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Notes on the genus *Amorphophallus* (Araceae) IV. Revision of the species in Taiwan

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Abstract. Of the genus *Amorphophallus*, four species from Taiwan are recognized—*A. henryi* N.E. Br., *A. hirtus* N.E. Br., *A. kiusianus* (Makino) Makino, and *A. paeoniifolius* (Dennst.) Nicolson. The first two species are endemic to Taiwan. *Amorphophallus gigantiflorus* Hayata and *A. niimurai* Yamam., both from Taiwan, are reduced to the synonymy of *A. paeoniifolius* and *A. henryi*, respectively. *Amorphophallus kiusianus* is newly recorded in Taiwan and the mainland Chinese *A. sinensis* Belval is here reduced to its synonymy. Biogeographic considerations and phylogenetic affinities of the species are discussed.

Keywords: *Amorphophallus*; Araceae; Distribution; Taiwan; Taxonomy.

Introduction

The name *Amorphophallus* was first published as a *nomen nudum* by Blume in 1825 and validated by Decaisne in 1834 (type species *A. campanulatus* Decne. = *A. paeoniifolius* (Dennst.) Nicolson). The first two species from Taiwan described were *A. henryi* and *A. hirtus*, simultaneously published by N. E. Brown (1903) based on collections made by A. Henry. Both species were found in the same locality—Kaohsiung city, Shoushan ('Takow, Ape's Hill'). In 1916 Hayata described *A. gigantiflorus* from Taiwan. This species is here synonymized with *A. paeoniifolius*. *Amorphophallus kiusianus*, the most recent addition of an *Amorphophallus* to the flora of Taiwan, was collected for the first time in northern Taiwan (sterile, previously unidentified specimen) in 1933, and again half a century later from several other localities by C.-I Peng and his associates. Hitherto this species was only known in southern Japan and SE mainland China (as *A. sinensis* Belval).

Phylogenetic Considerations

A few characters rare in *Amorphophallus* indicate a rather close phylogenetic affinity between *A. henryi*, *A. hirtus*, and *A. kiusianus*. These characters are the hairs on the appendix, the red-margined leaflets, and the blue berries. This species group probably constitutes a monophyletic assemblage in *Amorphophallus*, and may include a few other species from Indochina. *Amorphophallus macrorhizus* Craib from northern Thailand has occasional hairs on the appendix, but for several reasons does not appear to belong to this group. *Amorphophallus cirrifer* Stapf (Thailand) may also prove to be a member of this group, but more details of its morphology, e.g. the color of the leaflets and the shape of the tuber, need to be studied.

Engler (1911: 66) created section *Dysamorphophallus* for *A. hirtus*, based solely on the presence of hairs on the appendix. Because *A. henryi* was initially described as having a naked appendix, this species was assigned not to section *Dysamorphophallus* but to the very heterogeneous section *Conophallus* (Schott) Engl. (*nom. illeg.*, the correct name being *Adenophallus* Bl. or *Leiophallus* Bl., currently under investigation). *Amorphophallus kiusianus* was unknown to Engler at the time.

A phylogenetic analysis of the entire genus is being undertaken by W.L.A. Hetterscheid, but is not yet completed. Section *Dysamorphophallus* may be upheld when it is shown to be monophyletic and not leave another group paraphyletic.

Amorphophallus paeoniifolius belongs to a different alliance of species, with long anthers, conical or fusiform-conical but highly variable appendices, and large, 2- or 3-lobed stigmas. This group contains *A. hirsutus* Teysm. & Binnend. [Sumatra], *A. koratensis* Gagnep. [Thailand], *A. opertus* Hett. [Vietnam], *A. prainii* Hook. f. [southern Thailand, Malay Peninsula, northwest Sumatra], and *A. scaber* Serebr. & Hett. [Vietnam]. The monophyly of this group is uncertain. Engler (1911) separated *A. paeoniifolius* (sub *A. campanulatus* (Roxb.) Blume, *A. rex* Prain and *A. dubius* Blume) and *A. prainii* by assigning them to sections *Cundarum* (Reich.) Engl. and *Cundaropsis* Engl., respectively. The separation was based on the short style of *A. prainii* versus the long style in species of section *Cundarum*. We consider this an artificial separation, because of the much larger number of similarities that exist between these species.

Ying (1990) revived the long-subsumed genus *Hydrosme* Schott by publishing two new combinations—*H. gigantiflorus* (Hayata) S.S. Ying and *H. niimurai* (Yamam.) S.S. Ying. Engler (1911) reduced *Hydrosme* to a section of *Amorphophallus* for lack of any consistent character to separate it from *Amorphophallus*. New studies of *Amorphophallus* have revealed no characters that could lead to reverting this decision and we consider Ying's action as unwarranted and poorly supported, and have reduced his new combinations to the synonymy of *A. peaoniifolius* and *A. henryi*, respectively.

