Burtt
Melastomataceae	<i>Medinilla botryocarpa</i> Regalado
Moraceae	<i>Ficus hemselyana</i> King <i>Streblus macrophyllus</i> Blume
Orchidaceae	* <i>Adenoncos triloba</i> Carr <i>Didymoplexiella borneensis</i> (Schltr.) Garay <i>Dossinia marmorata</i> E.Morren
Pandanaceae	<i>Pandanus calcinactus</i> St John ex Stone

and *Paraboea speluncarum* (Gesneriaceae) and *Adenoncos triloba* (Orchidaceae), known only from the type specimen. In addition, five species are probably new to science but have yet to be described: *Schefflera* 'niah' (Araliaceae), which grows on mudstone outcropping from riverbank (D. Frodin *pers. comm.*), *Schismatoglottis* (Araceae) from the foot of the limestone hill (A. Hay, *pers. comm.*), an *Anadendrum* (P.C. Boyce, *pers. comm.*), a *Paraboea* (Gesneriaceae), a *Schumannianthus* (Marantaceae, A. Poulsen *pers. comm.*), and a *Boesenbergia* sp. collected by A. Poulsen (A. Poulsen *pers. comm.*).

Conclusion

Niah NP is remarkable on account of the variety of vegetation types represented, including a variety of limestone habitats, as well as its history of human interaction. That the Park should support a rich and varied flora is not unexpected in view of the diversity of substrates, relief (especially in karst areas) and processes (flooding, fire and human disturbance, including shifting cultivation and extraction of timber and forest products). While the limestone is relatively dry and mostly without peat formation at summits, it still supports a number of plants that have yet to be described or could not be identified by reference to the SAR collection, as well as new records for Sarawak and Niah. Inaccessible parts of the limestone are still to be explored botanically. Meanwhile, a range of stresses impacts the Park. These include its isolation by surrounding development, human disturbance by bird nest and guano collectors, visitors and, just outside the Park boundary, quarrying, and the depletion of Park resources (birds' nests, guano, timber, forest products, ornamentals, hunted wildlife, etc). An initiative to fully explore, interpret and conserve this special area is urgently needed.

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Appendix: Preliminary Checklist of Plants Collected and Reported from Niah National Park

Note: Most descriptions of plants and habitats are taken directly from field notes. The specimens listed are deposited in the Herbarium, Sarawak Forestry Department (SAR).

emperan is the Sarawak term for alluvial forest

kerangas is the Iban word for forest that when cleared is not suitable for growing hill padi

* species associated with limestone at Niah National Park

^E species endemic to Borneo

G Gunung (mountain)

MDF mixed dipterocarp forest

NP National Park

Sg Sungai (river or stream)

Tj Tanjung (headland)

ACANTHACEAE

Cosmianthemum dido Burtt & Smith

Pathside in primary forest. Pengkalong Lobang to Niah Cave *B.L. Burtt & P.J.B. Woods B 1998*.

Cosmianthemum magnifolium Brem.

Herb 25–40 cm tall. Disturbed peat swamp forest, open area by trail, peat soil. Along N Park boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89235*; MDF, brown clay soil. Sekaloh *Jemree Sablee et al. S 89017*.

**Hemigraphis* sp.

Woody shrub 60 cm tall. Exposed limestone rocks and humus soil, open, canopy 5 m tall. Just below summit of G Subis. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89429*.

**Justicia* sp.

Woody shrub *c.* 1 m tall. Exposed limestone rocks and humus soil, open, canopy 5 m tall. Just below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89430*.

**Linariantha bicolor* Burtt & Smith

Creeping herb. Limestone forest at foot of limestone hill, light shade, in soil at base of limestone rocks. On path to Telaga Kumang *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89410*.

?*Polytrema* sp.

Herb 25 cm tall. On trail, open area, clay soil. Near Sg Subis *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89457*.

*?*Pseuderanthemum* sp.

Shrub 40 cm tall. Foot of limestone hill. Ulu Sg Tangap *Jemree Sablee et al. S 89072*.

**Ptyssiglottis* sp.

Semi-woody plant c. 60–200 cm tall. Forest at base of limestone crags, light shade, humus soil also high ground, light shade by path, loamy soil (locally common) *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89272*; Along N Park boundary from Tj Belipat. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89236*.

Acanthaceae sp.

Creeping herb. On trail in open, clay soil. Near Sg Subis *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89456*.

ADIANTACEAE

**Adiantum* cf. *malesianum*^E Ghatak

Creeping herb c.15 cm tall. Light shade in forest, humus soil among limestone outcrops, under wall of limestone, below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89438*.

Syngamma alismifolia (C. Presl) J.Sm.

Herb 30 cm tall. Disturbed peat swamp forest, open area by trail, peat soil. Along N Park boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89219*.

Syngamma wallichii Hook.

Collected by H. Schneider (*pers. comm.*).

Taenitis trilobata Holttum

Niah. *C. Hose s.n., 1890*. (in Holttum, 1968).

ANACARDIACEAE

**Dracontomelum dao* (Blanco) Merr. & Rolfe

Tree c. 1 m girth, 24 m high. S side of G Subis, in Sg Sekaloh, Niah. *J.A.R. Anderson, Sonny Tan & E. Wright S 27577*.

Mangifera pajang Kosterm.

Observed behind the banks of Sg Niah.

Semecarpus rufovelutinus Ridley

Tree 8 m tall, c. 5 cm diam. Disturbed peat swamp forest, open area by trail, peat soil with pools of standing water. Along N Park boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89216*.

ANISOPHYLLACEAE

Combretocarpus rotundatus (Miq.) Danser

Observed in seasonal swamp forest on peat soils in the N of Park.

ANNONACEAE

Cyathocalyx cf. *havilandii* Boerl.

Treelet 2 m tall. Disturbed forest, moderate shade. Tj Belipat, along boundary from Sg Niah, 100 m from river *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89203*.

Ellipeia cuneifolia J.D.Hook. & Thompson

Woody climber 12 m tall, base of stem 6 cm diam. Seasonal swamp forest (disturbed), light shade, clay soil. Trail into park from Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89284*.

**Enicosanthum macranthum* (King) J. Sinc.

Tree 10 m tall, 16 cm diam. Alluvial limestone lowland forest at the foot of limestone hills from Rumah Chang, Sg Tabau *Julaihi Abdullah, Kit Pearce et al. S 89321.*

Goniothalamus cf. calcareus^E Mat Salleh

Treelet 1.5–2 m tall, 1 cm diam. MDF, brown clay soil also secondary forest, moderate shade, loam soil. Sekaloh. *Jemree Sablee et al. S 89008*; Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89251.*

**Goniothalamus cf. uvarioides* King

Tree 7 m tall, 6 cm diam. Limestone forest, alluvial, medium shade. Gua Sibau, trail from Rumah Chang, NE of the Park. *Julaihi Abdullah, Kit Pearce et al. S 89318.*

Goniothalamus velutinus^E Airy Shaw

Treelet 2 m tall, 2 cm diam. MDF, brown clay soil. Sekaloh *Jemree Sablee et al. S 89018.*

Orophea kostermansia Kessler

Tree to 6 m tall, 20 cm diam. Shady lowland alluvial forest. Along plank walk to Niah Caves *Julaihi Abdullah, Kit Pearce et al. S 89305.*

**Orophea sarawakensis*^E Kessler

Tree 7 m tall, 5 cm diam. S boundary of park, E of Quarry *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89495.*

Polyalthia cauliflora J.D.Hook. & Thompson var. *beccarii* (King) Sinclair

Tree 6 m tall, 7 cm diam. MDF, Sg Sekaloh *Jemree Sablee et al. S 89031.*

Polyalthia motleyana (Hk.f.) Airy Shaw var. *motleyana*

Tree 4 m tall, 7 cm diam. MDF, Sg Sekaloh *Jemree Sablee et al. S 89036.*

Popowia pisocarpa (Blume) Endl.

Tree c 7 m tall, 5 cm diam. Secondary forest, moderate shade, loam soil. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89250.*

**?Popowia*

Small tree 3 m tall, 6 cm diam. Limestone forest. G Subis *Jemree Sablee et al. S 89046.*

**Uvaria grandiflora* Roxb. ex Homem.

Woody climber 17 m tall, 2 cm diam. Limestone forest, light shade, humus soil among limestone rocks at the top of limestone summit *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89404.*

Uvaria sp.

Woody climber c. 15 m tall, stem 3 cm diam. Disturbed peat swamp forest, open area by trail, peat soil. Along N Park boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89225.*

Woodiellantha sympetala (Merr.) Rauschert

Small tree 8 m tall, 7 cm diam. MDF. Sg Sekaloh *Jemree Sablee et al. S 89024.*

APOCYNACEAE

**Alstonia scholaris* R. Br.

Observed at the mouth of the Great Cave.

Dyera polyphylla (Miq.) Ashton

Observed along the plank walk to the Great Cave.

Tabernaemontana macrocarpa Jack

Tree 7 m tall, 6.5 cm diam. Disturbed forest, grey clay under 25 cm peat, moderate shade. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89257*.

Tabernaemontana pauciflora Blume

Shrub 1 m tall. Seasonal swamp forest (disturbed), open area. Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89469*.

AQUIFOLIACEAE

**Ilex* sp.

Tree to 3 m tall, 10 cm. diam. Shady lowland alluvial forest. Limestone hill next to Quarry *Julaihi Abdullah, Kit Pearce et al. S 89313*.

ARACEAE

Aglaeonema nebulosum N.E.Br.

Herb c. 15–20 cm tall. Tj Belipat, along boundary from Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89208*; On path to Telaga Kumang *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89409*.

Aglaeonema nitidum (Jack) Kunth

Herb 60–100 cm tall. Just beside inundated area with standing water, clay soil, moderate shade, also seasonal swamp forest (disturbed), light shade and secondary forest, moderate shade, loam soil. Tj Belipat, along boundary from Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89211*; Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89464*; Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89247*.

**Alocasia venusta* A. Hay

Herb to 45 cm tall. Lithophytic on limestone in swamp forest c. 200 m alt. Path between Niah town and Niah caves *Hay et al. 9346*.

**Amorphophallus brachyphyllus* Hett.

Lithophytic herb c. 1.5 m tall, stem c. 60 cm, 2.5 cm diam. Disturbed forest among limestone rocks, light shade also shady lowland alluvial forest. Below W mouth of Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89487*; Along plank walk to Niah Caves *Julaihi Abdullah, Kit Pearce et al. S 89309*.

**Amorphophallus hewittii* Alderw.

Herb 1 m tall. Limestone forest, light shade, humus soil amongst limestone rocks. Top of limestone summit *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89408*.

Anadendrum microstachyum (deVr. & Miq.) Baker & Alderw.

Herbaceous climber 1.5 m tall. *Emperan* forest, dark brown clay soil, also MDF, light shade,

loam soil *Jemree Sablee et al. S 89006*; Across river from Park HQ *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89444*.

Anadendrum sp. nov.

Climbing herb 1 m tall. Cut petiole without raphides, immature fruits yellow-green. Disturbed swamp forest in standing water, moderate shade, grey clay with wet humus layer. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89264*.

**Arisaema filiforme* Blume

Herb 30 cm tall. Forest at base of limestone crags, light shade, humus soil *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89273*.

Cryptocoryne zonata de Wit

Aquatic herb with leaves slightly above water surface. In water in dry regenerating peat swamp forest also in stagnant pool, light shade, disturbed forest. *Jemree Sablee et al. S 89041*; Across river from Park HQ *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89440*.

Homalomena cf. *hostifolia* Engl.

Herb 20 cm tall. Undisturbed MDF, medium shade, loamy soil *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89268*.

**Homalomena humilis* (Jack) Hk.f.

Herb 15 cm tall. Limestone forest on stone, also on limestone rocks in forest at base of limestone crags in light shade, stony mineral soil and on limestone rocks in pockets of mineral soil, medium shade. G Subis *Jemree Sablee et al. S 89042*; *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89275*; Near Sg Subis *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89459*.

Homalomena sp.

Herb 70 cm tall. MDF, light shade, loamy soil. At base of limestone crags *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89279*.

Lasia spinosa (L.) Thwaites

Herb c. 1.3 m tall. Just beside inundated area with standing water, clay soil, moderate shade, among litter. Tj Belipat, along boundary from Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89209*.

Raphidophora korthalsii (*tenuis facies*) Schott.

Herb c. 50 cm tall. Disturbed peat swamp forest, open area by trail, peat soil. Along N Park Boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89234*.

**Raphidophora lobbii* Schott.

Climber 10–350 cm tall. Disturbed peat swamp forest among limestone rocks, also open area by trail, peat soil with pools of standing water, light shade. Below W mouth of Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89486*; Along N Park boundary from Tj. Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89217*; *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89222*.

**Schismatoglottis elegans* A. Hay

Lithophytic herb c. 50 cm tall. Limestone forest, alluvial, medium shade, on limestone outcrops. Gua Sibau, trail from Rumah Chang, NE of Park *Julaihi Abdullah, Kit Pearce et al. S 89319*.

**Schismatoglottis niahensis* A. Hay

Clustering herb 0.6 m tall. Limestone forest, medium shade, peaty soil at base of limestone rocks. Near Sg Subis *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89454*

**Schismatoglottis puberulipes* Alderw.

Limestone. *Hay et al. 9369.*

**Schismatoglottis* sp. nov. (P.C. Boyce, *pers. comm.*)

Herb 25 cm tall. Leaf upper surface lustrous, dark green, pale beneath, spathe pale green with brownish purple bracts, ovaries green, stamens (above) cream. Limestone forest at foot of limestone hill, light shade, in soil at base of limestone rocks. On path to Telaga Kumang *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89411.*

ARALIACEAE

**Schefflera burkillii* Merr.

Herbaceous climber 1.5 m tall. Open summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89413.*

**Schefflera petiolosa* (Miq.) Harm.

Lithophytic shrub 1.5–5 m tall. Limestone rock in secondary seasonal swamp forest also disturbed seasonal swamp forest, light shade, by stream. Trail into park from Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89290*; Beside Plank Walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89467.*

Schefflera sp. nov. (D. Frodin, *pers. comm.*)

Epiphyte. Greenish orange fruits. Ulu Sg Sekaloh, Sg Niah *J.A.R. Anderson S 27296.*

**Schefflera* sp.

Herb 1 m tall, climbing on rocks. Open summit of G Subis. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89412.*

ARECACEAE

**Areca andersonii* ^E J. Dransf.

Palm 1–2. 6 m tall, 1.5 cm diam. MDF, Sekaloh *Jemree Sablee et al. S 89019*; Sg Sekaloh, G Subis, Niah *J.A.R. Anderson S 31937.*

Areca minuta Scheff.

