

A Review of the White-flowered *Amorphophallus* (Araceae: Thomsonieae) Species in Sarawak

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Abstract

A review of the white-flowered *Amorphophallus* species in Sarawak is presented. A total of five species are recognized, four of which belong to the Eburneus Group and are restricted to limestone, and moreover, locally endemic: *A. eburneus* Bogner (Padawan and Tebedu areas), *A. brachyphyllus* Hett. (Bau), *A. juliae* sp. nov. (Merirai) and *A. niahensis* sp. nov. (Niah). A fifth species, *Amorphophallus infundibuliformis* Hett., A. Dearden & A. Vogel, of doubtful affinity, is widespread and locally abundant on a variety of substrates excluding limestone. A key to the white-flowered species in Sarawak is presented and all species are illustrated.

Introduction

Fieldwork on forested limestone areas of Sarawak is proving remarkably productive in revealing hitherto undescribed species of *Amorphophallus*. As this paper exemplifies, even supposedly well-botanized areas can be revealed to have new taxa and, thus, it is no great surprise that when remote and not easily accessible limestone areas are scrutinized, these, too, prove to have their complement of novel species.

Batu Niah is a significant limestone formation in Miri Division, northeast Sarawak. Bukit Merirai is a smaller but more remote limestone formation on the border of Kapit and Bintulu Divisions. Both areas are geographically separated from the limestones of Mulu (Miri and Limbang Divisions) and from the isolated Bukit Sarang limestones on the Bintulu/Kapit Division border, and from areas further east in Sarawak and Sabah, as too from the complex limestone formations in western Sarawak that

have received the most attention in recent years. Fieldwork in these areas has shown that while such formations have aroid species in common, there are also for each formation, suites of closely related but morphologically distinct, presumably vicariant, local endemics. In addition to examples in the genus *Schismatoglottis* (see especially Hay and Yuzammi, 2000), and *Alocasia* (see Hay, 1998, 2000), this phenomenon is particularly well exemplified by *Amorphophallus*, in which the species on limestone in western Sarawak [*A. eburneus* Bogner (Bau limestone), *A. brachyphyllus* Hett. (Padawan limestone), and from Serian (*A. ranchanensis* Ipor, Tawan, A.Simon, Meekiong & Faud)] are mirrored in eastern Sarawak by the recently described Mulu-endemic, *A. julaiihii* Ipor, Tawan & P.C. Boyce, the two novel species here described, and thence to Sabah where *A. tinekeae* Hett. & A. Vogel is restricted to the limestone at Gua Gomontong.

The two novelties described here take to 17 the number indigenous endemic *Amorphophallus* species recorded for Borneo (see also Mayo and Widjaja, 1982; Bogner *et al.*, 1985; Bogner, 1989; Bogner and Hetterscheid, 1992; Hetterscheid, 1994; Hetterscheid and van der Ham, 2001; Ipor *et al.*, 2004, 2007). Remarkably, 15 of these species have been described within the past 30 years. Additionally, a further four species recorded for Borneo are either introduced or of doubtfully native provenance: *A. konjac* K.Koch, *A. paeoniifolius* (Dennst.) Nicolson, *A. prainii* Hook. f. and *A. muelleri* Blume.

Taxonomy

The limestone-obligate white-flowered *Amorphophallus* in Sarawak are seemingly closely related, and are currently referred to as informal Eburneus Group. The common characters, admittedly polythetic, for the Eburneus Group, are: irregularly bulging tubers, presence of corky outer tuber skin, turgid petioles, at least upper male flowers vertically aligned, inflorescence with a fishy smell at anthesis, and large (to 2 cm long) elongate fruits that, except for those of *A. titanum* (Becc.) Becc. (5-6 cm long), are the largest in the genus.

The systematic position of non-limestone *A. infundibuliformis* is unclear. The leaf, especially the intricate morphology of the petiole ornamentation, is quite different to the turgid, smooth, usually unmarked light green, rarely with smooth paler green or reddish circular markings typical of the Eburneus Group. The tuber is also markedly different and striking by the inside flesh deep red.

The use of an informal subordinate grouping is in line with the approach used in other taxonomically intractable groups (e.g., *Alocasia* G.Don., *Schismatoglottis* Zoll. & Moritzi, the Potheae Engl., and *Rhaphidophora* Hassk.), where the establishment of informal groups has become a standard

approach until such time as phylogenetic testing *can* be undertaken leading to the establishment of evolutionarily robust groups (see Boyce and Wong, 2008 for commentary on this approach). Other species in the Eburneus Group are *A. julaihii* (Mulu), *A. hottae* Bogner & Hett., and *A. palawanensis* Bogner & Hett. in the Philippines (Palawan). All except *A. hottae* are limestone obligates.

