The Pandanaceae of the Bukit Baka Bukit Raya National Park and adjacent areas, West and Central Kalimantan, Indonesia, with notes on their nomenclature and the rediscovery of *Pandanus aristatus* and several new records

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ABSTRACT. Eight species of Pandanaceae (3 *Freycinetia* spp., 5 *Pandanus* spp.) were recorded from the Bukit Baka Bukit Raya National Park and adjacent areas in the West and Central Kalimantan Provinces, Indonesia. *Pandanus aristatus* was recollected and the description improved. *Pandanus motleyanus* has been assigned to synonymy under *P. yvanii*. *Pandanus yvanii* and *P. helicopus* were found to occupy different niches in the peat swamps. *Pandanus epiphyticus* Martelli and *P. pachyphyllus* Merrill were recorded for the first time in Kalimantan. The doubtful presence of *F. sumatrana* in Java is resolved. Two Eastern Malesian species, *F. amboinensis* and *F. ceramensis* are synonyms of *F. sumatrana*, thus the species is now an exceptionally widespread species in both western and eastern Malesia. Full descriptions of species are provided.

Keywords. Borneo, Bukit Baka Raya, *Freycinetia*, Kalimantan, Pandanaceae, *Pandanus*

Introduction

The *pandan* flora of Borneo has been studied by Stone (1970a, 1993). Most of the species enumerated were from Sarawak and Sabah and little was known from Kalimantan, the Indonesian part of Borneo, particularly from the southwestern part, where the Bukit Baka Bukit Raya National Park is located.

Bukit Baka Bukit Raya National Park is a protected area within the Schwaner Range on the border between the Indonesian Provinces of West and Central Kalimantan, with an area of approximately 181,090 hectares. Prior to this study, the latest *pandan* collecting activity in the vicinity was by Nieuwenhuis in the western and central parts of Kalimantan (Nieuwenhuis 1898, Steenis 1950). The *pandan* collections collected during the Nieuwenhuis expedition were identified by Martelli and later mentioned in his two enumerations (Martelli 1910, 1913). Merrill (1922) and Martelli (1929) also cited these expedition specimens in their accounts on the *pandan* of Borneo, in which

many of the collections had been appointed as types.

Although numerous publications have been produced since (see Kanehira 1938; St. John 1961, 1965; Stone 1967a, 1967b, 1970a, 1978, 1980, 1982, 1983b, 1993), the *pandan* flora of the Bukit Baka Bukit Raya National Park and surrounding areas was hardly mentioned and still made reference to Martelli (1929). Only *Pandanus aristatus* was mentioned for the National Park (Stone 1993). The most recent expedition carried out within the National Park was the 1982–1983 expedition in Bukit Raya conducted by Reuler (1987), when no *pandan* was collected.

This paper describes several species of the pandan flora in the Bukit Baka Bukit Raya National Park and adjacent areas, including the Gunung Kelam Ecopark and Baning Protected Forest, based on the most recent expedition in 2006, as well as observations made with herbarium specimens kept in the BO Herbarium.

Enumeration of species

Freycinetia

1. ***Freycinetia kartawinatae*** A.P. Keim, Reinwardtia 13(1): 15 (2009). TYPE: *A.P. Keim 770* (holo BO!), Indonesia, West Kalimantan, Katingan Hulu, Waringin Timur, on logging road, 2 May 2006. (Fig. 1)

Robust climbing *pandan*, to 50 m high. *Stem* c. 9.5 cm girth (c. 3 cm diameter). *Leaves* spirally arranged in 3 ranks (tristichous); blade lanceolate-elongate, c. 43.5–44 cm long, c. 3 cm wide, apex acuminate, margin with spines up to distal 1/3 of the length; adaxial surface green, glabrous; abaxial surface pale green, glabrous; auricle tapered, margin entire, brownish yellow to creamy brown; leaf sheath yellowish green. *Infructescence* terminal, c. 14 cm long, consisting of 3 to 4 spirally arranged cephalia; pedicel yellow to pale yellowish orange, glabrous; bracts distinctively bright orange, thick, hard, fleshy, glabrous, apex acuminate, margin with spines, each boat shaped, c. 22.5–23 cm long, caducous. *Cephalium* cylindric-elongate, c. 9 cm long, c. 3 cm wide, pale green to dull greyish green; stigma 4–5, mostly 4.

Distribution. Endemic to Kalimantan.

Habitat. Lowland tropical rain forest at about 300 m altitude.

Vernacular names. Kajak rajak, *mèrajak* (Dayak, Belaban dialect).

Uses. Although not used by local people, orang utans and gibbons are said to consume the bracts.

Notes. In general appearance, *F. kartawinatae* is very similar to *F. insignis*, but differs in its orange infructescence bracts compared to the purplish white bracts in *F. insignis*.

Fig. 1. *Freycinetia kartawinatae* A.P. Keim. **A.** A terminal infructescence with four spirally arranged cephalia and very distinctive bright orange bracts (above). **B.** Terminal infructescence with three spirally arranged cylindric-elongate cephalia with yellow glabrous pedicels, the bracts already fallen away (below). Photos: A.P. Keim, Rugayah & H. Rustiami.

Among members of the section *Polystachya* in Borneo that have infructescences with 3 cephalia or more, *F. kartawinatae* differs from *F. kinabaluana* in its terminal infructescences with 3–4 cephalia, compared to the lateral infructescences of *F. kinabaluana* that have 5–6 cephalia per infructescence. *Freycinetia kuchinensis* also has reddish orange bracts, but differs in having 2–3 cephalia per infructescence (*fide* Martelli 1910) that are globose, compared to the 3–4 cylindric-elongate cephalia per infructescence in *F. kartawinatae*. Although it has similarly long (40–60 cm) leaves and also 3–4 stigmas, *F. sarawakensis* differs from *F. kartawinatae* in its lateral (not terminal) infructescences and scabrid (not glabrous) pedicels.

A taxon from Sarawak would appear to have many similarities with *F. kartawinatae*, especially in having orange bracts, terminal infructescences, and 3–4 cephalia per infructescence. This taxon was named *F. andersoniana* by Stone (1967c), but invalidly published.

Specimens examined: Only known from the type.

2. *Freycinetia sumatrana* Hemsley, J. Linn. Soc. Bot. 30: 167 (1894). TYPE: *Beccari 211* (holo K; iso FI), Indonesia, Sumatra, Mount Singalan (presumably Mount Singgalang in West Sumatra), June 1878. (Fig. 2–5)

Freycinetia valida Ridley, Mat. Fl. Mal. Penins. 2: 234 (1907). LECTOTYPE: *Ridley 3937* (SING!), Malaysia, Malay Peninsula.

Freycinetia auriculata Merrill, Philipp. J. Sci., C. Bot. 3: 312 (1908). TYPE: *Bur. Sci. Foxworthy 876* (holo PNH†; iso A), Philippines, Palawan, Puerto Princesa, May 1906.

Freycinetia loheri Martelli, Webbia 3: 15 (1910). SYNTYPES: *Loher 1577* (K; iso PNH†), Philippines, Luzon, Benguet, 1908–1915; *Loher* 1578; *Loher* 5469, Luzon, Montalban, June 1908–1915.