Palm 2.5 m tall, 1 cm diam at base. MDF/*Kerangas* forest, moderate shade, sandy loam soil. Jalan Madu Trail *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89447.*

Calamus myriacanthus ^E Becc.

Rattan 2–7 m tall. MDF, light shade, loam soil. Across river from Park HQ *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89445 & S 89446.*

Calamus myriacanthus ^E Becc.

(All Borneo Rattan Database, J. Dransfield, 2000)

Caryota no Becc.

Observed in the valley outside the West Mouth of the Great Cave.

Daemonorops korthalsii Blume

Rattan c. 10 m tall. Disturbed secondary forest, moderate shade, clay soil. Along N Park boundary from Tj Belipat. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89212.*

**Daemonorops longipes* (Griff.) Mart.

Rattan 6 m long. Foot of limestone, 17 m asl. G Brangin, Ulu Sg Subis, Niah NP *Yii Puan Ching S 40174.*

Daemonorops sparsiflora Becc.

Rattan 10 m long. Riverine forest, along Sg Niah, Niah NP *Yii Puan Ching S 40147.*

Iguanura curvata Kiew

Palm c. 1 m tall. In disturbed alluvial forest with silty clay soil (not very common). Niah NP *Paul Chai S 40056.*

Licuala borneensis^E Becc.

Clustered palm 80 cm tall. Secondary forest, moderate shade, loam soil. Close to Sg Niah. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89248.*

Licuala sp. 1

Solitary to 1 m tall. Shady lowland alluvial forest. Along plank walk to Niah Caves *Julaihi Abdullah, Kit Pearce et al. S 89301.*

Licuala sp. 2

Clustered palm 1 m tall. Disturbed swamp forest, in standing water, moderate shade, grey clay with wet humus layer. Close to Sg Niah. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89263*

**Pinanga albescens* Becc.

Palm in shade on limestone rock at base of limestone hill *J.A.R. Anderson S 16028.*

ASCLEPIADACEAE

**Dischidia albida*

Vegetation verification plot specimen at summit of Bukit Kasut.

**Dischidia hirsuta* (Blume) Decne.

Small climbing epiphyte. Lower slopes of limestone hill, large limestone boulders. Sg Sekaloh, G Subis, Niah *J.A.R. Anderson S 31924.*

**Dischidia cf. tubulifera* King & Gamble

Small climber. Summit ridge of limestone, 270 m altitude, limestone strongly dissected and covered by 15–22 cm peat layer. Sg Sekaloh, G Subis, Niah *J.A.R. Anderson S 31930*

ASPLENIACEAE

**Asplenium macrophyllum* Sw.

Terrestrial fern. Rare on limestone rocks in semi-exposed position, slope between caves, limestone rocks and residual soil, trees mainly felled, habitat semi-exposed. also inside Gua Tulang on rock. Great Cave, G Subis, Niah *J.A.R. Anderson S 31916; Mohidin S 21691; Niah Ahmad 104.*

**Asplenium nidus* L.

On tree in old forest. G Subis Ahmad 102.

**Asplenium nitidum* Sw.

Epiphyte on rock. Shady lowland alluvial forest. Along plank walk to Niah Caves Julaihi Abdullah, Kit Pearce et al. S 89307.

**Asplenium salignum* Blume

Herb (may be epiphytic) 60 cm tall. Disturbed limestone forest on and among rocks, light shade. Below W mouth of Great Cave Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89485; Ulu Sg Sekaloh, near Quarry Jemree Sablee et al. S 89069.

**Asplenium scandens* J.Sm. ex Mett.

Herb c. 50 cm tall. On limestone rocks, light shade, almost no soil. Near Sg Subis Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89461.

**Asplenium subnormale*^E Copel.

Creeping herb. On limestone rocks in pockets of mineral soil, medium shade also shady lowland alluvial forest. Near Sg Subis Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89453; Along plank walk to Niah Caves Julaihi Abdullah, Kit Pearce et al. S 89304.

**Asplenium vittaeforme* Cav.

Epiphytic fern on fallen branch. Foot of limestone forest, sandy soil. Ulu Sg Trusan Jemree Sablee et al. S 89056.

BEGONIACEAE

**Begonia kachak* K.G.Pearce

Creeping herb, 11–25 cm tall. Foot of limestone hill, on rocks, light shade, almost no soil also shade at base of limestone cave wall. Great Cave Jemree Sablee et al. (S 89062), Kit Pearce, Bibian Diway, Saupel Atot and Dami Jude S 78536; Near Sg Subis Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89463.

**Begonia kasutensis* K.G.Pearce

Creeping fleshy herb c. 10 cm tall. Limestone forest also on steep path in soil between limestone rocks where canopy cover starts to thin out. G Subis Jemree Sablee et al. S 89049; On route to Bukit Kasut Kit Pearce & Narawi Johari S 78596.

**Begonia niahensis* K.G.Pearce

Sprawling herb c. 40 cm long. On limestone rocks, light shade, almost no soil also exposed steeply sloping limestone rocks, rooted in a pocket of soil in the rocks. Near Sg Subis Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89460; Great Cave Kit Pearce, Bibian Diway, Saupel Atot and Dami Jude S 78537.

**Begonia stichochaete* K.G.Pearce

Erect herb 15–25 cm tall. Undisturbed MDF, medium shade, loamy and brown clay soil, also disturbed *emperan* forest, deep alluvial soil, light shade also on low limestone outcrops and in soil surrounding limestone outcrops in deep shade and damp conditions. Sekaloh Jemree Sablee et al. S 89014; Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89267; Banks of Sg Niah near confluence with Sg Subis Kit Pearce, Bibian Diway, Saupel Atot and Dami Jude S 78539; On route to Bukit Kasut Kit Pearce & Narawi Johari S 78597.

**Begonia subisensis* K.G.Pearce

Herb c. 45 cm tall. Near summit on limestone rooted in crevices in soil pockets, partial shade also on steep slopes between limestone rocks where canopy cover starts to thin out (locally frequent). Bukit Kasut *Kit Pearce*, *Bibian Diway*, *Saupeh Atot* and *Dami Jude S 78538*; On trail to Bukit Kasut *Kit Pearce & Narawi Johari S 78598*.

BIGNONIACEAE

**?Tecomanthe* sp.

Woody climber 5 m tall. In forest with canopy c. 20 m tall, light shade, humus soil among limestone outcrops. Below summit of G Subis *Kit Pearce*, *Yahud Wat*, *Serukit Dubod & Jeffri Johari S 89436*.

CASUARINACEAE

Gymnostoma nobile (Whitmore) L.A.S. Johnson

Observed on summits. Abundant.

CELASTRACEAE

Microtropis sp.

Treelet 1.5 m tall, 2 cm diam. MDF. Sg Sekaloh *Jemree Sablee et al. S 89034*.

CHLORANTHACEAE

**Chloranthus erectus* (Buch.-Ham.) Verdc.

Herb c. 1 m tall. Limestone forest, alluvial, medium shade. Gua Sibau, trail from Rumah Chang, NE of park *Julaihi Abdullah, Kit Pearce et al. S 89324*.

CHRYSOBALANACEAE

Parinari sp.

Tree c. 40 m tall, 90 cm diam above 6 m tall buttresses. Secondary forest, moderate shade, loam soil. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89252*.

CLUSIACEAE

**?Mesua/Mammea/Kayea*

Tree 2.2 m tall, 1.5 cm diam. Forest at base of limestone crags, light shade, stony mineral soil *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89269*.

CONVALLARIACEAE

**Peliosanthes teta* Andr. ssp. *humilis* (Andr.) Jessop

Erect herb c. 35 cm tall. Limestone forest, medium shade, in litter at base of limestone rock. Abundant in this seasonally wet location. Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89472*.

COSTACEAE

Costus speciosus (Koenig) R.M. Smith

CRYPTERONIACEAE

Dactyloclados stenostachys Oliv.

Observed in seasonal swamp forest on peat soils in the N of the Park.

CYPERACEAE

Hypolytrum nemorum (Vahl) Spreng

Herb c. 80 cm tall. Along N Park boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89241*.

DATISCACEAE

Octomeles sumatrana Miq.

Medium sized tree 23 m tall, 1 m girth. River bank on sandy soil. Ulu Sg Sekaloh, Sg Niah
J.A.R. Anderson S 27298.

DENNSTAEDTIACEAE

Lindsaea borneensis

Collected by H. Schneider (*pers. comm.*).

Lindsaea doryphora Kramer

Terrestrial herb c. 25 cm tall. Disturbed peat swamp forest, moderate shade, peat soil. S of trail from Tj Belipat along N Park boundary *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari* S89233.

DIPTEROCARPACEAE

Dipterocarpus confertus Slooten

Observed in MDF in the SW of the Park.

Dipterocarpus oblongifolius Blume

Large tree 3 m girth, 17 m tall. On riverbank, sandy soil. About 1 km upstream from Kuala Sekaloh of Sg Niah. *Banyeng & Adenan* S 22571.

Dryobalanops beccari Dyer

Observed in MDF on route to G Subis.

Dryobalanops lanceolata Burck

Observed in MDF.

Dryobalanops rappa Becc.

Observed in seasonal swamp forest on peat soils in the N of the Park.

**Hopea andersonii* Ashton ssp. *andersonii*

Large tree 2 m girth, 33 m tall. On limestone rock near river on S slope of G Subis in Sg Sekaloh, Niah. *Sibat & Adenan* S 22566; G. Subis, Niah, S side near Sg Sekaloh *J.A.R. Anderson* S 31645.

**Hopea dryobalanoides* Miq.

Tree 2 m girth, 27 m tall. On limestone rock near river on S slope of G Subis in Sg Sekaloh, Niah. *Sibat & Adenan* S 22563.

**Hopea pachycarpa* (Heim.) Sym.

Tree 2 m girth, 27–37 m tall. On limestone rock near river, also on lower slopes of limestone hill and on limestone boulders on southern slope of G Subis in Sg Sekaloh, Niah. *Sibat & Adenan* S 22565; *Sonny Tan & E. Wright* S 27262.

Parashorea macrophylla Wyatt-Smith

Observed along Jalan Madu Trail, MDF/*Kerangas* forest.

Shorea agami Wood. ssp. *agami*

Tree. Lowland poorly drained site. Niah NP. *S.H. Rogstad* 725.

**Shorea falciferoides* Foxw. ssp. *glaucescens* Meijer
G. Subis area, Niah. *Mohidin S 21681*.

**Shorea guiso* (Blanco) Blume
Large tree 2.7 m girth, 37 m tall. Lower slopes of limestone hill, numerous limestone boulders. Southern slopes of G Subis, near Sg Sekaloh *Sonny Tan & E. Wright S 27265*.

**Shorea havilandii* Brandis
Medium-sized tree, 75–120 cm girth, 13–23 m tall. Lower slopes of steep limestone hill, numerous limestone boulders. South side of G Subis, in Sg Sekaloh, Niah *J.A.R. Anderson, Sonny Tan & E. Wright S 27555; Sibat & Adenan S 22570*.

**Shorea parvifolia* Dyer
Large tree about 40 m high, 100 cm diam. On relatively steep slope of small river valley in rather open *Dipterocarpus* forest. Limestone area of Bukit Subis to right of Sg Sekalau, to right of footpath from Kuala Sekalau to Bukit Drusau, 120 m asl. *H.P. Fuchs 21275*.

**Shorea patoiensis* Ashton
Tree 15–17 cm girth and 23 m tall. On limestone rock near river, south side of G Subis, in Sg Sekaloh, Niah *Sibat & Adenan S 22567*.

Shorea quadrinervis Slooten.
Observed in MDF in the SW of the Park.

**Vatica chartacea* (Ashton) Kost.
Tree 15 m tall, 45 cm girth. Foot of limestone 17 m asl, G Branging, Ulu Sg Subis, Niah NP. *Yii Puan Ching S 40177*.

**Vatica rynchocarpa* Ashton
Small tree 87 cm girth, 17 m tall. On riverbank, sandy soil. About 1/2 mile upstream from Kuala Sekaloh of Sg Niah *Banyeng & Adenan S 22572*.

Vatica mangachapoi Blanco
Observed in seasonal swamp forest on peat soils in the N of the Park.

DRYOPTERIDACEAE

**Cyclopeltis presliana* J.Sm.
Lithophytic or terrestrial herb 50 cm high. Foot of limestone forest, sandy soil, on limestone cliff also rocks in pockets of mineral soil, medium shade. Ulu Sg Trusan *Jemree Sablee et al. S 89058*; Near Sg Subis *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89458*.

**Heterogonium pinnatum* (Copel.) Holttum
Herb 50 cm tall. Limestone forest on soil on rock on hillside, moderate shade, loamy soil with humus. SW of Telaga Kumang *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89297*.

**Tectaria andersonii* Holttum
Terrestrial fern in shaded localities on limestone outcrop. Upper slopes of limestone hill, 12.5 m below summit ridge, limestone rocks outcropping and deep 'mor' soil. Sg Sekaloh, G Subis, Niah *J.A.R. Anderson S 31963*

Tectaria aurita (Sw.) S. Chandra
Collected by H. Schneider (*pers. comm.*).

**Tectaria devexa* (Kunze) Copel.

Lithophytic herb c 25 cm tall. On limestone rocks in pockets of soil between rocks. Medium shade. Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89478*.

**Tectaria labrusca* (Hook.) Copel.

Herb c. 60 cm tall on rocks. Forest canopy c. 20 m tall, light shade, humus soil among limestone outcrops. Below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89437*.

Tectaria subdigitata (Baker) Copel.

Rheophyte. Niah C. *Hose 196* (from Holttum, 1991).

**Tectaria ternata* (Baker) Copel.

Terrestrial. Foot of limestone forest, sandy soil. Ulu Sg Trusan *Jemree Sablee et al. S 89052*.

EBENACEAE

**Diospyros euphlebia* ^E Merr.

Tree 3–4 m tall, 3–4 cm diam. Disturbed forest among limestone rocks also foot of limestone hill, light shade. Below W mouth of Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89481*; Ulu Sg Tangap *Jemree Sablee et al. S 89073*.

**Diospyros pilosanthera* (Blanco) var. *pilosanthella*

Large tree about 30 m high, 80 cm diam. On steep slope of small river-valley in rather open *Dipterocarpus*-forest. Limestone area of G Subis to right of Sg Sekalau, to right of footpath from Kuala Sekalau to Bukit Drusau, 120 m asl. *H.P. Fuchs 21275*.

Diospyros pyrrocarpa Miq.