Key to the white-flowered *Amorphophallus* species in Sarawak

- 1. Petioles turgid, smooth, rachises of fully developed leaf spreading. Spadix appendix smooth, rugulose or echinate but never with hooked staminodes. Plants of limestone 2
- 1. Petioles not turgid, conspicuously white-warty, rachises of fully developed leaf ascending. Spadix appendix with conspicuous hooked staminodes. Plants of a variety of substrates but never on limestone 3. ***A. infundibuliformis***
- 2. Spadix appendix echinate. Male flowers not fused into longitudinal rows. Spathe limb reflexing during anthesis. C and N.E. Sarawak 3
- 2. Spadix appendix smooth or weakly rugulose. Male flowers fused into longitudinal rows. Spathe limb remaining erect throughout anthesis. S.W. Sarawak 4
- 3. Petioles dull pale red with strongly demarcated irregular reddish brown spots and elongated streaks. Opening of lower part of spathe strongly recurving to form a conspicuous collar *ca* 1cm wide during anthesis, spathe limb margins recurving markedly. Spadix appendix stongly echinate. Merirai 4. ***A. juliae***
- 3. Petioles pale to medium green, concolorous or very occasionally with obscure paler green circles. Opening lower part of spathe not or only minutely recurved, spathe limb incurved or planate, margins not recurving. Gua Niah 5. ***A. niahensis***
- 4. Petiole to 120 cm, long relative to the lamina diameter; lamina little divided, leaflets to 60 cm long, never petiolulate; cataphylls greyish brown. Ovaries densely congested, dark purple, stigma diameter equalling ovary. Padawan limestones 2. ***A. eburneus***
- 4. Petiole to 50 cm, very short relative to the lamina diameter; lamina much divided, leaflets to 35 cm long, terminal leaflets petiolulate; cataphylls off white. Ovaries distant, pale purple, stigma diameter distinctly smaller than ovary. Bau limestones 1. ***A. brachyphyllus***

1. *Amorphophallus brachyphyllus* Hett., Blumea 46(2): 258 (2001). – **Type:** Malaysia, Sarawak, Kuching, Division, Bau district, exact locality unknown, (described from plant cultivated in Hortus Botanicus, Leiden); orig. coll. *P. Kessler EVK 246 sub. Hetterscheid H.AM.032C-T* (holo, L, spirit coll.). **Fig. 1.**

Medium-sized, robust aseasonally dormant geophytic **herb** to 90 cm. **Tuber** depressed globose, not offsetting, with irregular raised areas, to 32 cm diam. \times 15 cm high, surface with a grey, corky layer. **Leaf** solitary; petiole short, to 50 \times 5 cm diam., uniformly green, very turgid; lamina to 188 cm diam., highly dissected, rachises naked; **leaflets** elliptic-lanceolate, to 35 \times 11 cm, those on the most proximal parts of the rachises petiolulate, upper surface mid-green, slightly glossy or dull, slightly coriaceous. **Inflorescence** solitary, rarely two together, short pedunculate; cataphylls off-white; peduncle 8-13 \times 1- 2.2 cm diam., entirely subterranean, white with a faint greenish flush, smooth, very tightly enveloped by the cataphylls; **spathe** erect, suborbicular, often broader than long, 10-13.5 \times 11.5-16 cm diam., limb obliquely spreading at female anthesis, erect at male anthesis, lower part tubular, strongly convolute, largely hidden in cataphylls, spathe exterior off-white, occasionally flushed pale reddish purple on the inside limb margins, interior with base reddish purple, and with scattered small warts, or coarsely grooved, with grooves distinctly verruculate. **Spadix** longer than spathe, stipitate, 13.5-21 cm long; stipe massive, oblique, off-white, 0.6-1 \times 1.6 cm diam. (base); **female flower zone** 1.5-2.5 cm \times 1.5-2.3 cm diam., slightly conic, flowers in vertically separate sinuous chains; **male flower zone** conic, 3-4.5 \times 1.1-2.2 cm diam., flowers arranged as female flowers but chains closer together, or partly or entirely fused vertically, sometimes forming vertical chains; appendix fusiform, 8-14 \times 1.2-2.8 cm diam., slightly laterally compressed, subacute, yellowish white, surface rugulose and with narrow, shallow grooves, producing a strong smell of fried fish and oozing out droplets at female anthesis. Pistil (**female flower**) with an ovate or slightly depressed ovary, 2-3 mm diam. \times 2.5-3 mm high, base off-white, top dirty reddish brown, unilocular, one basal ovule; style excentrically placed, consisting of three acute branches, two acroscopic small ones and one basiscopic longer one, pale dirty reddish brown, *ca* 1.5 mm diam. \times 0.3-0.8 mm long; stigma thin, *ca* 1.5 mm diam. \times *ca* 0.5 mm high, irregularly, shallowly lobed-sinusoid, surface very pale dirty brownish, verruculate. **Male flower** consisting of *ca* 3 stamens but pattern often obscured by lateral and vertical fusion of flowers; stamens *ca* 1 mm high, \times *ca* 1-2 mm diam., often fused with adjacent stamens; filaments *ca* 0.5 mm long, entirely connate; anthers *ca* 0.5 mm long, truncate, often entirely connate, ivory-white; pores apical, rounded, oval or variously elongate, often confluent with adjacent pores in various ways. **Fruit** a very large, elongate, slightly angulate berry, up to 4 \times 2 cm, ripening red, 1-seeded. **Seeds** elongate-