Freycinetia lucida Martelli, Webbia 3: 168 (1910). TYPE: *H. Hallier 3188* (holo BO!; iso L), Indonesia, Kalimantan, Amai-Ambit, 1893–1894.

Freycinetia ceramensis Martelli, Webbia 3: 169 (1910). TYPE: *G.H. de Vriese s.n.* (holo L), Indonesia, Moluccas, Seram, 1857–1861.

Freycinetia amboinensis Martelli, Webbia 3: 170 (1910). TYPE: *Teysman s.n.* (holo BO! iso L), Indonesia, Moluccas, Ambon.

Freycinetia sumatrana Hemsley var. *penangiana* B.C.Stone, Gard. Bull. Singapore 25(2): 202 (1970). TYPE: *Stone5890* (holo KLU), Malay Peninsula, Selangor, Templer Park, Kanching, June 1965.

Robust climbing *pandan*, to 20 m high. *Stem* 7–8 cm girth. *Leaves* spirally arranged in 3 ranks (tristichous); blade lanceolate-elongate, apex acuminate, margin with spines throughout, 60–135 cm long, 2.5–3.5 cm wide; adaxial surface green, glabrous; abaxial surface pale green, glabrous; auricle lobed, margin entire, pale purplish red to pale brownish yellow; leaf sheath white, purplish red in young leaf. *Infructescence* terminal, consisting of 3–4 spirally arranged cephalia. *Cephalium* elongate, 16–19 cm long, green to yellowish green; stigmas 2–4, mostly 2; pedicel 9–10 cm long, glabrous, pale yellowish green.

Distribution. Andaman Islands, Malay Peninsula, Sumatra, Java, Borneo, the Philippines, and Moluccas.

Habitat. Lowland tropical rain forest. In Bukit Baka Bukit Raya National Park commonly found at elevations lower than 500 m (Fig. 2). One specimen (*F.H. Endert 3875*, BO!) was collected from Mount Kemoel in East Kalimantan at 1200 m.

Vernacular names. *Rajak* (Dayak, Balaban dialect).

Uses. Leaves are used for baskets, mats and handicrafts.

Notes. The differences between *F. sumatrana* and the taxa listed above in the synonymy are slight and merely in leaf dimensions, cephalia size, colour of bracts, appearance of auricles, pedicel surface, and stigma number.

The possession of lobed auricles is a more important feature that distinguishes this species, as acknowledged previously by Stone (1968), who newly proposed the section, *Auriculifoliae* based on this character. A year later, Stone (1969) excluded *F. loheri* and *F. vidalii* from the section based on the fact that neither of these two species actually possessed lobed auricles. In the same publication *F. auriculata* was placed as a synonym of *F. sumatrana*. Finally, *F. valida* was included into synonymy (Stone 1970a).

The present study supports Stone in placing *F. auriculata* and *F. valida* as synonyms of *F. sumatrana*. Despite no information concerning bract colour and the relatively smaller size of the cephalium, there is no significant difference between *F. auriculata* and *F. sumatrana*.

For *F. valida*, Ridley (1907; 1925) did not mention anything about the bract colour. Only a brief note on the female bract was given, which was described as leaf-like and not coloured. We interpret "not coloured" as white, so that is not different from *F. sumatrana*. Actually, Ridley (1925) himself noted that *F. valida* is very near to *F. sumatrana*.

Regardless of the immature state of the cephalia, the observations made on the types indicate that there is no single decisive morphological character that can be used to distinguish *F. amboinensis* or *F. lucida* from *F. sumatrana*.

The placement of *F. amboinensis* as synonym has a further consequence that *F. sumatrana* is now found in the Moluccas, particularly in Ambon and Halmahera

Fig. 2. *Freycinetia sumatrana* Hemsley from Bukit Baka Bukit Raya National Park. **A.** Robust habit with terminal infructescence. **B.** Infructescence of four elongate-ellipsoidal cephalia. Photos: A.P. Keim, Rugayah & H. Rustiami.

Islands; thus new records of *F. sumatrana* for the two islands. The presence of *F. sumatrana* in the Moluccas is also supported by the placement of *F. ceramensis* into its synonymy. Although *F. ceramensis* possesses auricles with more pronounced spines (Fig. 3), this is insufficient for distinction from *F. sumatrana*. Observations made on specimens recently collected from Seram, an island within the Moluccas Archipelago just north of Ambon (Keim et al. 2008) indicate that the spines vary from minute to apparent even in the same branch. Auricles with minute spines are usually observed on younger leaves (i.e., the terminal part of the branch), whereas auricles with larger spines are found on older leaves. Prior to this placement *F. ceramensis* was known as an endemic of Seram Island; so now *F. sumatrana* is also newly recorded for the island.

The placement of two Eastern Malesian species (*F. amboinensis* and *F. ceramensis*) into the synonymy of *F. sumatrana* has the consequence that the species is now recognised as one of the most widespread species of the genus in Malesia, occupying both western and eastern parts. The other such species is *F. scandens*.

Stone (1970b) described the smaller overall dimensions and "entire auricle" as two important characters that distinguish *F. lucida* from *F. sumatrana*. That description of the auricle does not agree with the protologue (Martelli 1910) that clearly described the auricle as with minute spines (original text: "*ad margines crebre et minute fimbriato-denticulatis*"). The present study is in favour of Martelli; thus, the possession of spiny auricles helps place *F. lucida* in the synonymy of *F. sumatrana*.

Stone (1970a) identified a specimen collected from the top of Mount Beratus (altitude 1200 m) in South Kalimantan, *W. Meijer 904* (BO! with duplicate at L) as *F. lucida*. This specimen has now been determined as *F. sumatrana*, and marks the first record of *F. sumatrana* in the Indonesian part of Borneo (Kalimantan). The collections made in this present study support the identification of the species in Kalimantan. Previously *F. sumatrana* was only known from Sarawak and Sabah (Stone 1970a). As a consequence, *F. sumatrana* is now known to be more widely distributed throughout Borneo. A specimen (*F.H. Endert 3875*) was also collected from 1200 m, and in Sumatra and the Malay Peninsula, the species can still be found at an altitude of approximately 1828 m (Stone 1970b).

The varietal status of *F. sumatrana* var. *penangiana* is not accepted as the slight differences in the shape and colour of the auricles mentioned by Stone (1970b) are regarded as insufficient distinction, based on observations from the Bukit Baka Bukit Raya National Park. The specimens clearly show that auricles can vary from tapered to lobed even in the same shoot (Fig. 4). There is also variation in auricle colour from bright purplish pink to light brownish yellow. Actually the variation in the type of auricle in *F. sumatrana* is not unusual.