Tree c. 20 m tall, c. 15 cm diam. By path, moderate shade, wet clay soil. Along N Park boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89238*.

**Diospyros sumatrana* Miq.

Small tree 3.5–5 m tall, 2–8 cm diam. Dry regenerating peat swamp forest also limestone forest, alluvial, medium shade. *Jemree Sablee et al. S 8904*; Gua Sibau, trail from Rumah Chang, NE of park *Julaihi Abdullah, Kit Pearce et al. S 89322*.

**Diospyros toposia* Ham. var. *toposioides* (King & Gamble) Phengklai

Tree 10 m tall, 5 cm diam. Limestone forest, light shade, humus soil among limestone rocks. Top of limestone summit. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89405*.

? *Diospyros* sp.

Woody climber [sic] c. 7 m tall, 5 cm diam. Just beside inundated area with standing water, clay soil, moderate shade. Tj Belipat, along boundary 50 m from Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89207*.

ELAEOCARPACEAE

Elaeocarpus stipularis Blume

Shrub about 6 m tall. Riverine forest about 17 m asl, soil loamy. Kuala Sg. Sekaloh, Niah NP *Yii Puan Ching S 40105*.

EUPHORBIACEAE

**Antidesma montanum* Blume

Tree 2–5 m tall, 3 cm diam. Alluvial limestone lowland forest, on limestone cliff also disturbed peat swamp forest, open area by trail, peat soil. Foot of limestone hills from Rumah Chang, Sg Tabau *Julaihi Abdullah, Kit Pearce et al. S 89326*; Along N Park boundary from Tj. Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89223*.

Antidesma neurocarpum Miq.

Tree 5 m tall, 4 cm diam. Undisturbed MDF, medium shade, loamy soil *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89271*.

Antidesma tomentosum Blume var. *tomentosum*

Small tree 3–7 m tall, 3–10 cm diam. *Emperan* forest, dark brown clay soil also MDF/*kerangas* forest, moderate shade, sandy loam soil. *Jemree Sablee et al. S 89005*; Jalan Madu Trail *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89450*.

Baccaurea sp.

Tree 9 m tall, 18 cm diam. MDF, brown clay soil. Sekaloh *Jemree Sablee et al. S 89012*.

Blumeodendron tokbrai (Blume) Kurz.

Tree 20 m tall, 75 cm girth. Peat swamp forest. Niah NP. *Bernard Lee M.H. S 40065*.

?Claoxylon

Treelet 1.5 m tall, 2 cm diam. MDF, Sg Sekaloh *Jemree Sablee et al. S 89035*.

Cleidion javanicum Blume

Tree 7–10 m tall, 15–20 cm diam. Seasonal swamp forest (disturbed) also shady lowland alluvial forest, open area. Beside plank walk to Great Cave *Julaihi Abdullah, Kit Pearce et al. S 89308*; *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89470*.

**Cleistanthus megacarpus* C.B.Rob.

Tree 6–8 m tall, 4–10 cm diam. Alluvial limestone lowland forest also by path, moderate shade, wet clay soil. Foot of limestone hills from Rumah Chang, Sg Tabau *Julaihi Abdullah, Kit Pearce et al. S 89325*; Along N Park Boundary from Tj. Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89237*.

Croton oblongus Burm.f.

Treelet c. 9 m tall, 18 cm diam. Just beside inundated area with standing water, clay soil, moderate shade. Tj Belipat, along boundary from Sg Niah (200 m from river) *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89204*.

Drypetes microphylla (Merr.) Pax et Hoffm.

Tree 8 m tall, 8 cm diam. MDF/*kerangas* forest, moderate shade, sandy loam soil. Jalan Madu Trail *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89449*.

**?Erismanthus obliquus* Wall ex Muell.-Arg

Small tree 4–7 m tall, 7–10 cm diam. Limestone forest, light shade, humus soil amongst limestone rocks. G Subis *Jemree Sablee et al. S 89043*; Top of limestone summit *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89401*.

**Macaranga endertii* Whitmore

Tree 35 cm girth, 15 m high. Lower slopes of limestone hill, numerous limestone boulders. S slopes of G Subis, near Sg Sekaloh. *Sonny Tan & E. Wright, S 27275.*

Mallotus floribundus (Blume) Muell.-Arg.

Tree 6–10 m tall, 3–17 cm diam. Just beside inundated area with standing water, clay soil, moderate shade also seasonal swamp forest (disturbed), light shade, clay soil, beside water channel. Tj Belipat, along boundary from Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89206*; Trail into park from Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89289.*

**Mallotus miquelianus* (Scheff.) Boerl.

Treelet 2 m tall, 1.5 cm diam. Limestone forest among rocks on hillside, moderate shade, loamy soil with humus. SW of Telaga Kumang *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89295.*

**Wetria insignis* (Steud.) Airy Shaw

Tree 20 m tall, 4 cm diam. Limestone forest, light shade, humus soil amongst limestone rocks. Top of limestone summit. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89403*

*Euphorbiaceae sp.

Tree 4 m tall, 2 cm diam. On humus soil among limestone outcrops. Below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89434.*

FABACEAE (PAPILIONOIDEAE)

Canavalia cathartica Thouars

Semi-woody plant to 0.5 m tall. Shady lowland alluvial forest. Along plank walk to Niah Caves *Julaihi Abdullah, Kit Pearce et al. S 89310.*

Copaeifera palustris (Sym.) de Wit

Observed in seasonal swamp forest on peat soils in the N of the Park.

Koompassia excelsa (Becc.) Taubert

Observed in MDF on route to G Subis.

Ormosia sumatrana (Miq.) Prain

Observed on the summit of Bukit Kasut.

FAGACEAE

Lithocarpus blumeanus (Korth.) Rehder

Observed in forest transitional between riverine and seasonal swamp forest.

Lithocarpus gracilis (Korth.) Soepadmo

Tree c. 25 m tall, 45 cm diam. Seasonal swamp forest (disturbed), light shade, clay soil. Trail into park from Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89288.*

Lithocarpus sp.

Tree c. 5 m tall, 15 cm diam. Disturbed peat swamp forest, moderate shade, peat soil. S of trail from Tj Belipat along the N boundary of Niah NP. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89228.*

FLACOURTIACEAE

Casearia grewiiifolia Vent.var. *gelonioides* (Bl.) Sleumer

Treelet 2 m tall, 1.5 cm diam. Disturbed peat swamp forest, open area by trail, peat soil. Along N Park Boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89218.*

Hydnocarpus gracilis (Sloot.) Sleum.

Tree 20 m tall, 45 cm diam. MDF, Sg Sekaloh *Jemree Sablee et al. S 89029.*

GESNERIACEAE

**Aeschynanthus tricolor* Hook.

Epiphyte. On trees on swampy alluvial soils at base of limestone hill, subject to periodic inundation. On southern slopes of G Subis in Sg Sekaloh, Niah *J.A.R. Anderson, Sonny Tan & E. Wright S 26086.*

**Aeschynanthus cf. tricolor* Hook.

Herbaceous climber c. 10 m up on trunk of tree. Limestone forest (disturbed including by logging), on exposed rocks, shady area, soil peaty humus between rocks. S boundary of Park, E of Quarry *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89494.*

**Aeschynanthus parvifolius* R.Br.

Epiphytic on tree. Foot of limestone hill, Great Cave *Jemree Sablee et al. S 89065.*

**Cyrtandra bracheia* B.L.Burtt

Shrublet 45–60 sm high. Broad sloping ravine between two vertical limestone hills, numerous limestone boulders, some residual soil (very localized). On southern slopes of G Subis in the Sg Sekaloh, Niah *J.A.R. Anderson, Sonny Tan & E. Wright S 26092.*

**Cyrtandra cretacea*^E Kraenzl.

On rough limestone rocks just before reaching caves. Niah Caves *B.L. Burtt & P.J.B. Woods B 1991; Haviland & Hose 3530.*

Cyrtandra erectipila B.L.Burtt

Herb 30 cm tall, 1 cm diam. MDF. Sg Sekaloh *Jemree Sablee et al. S 89033.*

**Cyrtandra incrustata*^E B.L.Burtt

Solitary herb or small shrublet 15–22 cm tall. In limestone forest on exposed rocks, medium shade also base of limestone cliff, somewhat dry and shaded at 100 m altitude. S boundary of the Park, E of Quarry *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89496;* South side of G Subis, in Sg Sekaloh, Niah *J.A.R. Anderson, Sonny Tan & E. Wright S 27575.*

**Cyrtandra oblongifolia* (Blume) C.B.Clarke

Epiphytic shrub. In limestone forest on rocks, medium shade, also on limestone rock at 50 m altitude. S Boundary of park, E of Quarry *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89499;* Valley in front of Niah Caves *B.L. Burtt & P.J.B. Woods B 2037;* Ulu Sg Subis, Niah NP *Bernard Lee S 40083.*

**Cyrtandra spelaea*^E B.L.Burtt

Prostrate herb or shrublet 60–90 cm tall. Back of shallow cave, base of cave wall, somewhat dry and completely shaded, slopes of limestone hill immediately below cliff c 130 m altitude,

litter layer overlying limestone boulders, abundant on vertical limestone rock face. Niah Cave *B.L. Burt & P.J.B. Woods B 2018 & B 3020* and *Alphonso & Samsuri A 239*; Sg Sekaloh, G Subis *J.A.R. Anderson S 31958*; Great Cave *J.A.R. Anderson S 31918*; Inside Niah Cave on rock *Ahmad 11*; Niah *Haviland & Hose 3531*; *Syng 615*.

**Cyrtandra trisepala* C.B.Clarke

Herb or shrublet 85 cm tall. On limestone rocks and pavement, gully between limestone hill, heavily dissected, mineral soil very sparse. G Subis *J.A.R. Anderson S 31671*.

**Cyrtandra tubiflora* Kraenzl.

On bare limestone, shaded. Valley below main Niah Cave *B.L. Burt & P.J.B. Woods B 2015*.

**Epithema sarawakensis* Hill & B.L.Burt

Herb. Limestone forest on stone, G Subis *Jemree Sablee et al. S 89048*.

Henckelia cf violoides (C.B.Clarke) B.L.Burt

Niah. *Haviland & Hose 3534*.

**Monophyllaea merrilliana* Kraenzl.

Herb. Infrequent on damp limestone rock in deep shade *Kit Pearce & Narawi Johari S 78595*.

**Paraboea speluncarum* (B.L.Burt) B.L.Burt

Herb or shrublet. Cave and large overhang 100 m up on steep limestone hill, light dry soil, partly composed on guano, also forest. Gua Pangomah, G. Subis, *Niah J.A.R.Anderson S 31675*; Niah Caves *Alphonso & Samsuri 241*.

Paraboea sp. nov.

Large herb 75–120 cm tall. On bare, exposed limestone rock near summit of limestone pinnacles or crest of limestone hill, 'mor' soil, 130 m asl, Niah *J.A.R. Anderson S 16045*; S slope of G Subis near Sg Sekaloh *Sonny Tan & E. Wright S 27279*.

GNETACEAE

Gnetum gnemon L.

Tree 5 m tall, 2 cm diam. Disturbed secondary forest, moderate shade, clay soil. Along N Park boundary from Tj. Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89215*.

**Gnetum leptostachyum* Blume

Woody climber 10 m tall, 2.5 cm diam. Limestone forest among rocks on hillside, moderate shade, loamy soil with humus. SW of Telaga Kumang *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89298*.

Gnetum neglectum Blume

Woody climber or liana at least 10 m tall, 2 cm diam. Secondary forest, moderate shade, loam soil under 15 cm humus, moderate shade. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89259 & S 89246*.

HANGUANACEAE

Hanguana malayana (Jack) Merr.

Herb 1 m tall. Disturbed swamp forest, in standing water, moderate shade, grey clay with wet humus layer. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89242*.

ICACINACEAE

Gonocaryum macrophyllum (Blume) Sleumer

Treelet 4 m tall, 2.5 cm diam. Secondary forest, moderate shade, loam soil. Close to Sg Niah Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89245.

Stemonurus secundiflorus var. *lanceolatus*

Tree 15 m tall, 10 cm diam. Disturbed peat swamp forest, open area by trail, peat soil. Along N Park boundary from Tj Belipat Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89226.

LAURACEAE

**Dehaasia brachybotrys* (Merr.) Kosterm.

Tree 5 m tall, 5 cm diam. Foot of limestone hill. Ulu Sg Tangap Jemree Sablee et al. S 89076.

Eusideroxylon zwageri Teijsm. & Binn.

Cut stumps observed in alluvial habitats, on hills and in damp valley.

Litsea oppositifolia (Blume) Vill.

Tree c. 6 m tall. Just beside inundated area with standing water, clay soil, moderate shade. Tj Belipat, along boundary from Sg Niah Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89210.

Litsea sp. 1

Treelet 2 m tall, < 1 cm diam. Disturbed peat swamp forest, open area by trail, peat soil. Along N Park boundary from Tj Belipat Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89220.

**Litsea* sp. 2

Tree 3 m tall, 1.5 cm diam. Limestone forest, alluvial, medium shade. Gua Sibau, trail from Rumah Chang, NE of Park. Julaihi Abdullah, Kit Pearce et al. S 89317.

Lauraceae sp. 1

Treelet 1.5 m tall, 1 cm diam. Dry regenerating peat swamp forest Jemree Sablee et al. S 89039.

Lauraceae sp. 2

Small tree 3 m tall, 4 cm diam. MDF, brown clay soil. Sekaloh Jemree Sablee et al. S 89013.

Lauraceae sp. 3

Small tree 5 m tall, 7 cm diam. MDF, brown clay soil. Sekaloh Jemree Sablee et al. S 89016.

LOGANIACEAE

**Fagraea* sp.

Tree 2 m tall, 3 cm diam. Exposed limestone rocks with humus soil around, summit of G Subis Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89420.

LOMARIOPSISACEAE

Bolbitis heteroclita (C. Presl) Ching

Herb 30 cm tall. Disturbed seasonal swamp forest, light shade, grey clay soil. Sg Subis Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89294

LYCOPODIACEAE

Huperzia phlegmaria (L.) Rothm.

Herbaceous epiphyte c. 1.5 m long. Seasonal swamp forest (disturbed), light shade, clay soil. Trail into Park from Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89283.*

MARANTACEAE

Schumannianthus sp. nov.