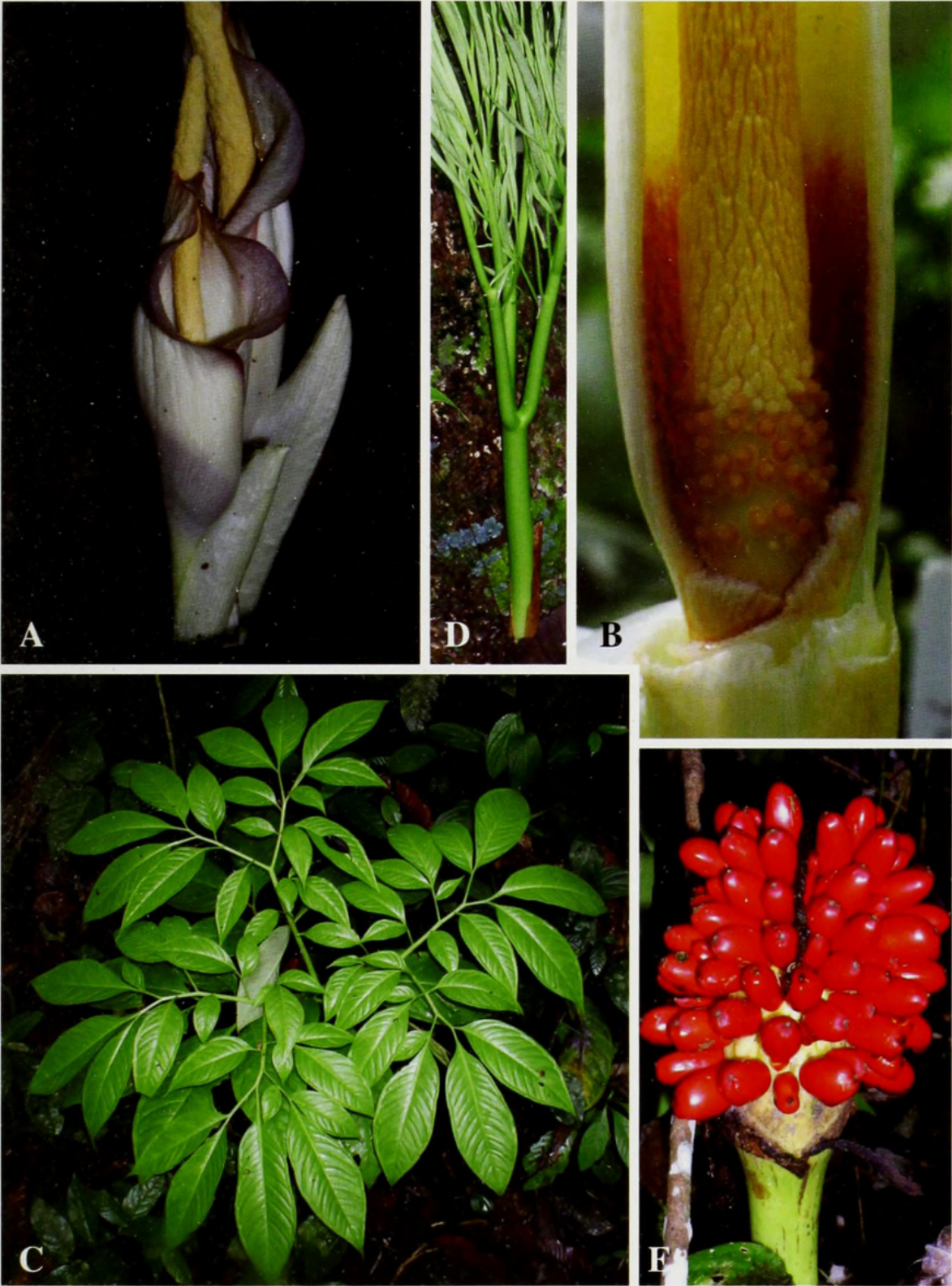


Figure 1. *Amorphophallus brachyphyllus* Hett. A. Flowering plant in habitat, note the erect spathe limb and rugulose spadix appendix; B. Inflorescence with spathe artificially opened. Note the scattered pistils, and the male flowers fused into longitudinal rows; C. Mature leaf. Note the complex lamina division and the distal-most leaflets are petiolate; D. Newly emerging leaf. Note the unmarked, turgid petiole; E. Mature infructescence. [Images: A, C-E © Peter Boyce. Image B © W.L.A. Hetterscheid].

oblongo-conical, *ca* 3 cm × 1.2 cm diam. at the point of germination, 0.7 at the opposite end, skin brownish.

Distribution: East Malaysia, Sarawak, endemic to Karst limestone formations in the Bau area of Kuching Division.

Ecology: On rocky lowland forested limestone slopes under perhumid to everwet evergreen forest, in humus layer or humus-filled pockets, less often in clay at the base of limestone formations, 15-60 m asl.

Notes: *Amorphophallus brachyphyllus* is without doubt closely related to *A. eburneus* and the inflorescences are deceptively similar, although separable by these characters: stigma of *A. brachyphyllus* is half the size of that of *A. eburneus*, while the pistils are much more regularly placed and more congested in *A. eburneus*. In addition to these small but consistent differences there is a marked difference in leaf morphology. In *A. eburneus* the leaf has a long petiole (to 120 cm) relative to the lamina diameter (the reverse in *A. brachyphyllus*). Moreover, the lamina in *A. eburneus* is considerably less strongly divided, with the leaflets distinctly larger (to 60 cm) and never petiolulate. Cataphylls in *A. eburneus* are greyish brown, those in *A. brachyphyllus* off-white. These vegetative differences remain constant, and coupled with geographical separation, and differences in the inflorescence, strongly support the recognition of two discrete but closely related, probably vicariant, taxa. *Amorphophallus niahensis*, described elsewhere in this paper is also in this complex, as too is *A. juliae*.

Etymology: The epithet *brachyphyllus* (Greek: *brachy* - short; *phyllus* - leaf) refers to the very short petiole length relative to the diameter of the lamina.

Other specimens seen: MALAYSIA. Sarawak. **Kuching Division**: Bau, Gua Angin, 5 Jun 1999, C.C. Lee AM-21.1 (SAR); Bau, Jambusan, 26 May 2004, P.C. Boyce & Jeland ak Kisai AM-31 (SAR); Bau, Gunung Bidi, 01° 23' 27.0"; 110° 07' 07.6", 7 Dec 2004, P.C. Boyce & L.Jenkins AM-88 (SAR); Bau, without further locality data: Hetterscheid H.AM.031A (L).