An infructescence with 4 cephalia observed in one of the collections made for this study (*A.P. Keim 764*, BO!; Fig. 2) raises the possibility that this could be a member of the section *Polystachya*, which in Borneo is represented by a single known species, *F. kinabaluana* (Stone 1970a). However, the specimen clearly possesses a lobed auricle, a feature that is completely absent in *F. kinabaluana*. *Freycinetia kinabaluana*, on the other hand, has a lateral infructescence consisting of 5–6 cephalia. *Freycinetia*

Fig. 3. *Freycinetia ceramensis* Martelli, just recently rediscovered and collected from Ceram Island in the Moluccas (Keim et al. 2008). **A.** Robust habit and climbing to more than 20 m high. **B.** Ternate staminate inflorescences (the bracts are pale yellow and basally tinged reddish purple) that are obviously simlar to those of *F. sumatrana*. **C.** Infructescences, here binate but mostly ternate. **D.** The distinctive lobed auricles with spines on the margins. The characters shown in these pictures are regarded as clearly supporting the placement of *F. ceramensis* into the synonymy of *F. sumatrana*. Photos: A.P. Keim & S. Susiarti.

sumatrana always has terminal infructescences and has never been reported having more than 4 cephalia in one infructescence. Stone (1970c) notes that *F. sumatrana* in the Malay Peninsula has 3–4 cephalia per infructecence, and we know of at least one collection with 4 cephalia, *Endert 3875* (BO! duplicate at L), which was collected from Sumatra.

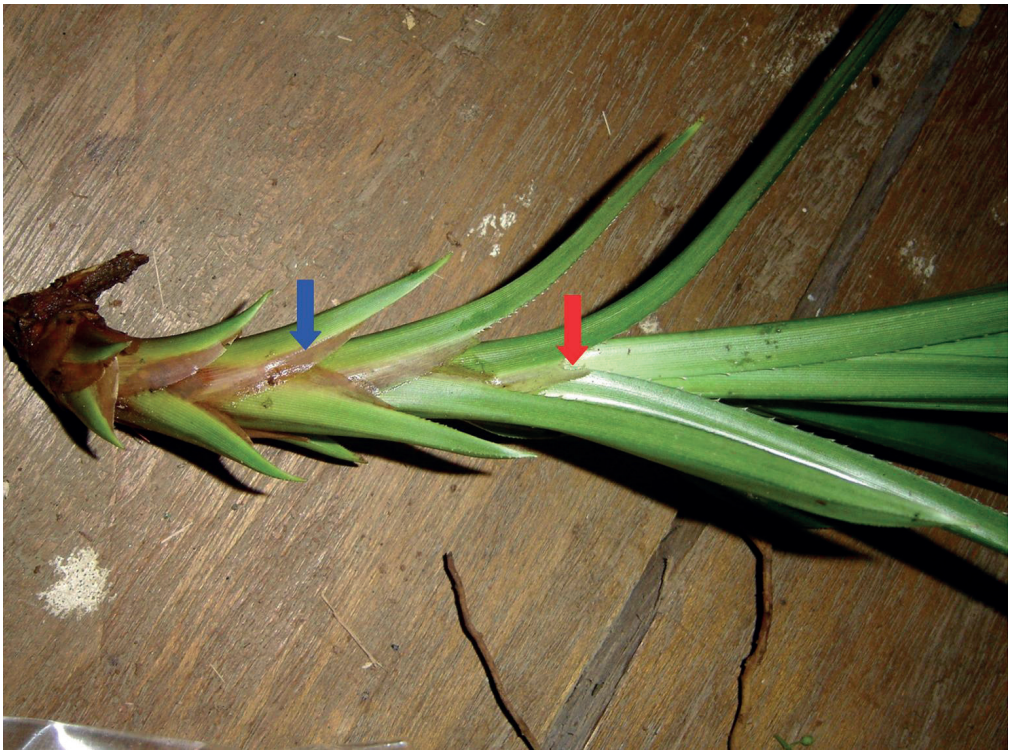

Fig. 4. Auricle variation in *F. sumatrana* from Bukit Baka Bukit Raya National Park. Tapered (left arrow) and lobed (right arrow) auricles can be found in the same young shoot (auricles are purplish pink in fresh specimens, but on mature branches or stems, brownish yellow ones are more common). Photo: A.P. Keim, Rugayah & H. Rustiami.

Numerous specimens from Java kept in BO that were previously labelled *F. valida* had been identified by Stone as *F. sumatrana*. Based on this, Stone (1972) suggested the presence of the species in Java. The same specimens have been re-identified in the present study as belonging to *F. insignis* based on the fact that none of those specimens actually has the distinctive lobed auricle and information from the fieldnotes clearly mentioned deep red or pale purplish red bracts, a feature that is characteris of *F. insignis*.

The presence of the true auriculate *F. sumatrana* in Java was finally proven based on collections recently made in the Gunung Tukung Gede Nature Reserve in Banten, western Java (*T. Djarwaningsih 1499*; Djarwaningsih pers. comm., 2010; Fig. 5). This is expected, as the islands of Java and Sumatra are only separated by the