Clustering herb 1 m tall. MDF, light shade, loam soil. Across river from Park HQ *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89442.*

MELASTOMATACEAE

**Medinilla botryocarpa*^E Regalado

Woody shrub 1 m tall. Exposed limestone rocks with humus soil, summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89419.*

Medinilla crassifolia (Reinw. ex Blume) Blume

Semi-woody epiphyte 3.5 m up tree. MDF/*kerangas* forest, moderate shade, sandy loam soil. Jalan Madu Trail *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89448.*

Memecylon paniculatum Jack

Tree 6 m tall, c. 3 cm diam. Disturbed secondary forest, light shade, clay soil. Along N Park Boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89214.*

Pternandra cf. *crassicalyx* Maxwell

Tree 6 m tall, c. 4 cm diam. Secondary forest, moderate shade, loam soil. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89253.*

MELIACEAE

**Aglaiia korthalsii* Miq.

Tree 10 m tall, 10 cm diam. Forest on humus soil among limestone outcrops. Below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89435.*

**Aglaiia simplicifolia* (Bedd.) Harms

Small tree 4 m tall, 5 cm diam. Foot of limestone forest, sandy soil. Ulu Sg Trusan *Jemree Sablee et al. S 89051.*

Chisocheton polyandrus Merr.

Small tree 5 m tall, 4 cm diam. MDF, brown clay soil. Sekaloh *Jemree Sablee et al. S 89021.*

Dysoxylum excelsum Blume

Tree 10 m tall, 13 cm diam. *Emperan* forest, dark brown clay soil *Jemree Sablee et al. S 89001.*

Dysoxylum oppositifolium F.Muell.

Small tree 2 m tall, 6 cm diam. MDF, Sg Sekaloh *Jemree Sablee et al. S 89027.*

MENISPERMACEAE

?*Parabaena hirsuta* (Becc.) Diels

Herbaceous climber, twining to 6 m tall. Seasonal swamp forest (disturbed), light shade, clay soil. Trail into the Park from Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89286.*

MONIMIACEAE

**Matthaea sancta* Blume

Small tree 4 m tall, 7 cm diam. Foot of limestone forest, sandy soil. Ulu Sg Trusan *Jemree Sablee et al. S 89054.*

MORACEAE

Antiaris toxicaria Lesch.

Photographed in MDF.

Artocarpus odoratissimus Blanco

Observed behind the banks of Sg Niah.

**Ficus deltoidea* Jack var. *deltoidea*

Woody shrub 70 cm tall or epiphyte. Dry limestone forest, open, with litter and exposed limestone rocks with humus soil around, open. Limestone hill next to Quarry *Julaihi Abdullah, Kit Pearce et al. S 89311*; Summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89416.*

**Ficus depressa* Blume

Epiphyte or huge strangler to 4 m tall, 20 cm diam. Limestone forest or shady lowland alluvial forest. Ulu Sg Sekaloh, near Quarry *Jemree Sablee et al. S 89070*; Limestone hill next to Quarry *Julaihi Abdullah, Kit Pearce et al. S 89316.*

**Ficus hemselyana* ^E King

Lithophytic shrub c. 2 m tall, 1.5 cm diam at base. Disturbed forest among limestone rocks, light shade also in limestone forest on exposed rocks, medium shade. Below W mouth of Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89488*; S Boundary of Park, E of Quarry *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89497.*

Ficus obscura Blume var. *lanata* Kochummen

Epiphytic tree c. 4 m tall, 3 cm diam. about 4 m from ground on large tree. Seasonal swamp forest (disturbed), light shade. Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89465.*

**Ficus subulata* Blume

Shrub sprawling to c. 4 m or much branched lithophytic climber at least 10 m tall, c. 5 cm diam at base. On limestone rocks in pockets of mineral soil, medium shade. Near Sg Subis *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89455*; Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89477.*

**Ficus sumatrana* (Miq.) Miq.

Woody shrub 1 m tall. Exposed limestone rocks with humus soil, summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89415.*

**Ficus tinctoria* G.Forst. var. *gibbosa* (Blume) Corner

Shrubby epiphyte to 1 m long. Shady lowland alluvial forest, limestone hill next to Quarry *Julaihi Abdullah, Kit Pearce et al. S 89312.*

Ficus sp.

Epiphyte. Dry regenerating peat swamp forest *Jemree Sablee et al. S 89038.*

**Streblus macrophyllus*^E Blume

Small tree 1.5–2.5 m tall, 1–5 cm diam. Foot of limestone hill also on limestone rocks in forest at base of limestone crags, light shade, stony mineral soil. Ulu Sg Tangap. *Jemree Sablee et al.* (S 89075); At base of limestone crags *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari* S 89274.

MYRISTICACEAE

Knema glauca (Blume) Peterman

Tree 12 m tall, 20 cm diam. MDF, brown clay soil. Sekaloh *Jemree Sablee et al.* S 89023.

**Myristica guatteriifolia* A.DC.

Tree 20 m tall, 30 cm diam. Summit of limestone hill, light shade, with loose limestone rocks and humus soil. SW of Telaga Kumang *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari* S 89299.

MYRSINACEAE

Ardisia sanguinolenta Blume

Small tree 5–7 m tall, 4–12 cm diam. *Emperan* forest, dark brown clay soil *Jemree Sablee et al.* S 89003 & S 89007.

Labisia pumila Benth. & Hook.f.

Herb 35 cm tall. Disturbed peat swamp forest, open area by trail, peat soil. Along N Park boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari* S 89227.

**Systellantha brookeae* Stone

Treelet 1–2.5 m tall, 1–1.5 cm diam or shrub c. 40 cm tall. By path, moderate shade, wet clay soil also foot of limestone hill, also limestone forest (disturbed, including by logging) on exposed rocks, light shade, soil peaty humus between rocks. Along N Park boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari* S 89239; Ulu Sg Tangap. *Jemree Sablee et al.* S 89071; S Boundary of park, E of Quarry *Kit Pearce, Julaihi Abdullah & Serukit Dubod* S 89493.

MYRTACEAE

**Syzygium hirtum* Korth.

Tree 14 m tall, 20 cm diam. Shady lowland alluvial forest. Limestone hill next to Quarry *Julaihi Abdullah, Kit Pearce et al.* S 89314.

Syzygium sp. 1

Tree c. 10 m tall, 20 cm diam. Disturbed peat swamp forest, moderate shade, peat soil. S of trail from Tj Belipat along N Park boundary. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari* S 89229.

**Syzygium* sp. 2

Tree 3 m tall, 3 cm diam. Exposed limestone rocks with humus soil around, summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari* S 89417.

**Syzygium* sp. 3

Small tree 2 m tall, 5 cm diam. Foot of limestone forest, sandy soil. Ulu Sg Trusan *Jemree Sablee et al.* S 89055.

**Syzygium* sp. 4

Small tree 3 m tall, 3 cm diam. Foot of limestone hill. Great Cave *Jemree Sablee et al. S 89066.*

**Syzygium* sp. 5

Tree 6 m tall, 7 cm diam. Foot of limestone hill. Ulu Sg Tangap *Jemree Sablee et al. S 89074.*

**Syzygium* sp. 6

Tree 7 m tall, 6 cm diam. Forest on humus soil among limestone outcrops, below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89433.*

Syzygium sp. 7

Tree 12 m tall, 80 cm diam. Secondary forest, loam soil under 15 cm humus, moderate shade. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89261.*

NEPENTHACEAE

Nepenthes mirabilis (Lour.) Druce

Climber 4 m long. Disturbed forest, grey clay under 25 cm peat, light shade. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89254.*

OPHIOGLOSSACEAE

Helminthostachys zeylanica (L.) Hook.

Terrestrial fern, 40 cm tall. On rock near river. Sg Sekaloh *Jemree Sablee et al. S 89037.*

ORCHIDACEAE

**Adenoncos triloba*^FCarr

Epiphyte. Lowland limestone hills at 300 m altitude. Niah *Syngé S 603.* (from Beaman *et al.*, 2001).

**Agrostophyllum glumaceum* Hook.f.

Epiphytic herb c. 2.5 cm tall, c. 2.5 cm up woody liana. Limestone forest, alluvial, medium shade. Gua Sibau, trail from Rumah Chang, NE of Park *Julaihi Abdullah, Kit Pearce et al. S 89323.*

**Agrostophyllum* sp.

Epiphyte. Exposed limestone rocks and humus soil, just below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89432.*

**Anoectochilus* sp.

Terrestrial jewel orchid photographed by trail to Bukit Kasut.

**Appendicula* cf. *anceps* Blume

Herb 30 cm tall. Foot of limestone forest, sandy soil. Ulu Sg Trusan *Jemree Sablee et al. S 89060.*

**Appendicula* cf. *uncata* Ridley ssp. *sarawakensis* J.J. Wood

Herb 25 cm tall or epiphytic. Disturbed peat swamp forest, moderate shade, peat soil also exposed limestone rocks with humus soil around, open. S of trail from Tj Belipat along N Park boundary. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89232:* Summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89422.*

**Appendicula* sp.

Epiphyte. Disturbed forest among limestone rocks, light shade. Below W mouth of Great Cave Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89489.

**Bulbophyllum* cf. *acutum* J.J.Sm.

Epiphyte. Limestone forest, alluvial, medium shade. Gua Sibau, trail from Rumah Chang, NE of Park Julaihi Abdullah, Kit Pearce et al. S 89320.

**Bulbophyllum minutulum* Ridley

Epiphyte. On limestone. Niah Vermeulen LC 26546 (from Beaman et al. 2001).

**Bulbophyllum vaginatum* (Lindl.) Rchb.f.

Epiphyte. G Subis, 50 m Vermeulen 1171 (from Beaman et al. 2001).

Calanthe triplicata (Willemet) Ames

Terrestrial. G Subis J.A.R. Anderson S 31668; Niah, 300 m Burt & Woods B 2031; Niah. Syngé, S. 577. (from Beaman et al. 2001).

**Calanthe* cf. *triplicata* (Willemet) Ames

Lithophytic herb 80 cm tall. On limestone rocks in forest at base of limestone crags, light shade, stony mineral soil Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89270.

**Calanthe* sp.

Herb 50 cm tall. Limestone forest. G Subis Jemree Sablee et al. S 89050.

Claderia viridiflora Hook.f.

Terrestrial. Observed by path from Pengkalan Lobang to Great Caves.

**Cleisostoma* or *Pomatocalpa* sp.

Herb creeping on rock. Exposed limestone rocks with humus soil, summit of G Subis Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89414.

Coelogyne verrucosa S.E.C. Sierra

Epiphyte. Niah 10–300m Vermeulen LC 26555 (from Beaman et al. 2001).

Coelogyne pandurata Lindl.

Epiphyte. G Subis Mohidin S 21682 (from Beaman et al. 2001).

Didymoplexiella borneensis^E (Schltr.) Garay

Saprophyte. G Subis Sonny Tan & Wright S 27273 (from Beaman et al. 2001).

**Dossinia marmorata*^E E.Morren

Small terrestrial orchid. On moss on exposed limestone rocks and humus soil, also in shade near base of limestone hill. Just below summit of G Subis Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89425; Niah J.A.R. Anderson S 16025.

**Eria* (Sect. *Cylindrolobus*) aff. *leptocarpa* Hook.f.

Epiphyte. Disturbed forest among limestone rocks, light shade. Below W mouth of Great Cave Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89480.

**Eria* sp.

Epiphyte. MDF, below limestone, moderate shade, loamy soil. Abundant. At base of limestone crags *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89278.*

**Liparis* cf. *gibbosa* Finet

Epiphyte. Exposed limestone rocks and humus soil. Just below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89426.*

**Liparis elegans* Lindl.

Epiphytic herb c. 20 cm tall. Exposed limestone rocks with humus soil. Summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89424.*

**Liparis* cf. *grandiflora* Ridley

Epiphyte. Disturbed forest among limestone rocks, light shade. Below W mouth of Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89483.*

Liparis wrayi Hook.f.

Terrestrial herb 20 cm tall. By path, moderate shade, wet clay soil. Along N Park boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89240.*

Malaxis andersonii (Ridl.) Ames

Terrestrial. Niah *Synge S 599* (from Beaman *et al.* 2001).

Plocoglottis borneensis Ridl.

Terrestrial orchid in forest. Niah *Ahmad 45*. G Subis *Mohidin S 21678* (from Beaman *et al.* 2001).

Plocoglottis cf. *borneensis* Ridl.

Terrestrial herb 40 cm tall. Disturbed swamp forest, in standing water, moderate shade, grey clay with wet humus layer. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89265.*

**Podochilus* cf. *serpillifolius* (Blume) Lindl.

Epiphyte. Exposed limestone rocks with humus soil, summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89423.*

Thecostele alata (Roxb.) C.S.P.Parish

Herbaceous epiphyte. MDF/*kerangas* forest, moderate shade, sandy loam soil. By Sg Subis, Jalan Madu Trail *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89451.*

OXALIDACEAE

**Oxalis corniculata* L.

Lithophytic herb creeping on limestone rock. Limestone forest, moderate shade, beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89475.*

PANDANACEAE

**Freycinetia rigidifolia* Hemsley

Shrub 1 m tall. On 'mor' layer on summit of sharp limestone hill. G Subis, Niah 130 m. *J.A.R. Anderson S 16426.*

Pandanus basilocularis Martelli

Observed along plank walk to Painted Cave.

Pandanus calcinactus St John ex Stone

Observed just below the summit of G Subis.

PASSIFLORACEAE

Adenia macrophylla (Bl.) Koord. var. *smilacina* (Hall.f.) deWilde

Woody climber 7 m tall, c. 1 cm diam. Disturbed *emperan* forest, by path in open area, clay soil. Tj Belipat, along boundary from Sg Niah (50 m from river) *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89201.*

PIPERACEAE

Piper caninum Blume

Semi-woody climber 1.5 m tall. Disturbed peat swamp forest, open area by trail, peat soil. Along N Park boundary from Tj. Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89221.*

Piper muricatum Blume

Herb c. 30 cm tall. Well-developed secondary forest by stream, moderate shade, alluvial soil. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89262.*

Piper sarmentosum Roxb. ex Homem.