2. *Amorphophallus eburneus* Bogner, Willdenowia 18: 441 (1989). – **Type**: Malaysia, Sarawak, 'near Padawong, north of Bau' (see notes below), Bogner 1772 [described from plant cultivated in Munich Botanical Garden; orig. coll. York Meredith s.n. sub. Bogner 1772 (holo, M)]. **Fig. 2.**

Medium-sized to large, robust, aseasonally dormant geophytic **herb** to 1.3 m. **Tuber** depressed-globose, not offsetting, to *ca* 35 cm diam. × *ca* 20 cm high,



Figure 2. *Amorphophallus eburneus* Bogner. A. Flowering plant in habitat, note the erect spathe limb and rugulose spadix appendix; B. Inflorescence with spathe artificially opened. Note the scattered pistils, and the male flowers fused into longitudinal rows; C. Mature leaf. Note the simple lamina division and no leaflets are not petiolate; D. Mature leaf, infructescence and seedling. Note the unmarked, turgid petiole; E. Mature infructescence. [Images A-C & E © Peter Boyce. Image D © Art Vogel (used with permission)].

pale greyish brown, skin corky, broken up in numerous, small, angulate fields separated by narrow grooves. **Leaf** solitary; petiole very turgid, to $ca\ 120 \times ca\ 10$ cm diam., smooth, uniformly pale green or occasionally with a few scattered whitish greenish spots; lamina moderately dissected, up to $ca\ 240$ cm, diam., rhachises winged distally from the basal branches; leaflets elliptic or elliptic-lanceolate, 12-60 cm long, 5.5-21 cm diam., mid or pale green, coriaceous, long acuminate. **Inflorescence** solitary, short pedunculate, largely hidden in cataphylls; cataphylls $ca\ 6$, lanceolate, pale olive brown to whitish or greenish with pale brownish flushes, largest up to $ca\ 35 \times 10$ cm; peduncle $15-20 \times ca\ 2.5$ cm diam., pale green, entirely hidden by cataphylls; **spathe** erect, infundibuliform, ovate, base strongly convolute and hidden by cataphylls, separated from limb by a shallow constriction, limb slightly spreading, acute, margins revolute, $20-23 \times 19-21$ cm, outside creamy white, upper margins sometimes flushed with purple, inside base dark purple and then cream, limb cream with or without a pale purple flush, base within with numerous irregular, shallow warts and some shallow grooves. **Spadix** slightly longer than spathe, shortly stipitate, 21-26 cm long; **female flower zone** slightly conic, $2.5-3 \times 2-2.5$ cm diam., flowers slightly or variably distant; **male flower zone** cylindric, $4-5 \times 1.5-2$ cm diam., flowers congested; appendix $14-18 \times 1.5-3$ cm diam., terete or laterally compressed, acute, cream, turning pale yellowish during male anthesis, surface rugulose and with scattered, short, shallow grooves, producing a smell of fish during female and male anthesis. Pistil (**female flower**) comprised of a depressed pyriform or oblong ovary, $2.5-4$ diam. $\times ca\ 4-5$ mm high, uni- or rarely (?) bilocular, top divided in three narrow lobes, base white or pale green, remainder dark purple; stigma thin, strongly sinuous, stellate, ± 2 -lobed, partly sunken in between the three lobes emanating from the ovary, surface densely scaberulate, dirty greyish stained with purple, $ca\ 1.5-2.5$ diam. $\times ca\ 0.5-1$ mm high, \pm quadrangular in cross-section. **Male flower** consisting of 4-6 stamens, often elongate parallel to the spadix-axis and connate with upper and/or lower flowers; stamens $ca\ 1$ mm long $\times ca\ 1-2$ mm diam.; filaments $ca\ 0.5$ mm long, connate; anthers $ca\ 0.5$ mm long, free or connate, truncate or subtruncate, pores apical, free or connected within one flower or with other flowers and then irregularly elongate. **Fruit** a berry, very large, elongate, slightly angulate, 4.5×2 cm, red, 1-seeded. **Seeds** elongate conical, 3.5 cm long $\times 1.2$ cm diam. at the point of germination, 0.7 at the opposite end, testa brownish.

Distribution: East Malaysia, Sarawak, endemic to Karst limestone formations of Padawan (Kuching Division) and Tebedu (Samarahan Division).

Ecology: Perhumid lowland forested limestone, growing deep in limestone cracks with leaf litter 25- 350 m asl.

Notes: There are two errors in the type locality cited by Bogner (1989). Padawan (Padawong, *sic*) is southeast, not north, of Bau. The limestones of the Padawan area are both geographically and floristically distinct from the Bau limestones and extend down to the Kalimantan border in the direction of Tebedu and Serian (Samarahan Division), with their northern boundary to the east of the Bungo range. *Amorphophallus eburneus* is restricted to these limestones. For differences between *A. eburneus* and *A. brachyphyllus* see under that species.

Etymology: The epithet *eburneus* (Latin: ivory white) is in allusion to the white spathe and spadix.