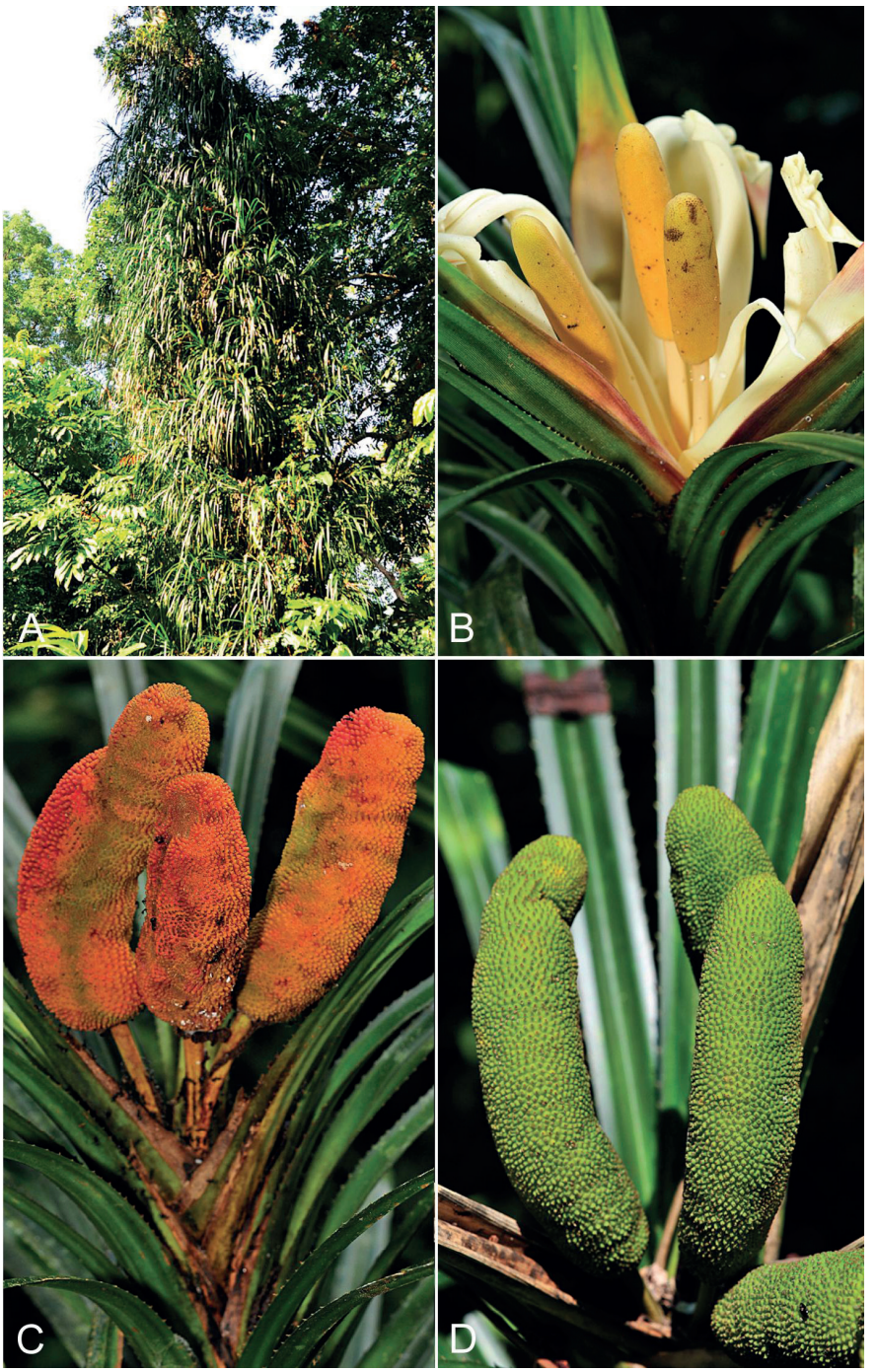

Fig. 5. *Freycinetia sumatrana* Hemsley from the Gunung Tukung Gede Nature Reserve in Banten, western Java. **A.** Habit. **B.** Young terminal ternate infructescence with the characteristic creamy white-pale yellow bracts with reddish purple-tinged basal part. **C.** Mature terminal ternate infructescence showing the distinctive lobed auricle. **D.** Young terminal quaternate infructescence, not uncommon in *F. sumatrana*. Photos: T. Djarwaningsih & A. Supriatna.

relatively narrow Sunda Strait.

Freycinetia walkeri shares many morphological similarities with *F. sumatrana*, particularly the lobed auricle and the number of stigmas. Indeed, other than the colour of the bracts, there is no substantial difference between this species and *F. sumatrana*. Stone (1975) mentioned that *F. walkeri* differs from *F. sumatrana* only in the smaller size of the cephalium (Stone wrote "fruits") and red floral bracts. Solms (1878) did not mention bract colour and it was Stone (1969; 1975) who mentioned the red bract colour based on observations he made on several non-type specimens, particularly *N. Wirawan 818*.

The BO Herbarium has two specimens identified by Stone (1975) as *F. walkeri*, *N. Wirawan 818* (BO!) and *Kostermans 24071* (BO!). *Wirawan 818* is a staminate collection from the vicinity of Ratnapura, Ceylon in 1969, in which the bract colour is noted as bright red, while *Kostermans 24071* (collected also in Ratnapura vicinity, Ceylon in 1973) is a pistillate collection with a fieldnote mentioning the fruit as dark red. Stone did visit Ceylon, but mostly worked in the Peradeniya Botanic Garden, thus he had never seen or collected *F. walkeri* in the field and was apparently using only specimens and citing from fieldnotes. The result of this current study is not in accordance with Stone in recognising the two specimens as *F. walkeri*. Neither has the distinctive lobed auricle, and the specimens are unlikely to be *F. walkeri*. Therefore, Stone's description of the bract colour in *F. walkeri* as red is considered doubtful. Until better specimens become available *F. walkeri* is regarded as a distinct species but closely allied to *F. sumatrana*. Further study is still required. When the matter of bract colour is resolved, *F. sumatrana* is likely to become a synonym of *F. walkeri* based on the law of priority.

Specimens examined: INDONESIA. **West Kalimantan**, Amai-Ambit, 1893–1894, *H. Hallier 3188* (holo BO! iso L); Sungai Betas Dalam, 29 Apr 2006, *A.P. Keim 757* (BO!); Bukit Siman, Camp 35, 30 Apr 2006, *A.P. Keim 764* (BO!); **Central Kalimantan**, Area Bukit Raya, Km 44, Sungai Wah, Kasongan, Sinamang Mentikay, 1 May 2006, *A.P. Keim 766* (BO!); **East Kalimantan**, Mount Kemoel, Km 47, 10 Oct 1925, *F.H. Endert 3875* (BO!); Nunukan Island, N of Tarakan, Nov 1953, *W. Meijer 2163* (BO!); **South Kalimantan**, Bandjarmasin-Martapoera, Km 14, 12 Oct 1939, *B. Polak 494* (BO!); **Moluccas**, Ambon, *Teysman s.n.* (holo BO! iso L); **West Java**, Banten, Gunung Tukung Gede Nature Reserve, Cikolelet, 02 Oct 2009, *T. Djarwaningsih 1499* (BO!).

3. *Freycinetia* cf. ***tenuis*** Solms (Fig. 6)

Slender climbing *pandan*, up to 40 m. *Leaves* small, short, lanceolate-elongate, c. 6 cm long, 0.5 cm wide, apex acuminate and with minute spines, spines only on terminal and basal parts of leaf; adaxial surface green, glabrous; abaxial surface pale green, glabrous; leaf sheath deep purplish red, apical part with minute spines; auricle tapered, small, deep purplish green to red.

Distribution. Sumatra and Borneo. In the Bukit Baka Bukit Raya National Park the species was only found at one site and appears to be rare.

Habitat. Lowland tropical rain forest. In Bukit Baka Bukit Raya, it is found in a rather open area close to a creek.

Vernacular name and uses. Not recorded.

Notes. Unfortunately the only specimen collected in this current study (*AK 769*) is a sterile one. Identification of this material as possibly belonging to *F. tenuis* is based on the habit, leaf dimensions, and colouration of auricles, which are in accordance with the protologue (Solms 1879; see also Warburg 1900), particularly the distinctive deep purplish red leaf sheath and tapered auricles. *Freycinetia tenuis* is the smallest member of the genus in Borneo. The species was recorded for Borneo by Stone (1970a) in Sabah, North Borneo; thus, as in the case of *F. sumatrana*, the presence of *F. tenuis* in Borneo strengthens the biogeographical link between Sumatra and Borneo (i.e., Sahulland).

Specimens examined: INDONESIA. **Central Kalimantan**, Kantor PT Sari Bumi Kusuma Timber, Katingan Hulu, Kota Waringin Timur, 1 May 2006, *A.P. Keim 769* (BO!); **South Kalimantan**, Bandjermasin to Martapoera, Km 14, 12 Oct 1939, *B. Polak 513* (A, BO! L).

Fig. 6. *Freycinetia* cf. *tenuis* Solms (*A.P. Keim 769*) showing the very slender habit and small lanceolate-elongate leaves; the overlapping leaf sheaths along the stem are a characteristic deep purplish red in live specimens, with tapered auricles. Photo: A.P. Keim, Rugayah & H. Rustiami.