Sprawling herb c. 60 cm tall. Disturbed seasonal swamp forest, light shade, grey clay soil. Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89292.*

**Piper ?stylosum* Miq.

Climber up to 1.5 m high on small tree. Foot of limestone forest, sandy soil. Ulu Sg Trusan *Jemree Sablee et al. S 89053.*

**Piper* aff. *vestitum* C.DC.

Erect herb 25–50 cm tall. Limestone forest, light shade, humus soil amongst limestone rocks, also on limestone rocks in forest at base of limestone crags, light shade, stony mineral soil and top of limestone summit *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89407;* At base of limestone crags *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89276.*

Piper sp. 1

Herbaceous climber 1.2 m tall. Disturbed forest, grey clay under 25 cm peat, moderate shade. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89255.*

Piper sp. 2

Herbaceous climber, c. 2 m tall. Disturbed seasonal swamp forest, light shade, grey clay soil. Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89293.*

Piper sp. 3

Climber on tree. MDF. Sg Sekaloh *Jemree Sablee et al. S 89028.*

Piper sp. 4

Shrub 1.5 m tall. Secondary forest, moderate shade, loam soil. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89243.*

POACEAE

Schizostachyum or *Bambusa*

Bamboo to 3 m tall, 3 cm diam. Shady lowland alluvial forest. Along plank walk to Niah Caves. *Julaihi Abdullah, Kit Pearce et al S 89303.*

PODOCARPACEAE

**Podocarpus confertus* deLaubenfels

Tree 10 m tall, 12 cm dbh. Exposed limestone rocks and humus soil, just below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89428.*

POLYPODIACEAE

Microsorium linguiforme (Mett.) Copel.

Epiphyte. Shady lowland alluvial forest. Along plank walk to Niah Caves *Julaihi Abdullah, Kit Pearce et al. S 89302.*

**Paragramma longifolia* (Blume) T. Moore

Epiphyte c. 40 cm tall. Exposed limestone rocks and humus soil, just below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89431.*

**Phymatosorus nigrescens* (Blume) Pic.Serm.

Lithophytic herb 1 m tall: Limestone forest, moderate shade, on limestone rock. Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89473.*

**Pyrrosia lanceolata* (L.) Farw.

Epiphyte. Foot of limestone forest, sandy soil. Ulu Sg Trusan *Jemree Sablee et al. S 89057.*

RUBIACEAE

*?*Timonius*

Shrub 1 m tall. Limestone forest (disturbed, including by logging) on exposed rocks, shady area, soil peaty humus between rocks. S Boundary of Park, E of Quarry *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89500.*

Acranthera cf. *involuta* Val.

Herb 30–150 cm tall, 1 cm diam. MDF, also secondary forest, moderate shade, loam soil. Sg Sekaloh *Jemree Sablee et al. S 89032*; Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89244.*

Anthocephalus cadamba (Roxb.) Miq.

Vegetation verification plot specimen in seasonal swamp forest on gley soils.

Cephaelis stipulacea Blume

Trelet 1 m tall, 0.8 cm diam. MDF, brown clay soil. Sekaloh *Jemree Sablee et al. S 89009.*

Geophila repens (L.) Johnston

Creeping herb. Seasonal swamp forest (disturbed), by path, light shade, clay soil. Along Jalan Madu Trail *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89490.*

Lasianthus constrictus Wight

Trelet 1 m tall. MDF, brown clay soil. Sekaloh *Jemree Sablee et al. S 89015.*

Lasianthus stipularis Blume

Treelet 2.5 m tall, 1.5 cm diam. Seasonal swamp forest (disturbed), light shade, clay soil. Trail into park from Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89287*.

**Mussaenda* sp.

Herbaceous climber 3 m long. Exposed limestone rocks with humus soil, summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89421*.

**Ophiorrhiza* sp.

Herb to 25 cm tall. Dry limestone forest, open, with litter. Limestone hill next to Quarry *Julaihi Abdullah, Kit Pearce et al. S 89315*.

Pavetta indica L.

Treelet 2–4 m tall, < 1–2.5 cm diam. Disturbed forest, grey clay under 25 cm peat, moderate shade also disturbed, regenerating *emperan* forest, light shade, alluvial soil. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89256*; Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89281*.

Psychotria cf. *aurantiaca* Blume

Shrub or treelet 70–100 cm tall. *Emperan* forest, dark brown clay soil also just beside inundated area with standing water, clay soil, moderate shade. *Jemree Sablee et al. S 89004*; Tj Belipat, along boundary 50 m from Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89205*.

**Psychotria* cf. *obovata* Wall.

Herbaceous climber to 1 m tall. Exposed limestone rocks and humus soil, just below summit of G Subis. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89427*.

Saprosma arborea Blume

Treelet 4 cm diam. Disturbed secondary forest, moderate shade, clay soil. Along N Park Boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89213*.

Tarenna aff. *costata* Val.

Treelet 1.5 m tall. MDF, brown clay soil. Sekaloh *Jemree Sablee et al. S 89022*.

Urophyllum hirsutum Wight

Tree 3 m tall or shrub 1.5 m tall, 1.5 cm diam. Disturbed MDF, light shade, grey clay soil with humus 5 cm deep (locally abundant), also *emperan* forest, dark brown clay soil. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89249*; *Jemree Sablee et al. S 89002*.

RUTACEAE

**Micromelon minutum* (G. Forst) Wight & Arn.

Tree c. 6 m tall, c. 5 cm diam. Disturbed forest among limestone rocks, light shade. Below W mouth of Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89484*.

SAPINDACEAE

Allophyllus cobbe (L.) Rauschel

Leaning treelet 4 m tall, 3 cm diam. Seasonal swamp forest (disturbed), light shade, clay soil. Trail into Park from Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89285*.

**Lepisanthes falcata* (Radlk.) Leenh.

Treelet 7 m tall, 5 cm diam. Limestone forest among rocks on hillside, moderate shade, loamy soil with humus. SW of Telaga Kumang *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89300.*

**Lepisanthes tetraphylla* (Vahl) Radlk.

Tree 2 m tall, 2 cm diam. In limestone forest at summit on exposed rocks, medium shade. S boundary of Park, E of Quarry *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89498.*

Nephelium sp.

Tree 7 m tall, 1.5 cm diam. MDF, brown clay soil. Sekaloh *Jemree Sablee et al. S 89011.*

Pometia pinnata J.R. Forst. & G.Forst.

Observed along riverbanks.

?Sapindaceae

Small tree 4 m tall, 6 cm diam. MDF Sg Sekaloh *Jemree Sablee et al. S 89030.*

SAURAUACEAE

Saurauia sp.

Tree to 2 m tall, 4 cm. diam. Shady lowland alluvial forest. Along plank walk to Niah Caves *Julaihi Abdullah, Kit Pearce et al. S 89306.*

STERCULIACEAE

Leptonychia caudata (Wall. ex G.Don) Burret

Small tree 3 m tall, 4 cm diam. MDF, brown clay soil. Sekaloh *Jemree Sablee et al. S 89010.*

Pterospermum subpeltatum C.B. Rob.

Vegetation verification plot specimen in seasonal swamp forest on gley soils.

Sterculia aff. *coccinea* Jack

Small tree. Seasonal swamp forest (disturbed), open area. Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89471.*

Sterculia rubiginosa Vent.

Tree c. 11 m tall, 25 cm diam. Disturbed, regenerating *emperan*, light shade, alluvial soil. Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89280.*

Sterculia stipulata Korth.

Tree 4 m tall, c. 3 cm diam. Seasonal swamp forest (disturbed), light shade by stream. Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89466.*

**Sterculia rubiginosa* or *stipulata*

Treelet 6 m tall, 5 cm diam. Disturbed forest among limestone rocks, light shade. Below W mouth of Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89482.*

?*Sterculia*

Small tree 7 m tall, 5 cm diam. MDF, Sg Sekaloh *Jemree Sablee et al. S 89026.*

THELYPTERIDACEAE

Mesophlebion oligodictyon (Baker) Holttum
Niah C. Hose 1341.

TILIACEAE

Grewia aff. *pearsonii* (Merr.) Burret
Tree 2.5 m tall, 1.5 cm diam. MDF, below limestone, loamy soil. At base of limestone crags
Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89277.

Shoutenia glomerata King

Observed growing gregariously along Sg Subis along Jalan Madu Trail.

URTICACEAE

**Elatostema acuminata* (Poir.) Brongn.

Creeping terrestrial herb c. 20 cm tall. Limestone forest on stones and humus on top of rock in secondary seasonal swamp forest. G Subis *Jemree Sablee et al. S 89047*; Trail into park from Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89291*

Elatostema sp.

Herb 25 cm tall. Secondary forest, loam soil under 15 cm humus, moderate shade. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89260.*

**Oreocnide trinervis* (Wedd.) Miq.

Small tree 4–5 m tall, 4–5 cm diam. Limestone forest, light shade, humus soil amongst limestone rocks. Ulu Sg Sekaloh, near Quarry *Jemree Sablee et al. S 89067*; Top of limestone summit *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89402.*

?*Pilea* sp. 1

Sprawling herb c. 30 cm tall. Disturbed peat swamp forest, moderate shade, peat soil. S of trail from Tj Belipat along N boundary of Niah N.P. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89231.*

?*Pilea* sp. 2

Semi-woody plant c. 20 cm high. Disturbed peat swamp forest, open area by trail, peat soil. Along N Park boundary from Tj Belipat *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89224.*

*Urticaceae sp. 1

Creeping herb. Foot of limestone hill, on rock. Great Cave *Jemree Sablee et al. S 89063.*

*Urticaceae sp. 2

Creeping herb. Forest canopy c. 20 m tall, light shade, humus soil among limestone outcrops, on loose soil below wall of limestone. Below summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89439.*

*Urticaceae sp. 3

Terrestrial herb. Limestone forest. G Subis *Jemree Sablee et al. S 89044.*

*Urticaceae sp. 4

Lithophytic herb. Limestone forest (disturbed, including by logging) on exposed rocks,

shady area, soil peaty humus between rocks. S boundary of park, E of Quarry *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89492*.

*Urticaceae sp. 5

Herb 35 cm tall. MDF, Sg Sekaloh *Jemree Sablee et al. S 89025*.

*Urticaceae sp. 6

Herb c. 30 cm tall. On limestone rocks, light shade, almost no soil. Near Sg Subis *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89462*.

VERBENACEAE

**Clerodendrum* sp.

Semi-woody plant 25 cm tall. On limestone rocks in pockets of soil between rocks, medium shade. Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89479*.

*Verbenaceae sp.

Woody herb 30 cm tall. Foot of limestone hill. Great Cave *Jemree Sablee et al. S 89064*.

VIOLACEAE

**Rinorea bengalensis* (Wall.) O.K.

Treetlet 2.5 m tall, 2 cm diam. Limestone forest among rocks on hillside, moderate shade, loamy soil with humus. SW of Telaga Kumang *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89296*.

**Rinorea horneri* (Korth.) O.K.

Small tree 1.5–5 m tall, 3–8 cm diam. Limestone forest. G Subis *Jemree Sablee et al. S 89045*; Ulu Sg Sekaloh, near Quarry *Jemree Sablee et al. S 89068*.

VISCACEAE

Ginjalloa falcata Dans.

Hemi-parasitic shrub on branch. Seasonal swamp forest (disturbed), open area. Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89468*.

VITACEAE

*?*Cayratia* sp. 1

Herbaceous creeping scrambler 2 m long. Exposed limestone rocks with humus soil, summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89418*.

*?*Cayratia* sp. 2

Semi-woody climber c. 10 m tall, 1 cm diam. Limestone forest, light and moderate shade, humus soil amongst and climbing over limestone rocks. Top of limestone summit of G Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89406*; Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89476*.

*?*Cayratia* sp. 3

Creeping herb. Limestone forest. Moderate shade on limestone rock. Beside plank walk to Great Cave *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89474*.

Cissus cf. *angustata* Ridley

Semi-woody climber c. 5 m tall. MDF, light shade, loam soil. Across river from Park HQ *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89443.*

Pterisanthes polita (Miq.) Lawson

Herbaceous climber 1.5 m long. MDF, light shade, loam soil. NE of Kuala Sg Sekaloh *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89266.*

Tetrastigma cf. *diepenhorstii* (Miq.) Latiff

Woody climber c. 12 m long, c. 7 cm diam at base. Disturbed forest, by path, moderate shade. Tj Belipat, along boundary from Sg Niah (100 m from river) *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89202.*

VITTARIACEAE

**Antrophyum parvulum* Blume

Vegetation verification plot specimen near summit of Bukit Kasut.

Monogramma paradoxa Bedd.

Collected by H. Schneider (*pers. comm.*).

ZINGIBERACEAE

**Alpinia ligulata* K.Schum.

Clustering herb 2.5 m tall. Foot of limestone hill. Great Cave *Jemree Sablee et al. S 89061.*

Amomum borneense K.Schum.

Epiphytic herb. Locally abundant. MDF, light shade. Across river from Park HQ *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89441.*

**Boesenbergia* sp.

Creeping herb. At base of limestone rocks, medium shade, damp. Along Jalan Madu Trail *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89491.*

This species belongs to the *B. aurantiaca/belalongensis/ornata* group.

**Boesenbergia* sp. nov. (A. Poulsen, *pers. comm.*)

Yellow-flowered herb collected by A. Poulsen.

Globba atrosanguinea Teijsmann & Binnend.

Herb 60 cm tall. Disturbed forest, grey clay under 25 cm peat, moderate shade. Close to Sg Niah *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89258.*

**Globba ?propinqua*

Herb 50 cm tall. Limestone forest, medium shade, peaty soil at base of limestone rocks. Near Sg Subis. *Kit Pearce, Julaihi Abdullah & Serukit Dubod S 89452.*

Globba tricolor Ridley var. *gibbsiae* (Ridley) R.M.Smith

Solitary herb 40 cm tall. MDF, brown clay soil. Sekaloh *Jemree Sablee et al. S 89020.*

Zingiber cf. *albiflorum* (Ridley) R.M.Smith

Clustering herb 1.5 m tall. Disturbed peat swamp forest, moderate shade, peat soil. S of trail from Tj Belipat along N Park boundary. *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89230.*

Zingiber cf. martinii R.M.Smith

Erect, clustering herb 2.4 m tall. Disturbed, regenerating *emperan* forest, light shade, alluvial soil. Kuala Sg Subis *Kit Pearce, Yahud Wat, Serukit Dubod & Jeffri Johari S 89282.*

*Family unknown

Climber on tree. Limestone forest, sandy soil. Ulu Sg Trusan *Jemree Sablee et al. S 89059.*

A New Species of, and Reinstatements in, *Octamyrtus* (Myrtaceae)

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Abstract

The taxonomy of *Octamyrtus* Diels is reviewed and six species are recognised. *Octamyrtus halmaherensis* Craven & Sunarti is newly described and *O. arfakensis* Kaneh. & Hatus. ex C.T. White and *O. glomerata* Kaneh. & Hatus. ex C.T. White are reinstated. Neotypes are designated for *O. behrmannii* Diels and *O. insignis* Diels. A key to the species is provided.