Other specimens seen: MALAYSIA. Sarawak. **Kuching Division:** Padawan, Gunung Braang, 2 May 2001, C.C. Lee AM-67.1, AM-67.2 (SAR); Padawan, Bukit Manok, 01° 12'; 110° 18', 18 Mar 2004, P.C. Boyce AM-67.3 (SAR); Padawan, Vogel 940011 (L, cult. in Hortus Botanicus, Leiden, *sub. Hetterscheid* H.AM.402); Vogel 940012 (L, cult. Hortus Botanicus, Leiden, *sub. Hetterscheid* H.AM.394); Vogel 970618 (L, cult. Hortus Botanicus, Leiden, *sub. Hetterscheid* H.AM.893); Padawan, Gunung Penrissen, Vogel *s.n.* (L, cult. Hortus Botanicus, Leiden, *sub. Hetterscheid* H.AM.311). **Samarahan Division:** Serian, Pichin, Umon Murut, Tiab Belanting, 01° 08' 03.7"; 110° 27' 00.3", 15 Jun 2005, P.C. Boyce *s.n.* (image record SAR); Serian, Mongkos, Kampung Batuh, Gunung Selabur, 00°57' 26.2"; 110° 30' 15.8", 15 Mar 2006, P.C. Boyce *s.n.* (image record SAR);

3. *Amorphophallus infundibuliformis* Hett., A. Dearden & A. Vogel, *Blumea* 39(1-2): 259 (1994). – **Type:** Malaysia, Sarawak, Kuching Division, without further locality, 1990, Dearden *s.n.* (holo, L). **Fig. 3.**

Medium-sized, slender, aseasonally dormant geophytic **herb** to 1.3 m. **Tuber** depressed-globose to subglobose, pinkish externally, internally deep red, without offset development. **Leaf** solitary; petiole, pale grey-green to dark green to dark green-purple, with dirty whitish with numerous, confluent, irregular, green spots and scattered white punctiform dots and patches, these more or less raised; lamina weakly dissected, up to 35 cm diam., thinly coriaceous, adaxial surface deep, sometimes weakly metallic, glossy green, abaxial surface paler, rachises naked, ascending, very shallowly and narrowly canaliculate, greyish-green with irregular dark green patches; leaflets lanceolate, margin with numerous small undulations, main veins impressed, 2-11 × 2-5 cm, shortly petiolulate, petiolule 0.2-1 mm long, very slightly canaliculate adaxially, lowermost pair of leaflets symmetrical, all others asymmetrical and obliquely inserted on petiolule, apex shortly acuminate to



Figure 3. *Amorphophallus infundibuliformis* Hett., A.Dearden & A.Vogel. A. Flowering plant in habitat, note the funnel-form erect spathe; B. Inflorescence with spathe artificially opened. Note hooked staminodes covering much of the spadix appendix; C. Detail of petiole to show the diagnostic raised white warts; D. Mature leaf. Note ascending rachises; E. Mature infructescence. [Images A-E © Peter Boyce].

long acuminate, up to 1.5 long; margins of larger leaflets very slightly sinuate; 5-8 pairs of primary lateral veins, venation forming distinct submarginal veins; interprimary veins much less defined, secondary veins forming a weak reticulum. **Inflorescence** solitary, short pedunculate; cataphylls whitish with numerous small, pinkish dots and many larger, blackish green, irregular spots; peduncle 4 cm \times ca 0.8 cm diam. (base), lengthening in fruit; **spathe** strongly convolute, funnel-form, obconic in side-view, transversely orbicular-elliptic, 6 \times ca 8 cm diam., very widely acute, limb and base poorly differentiated, outside dirty whitish with pale brownish venation and scattered, small, angulate, blackish green spots, inside whitish, the lower half dark maroon, base within strongly, longitudinally ridged. **Spadix** sessile, very obliquely inserted, slightly longer than spathe; **female flower zone** oblique, annuliform, 1 mm (dorsal side)-5 mm (ventral side) long \times ca 1 cm diam., flowers congested; **male flower zone** cylindric, base oblique, 0.8-1.3 cm \times ca 1 cm \times diam., flowers congested; appendix cylindric, obtuse, whitish, 6.5 \times 1 cm diam., entirely or at least almost entirely, densely covered with hooked staminodes, these in the lower third shortly conical to aristate, sometimes uncinatate and with long, narrowly decurrent, ridge-like bases, upwards shorter or reduced to only the base, up to 2 mm long, bases longitudinally confluent. Pistil (**female flower**) with ovaries depressed, irregular or cubic, angulate in cross-section, 0.9-1.5 \times 1.2-1.5 mm, reddish brown, near the style insertion maroon, unilocular; style absent or only basiscopically developed; stigma sessile or partly sessile, acroscopically orientated, reniform, a shallow depression in the middle, one conic lobe on the outward facing margin, 0.8-1 mm \times 0.3-0.5 mm high, dark greyish brown, surface densely verruculate. **Male flower** upwards fused into longitudinal chains, otherwise consisting of 3-5 stamens, upper flowers confluent with the lowermost staminodial ridges; stamens ca 1-1.3 \times ca 0.7 mm long, rounded, oval or irregular in cross-section, white; filaments absent or nearly so, entirely connate; anthers truncate; pores apical, rounded or elongate (confluent). **Infructescence** with few to rather many berries, irregular; berries elongate, ca 2 \times 0.75 cm, slightly conic, top truncate, orange-red, one-seeded. **Seed** elongate ellipsoid, ca 1.8 \times 0.5 cm, testa pale brown.

Distribution: East Malaysia, Sarawak (Kuching, Sri Aman & Kapit Divisions but probably throughout the state and overlooked); Indonesia, Kalimantan Barat.

Ecology: Perhumid to everwet lowland mixed dipterocarp to upper hill forest, mainly on sandstones, occasionally on shale, rarely on raised podzols, 50-875 m asl.

Notes: *Amorphophallus infundibuliformis* cannot be mistaken for any other

species in the genus in Sarawak by virtue of the spadix appendix with hooked staminodes. The petiole, with ascending rachices and intricately ornamented with dark patches and conspicuous raised, white warty areas is approached by that of *A. ranchanensis*, in which the raised areas are scutelliform and pale grey-green. The inflorescences of *A. infundibuliformis* and *A. ranchanensis* are profoundly dissimilar.