Pandanus

1. *Pandanus aristatus* Martelli, Webbia 4 (1): 6 (1913). TYPE: *H. Hallier 2250* (holo BO! iso FI), Indonesia, Kalimantan (then Dutch Borneo), Sungai Djemala, Gunung Kelam, 1893–1894. (Fig. 7)

Pandanus andersonii H.St.John, Pacific Sci. 15(4): 576 (1961). TYPE: *J.A.R. Anderson s.n.* (holo SAR), Malaysia, Sarawak, Lawas, Kayangeran Forest Reserve, Nov 1960. PARATYPE: *J.A.R. Anderson S2815* (SAR), Malaysia, Sarawak, Loba Kabang Protected Forest, 16 May 1954.

Robust shrubby *pandan*, 2–3 m high. *Prop roots* absent. *Stem* very short (1.5–2 cm) or stemless. *Leaves* in a rosette of 20 or more, spirally arranged in 3 ranks (tristichous); each leaf lanceolate-elongate, 250–350 cm long, 4–10 cm wide, stiff, apex acute to acuminate, margin with obvious spines throughout the length; adaxial surface green, glabrous, main vein apparent, adaxial ventral pleats not observed or present; abaxial surface pale green, glabrous, main vein obvious, recurved spines obvious, very sharp; leaf sheath white to yellowish white. *Staminate inflorescence* terminal, creamy white, 107–115 cm long; rachis 44–66 cm long, with 8–10 rachillae; rachilla elongate, 28–30 cm long; peduncle 68–70 cm long, glabrous; bracts 13, each 10–140 cm long, persistent, boat shaped, pale brown. *Staminate flower* pale creamy yellow, odorous; stamens numerous. *Pistillate inflorescence* terminal, ascending; peduncle 10 cm long, diameter 2.5 cm, obtusely trigonous. *Infructescence* terminal, pendulous, 15–20 cm long, with a solitary cephalium or a spike consisting of 2 to 3 unequally sized cephalia; peduncle c. 8.5 cm. *Cephalium* elongate-ellipsoid or broadly ellipsoid to subglobose, obtusely trigonous, light to dark brown, 8.5–14 cm, c. 3 cm diameter, consists of numerous drupes. *Drupe* oblong-ellipsoid, 35–80 mm long, 6–7 mm wide, 5–6 mm thick, fusiform, 5–6 angled; pileus conical, 13–17 mm long, gradually narrowed into the style; style 5–7 mm long, subulate, arcuate, beaked, glabrous; stigma 4–5 mm long, appointed, needle-like and sharp.

Distribution. Borneo.

Habitat. Peat swamp forest, riversides and riverine forest. In villages close to the Bukit Baka Bukit Raya National Park, this species is cultivated. *Pandanus aristatus* is the most abundant species in the National Park and surrounding areas, particularly in the peat swamp forests.

Vernacular name. Kajak (Dayak, Belaban dialect).

Uses. Leaves used for baskets, mats, bags, hats, and handicrafts.

Notes. Previously *P. aristatus* was known only from the type (*H. Hallier 2250*), which is a staminate collection. As the classification of the Pandanaceae is basically based

Fig. 7. *Pandanus aristatus* Martelli. **A.** Robust-shrubby and stemless habit with large male inflorescence, beside the Nenga Pinoh-Sintang Highway, West Kalimantan. **B.** Staminate inflorescence at anthesis showing numerous minute, crowded, pale creamy yellow male flowers and layers of pale brown bracts; same venue as A. **C.** Within the Bukit Baka Bukit Raya National Park, *P. aristatus* is common along riversides. Photos: A.P. Keim & H. Rustiami.

on pistillate characters, the identity of *P. aristatus* was thus unresolved. Pistillate material is apparently rare, as even the present study has only succeeded in obtaining five staminate collections from various area and habitats within the National Park to the Nenga Pinoh-Sintang highway (Fig. 7), including the Gunung Kelam Ecopark (the type locality); these were from riversides to peat swamp forests or open areas. These findings not only increase the known distribution of the species, but also add new information on preferred habitats. A visit to the type location was also without success as individuals observed were not in flower or fruit. Nonetheless, the comparison between these five specimens and the holotype available at BO indicate that they undoubtedly belong to *P. aristatus*.

Apart from the lack of pistillate material in *P. aristatus* and staminate material in *P. andersonii*, no other significant morphological character could be used to differentiate *P. andersonii* from *P. aristatus*. Also, besides sharing the same habit as robust shrubby *pandan* with extremely short stems (less than 50 cm high); the two taxa also inhabit the same habitat, peat swamp forests. St. John (1961) described *P. andersonii* as the dominant species in peat swamp areas. Stone (1993) even stated that *P. andersonii* was a distinctive species of freshwater swamp forest, as is the case with *P. aristatus*. Now that the pistillate data for *P. aristatus* has become available; it is clear that *P. aristatus* belongs to subgenus *Acrostigma* and section *Acrostigma*. A specimen from South Kalimantan (*J. Dransfield & D. Saerudin 2102*) has been identified by the senior author as belonging to *P. aristatus*. *Pandanus aristatus* is regarded as one of the three main species in the peat swamps of Borneo, the other two being *P. atrocarpus* and *P. yvanii*.

Specimens examined: INDONESIA. **West Kalimantan**, Kampung Belaban, 1 May 2006, *A.P. Keim 768* (BO!); Km 35, Kampung Belaban, 3 May 2006, *A.P. Keim 776* (BO!); Nenga Pinoh-Sintang, Kampung Pandan, 5 May 2006, *A.P. Keim 778* (BO!); **Central Kalimantan**, Katingan Hulu, Sungai Sahaur, Km 54, 2 May 2006, *A.P. Keim 771* (BO!); *A.P. Keim 772* (BO!); **South Kalimantan**, Djaro Dam, Muara Uja, 11 Nov 1971, *J. Dransfield & D. Saerudin 2102* (BO! KLU, L).

2. *Pandanus discostigma* Martelli, Webbia 4 (1): 12 (1913). TYPE: *Jaheri 662* (holo BO!), Indonesia, Central-West Kalimantan, Maguc River, Nieuwenhuis Expeditie, 1896–1897. (Fig. 8 & 9)

Pandanus matthewsii Merrill, J. Str. Br. Roy. Asiat. Soc. 85: 153 (1922). TYPE: *Ramos 1321* (holo PNH† iso BO!), Malaysia, Sabah, Sandakan.

Slender clustered shrubby *pandan*, 0.5–1 m high. *Prop roots* very short, not obvious. *Stem* very short, not obvious, brown to reddish brown. *Leaves* in a rosette, spirally arranged in 3 ranks (tristichous); each lanceolate-elongate, c. 56 cm long, c. 1.5 cm wide, apex acuminate, margin with minute spines throughout the length; adaxial surface green, glabrous, adaxial ventral pleats not obvious; abaxial surface pale green,

Fig. 8. *Pandanus discostigma* Martelli. **A.** Slender clustered habit of plants beside the Betas Dalam River in the Bukit Baka Bukit Raya National Park, with other populations found submerged. **B.** Young solitary and terminal pale yellow cephalium. Photos: A.P. Keim, Rugayah & R. Asmarayani.

glabrous, recurved spines present; leaf sheath purplish red. *Infructescence* terminal, solitary. *Cephalium* globose, c. 9 cm long, 11.5–16.5 cm in circumference, pale creamy yellow when young, turning brownish yellow when mature, cephalium consists of numerous creamy yellow drupes; style short; stigma depressed to form a disc-like structure, brown.