Introduction

Due to its largish, multipetalled flowers that commonly are red or pink, *Octamyrtus* Diels is an intriguing genus of Papuan Myrtaceae. The syndrome of floral features, i.e. long, more or less tubular, often brightly coloured flowers, suggests that its several species may be pollinated by birds. The genus was revised in 1978 by Scott who recognised three species, *O. behrmannii* Diels, *O. insignis* Diels and *O. pleiopetala* Diels, with the last-named species containing two varieties, *O. pleiopetala* var. *arfakensis* (Kaneh. & Hatus. ex C.T. White) A.J. Scott and the typical morph (Scott 1978a).

The first author's long-standing interest in this attractive genus was re-kindled by an inquiry from Marcel Polak, Leiden, as to the identity of collections he had made on the Vogelkop, Indonesian New Guinea, in 1995 and 1996. Polak's specimens had extremely large leaves with the lamina decurrent to the petiole and yellowish-coloured flowers; they keyed to *O. insignis* in Scott's key (1978a). Upon comparison with collections lodged in herb. CANB, and those cited by Scott (1978a) in his revision as being *O. insignis*, the Polak specimens proved to be significantly different. The CANB specimens of *O. insignis* had distinctly petiolate, non-decurrent leaves and pink to red flowers. During collaborative investigations of *Octamyrtus* specimens in BO, the first author noted that the Polak specimens had much in common with an isotype

specimen of *O. glomerata* Kaneh. & Hatus. ex C.T. White, a species placed in synonymy with *O. insignis* by Scott (1978a).

The investigations were continued during a study visit by the second author to CANB in 2003 with the conclusion that the Polak specimens were conspecific with the type collection of *O. glomerata* and that this species was distinct from *O. insignis*. It was further concluded that Scott had inappropriately combined *O. arfakensis* Kaneh. & Hatus. ex C.T. White with *O. pleiopetala* although he did give the former taxon status at the rank of variety. An anomalous collection from Maluku (*de Vogel 3140*), differs from all other collections of the genus that we have seen in possessing sessile, cordate leaves and we conclude that this represents a new species, described below as *O. halmaherensis* Craven & Sunarti.

Octamyrtus has much in common with *Rhodomlyrtus* (DC.) Rchb., but differs from this genus in having a greater number of petals, 6, 8 or 12 as against 4 or 5 in *Rhodomlyrtus* (Scott 1978a). The petals in *Octamyrtus* are often red or pink and may be up to c. 6 cm long. In most species of Malesian rainforest Myrtaceae, the petals are relatively insignificant with the stamens providing the primary visual signal for pollinators; in this respect *Octamyrtus* appears to be unique. Nonetheless, in features of the ovules and placentation, and seeds and fruit morphology the species of *Octamyrtus* are so similar to Papuanian *Rhodomlyrtus* that they may in future be found to be better placed in that genus.

Taxonomy

Octamyrtus Diels

Octamyrtus Diels, Bot. Jahrb. Syst. 57 (1922) 373. –**Type:** *Octamyrtus insignis* Diels (lecto, vide McVaugh, Taxon 5 (1956) 144).

1. *Octamyrtus arfakensis* Kaneh. & Hatus. ex C.T. White

Octamyrtus arfakensis Kaneh. & Hatus. ex C.T. White, J. Arnold Arb. 32 (1951) 144. *Octamyrtus pleiopetala* var. *arfakensis* (Kaneh. & Hatus. ex C.T. White) A.J. Scott, Kew Bull. 33 (1978) 305. –**Type:** Indonesian New Guinea, Arfak Mountains, Lake Gita, 1900 m, *Kanehira & Hatusima 14028* (lecto A, not seen (image seen); isolecto BO, BRI not seen).

Notes: Although White (1951) cited the Kanehira and Hatusima collection as being the type when he described *O. arfakensis*, he did not designate a holotype. Scott (1978a) designated the specimen lodged in A as holotype and thus effectively has selected the lectotype. The BRI material cited by Scott as an isotype is fragmentary, consisting of a single leaf only (A.R. Bean, *pers. comm.*) and Scott's choice of the A specimen as lectotype is appropriate.

2. *Octamyrtus pleiopetala* Diels

Octamyrtus pleiopetala Diels, Bot. Jahrb. 57 (1922) 373. *Eugenia pleiopetala* F. Muell., Descr. Notes Papuan Pl. 1 (1877) 106 sub *Myrtella hirsutula*, nom. inval. (nom. prov.). –**Type**: Indonesia, Moluccas, Aru Islands, *Beccari s.n.* (?lecto MEL, not seen; isolecto K, L, not seen (images seen)).

Octamyrtus lanceolata C.T. White, J. Arnold Arb. 32 (1951) 145. –**Type**: Papua New Guinea, Western Province, *Brass 7701* (lecto A, not seen (image seen); isolecto BO; BM, BRI, K, L, not seen (image seen from L)).

Notes: Scott (1978a) followed Diels (1922) in treating the name *O. pleiopetala* as being a combination resulting from the transfer of Mueller's (1877) *Eugenia pleiopetala* to *Octamyrtus*. Scott, however, appears to have overlooked the long-standing provision of the various editions of the International Code of Botanical Nomenclature, including the most recent version (the Saint Louis Code), that pertains to names not accepted by their author(s) (Art. 34.1; Greuter *et al.* 2000). Mueller's (1877) name is invalidly published as he was tentative as to bestowing the epithet *pleiopetala* upon it (i.e. "to which the name *E. pleiopetala* might be given", p. 106); that he was also unsure as to which genus the new plant belonged is immaterial. Diels (1922) did not validate Mueller's name in *Eugenia* as he was recognising the species as belonging to his new genus, *Octamyrtus*, and treated the species accordingly. Thus Diels apparently has provided the first validly published name for the plant and, as he was treating it under a different genus to Mueller, the name *Octamyrtus pleiopetala* should not be treated as a new combination, even though Diels' name is based on the species concept and descriptive text Mueller derived from Beccari's specimens and is to be typified by those specimens.

Scott (1978a) cited specimens of *O. pleiopetala* in K and L as isotypes, presumably regarding the material assumed to be at MEL as the primary type, in this case lectotype as Mueller did not designate a holotype. Type material of *O. pleiopetala* has not been located in MEL (J.H. Ross, *pers. comm.*) and may no longer be extant in which case a lectotype will need to be selected from the other sheets of Beccari's collection that are available.

As with *O. arfakensis*, White (1951) did not designate a holotype when describing *O. lanceolata* and Scott's (1978a) designation of the material at A as holotype has effected lectotypification. The BRI isolectotype material *fide* A.R. Bean (*pers. comm.*) consists of an adequate flowering specimen.

3. *Octamyrtus behrmannii* Diels

Octamyrtus behrmannii Diels, Bot. Jahrb. 57 (1922) 376. –**Neotype** (here designated): Papua New Guinea, Morobe Province, Aseki Patrol Area, near Haumga, 6 April 1966, *Craven & Schodde 1195* (neo CANB; isoneo A, BRI, CHR, K, L, LAE, TNS).

Notes: With the loss of the type designated by Diels (1922), i.e. Behrmann in *Ledermann 6969*, during the Second World War, a neotype should be selected. Scott (1978a) apparently did not locate any of the original material and a neotype that conforms with Diels' circumscription has been designated above.

4. *Octamyrtus insignis* Diels

Octamyrtus insignis Diels, Bot. Jarhb. 57 (1922) 374. –**Neotype** (here designated): Papua New Guinea, Morobe Province, foothills NW of the Waria River, alluvial terraces along Pao streambed by Yai Village, 4 June 1999, *Takeuchi et al. 13126* (neo CANB; isoneo LAE not seen).

Notes: With the loss of the type designated by Diels (1922), i.e. *Schlechter 17428*, during the Second World War, a neotype should be selected. Scott (1978a) apparently did not locate any of the original material and a neotype that conforms with Diels's circumscription has been designated above.

5. *Octamyrtus halmaherensis* Craven & Sunarti, **sp. nov.**

Octamyrtus halmaherensis Craven & Sunarti, a congeneribus foliis sessilibus et lamina cordata differt. –**Typus:** Indonesia, Maluku, Halmahera, Ekor, G. Panjang, 27 September 1974, *de Vogel 3140* (holo BO; iso CANB, L not seen).

Tree 10 m tall, clear bole to 5 m, dbh 10 cm, rather gnarled, without buttresses or knots; bark red-brown, not fissured, strongly peeling. Branchlets finely pubescent, 5–7 mm wide. Leaves sessile, obovate, finely pubescent with the hairs weathering away on the adaxial surface, with oil dots (the white material present on the only specimens seen apparently is an artefact of preservation), 22–31.4 x 9.2–12.5 cm; base cordate; apex acute to short acuminate; midrib strongly prominent and rounded abaxially and slightly impressed to flat adaxially; primary veins strongly prominent abaxially and slightly impressed adaxially, arching, confluent at their apex with the next vein and an intramarginal vein not developed; secondary veins not or poorly developed; tertiary veins prominent abaxially, linking the primary veins in a more or less ladder-like pattern. Flowers 1–2 on a distal-axillary spicate inflorescence, 3 x 1 cm, inflorescence axis up to c. 1 cm long, the axis bracts, bracteoles, hypanthium and sepals densely and finely pubescent; bracteoles persistent in fruit, narrowly ovate, 10 mm long, pedicel 3–4.5 mm long. Hypanthium funnel-shaped, very slightly stipitate or estipitate, 5.5–7 x 5–5.5 mm. Sepals 4, green, persistent in fruit, ovate to subtriangular, 10.5–13.5 x 6–6.5 mm. Petals 8, bright red, blade glabrous, margin pubescent, narrowly elliptic to elliptic, 20–28 mm long, oil glands present. Stamens 35–37 mm long, filaments violet, anthers yellow, 2.4–2.8 mm long. Style at least 30 mm long (fully mature style not seen), stigma

green, peltate. Ovary 4-locular, with 2 rows of ovules in each locule. Immature fruit ellipsoid, 18 mm long, seeds not seen but horizontal and vertical septa present.

Habitat & ecology: Found in rather dense primary forest 20 m tall, with little undergrowth, on a rather steep hill side on deep clayey soil, 40 m alt, gregarious.

Distribution: Known only from the type collection.

Notes: *Octamyrtus halmaherensis* is readily distinguished from all other species of the genus in its leaves, which are sessile and cordate. Although known from limited material only, its diagnostic features are unique in the genus.

6. *Octamyrtus glomerata* Kaneh. & Hatus. ex C.T. White

Octamyrtus glomerata Kaneh. & Hatus. ex C.T. White, J. Arnold Arb. 32 (1951)

145. –**Type**: Indonesian New Guinea, *Kanehira & Hatusima 14126* (lecto A, not seen (image seen); isolecto BO, BRI fragment not seen).

Notes: As with the other *Octamyrtus* species described by White (1951), a holotype was not designated. Scott's (1978a) designation of the A specimen as holotype effectively has nominated the lectotype. The BRI material cited by Scott as an isotype is fragmentary, consisting of some pieces of material in a packet (A.R. Bean, *pers. comm.*) and Scott's choice of the A specimen as lectotype is appropriate.

Key to the Species of *Octamyrtus*

- 1a. Leaves distinctly petiolate, the lamina not decurrent
 - 2a. Sepals up to 10 mm long
 - 3a. Leaves with a distinct intramarginal vein; petals white, lemon-white, greenish white or light yellow 1. **O. arfakensis**
 - 3b. Leaves without an intramarginal vein; petals pink or red, rarely yellowish white
 - 4a. Flowers inserted in the distal leaf axils 2. **O. pleiopetala**
 - 4b. Flowers usually inserted on the trunk or on branchlets below the leaves, rarely in leaf axils 3. **O. behrmannii**
 - 2b. Sepals 12 or more mm long 4. **O. insignis**
- 1b. Leaves sessile or the lamina strongly decurrent to the petiole
 - 5a. Leaves sessile, the lamina cordate 5. **O. halmaherensis**
 - 5b. Leaf lamina shortly petiolate, the lamina strongly decurrent to the petiole..... 6. **O. glomerata**

Excluded species

Octamyrtus elegans (Bl.) Steen., *Blumea* 19 (1971) 146; *Macropsidium elegans* Bl., *Mus. Bot. Lugd. Bat.* 1 (1849) 85; *Psidium elegans* (Bl.) Miq., *Fl. Ind. Bat.* 1, 1 (1855); *Rhodomyrtus elegans* (Bl.) A.J. Scott, *Kew Bull.* 33 (1978) 320. –**Type:** Indonesia, Maluku, Halmahera, in forests near Singanoli, Gilolo, July 1861, *Forsten s.n.* (holo L, not seen (image seen)).

Scott (1978a) considered this species to be conspecific with *Rhodomyrtus calophlebia* C.T. White and in a later paper (Scott 1978b) published the combination *Rhodomyrtus elegans* (Bl.) A.J. Scott.

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A new species of *Amorphophallus* (Araceae: Thomsonieae) from Sarawak, Borneo

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Abstract

Amorphophallus julaihii Ipor, Tawan & P.C. Boyce a new species from forested limestone in Mulu National Park, Sarawak, Borneo is described and illustrated.

Introduction

Recognition of *Amorphophallus julaihii* as a new species takes to fifteen the number of indigenous species of *Amorphophallus* recorded from Borneo (Bogner 1989; Hettterscheid 1994, 2001). Including *A. julaihii* there are eight species in Sarawak, viz: *A. angulatus* Hett. & A. Vogel, *A. brachyphyllus* Hett., *A. eburneus* Bogner, *A. hewittii* Alderw., *A. hottae* Bogner & Hett., *A. infundibuliformis* Hett., A. Dearden & A. Vogel, *A. pendulus* Bogner & Mayo. Five species have been recorded from Sabah: *A. hottae*, *A. lambii* Mayo & Widjaja, *A. rugosus* Hett. & A.L. Lamb., *A. tinekeae* Hett. & A. Vogel and *A. venustus* Hett., A. Hay & J. Mood. Eight species are recorded from Kalimantan: *A. borneensis* (Engl.) Engl. & Gehrm., *A. costatus* Hett., *A. hewittii*, *A. infundibuliformis*, *A. lambii*, *A. linguiformis* Hett., *A. pendulus* and *A. prainii* Hook.f. (the last perhaps based on a mis-labelled specimen; *A. prainii* is otherwise known only from Peninsular Malaysia and Sumatera). With the exception of *A. prainii* all Bornean *Amorphophallus* are endemic to Borneo. The most remarkable aspect of these data is that 13 of these 15 species have been described within the past 25 years. This extraordinary increase in recognized species is being repeated throughout the range of the genus such that *Amorphophallus* now numbers over 200 species, of which in excess of one third are novel taxa described since 1980. Recent and on-going fieldwork indicates that there are more novel Bornean *Amorphophallus* awaiting description.