Etymology: The specific epithet is from the Latin for funnel-shaped, referring to the shape of the spathe.

Other specimens seen: MALAYSIA. Sarawak: **Kuching Division**: Lundu, Gunung Gading, 01° 42'; 109° 50', 3 Mar 2004, *P.C. Boyce & Jeland ak Kisai AM-3* (SAR); Bau, Segong, Sungai Adis, 11 Mar 2004, *P.C. Boyce & Jeland ak Kisai AM-4.1* (SAR); Bau, Kampung Jugan, 26 Mar 2004, *P.C. Boyce & Jeland ak Kisai AM-4.2* (SAR); 22 May 2004, *P.C. Boyce, Jeland ak Kisai & Jipom ak Tisai AM-33* (SAR); Padawan, Puncak Borneo, trail behind Malesiana Tropicals Nursery to Hornbill Resort golf course maintenance kampong, 01° 07' 35.1"; 110° 13' 28.8", 10 Jun 2004, *P.C. Boyce & Jeland ak Kisai AM-36* (SAR); 01° 07' 35.1"; 110° 13' 28.8", 30 Nov 2004, *P.C. Boyce AM-87* (SAR); Sematan, Teluk Selabang Ulu Sungai, Selabang, 8 Oct 2004, *P.C. Boyce & Jipom ak Tisai AM-81* (SAR); Bau, Gunung Noka, 11 Oct 2004, *P.C. Boyce & Jeland ak Kisai AM-84* (SAR); Lundu, Brungea, 8 Jan 2005, *P.C. Boyce & Jipom ak Tisai AM-92* (SAR); Bau, Kampung Duyoh, Sungai Duyoh, 01° 20' 45.6"; 110° 02' 36.9", 8 Jun 2005, *P.C. Boyce & Jeland ak Kisai AM-95* (SAR); Matang, Kubah N.P., Waterfall Trail, 7 Mar 2009, *P.C. Boyce* (SAR, image record). **Sri Aman Division**: Lubok Antu, Batang Ai, Nanga Sumpa, 01° 12' 02.3"; 112° 03' 09.3", 27 Jul 2004, *P.C. Boyce, Jeland ak Kisai & N. Lembang AM-43* (SAR); Lubok Antu Batang Ai, Nanga Sumpa, Sungai Pedali, 01° 11' 58.9"; 112° 03' 27.0", 7 Apr 2005, *P.C. Boyce et al. AM-94* (SAR); Sri Aman, Lubok Antu, Batang Ai, Nanga Sumpa, Wong Ensalai, 01° 11' 51.0"; 112° 03' 39.9", 26 May 2008, *P.C. Boyce, Wong Sin Yeng & Jipom ak Tisai AM-200* (SAR). **Kapit Division**: Kapit, Taman Rekreasi Seabai, 01° 56' 45.6"; 112° 54' 16.8", 13 Dec 2004, *P.C. Boyce, Jeland ak Kisai & M. Gibernau AM-89* (SAR). INDONESIA. **Kalimantan**: Kalimantan Barat, Semeng, Sizemore 960031 (L, image record).

4. *Amorphophallus juliae* P.C. Boyce & Hett., sp. nov.

Ab omnibus speciebus in habitu calcicola lithophytica Borneensibus borealis combinatio appendice spadicis echinatis et petiolorum foliis pallide rubro et valde brunneis maculatis distinguitur; ab A. niahensis spathae lamina marginem valde revolutis et reflexis et appendice spadicis profunde echinatis differt. – **Type**: Sarawak, Kapit Division, Belaga District, Bukit Merirai, path

to Gua Tiang & Gua Spring, 2° 46' 07" N; 113° 38' 58" E, 6 Jul 2005, *P. Leong, R. Kiew, S. Julia et al.* PL 135 (Holotypus, SAR; isotypus, SING.). **Fig. 4.**

Medium-sized, moderately robust, aseasonally dormant geophytic **herb** to 1.2 m tall. **Tuber** depressed globose, with irregular slightly raised areas, up to 7 cm diam., 4 cm high, surface pale brown, interior white. **Leaf** solitary, petiole proportionately short compared to the lamina diameter; petiole up to 35 cm long, *ca* 2 cm diameter at base, moderately turgid, cylindrical, smooth, uniform dull pale red with strongly demarcated irregular reddish brown spots and elongated streaks, subtended by 2-3 marcescent cataphylls, these extending *ca* $\frac{1}{3}^{\text{rd}}$ the length of the petiole; lamina moderately dissected, up to 55 cm diam., thinly coriaceous, adaxial surface mid green, abaxial surface paler, rachises naked, narrowly canaliculate, pale pinkish green; leaflets elliptic-lanceolate, 2-13 × 2-5 cm, more-or-less sessile, lowermost pair of leaflets symmetrical, all others asymmetrical and obliquely inserted or rhachis, apex shortly acuminate to 1.5 long; margins of larger leaflets very slightly sinuate; 5-7 pairs of primary lateral veins, these adaxially flush to slightly impressed, abaxially very slightly raised; venation forming distinct submarginal veins; interprimary veins less defined, secondary veins forming a weak reticulum. **Inflorescence** solitary, occasionally two together, flowering before emergence of foliage leaves but in any one colony mature plants at all stages of growth (emerging leaves to ripe infructescences) present simultaneously; peduncle and lower part of spathe encased in sub-fleshy cataphylls; peduncle cylindrical, up to 13 cm long, 5-6 mm diam., pale green, pinkish where exposed to light; cataphylls several per inflorescence; elongate-ovate to linear, 2-15 cm × 1.5 -3.5 cm, pale greenish white, sub fleshy at anthesis, then soon withering and then decaying, drying mid brown. **Spathe** broadly oblong-ovate, funnel-form, up to 9 cm long × 3 cm wide (fresh), pressed material up to 7 cm diam.; spathe limb accounting for *ca* $\frac{1}{3}$ or less of the spathe length, margins recurved at anthesis and at first somewhat conspicuously green-veined; interior white, smooth, somewhat glossy, exterior very pale greenish white to white; lower spathe convolute and much inflated at anthesis, 2-7 cm long, interior muricate-verrucate, deep reddish purple, exterior pale greenish white, sometimes slightly pink-tinged, the margins recurving to form a conspicuous collar *ca* 1 cm wide, this somewhat glossy and frequently tinged and veined pale green at anthesis. **Spadix** exceeding spathe, 9-12 cm long. Appendix up to 11 cm long, slender elongate-fusiform, *ca* 9 mm diam. (fresh), *ca* 4 mm diam. (dried), white to dull cream, very pronounced-echinate, producing a mild odour of rotten fish during anthesis. Flowers unisexual; **male flower zone** weakly fusiform-cylindrical, up to 3 cm × 6 mm diam., cream; stamens *ca* 1 mm long, *ca* 0.5 mm broad across, pores paired, mostly solitary, the reduction in pore