Distribution. Borneo.

Habitat. Riversides in lowland tropical rain forest. In the National Park, the species occurs sparsely along riversides (Fig. 8) and plants are sometimes submerged.

Vernacular name. Ries (Dayak, Belaban dialect).

Uses. Cephalium and leaf are used to cure (stop) hyperurination in children.

Notes. Prior to this, *P. discostigma* was only known from the type, (Martelli 1913; see also Stone 1993). Although the exact location of Maguc River remains unknown, the Nieuwenhuis expedition covered most of the central-western part of Kalimantan, including the numerous tributaries that run through Menikung and Melawi. Thus, it is possible that the locations where the collections were made during the present study were in the vicinity of the Maguc River.

Our study agrees with Stone that *P. matthewsii* is a synonym of *P. discostigma*, based on the unique disc-like stigma (Fig. 9) and also comparison with the two collections of *P. matthewsii* available at BO (*Endert 4904* and *B.C. Stone 6690*). *P. discostigma* is now considered a widespread species found along the rivers of lowland forests in Borneo.

Specimens examined: INDONESIA. **West Kalimantan**, Sungai Betas Dalam, Km 37, Menikung, Melawi, 28 Apr 2006, *A.P. Keim 751* (BO!); Bukit Siman, Sungai Ela, 30 Apr 2006, *A.P. Keim 765* (BO!); **Central Kalimantan**, Maguc River, Nieuwenhuis Expedition, 1896–1897, *Jaheri 662* (holo BO! iso L); Kuala Kuangan, Sei Sampit, 27 Feb 1982, *J.J. Afriastini 428* (BO!); **East Kalimantan**, West Koetai, Km 19, Poekoes Hill, 14 Nov 1925, *F.H. Endert 4904* (BO!) — MALAYSIA. **Sabah**, Sandakan, *Ramos 1321* (PNH† iso BO!); Leila FR, 17 Mar 1967, *B.C. Stone 6683* (BO!).

3. *Pandanus epiphyticus* Martelli, Nuovi. Bull. Soc. Bot. Ital. 11: 304 (1904). TYPE: *Beccari s.n.* (holo FI), Malaysia, Sarawak, Mt. Mattang, near Kuching, Jun 1866. (Fig. 10)

Pandanus trigonus H.St.John, Pacific Sci. 19(1): 98, f. 207 (1965). TYPE: *H.N. Ridley s.n.* (holo K; iso SING), Malaysia, Sarawak, Bau. PARATYPE: *A.D.E. Elmer 21022* (BO! C, M, NY, PNH† SING), Malaysia, Sabah (then British North Borneo), Tawao, Oct 1922–Mar 1923.

Fig. 9. *Pandanus discostigma* Martelli has a fairly globose cephalium consisting of numerous drupes with distinctive disc-like stigmas that characterise this species, a character which supports the placement of *P. matthewsii* into its synonymy. Photo: A.P. Keim, Rugayah & R. Asmarayani.

Epiphytic *pandan*, c. 2 m high. *Leaves* in rosette, spirally arranged in 3 ranks (tristichous); each leaf lanceolate-elongate, 262–300 cm long, 9–10 cm wide, apex acuminate, margin with spines throughout the length; adaxial surface deep green, glabrous, adaxial ventral pleats not observed; abaxial surface pale green, glabrous, basal part with spines, recurved spines obvious; leaf sheath white and yellow. *Infructescence* terminal, 60–65 cm long, a spike consisting of 10 cephalia, cephalia not uniform in size, the most terminal one being the smallest; rachis c. 38 cm long, glabrous; peduncle 22–27 cm long, glabrous; bracts persistent. *Cephalium* elongate ellipsoidal, sausage-like, noticeably trigonous, yellowish white to dull greyish white, consisting of numerous compactly arranged drupes; style very short or sessile, not pointed; stigma short, not pointed, deep brown.

Distribution. Borneo, Malay Peninsula, and presumably also in Sumatra. Stone (1993) mentioned that the species used to be fairly frequently seen in Johor, Malay Peninsula before severe deforestration took place. One of the authors of this current study (APK) reported seeing *P. epiphyticus* in the peat swamp forest of Pelalawan in Riau, Sumatra in 2007, but no collection was made.

Fig. 10. *Pandanus epiphyticus* Martelli. An infructescence spike consisting of 10 elongate ellipsoid and trigonous, dull greyish cephalia. Photo: A.P. Keim & R. Asmarayani.

Habitat. This species is an epiphytic plant in lowland tropical rain forest, commonly found along gorges or riversides. In Bukit Baka Bukit Raya National Park, it is abundantly found in lowland forest, especially in the foot hills or close to rivers.

Vernacular name. Kajak (Dayak, Belaban dialect).

Uses. Leaves are used for thatching. Local people reported that the cephalium is eaten by orang utan and gibbons.

Notes. The presence of *P. epiphyticus* in Indonesian Borneo (Kalimantan) was reported by Stone (1993) based on a single collection, *Kostermans 9115* (BO! duplicate at L; see Stone 1993) from Nunukan, East Kalimantan. Nunukan is an island off the mainland East Kalimantan, so the present study confirms the presence of this species on the mainland.

Specimens examined: INDONESIA. **West Kalimantan**, Km 37, Sungai Betas Dalam, Menukung, Melawi, 28 Apr 2006, *A.P. Keim 747* (BO!); **East Kalimantan**, Nunukan, Northern part, 19 Dec 1953, *A. Kostermans 9115* (BO!) — MALAYSIA. **Sabah**, Tawao, Elphinstone Province, Oct 1922–Mar 1923, *A.D.E. Elmer 20490* (BO! PNH†); *A.D.E. Elmer 21022* (para BO! C, M, NY, PNH† SING).

4. *Pandanus pachyphyllus* Merrill, J. Str. Br. Roy. Asiat. Soc. 85: 154 (1922). TYPE: *Ramos 1541* (holo PNH† iso BO! A), Malaysia, Sabah, Sandakan. (Fig. 11 & 12)

Pandanus apicalis H.St.John, Pac. Sci. 22: 523, f. 276 (1968). TYPE: *Motley 1247* (holo K; iso BO! SING), Indonesia, Kalimantan (then Dutch Borneo), Banjarmasin, 1857–1858.

Robust shrubby *pandan*, 1–1.5 m high. *Prop roots* present, very short. *Stem* very short, not obvious. *Leaves* in a rosette, spirally arranged in 3 ranks (tristichous), 20–more leaves in a rosette; each leaf lanceolate-elongate, 205–206 cm long, c. 3.5 cm wide, apex acuminate, margin with obvious spines throughout the length; adaxial surface deep green, glabrous, adaxial ventral pleats present; abaxial surface pale green, glabrous, recurved spines present, obvious, very sharp. *Infructescence* terminal, solitary, c. 10 cm long; rachis c. 5 cm long, glabrous; peduncle c. 5 cm long, glabrous. *Cephalium* globose, yellowish green; style pointed, ascending; stigma pointed, sharp; in general appearance the cephalium superficially resembles the fruit of *durian* (*Durio zibethinus*, Malvaceae).