Ecology of *Amorphophallus* in Sarawak

Two of the authors (I.I. & P.C.B.) have been observing *Amorphophallus* populations in North Borneo for many years and based on these observed data the following summary of *Amorphophallus* ecology in Sarawak may be drawn.

Five of the eight Sarawak *Amorphophallus* species occur in limestone forest with three, *A. brachyphyllus*, *A. eburneus* and *A. julaihii*, seemingly restricted to this habitat. *Amorphophallus brachyphyllus* and *A. eburneus* occur sporadically and allopatrically on both the Bau and Padawan limestones. There are also records of *A. brachyphyllus* from the Mulu and Niah limestones, although these records have yet to be verified and it is quite possible that the Mulu and Niah plants represent one or more additional undescribed vicariant taxa in the species-rich Manta Group (Hettterscheid, in prep.). The single record from Mulu for the otherwise Sabahan *A. hottae* also requires verification not least because in Sabah *A. hottae* is never associated with limestone.

Amorphophallus hewittii as currently circumscribed is frequently found in association with limestone, occurring commonly on both the Bau and Padawan limestones where the flowering of large specimens occasionally receives coverage in the local press. However, *A. hewittii* is not restricted to calcareous rocks, and is also found on the hard sandstones of the Penrissen Range and occurs in several widely scattered, mostly sandstone, locations throughout Sarawak. It should be noted that this apparent ecological diversity may be an artifact of imperfect taxonomy. The large size of this plant, both florally and vegetatively, makes it an unpopular subject for herbarium collection and our knowledge of its morphology is based on a decidedly meagre collection of mediocre specimens.

All other Sarawak species appear to be sandstone or shale associated. *Amorphophallus pendulus*, described from Gn. Matang (Bogner *et al.* 1985), is widespread and frequently locally common on moist sandstones at least as far east as Kapit (Belaga). (Boyce, *pers. obs.*). *Amorphophallus infundibuliformis* is widespread but scattered and seldom locally abundant in Kuching and Sri Aman Divisions, with collections known from wet but well-drained sandstone sites between 60–870 m asl in Lundu, Padawan, Bau & Ulu Batang Ai. *Amorphophallus angulatus* was described from the sandstones of Gunung. Selantik (Sri Aman), is also recorded from Gunung. Ampungan (Samarahan) and has recently been discovered at Nanga Gaat (Kapit) where it occurs on hard shales exposed by stream action (Boyce, *pers. obs.*).

Relationships of *Amorphophallus julaihii*

Amorphophallus julaihii fits uncontroversially into Hettterscheid's 'Manta Group' (Hettterscheid, in prep), into which also belong all the other Sarawak

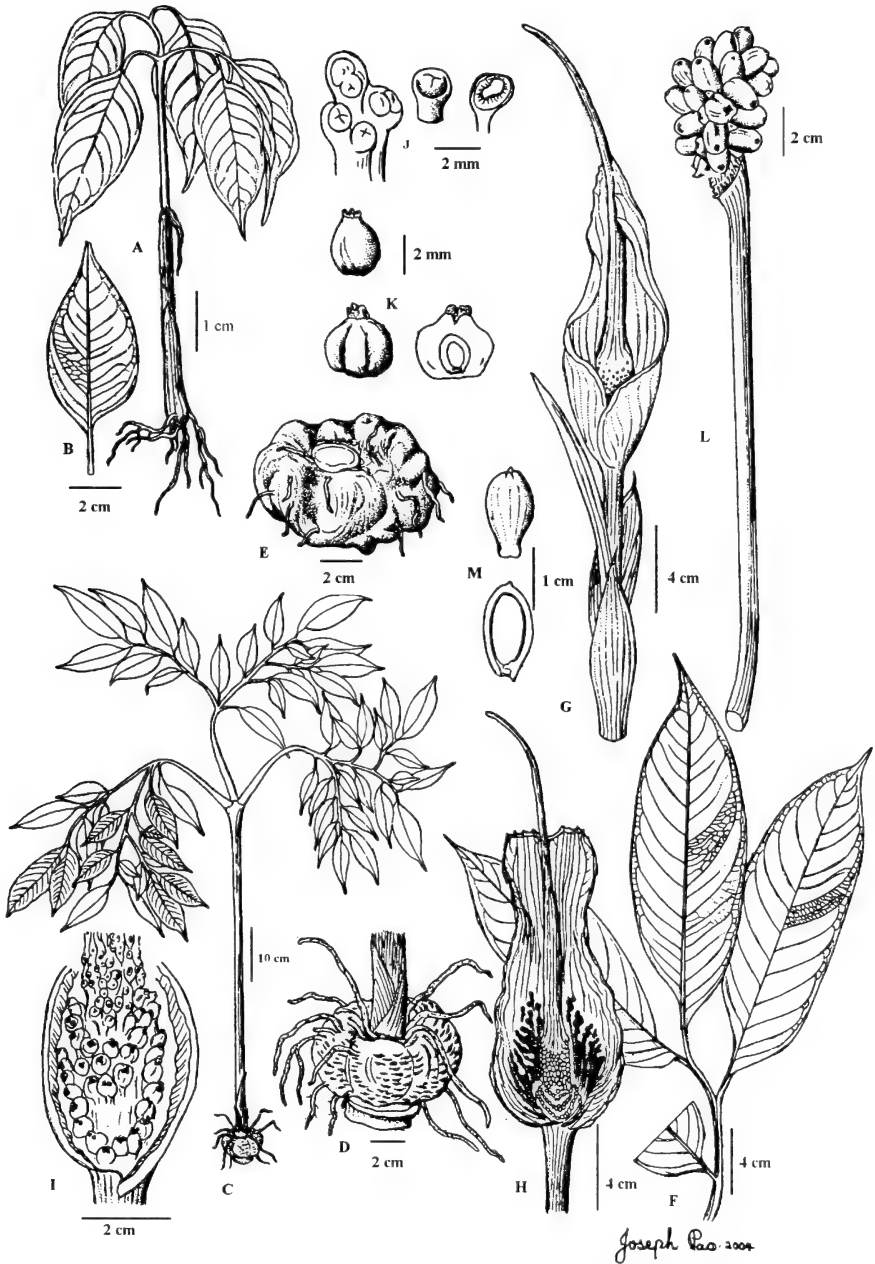


Figure 1. *Amorphophallus julaiihii* Ipor, Tawan & P.C. Boyce. **A.** seedling, **B.** leaflet of seedling, **C.** mature plant, **D.** tuber with adventitious roots, **E.** tuber from inflorescence, **F.** leaflets of mature plant, **G.** inflorescence with cataphylls, **H.** L.S. of the inflorescence, **I.** male and female zones, **J.** stamens, **K.** pistils, **L.** infructescence with berries, **M.** berry and in L.S..
 A, B, C & D, E, F, G, H, I, J, K from CST 2527, L & M from CST 2530 – drawings from fresh samples.

species to which *A. julaiihii* is most similar. The Manta Group is defined as: Small to medium-sized herbs with tubers depressed-globose or subglobose that are not offsetting; petioles sometimes forming an intercalary bulbil at the junction with the lamina (*A. angulatus*). Seedling leaves often flushed with dark red or lilac-red (*A. angulatus*, *A. pendulus*, - Boyce, *pers. obs.*) Spathe linguiform, narrow or broad. Spadix shorter than or only slightly longer than spathe. Male flowers often longitudinally elongate and fused into rows.

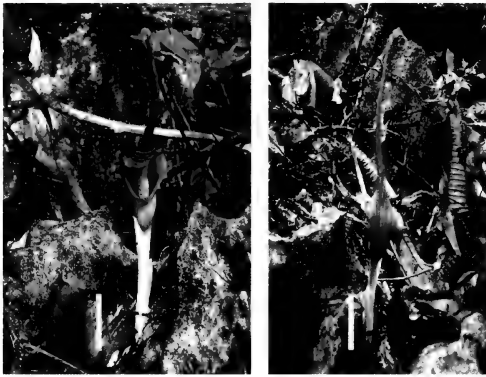
Amorphophallus julaiihii Ipor, Tawan et P.C. Boyce *sp. nov.* Ab omnibus speciebus in habitu calcicola lithophytica Borneensibus borealis spatha parva in toto atropurpureis differt. **Typus.** Sarawak, Miri Division, Mulu National Park, forest on limestone, *C.S. Tawan & I.B. Ipor* CST 2527, 14 April 2004 (**Holotypus:** HUMS (Herbarium Universiti Malaysia Sarawak) inflorescence and tubers in spirit; vegetative parts (petiole with leaflets, seedlings) - herbarium specimens.)

Small to medium-sized **herb**, 50–100 cm tall. **Tuber** depressed sub-cylindrical to globose, with irregular raised areas, up to 5.8 cm diam., 6.0 cm high, surface dull brown greyish, inner part fleshy, whitish. **Adventitious root** scars present on top portion of tuber at flowering stage, new roots developing during vegetative stage. **Petiole** up to 44 cm long, c. 19 mm diameter at base, turgid, cylindrical, smooth, bright green, enveloped basally by dried decaying brownish cataphylls; **lamina** highly dissected, rachises naked, narrowly channelled, yellowish green; **leaflets** elliptic-lanceolate, 11.0–13.0 x 4.0–4.4 cm, some petiolulate, petiolule 1.5–3.0 cm long, slightly channelled adaxially, ultimate leaflet sessile, leaflets asymmetrical, apex apiculate 1.5–2.0 cm long; base unequal; margin slightly wavy and sparsely fine-toothed; adaxial surface bright green, thin slightly leathery, abaxial surface pale green; 6–16 pairs of secondary veins with intermediate veins per leaflet, these adaxially channelled and adaxially raised; venation forming distinct submarginal veins; tertiary veins reticulate; lamina texture leathery when fresh, chartaceous when dry. **Inflorescence** solitary, flowering without foliage leaves; peduncle cylindrical, up to 17.5 cm long, 8–9 mm diam. at base, yellowish to creamy. **Cataphylls** 6; first 1–4 ovate to linear, 3–13 cm x 1.5–2.0 cm, brownish to dark brown, thin, soon withering and decaying; the next 5–6 linear-oblong, 15–21 x 2.4–3.5 cm, light purplish to whitish and slightly purplish stained. **Spathe** elongate-oblong, limb erect at anthesis, later recurved and twisted towards the base, up to 12 cm long, width at base 4.0 cm, at middle 4.0 cm, at apex 4.5 cm, lower spathe strongly convolute and forming a short tube 3.5–4.0 cm long; **inner surface** of upper spathe limb ribbed with distinct venation, purplish, lower part rough and verrucose, deep purple; **outer surface** of upper spathe limb with distinct longitudinal venation, margin thinly undulate, apex dentate; upper part of spathe



a. tuber, b. inflorescence with tuber, c. leaflet (Scale bars – 3 cm)

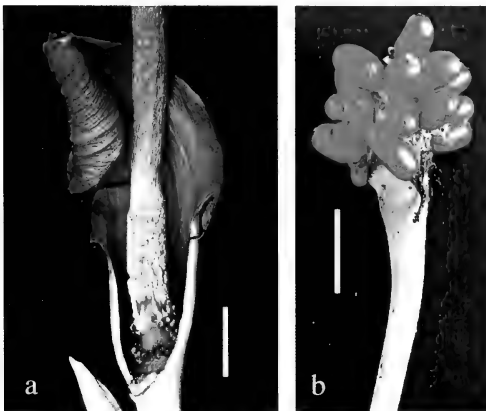
Foliage (Scale bar – 6 cm)



Inflorescence (scale bars — 6 cm)



Spathe (Scale bars – 4 cm)



a. Spathe and spadix, b. Infructescence. (Scale bars-2 cm)



Male and female zones of the spadix (Scale bar-2 cm)

Figure 2. *Amorphophallus julaiihii* Ipor, Tawan & P.C. Boyce

limb rich purple-scarlet, middle part and margins darker. **Spadix** exceeding spathe, 18.5–19.0 cm, short stipe, 1.0–1.5 cm long. **Appendix** up to 14 cm long, cylindrical, spongy, purplish, 9–9.2 mm diam. at base; 7.5 mm diam. at middle, 2 mm diam. at apex, surface verrucose with longitudinal lines, appendix producing an unpleasant odour similar to that of rotten fish. **Flowers** unisexual; **male zone** cylindrical, up to 3 cm long, 9 mm diam. at middle, whitish to creamy; **stamens** connate and short, *c.* 1 mm long, *c.* 0.5 mm broad across, fused with adjacent stamens, filaments *c.* 5 mm, truncate, pores apical, rounded or variously elongate. yellowish or creamy, pollen brownish. **Female zone** cylindrical, separated by irregular zone of sterile stamens from the male zone, 1.5–2 cm long, 10 mm diameter; pistils in irregularly rows, rather lax, sometimes almost in V-shaped rows; ovaries ovoid-subglobose, 2.5–3.0 mm in long, 1.8–2.0 mm broad at base, dark purple, unilocular rarely bilocular; stigma sessile, two to three lobed or sometimes irregularly lobed, **Infructescence** with up to 35 berries, pedunculate up to 22 cm long, 6 mm diam. at base, 9 mm diam. at apex, with blackish-dark brown V-shaped scar from the marcescent spathe, basally with remains of the cataphylls. **Berries** when ripe deep orange, ellipsoid 15–16 mm x 8–10 mm, apex rounded, with blackish stigma remnants, one seeded. **Seeds** ellipsoid, 12–14 mm x 7–8.2 mm wide, testa smooth, thin, yellowish green, seed copiously starchy, embryo small.

Distribution: Endemic in Sarawak, so far recorded only from Mulu National Park, Miri Division.

Ecology: Limestone forest, growing in shady areas, in humus-filled fissures and holes in limestone. Flowering recorded in April.

Notes: *Amorphophallus julaiihii* is most similar to *A. angulatus*, *A. brachyphyllus* and *A. eburneus*, (all Sarawak) and *A. costatus* (Kalimantan). From *A. angulatus* (with which *A. julaiihii* shares a purple spathe), it differs by the spadix appendix exceeding the spathe and by the smaller, not diamond-shaped male flowers. From *A. eburneus* and *A. brachyphyllus* (also both restricted to limestone), *A. julaiihii* is immediately separable by the purple ribbed spathe. The resemblance of *A. julaiihii* to *A. costatus* is in having an erect elongate triangular spathe with the base strongly convolute forming a narrow tube. In both species, the spadix exceeds the spathe but in *A. julaiihii* the spadix is shortly stipitate while it is sessile in *A. costatus*; the male zones in both species are similar - cylindrical, flowers slightly distinct, irregularly arranged or in longitudinal oblique, interrupted rows. The matt-purple spathe of *A. julaiihii* readily separates it from *A. costatus* in which the spathe interior is glossy maroon. To date *A. costatus* is recorded only from southern Kalimantan.