Figure 4. *Amorphophallus juliae* P.C.Boyce & Hett. A-B. Flowering plants in habitat, note the strongly echinate spadix appendix, the recurved lower spathe margins and recurved spathe limb; C. Mature leaf; D. Emerging leaf. Note the conspicuous petiole markings; E. Mature infructescence. [Images A-C, E © Julia anak Sang (used with permission). Image D © Peter Boyce].

number proceeding upwards towards the appendix, pollen pale yellow. **Female flower zone** cylindrical, contiguous with the maleflower zone, *ca* 4.5-7 × *ca* 7 mm diam.; **male flowers** dense, not arranged in longitudinal rows; pistils (**female flowers**) few, densely arranged, ovaries compressed globose, *ca* 1.5 × 1.5 mm, dark purple, mostly bilocular; stigma sessile, conspicuously three lobed. **Infructescence** with up to 50 berries, peduncle up to 18 cm long, but mostly buried, *ca* 7 mm diam. at base, 9 mm diam. at apex, with a dark brown V-shaped scar from the marcescent spathe. **Fruit** an ellipsoid berry 15-21mm × 8-10 mm, apex rounded, with conspicuous impressed blackish stigma remnants, one seeded, deep orange at maturity. **Seeds** ellipsoid, 12-17 mm × 7-8.2 mm wide, testa smooth, thin, yellowish green.

Distribution: Endemic to Sarawak, so far recorded only from Bukit Merirai, Belaga, Kapit Division.

Ecology: Lowland limestone forest, shady areas in humus-filled fissures and holes in limestone, *ca* 60 m asl.

Notes: By the leaf with a proportionately short petiole compared with the leaf lamina diameter, and in bearing numerous small leaflets *Amorphophallus juliae* is vegetatively most similar *A. brachyphyllus* and *A. niahensis*. From both, *A. juliae* differs in the pale reddish petioles with large darker reddish brown spots (*vs* pale to medium green, concolorous or very occasionally with obscure paler green circles in *A. brachyphyllus* and *A. niahensis*).

The male flowers not fused into longitudinal rows, the subentire to weakly bilobed stigma and echinate spadix appendix resemble those of *A. niahensis*, although the echinate texture is markedly more pronounced in *A. juliae*. *Amorphophallus juliae* is readily distinguished from *A. niahensis* by the opening of the lower part of spathe strongly recurving to form a conspicuous collar *ca* 1cm wide during anthesis (margins not or only minutely recurved in *A. niahensis*) and spathe limb margins recurving very markedly.

Amorphophallus juliae is most readily distinguished from *A. brachyphyllus* by the male flowers not fused into longitudinal rows, the densely arranged pistils, the proportionately shorter spathe limb (comprising *ca* 1/3 or less of the entire spathe *vs* 1/2 or more of entire spathe), and the spathe limb reflexing at male anthesis (*vs*. spathe limb erect throughout anthesis), and subentire to weakly trilobed stigma (versus deeply bi-trilobed).

Etymology: Named for Julia anak Sang, a forest botanist from the Forestry Research Department, Sarawak Forestry Corporation, Kuching, and co-collector of the type specimen.

Other specimen seen: MALAYSIA. Sarawak, **Bintulu/Kapit Division** border, Belaga District, Bukit Merirai, trail from Sungai Bekuyat to Gua Naga, 11 July 2005, *P. Leong, R. Kiew, S. Julia et al.* PL 270, (SAR, SING).

5. ***Amorphophallus niahensis*** P.C. Boyce & Hett., *sp. nov.*

Ad A. brachyphyllus spadix appendice echinatis, floribus masculinus nec in serialis longitudinaliter tectis, stigmatibus sessile subintegris; spathae anthesin feminibus reflexis, non erectis; ab A. juliae petiolorum foliis non pallide rubro et maculatis, spathae lamina marginem nec valde revolutis differt. –

Type: Sarawak, Miri Division, Niah Suai District, Gunung Subis, Gua Niah N.P., along plank walk to Niah caves, 21 Aug 2002, *Julaihi L et al.* S 89309 (Holotypus, SAR). **Fig. 5.**