Distribution. Borneo.

Habitat. Foothills and gorges in lowland tropical rain forest. In Bukit Baka Bukit Raya National Park, the species is commonly found in gorges. Although abundant, most were not fruiting.

Fig. 11. *Pandanus pachyphyllus* Merrill: a robust shrubby pandan with a very short, almost invisible, stem, and a terminal infructescence with a globose cephalium. Photo: A.P. Keim, Rugayah & H. Rustiami.

Vernacular name. Selinsik (Dayak, Belaban dialect).

Uses. Leaves are used for mats.

Notes. The record of *P. pachyphyllus* in Kalimantan was only based on the type of *P. apicalis*, which was placed as a synonym of *P. pachyphyllus* by Stone (1978). Observations made on the types of *P. apicalis* and *P. pachyphyllus* at BO, and the collection made in this current study, indicate that there is no substantial difference. The distribution of this species could be more widespread in Borneo than previously thought.

Specimen examined: INDONESIA. **Central Kalimantan**, Km 44, Sungai Wah, Kota Waringin Timur, Kasongan, Sinamang Mentikay, 1 May 2006, *A.P. Keim 767* (BO!).

Fig. 12. *Pandanus pachyphyllus*: a terminal infructescence with extremely short peduncle and solitary yellowish green *durian*-like cephalium. This photo also shows the conspicuous spines all along the leaf margin. Photo: A.P. Keim, Rugayah & H. Rustiami.

5. *Pandanus yvanii* Solms, Linnaea 42: 20 (1878). TYPE: *Yvan s.n.* (holo Herb. Delessert), Malaysia, Malay Peninsula, Malacca. (Fig. 13–16)

Pandanus motleyanus Solms, Linnaea 42: 21 (1878). SYNTYPES: *Korthals s.n.* (L), Indonesia, Kalimantan (then Dutch Borneo); *Motley 1057* (K), Malaysia, North Borneo.

Pandanus ridleyi Martelli, Bull. Soc. Bot. Ital. (1904) 303. SYNTYPES: *Cantley s.n.* (K, SING), Malaysia, Sungai Ujong, Gunong Berumban; *Kunstler s.n.* (K, SING), Malaysia, Perak.

Pandanus brevifolius Martelli, Bull. Soc. Bot. Ital. (1914) 302. TYPE: *Beccari PB 273* (holo FI), Malaysia, Sarawak, Siul near Kuching.

Pandanus sigmoideus H.St.John ex B.C. Stone, Fed. Mus. J. 17: 124, f. 15 (1972). TYPE: *Brunig S12384* (holo L; iso K, SAR), Malaysia, Sarawak, Marudi, Baram, Lobok Pasir, Apr 1961.

Slender clustered tree *pandan*, 2–3 m high, commonly forming dense thickets. *Prop roots* short, 20 cm or less. *Stem* unbranched (*A.P. Keim 777*) or branched in the terminal part (*A.P. Keim 779*), slender, older bark dark purplish brown, spiny, diameter c. 1.5 cm. *Leaves* in a rosette, spirally arranged in 3 ranks (tristichous); each lanceolate-elongate, 40–45 cm long, 1–1.5 cm wide, apex acute to acuminate, margin with spines throughout the length; adaxial surface green, glabrous, adaxial ventral pleats absent; abaxial surface pale green, glabrous, recurved spines present, small, brown; leaf sheath yellowish green to yellow. *Infructescence* solitary, terminal, 17–20.5 cm long; bracts persistent, each 10–28 cm long, c. 2.5 cm wide, brown to deep brown. *Cephalium* ellipsoidal elongated, creamy yellow to dull creamy yellow or dull yellowish orange (*A.P. Keim 779*), 7.5–11 cm long, 13–14 cm in circumference; style ascending, needle-like, 2–2.5 mm long; stigma pointed, sharp.

Distribution. Malay Peninsula, Sumatra (including Bangka Island), and Borneo. Previously, *P. yvanii* was known as an endemic species of Malacca in the Malay Peninsula; thus we newly record the species for Sumatra, Bangka Island, and Borneo. In Bukit Baka Bukit Raya National Park, the species is hardly noticeable at higher altitudes but in the lowland open areas in full sun, and peat swamps in the vicinity of the National Park, the species is abundant (Fig. 13) and this is in accordance with Stone (1966).

Habitat. Peat swamps, where it usually forms dense thickets. *Pandanus yvanii* sometimes grows along riversides or in riverine forest.

Vernacular name. Rasau or *Rassau* (Dayak, Nanga Pinoh).

Uses. Not recorded.

Notes. Pandanus yvanii is a common species of peat swamp forests in the Malay Peninsula, Sumatra and Borneo (Stone 1993, as *P. motleyanus*). In a number of places in these areas, the species is widely known by the vernacular name *rassau*. This vernacular name was first recorded by Kurz (see Kurz ex Miquel 1866) for *P. helicopus* Kurz ex Miq.; however, a string of morphologically similar taxa have been published

Fig. 13. *Pandanus yvanii* Solms. **A.** Collector holding a severed stem in Nanga Pinoh. **B.** A dense thicket of stems. **C.** Stems with sharp nodules on the outer surface (and a characteristic deep reddish brown when fresh). **D.** A solitary, terminal elongate-ellipsoidal young cephalium (creamy yellow when fresh) with persistent deep brown bracts; notice the obvious dark spines along the leaf margin. Photos: A.P. Keim, Rugayah & H. Rustiami.

with almost all bearing "rassau" as one of their vernacular names. The classic case involves *P. helicopus*, *P. motleyanus*, and *P. yvanii*, which share a common habitat, peat swamps.

Unlike *P. helicopus*, the protologues of both *P. motleyanus* and *P. yvanii* (Solms 1878) describe fewer morphological details. The situation is worsened by the fact that instead of comparing *P. motleyanus* or *P. yvanii* with *P. helicopus*, Solms (1878) compared *P. motleyanus* only with *P. yvanii*, which was also published as a new species in the same publication, only a page earlier. The identity of *P. yvanii* as a species in its own right was first questioned by Hooker (1894), who described the morphological characters given in the protologue of *P. yvanii* as being worthless for the identification of a species of *Pandanus*. Apparently due to the limitted specimens available, Warburg (1900) distinguished *P. motleyanus* from *P. yvanii* based only on a minor morphological character, the colouration of the leaf spines (*P. motleyanus* has dark brown leaf spines; *P. yvanii*, light brown) and distribution (*P. motleyanus* in Borneo, *P. yvanii* in Malacca in the Malay Peninsula). Warburg numbered the two species one after the other (*P. yvanii* was 107, *P. motleyanus* was 108), thus suggesting their close affinity. Ridley (1925) followed Hooker in arguing that *P. yvanii* was too imperfectly described to identify the species and placed it as a synonym of Martelli's *P. ridleyi*.