Etymology: This species is named after Mr. Julaihi Abdullah, Deputy Research Manager of Sarawak Forestry Corporation, who first showed the first two authors this species in the Mulu National Park, Sarawak. He was formerly Botanist of the Sarawak Forest Department, Kuching.

Other specimens seen: Type locality, inflorescence, *C.S. Tawan & I.B. Ipor* CST 2528, 14 April 2004 (HUMS); Type locality, inflorescence, *C.S. Tawan & I.B. Ipor* CST 2529, 14 April 2004 (SAR); Type locality, infructescence in spirit *C.S. Tawan & I.B. Ipor* CST 2530, 14 April 2004 (HUMS); Sarawak, Miri Division, Mulu National Park, unspecified locality, *J. Brodie* AM-39, 12 May 1999 (SAR).

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A New Species of *Stachyphrynium* (Marantaceae) from Borneo

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Abstract

Stachyphrynium calcicola, a new species of Marantaceae, was recently discovered in the Bau limestone area, Sarawak. It also occurs in Kalimantan. The new species is described and illustrated and the uses of Bornean Marantaceae are given.

Introduction

During a recent inventory of the flora of the limestone hills at Bau, Sarawak, a species was discovered (Poulsen *et al.*, 2004), which matched other collections in Borneo but none of the known types of species of Marantaceae. The new taxon is clearly a *Stachyphrynium*, because the sepals are very short relative to the corolla tube, whereas in *Phacelophrynium* K.Schum. and *Phrynium* Willd., the sepals are half the length of the corolla tube or longer.

In Borneo, the most recent revision of Marantaceae included only those from Sabah (Clausager & Borchsenius, 2003). The earliest account of the Bornean species by Ridley (1903) included two species, *Phrynium parviflorum* Roxb. (which is synonymous with *Stachyphrynium placentarium* (Lour.) Clausager & Borchs.) and *Phrynium fissifolia* Ridl. Existing accounts for nearby areas, include those for the Malay Peninsula (Ridley, 1899; Holttum, 1951), and the Philippines (Ridley, 1909). The largest part of Borneo, Kalimantan, is also the least studied and an intensified inventory on Marantaceae in Kalimantan with a subsequent flora account for Borneo is therefore much needed, not least because several species are useful to the indigenous communities (Christensen, 2002). As none of 13 species of Marantaceae recognized in the account for Sabah (Clausager & Borchsenius, 2003) are endemic to Sabah, this account is meanwhile a useful tool for the identification of species elsewhere in Borneo.

In Sabah, three species of *Stachyphrynium* are presently recognized (Clausager & Borchsenius, 2003): *S. borneense* Ridl. is widespread in Borneo and may be synonymous with *S. sumatranum* (Miq.) K.Schum.; *S. latifolium* (Blume) K.Schum. is widespread in the Malesian region (in Sabah it is found east of the Crocker Range, and a recent collection (*Poulsen 2301* from Mulu) confirms it from Sarawak west of the main range); and *S. placentarium* is widespread in SE Asia.

A fourth species, *Stachyphrynium lancifolium* Suksathan & Borchs., was recently described from Brunei (Suksathan & Borchsenius, 2003) and this species also occurs in Sarawak. The new species described below is consequently the fifth Bornean species of *Stachyphrynium* K. Schum.

In the description, the terminology of the inflorescence is taken from Clausager and Borchsenius (2003), as there still remains uncertainty as to the derivation of the inflorescence and its structure (see Andersson, 1976, 1981, 1998; Kunze, 1985, 1989).

Stachyphrynium calcicola* A. D. Poulsen & Clausager *sp. nov.

Stachyphrynium borneense similis in foliorum statura formaque, inflorescentia elongata differt. Praeterea *S. lancifolio* similis ac habitu generali ac inflorescentia elongata necnon corollae tubo longissimo, sed foliorum forma oblongo-elliptica nec lanceolata, inflorescentia multo maiore ramosa laxa, corollae lobis multo latioribus, staminodiis exterioribus maioribus differt.

Typus: Malaysia, Borneo, Sarawak, Bau area, Kampung Skiat (1°23'N; 110°12'E), 30 June 2003. *Poulsen, Jugah, Jais & Clausager 2026* (holo SAR; iso AAU, K, L, Sarawak Biodiversity Centre Flora Depository).

Figure 1.

Rhizomatous ground herb to 50 cm tall. *Leaves* basal, 2–5 per shoot, distichous; sheath to 16 cm long, greenish; petiole 8–18 cm long, greenish, glabrous; pulvinus 10–15 mm long, glabrous; lamina oblong-elliptic with entire margin, apex acuminate, 26.5 by 9 cm, glabrous, green. *Inflorescence* interfoliar, erect to 37 cm long; peduncle 1–17 cm long, glabrous, pale yellowish green; synflorescence lax, spiciform, simple or branched, to 20 cm; individual bracts elliptic to oblanceolate, to 3 by 0.8 cm, light green; bracts sub-distichously arranged, each covering a special paraclade, these with 1–2 flower pairs, each associated with a 2-keeled prophyll, oblong-lanceolate, 12–19 by 3.5–5.5 mm, and a lanceolate interphyll 8–15 by and 2.5–4 mm. *Flowers* c. 30–36 mm long, cream white except for a yellow touch on the mouth of the corolla tube. Sepals 3, triangular, free, sparsely hairy at base, 4 by 1 mm. Petal lobes subulate,

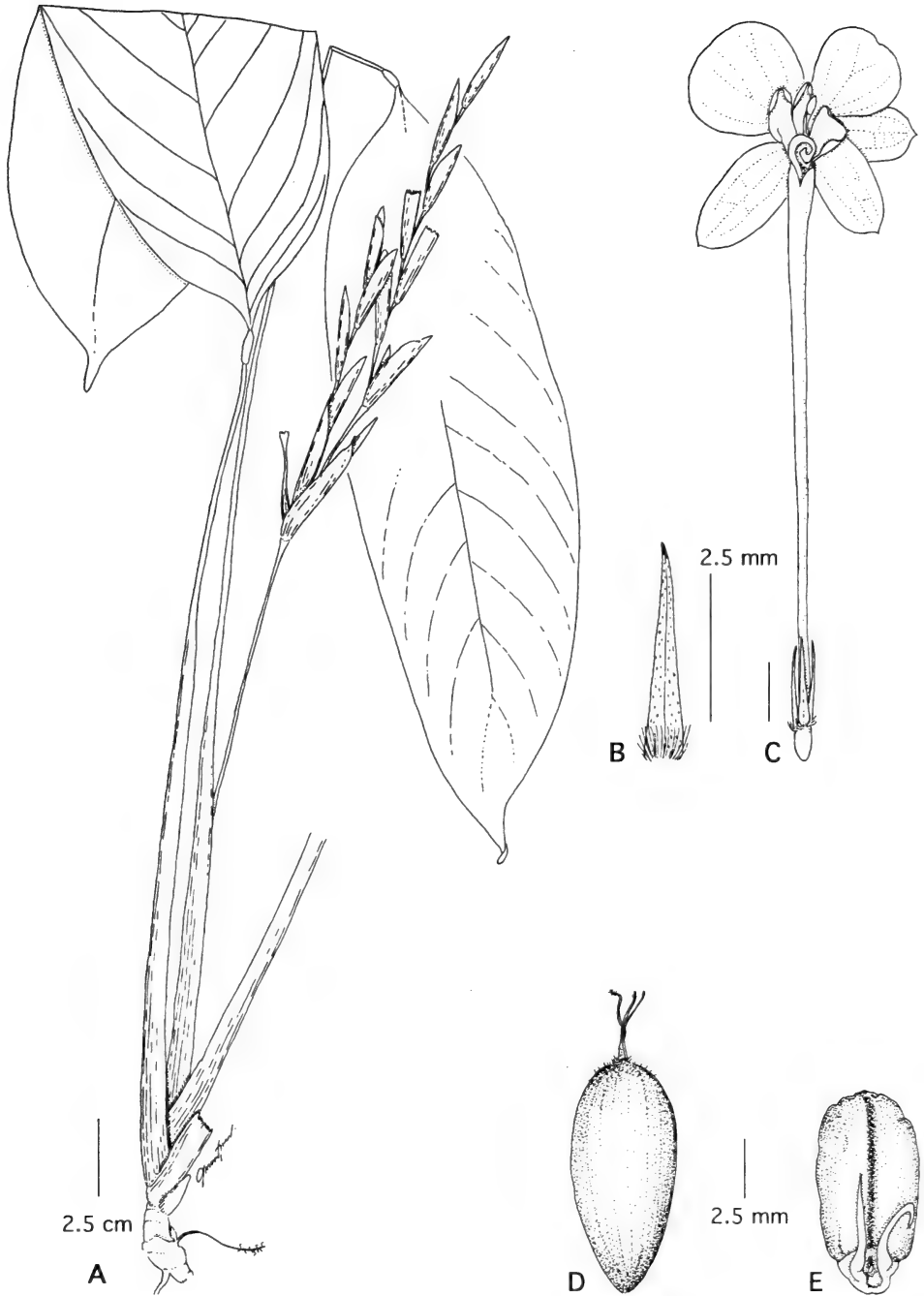


Figure 1. *Stachyphrynium calcicola* A.D.Poulsen & Clausager
A. habit; B. sepal; C. flower; D. fruit; E. seed with bilobed aril. Drawn by Piyakaset Suksathan from the type (Poulsen *et al.* 2026).

c. 5 by 3 mm; corolla tube 25–26 mm long, yellow on the inside. Staminodes and stamen basally adnate to the corolla tube; outer staminodes 2, subequal, obovate, with petaloid lobe 5–6 by 4–5 mm; cucullate staminode with the free part 3 by 1.5 mm; callose staminode truncate with the free part 2.5 by 2.5 mm; fertile anther 2.5 mm long with petaloid cucullate appendage 3 by 1.5 mm; style hooked with the free part 2.5 mm long; ovary 2.5 mm long. *Fruits* 10 by 4 mm, with one seed and persistent calyx, 3.5 mm. *Seeds* 8 by 3.8 mm, aril 2-appendiculate.

Distribution: Endemic in Borneo in lowland forest. Southern Sarawak and West and Central Kalimantan.

Ecology and etymology: The type collection was found in open forest with bamboo, growing near limestone outcrops and a small stream. Labels on most other collections mention presence of limestone in the habitat, which is the reason for the choice of epithet.

Notes: *Stachyphrynium calcicola* is distinguished from all other *Stachyphrynium* species from Borneo by the elongated and lax inflorescence. At the type locality this is at the most with two well-developed branches but some of the Kalimantan material (*Burley et al.* 3239) has at least six well-developed branches. In Borneo, the inflorescence of *S. calcicola* bears most resemblance to *S. lancifolium*, but can be distinguished simply by its much broader leaves. The leaves of *S. calcicola* resemble the widespread *Stachyphrynium borneense* Ridl., but in this case the difference between inflorescences is pronounced as *S. borneense* has compact inflorescences with red bracts, and *S. calcicola* has elongate, lax inflorescences with light green bracts. *S. latifolium* and *S. placentarium* are much larger plants than *S. calcicola*; the former also differs in the separate and simple inflorescence with water-containing bracts; the latter by its capitate inflorescence with pointed and stiff bracts.

In Sarawak, the leaves of most Marantaceae species are used by local people for wrapping food and for roofing (Christensen, 2002). One collection of *S. calcicola* from Sarawak (*Jamree et al.* S.73204) gives the vernacular name *rirek*. *Rirek* or *ririk* is a generic name in some Iban dialects for different species of Marantaceae (H. Christensen, *pers. comm.*). Some species that are used as a source of starch (*Maranta arundinacea* L.) are called *mulung ririk*, others where the leaves are used are called *daun* (meaning leaf) *ririk* (Christensen, 2002). The most commonly used big-leaved species, *Phacelophrynium maximum* (Blume) K. Schum, is called *daun lung besai* in one Iban dialect (Christensen, 2002). Another small-leaved species, *Schumannianthus acaulis* Suksathan, Borchs. & A.D.Poulsen ined., is also called *daun ririk* in Iban (*Poulsen 1943* from Niah, Sarawak). It is perhaps

surprising that species with small leaves are used. Possibly they substitute when the large-leaved species are not available.

Other specimens examined: SARAWAK. SE slope of Gunung Badug, Bau, lower slope of limestone hill, 300 ft, 1 Apr 1966, *Anderson S.19683* (SAR, K); Gunung Selabor, Upper Sadong Distr., wet place among fallen leaves at foot of limestone hill, 28 May 1975, *Burt B8210* (E, SAR); Bukit Terebat, Mongkos, Serian, near river bank, sandy soil, 18 Jun 1996, *Jamree, Banyeng & Enjah S.73204* (SAR, KEP n.v., K n.v., L n.v.); Bukit Jebong, Bau, at base of mountain in damp dyke area, forest, 350 ft, 7 Aug 1970, *Lehmann S.29433* (SAR); Gunung Doya, Bau, limestone, 160 m, 26 Feb 2002, *Meekiong Kalu et al. SBC 2234* (Sarawak Biodiversity Centre Floral Depository); Gunung Kawa, Bau, limestone foothill, 200 m, 7 May 2002, *Meekiong Kalu & Stephen J.J. SBC 3128* (Sarawak Biodiversity Centre Floral Depository); Gunung Lanyang, Bau, limestone, rock surface at boulders at foothill on the trail to G. Lanyang, 11 Apr 2002, *Julia Sang et al. SBC 2681* (Sarawak Biodiversity Centre Floral Depository); Gunung Tabai, Bau, limestone, flat area at foothill, 13 Mar 2002, *Julia Sang et al. SBC 2546* (Sarawak Biodiversity Centre Floral Depository); Gunung Berloban, 10 km Tebakang–Tebedu road, limestone cliff, 270 m, 24 Jun 1983, *Yi & Othman S.46243* (K, SAR).

KALIMANTAN. Headwaters of Sungai Kahayan, 5 km NW of Tumbang Sian logging camp, Sikatan Wana Raya logging concession, primary lowland forest, 150 m, 24 Apr 1988, *Burley et al. 798* (A, SAR); West Kalimantan, 5–10 km N of Masa village, 150 km NE of Pontianak. Ridge SW of Gunung Bentuang, mixed dipterocarp forest, sloped area, 700 m, 28 Jun – 6 Jul 1989, *Burley et al. 3239* (A).

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