Medium-sized, rather robust, aseasonally dormant geophytic **herb** to 1 m tall. **Tuber** depressed globose, with irregular raised areas, up to 12 cm diam., 6 cm high, surface pale brown, interior white. **Leaf** solitary, petiole proportionately short compared to the lamina diameter; petiole up to 60 cm long, *ca* 2.5 cm diameter at base, moderately turgid, cylindrical, smooth, uniform pale-green with a few obscure paler spots present in some individuals, subtended by 2-3 marcescent cataphylls, these extending *ca* 1/10th the length of the petiole; lamina moderately dissected, up to 1 m diam., thinly coriaceous, adaxial surface mid-green, abaxial surface paler, rachises naked except for terminal leaflets long-decurrent, narrowly canaliculate, mid-green; *leaflets* elliptic-lanceolate, 2-15 × 1.5-6 cm, terminal-most petiolulate, petiolule 1-2.5 cm long, narrowly canaliculate adaxially, lowermost pair of leaflets symmetrical, all others asymmetrical and obliquely inserted on petiolule, apex shortly acuminate; 3-9 pairs of primary lateral veins, these slightly impressed adaxially, abaxially slightly raised; venation forming distinct submarginal veins; interprimary veins less well-defined, secondary veins forming a weak reticulum. **Inflorescence** solitary, occasionally two or rarely three together, flowering before emergence of foliage leaves but in any one colony mature plants at all stages of growth (emerging leaves to ripe infructescences) present simultaneously; peduncle and lower part of spathe encased in sub-fleshy cataphylls, peduncle cylindrical, up to 17 cm long × 5-6 mm diam., pale green; cataphylls several per inflorescence; elongate-ovate, 3-16 cm × 1-4 cm, pale greenish white, sub fleshy at anthesis, soon withering and decaying, drying mid brown. **Spathe** broadly oblong-ovate, narrowly funnel-form, up to 9 cm long × 3 cm wide (fresh), pressed material up to 5 cm wide; spathe limb accounting for *ca* 1/3 or less of the spathe length, spathe mouth margins hardly recurved at anthesis and spathe limb margins planate; interior white, smooth, somewhat glossy, exterior very pale greenish white to white; lower spathe convolute and much inflated at anthesis, 2-7 cm long, interior muricate-



Figure 5. *Amorphophallus niahensis* P.C.Boyce & Hett. A. Flowering plants in habitat, note the echinate spadix appendix and recurved spathe limb; B. Inflorescence with spathe artificially opened. Note the warty lower spathe interior and the male flowers not in fused longitudinal rows; C. Mature infructescence; D. Mature leaf. Note the complex division. [Images A-D © Peter Boyce].

verrucate, deep reddish purple, exterior pale greenish white, sometimes slightly pink-tinged. **Spadix** exceeding spathe, 9-12 cm long. Appendix up to 9 cm long, elongate-fusiform, *ca* 9 mm diam. (fresh), *ca* 4 mm diam. (dried), white, moderately echinate, producing a sharp smell of rotten fish at anthesis. **Flowers** unisexual; **male flower zone** cylindrical, up to 3 cm long, 6 mm diam., cream; stamens *ca* 1 mm long, *ca* 0.5 mm broad across, pores paired, partially fused or solitary, pollen dark yellow. **Female flower zone** shortly cylindrical, contiguous with the male zone, *ca* 4.5-7 mm \times *ca* 7 mm diam.; pistils few, densely arranged; ovaries compressed globose, *ca* 1.5 \times 1.5 mm, dark purple, mostly bilocular; stigma sessile, three 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*. **Fruit** ellipsoid 15-16 \times 8-10 mm, apex rounded, with blackish stigma remnants, when ripe deep orange, one seeded. **Seeds** ellipsoid, 12-14 mm \times 7-8.2 mm wide, testa smooth, thin, yellowish green, seed copiously starchy, embryo small.

Distribution: East Malaysia, Sarawak, so far recorded only from Niah National Park.

Ecology: Limestone forest, growing shady areas in humus-filled fissures and holes in limestone, often on limestone emergent in swampy areas, *ca* 45 m asl.

Notes: *Amorphophallus niahensis* is most similar to *A. brachyphyllus*, especially in the rather short petiole compared to the lamina diameter, but is readily distinguished by the conspicuously echinate spadix appendix, the male flowers not arranged in longitudinal lines, the concolourous deep purple pistils, and the spathe limb reflexing at female anthesis.

Amorphophallus niahensis approaches *A. juliae* in the echinate spadix appendix morphology (although the echinate texture is markedly more pronounced in *A. juliae*), but is readily distinguished by the pale green (not pink) petiole lacking any markings (*vs* reddish-brown spotted) and the spathe limb margins not or only slightly recurving at anthesis.

Curious to note is that in nature the inflorescences very often produce two morphologically normal spathes, set at 180° to one another. Similar observations have been made with *A. eburneus* and *A. brachyphyllus*.

Etymology: The species is named for originating from Gua Niah, to which it is endemic.

Other specimens seen: MALAYSIA. Sarawak, **Miri Division:** Niah Suai District, Niah National Park, Gunung Subis, outside Great cave, 24 Apr 1972, J.A.R. Anderson S 31903 (SAR); Niah N.P., trail to Great cave, 03° 49' 09.9"; 113° 46' 52.3", 13 Oct 2005, P.C. Boyce, Jeland ak Kisai & Jipom ak Tisai AM-101 (SAR); Niah Suai District, Niah National Park, Madu Trail, 03°48' 57.9"; 113° 46'18.3", 13 Jul 2006, P.C. Boyce et al. AM-107 (SAR); Subis, Gua Niah N.P., below W mouth of Great cave, 22 Aug 2002, K. Pearce et al. S 89487 (SAR); Batu Niah. 113 46 E. 3 49 N, Vogel 970616 (L, cult. Hortus Botanicus, Leiden, sub. *Hettterscheid* H.AM.895).

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