Prior to the present study, *P. yvanii* was known only from a very few number of localities. BO has a specimen collected by Teijsmann in Muntok, Bangka Island (*Teijsmann s.n.*, BO! Fig. 14 & 15), which was named *P. yvanii* by Stone, but never published. This specimen possesses many morphological characters that match the protologue of *P. yvanii*, particularly the leaf and cephalium dimensions, and also the appearance of the style. We now have a firm record for the first time of its presence outside the type locality.

In contrast to Ridley (1925), this study places *P. ridleyi* in the synonymy of *P. yvanii*. Although there is a noticeable difference in the length of the cephalia, it is still within the range of *P. yvanii* and the synonymous *P. motleyanus*.

We place *P. sigmoideus* as a synonym of *P. yvanii*. St. John & Stone (1972) and Stone (1993) regarded *P. sigmoideus* as a distinct species from the then *P. motleyanus* based on the nature of leaf spines (reduced or obsolute, at most 1 mm long in *P. sigmoideus*, compared to developed, 1–2 mm long in *P. motleyanus*) and pollen surface (smooth in *P. sigmoideus*, minutely spinulose in *P. motleyanus*). We regard these two characters as less important and not discrete.

Martelli (1914) mentioned four distinctive characters of *P. brevifolius*: low shrub habit, brownish red stem, small leaves (hence the epithet "brevifolius"), and glabrous leaf margin. Observations made on specimens from Bukit Baka Bukit Raya and *Teijsmann s.n.* (BO! Fig. 14 & 15) indicate that those characters are also found in *P. yvanii*. Indeed, in the field *P. yvanii* can be seen as low shrubs with short brownish red stems, small narrowed glabrous leaves and subglobose cephalia; thus there is not sufficient reason to place *P. brevifolius* as a species on its own and it is regarded here as a synonym of *P. yvanii*.

Fig. 14. *Pandanus yvanii Solms* (*Teijsmann s.n.* "Muntok, Bangka", BO). This specimen shows two characters that match the protologue of *P. brevifolius*: small leaves without spines along the margin (see Martelli 1904). Photo: A.P. Keim.

Fig. 15. *Pandanus yvanii Solms* (*Teijsmann s.n.* "Muntok, Bangka", BO). This specimen shows two characters that match the protologue of *P. brevifolius* (see Martelli 1904): the deep reddish brown slender stem and small cephalium (apparently immature). Photo: A.P. Keim.

This present study does not agree with Stone (1993) in assigning *P. fruticosus* as a synonym of *P. motleyanus*. *Pandanus fruticosus* shares more similarities with *P. helicopus* in being a more robust pandan with longer (up to 5–10 mm long) drupes; whereas *P. motleyi* (or *P. yvanii*) is a more slender *pandan* with small (3 mm long) drupes. We regard *P. fruticosus* as a synonym of *P. helicopus*. Stone (1993), however, did recognise *P. yvanii* (then *P. motleyanus*) and *P. helicopus* as two distinct species.

Despite both being found in peat swamps, *P. yvanii* and *P. helicopus* occupy different ecological niches (Partomihardjo 2010 *pers. comm.*). *Pandanus yvanii* is commonly found forming dense thickets further inland in the peat swamps and has never been found on open riverbanks. On the contrary, *P. helicopus* is always found forming dense thickets along open riverbanks and streamsides in peat swamp areas and has never been found further in the forest. In other words, the two species are not fully cohabitant.

Also, the two species can almost instantly be identified in the field. *Pandanus yvanii* is a low shrub, possessing deep purplish brown stems, wide leaf scars, and bright yellow to yellowish green leafsheaths (Fig. 16). On the contrary, *P. helicopus* is larger, has pale brown stems, narrow leaf scars, and eye-catching bright orange-red leaf sheaths (Fig. 16).

Pandanus pumilus H.St.John shares many morphological characters and a habitat preference with *P. yvanii*; however, *P. pumilus* possesses a spike-like infructescence consisting of 4–5 cephalia (St. John 1961). *Pandanus yvanii*, so far as known, always has an infructescence with a solitary cephalium. The possibility of a variable pistillate inflorescence or infructescence structure needs to be further investigated. Until better data becomes available, we merely suggest that *P. pumilus* has a close affinity with *P. yvanii*.

Specimens examined: INDONESIA. **West Kalimantan**, Soengei Kelassar, 1893–1894, *H. Hallier 1549* (BO! L); West Koetei, 30 Nov 1925, *F.H. Endert 5413* (BO! L); Pontianak, Sei Raja, 12 Mar 1931, *Mondi 9* (BO! L); Pontianak, Kampoeng Mandor, 23 Dec 1931, *J.P. Schuitemaker 139* (BO! L); Mampawah, Mengkatja, 29 Sep 1948, *M. Enoh 399* (BO! K, L); Nanga Pinoh to Sintang, Kampung Pandan, 5 May 2006, *A.P. Keim 777* (BO!); *A.P. Keim 779* (BO!); *A.P. Keim 780* (BO!); **Central Kalimantan**, Sampit, 22 Aug 1940, *P. Buwalda 7647* (BO! L); Kapuas, Tewah, Desa Kasintu, 13 Oct 1999, *S. Riswan et al. TWH 025* (BO!); **East Kalimantan**, Nunukan Island, Tarakan, Samenggaris, Dec 1912, *Amdjah 1077* (BO!); Samarinda, Sungai Mukun, near Sango-Sango, 05 Aug 1952, *W. Meijer 1100* (BO!); Nunukan Island, N of Tarakan, SE of Kampong, 22 Nov 1953, *W. Meijer 2303* (A, BO! K, L, P, PNH, SING); Nov–Dec 1953, *W. Meijer 2308* (BO!); Nov–Dec 1953, *W. Meijer 2351* (BO!, L); 13 Dec 1953, *W. Meijer 2479* (BO!); West Kutei, Mount Palimasan near Tabang, on Belajan River, 09 Sep 1956, *A. Kostermans 12823* (BO!, L); **South Kalimantan**, Bandjarmasin-Martapoera, Km 19, 04 Oct 1939, *Polak 439* (BO!); Banjarmasin to Martapura, Km 22, 26 Jun 1974, *J. Dransfield & G. Hambali 4312* (BO!, L); 26 Jun 1974, *J. Dransfield & G. Hambali 4313* (BO!, L); **Sumatra**, Bangka Island, Muntok, *Teijsmann s.n.* (BO!).

Fig. 16. *Pandanus yvanii* (**A**) and *P. helicopus* (**B**) compared. *Pandanus yvanii* individuals are more slender compared to *P. helicopus* (photo taken in the Sebangau National Park, Central Kalimantan). Stems of *P. yvanii* are characteristically deep reddish brown with wider leaf scars; those of *P. helicopus* are bright reddish brown with distinctively narrow, dense and crowded leaf scars. The leaf sheath of *P. yvanii* is yellow or yellowish green, those in *P. helicopus* are strikingly reddish brown. Photos: A.P. Keim, Rugayah & H. Rustiami (A); E.A. Widjaja & M. Amir (B).

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