Distribution

Amorphophallus paeoniifolius is the most widespread species in the genus—it is found from Madagascar to the Polynesian Islands. It is suspected that most of its present-day distribution has been brought about by humans, because the species has been cultivated for many centuries as an important, though secondary, root crop (elephant-yam). It is not certain that Taiwan is part of its original, natural distribution.

Amorphophallus hirtus and *A. henryi* are endemic to Taiwan.

Amorphophallus kiusianus is distributed in southern Japan, Taiwan, and the southeastern part of mainland China (as *A. sinensis* Belval, *see* below). The discovery of *A. kiusianus* in Taiwan is a new record. Previous inclusion of Taiwan in the range of *A. kiusianus* by Japanese botanists (e.g. Ohashi, 1982) was based on Hotta's (1970) erroneous conclusion that *A. henryi* is synonymous with *A. kiusianus* (as *A. hirtus* var. *kiusianus* (Makino) M. Hotta).

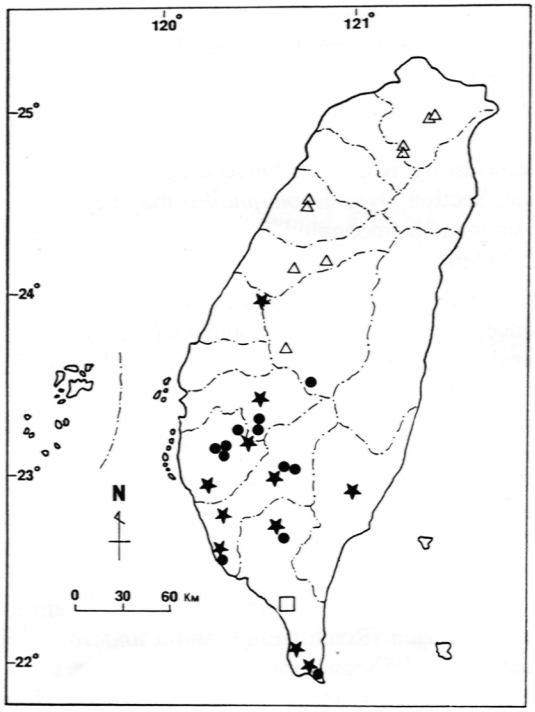


Figure 1. Distribution of *Amorphophallus henryi* (circles), *A. hirtus* (stars), *A. kiusianus* (triangles), and *A. paeoniifolius* (square) in Taiwan.

The distribution of the four species of *Amorphophallus* in Taiwan is illustrated in Figure 1.

Key to Species

a) Sterile specimens:

1. Petiole scabrate/verrucate; tubers with thickened, annulate rootscars ..... 4. *A. paeoniifolius*
1. Petiole smooth; tubers without annulate rootscars.
   2. Leaflets obovate or elliptic-ovate; offset tubers present, slender and rhizomatous ..... 2. *A. hirtus*
   2. Leaflets elliptic-lanceolate or lanceolate; offset tubers lacking or otherwise shaped.
      3. Petiole pale or dark green with white spots; offset tubers subglobose ..... 1. *A. henryi*
      3. Petiole as above, but with numerous tiny blackish green dots; offset tubers lacking ..... 3. *A. kiusianus*

b) Flowering specimens:

1. Peduncle equalling or shorter than spathe.
   2. Appendix irregularly globose-conic, up to 20 cm in diam. at base ..... 4. *A. paeoniifolius*
   2. Appendix slender, narrowly elongate fusiform, 1.8–4 cm at the widest part ..... 1. *A. henryi*
1. Peduncle much longer than spathe.
   3. Appendix purple, densely hirsute, 25–73 cm long ..... 2. *A. hirtus*
   3. Appendix blackish, glabrous or sparsely hirsute, 4–16 cm long ..... 3. *A. kiusianus*

c) Fruiting specimens:

1. Peduncle uniformly tan, berries (orange-) red at maturity ..... 4. *A. paeoniifolius*
1. Peduncle mottled or uniformly green, berries blue at maturity.
   2. Dried style remaining on berries 1 mm long ..... 3. *A. kiusianus*
   2. Dried style remaining on berries 3–4 mm long.
      3. Peduncle slender, plain green, to ca. 20 cm long ..... 1. *A. henryi*
      3. Peduncle massive, mottled, more than ca. 40 cm long (up to ca.120 cm) ..... 2. *A. hirtus*

1. **Amorphophallus henryi** N. E. Br. in Forbes & Hemsley, J. Linn. Soc., Bot. 36: 181. 1903; Engler, Pflanzenr. IV (23C): 93. 1911; Yamamoto, J. Soc. Trop. Agric. 5: 189. 1933; Liu and Huang, Quart. J. Taiwan Mus. 16: 130. 1963; Huang, Fl. Taiwan 5: 801. 1978; Li, Shiao and Tseng, Acta Phytotax. Sin. 15(2): 93. 1977 (key, in Chinese); Li, Fl. Reip. Pop. Sin. 13(2): 97. 1979. *A. hirtus* var. *kiusianus* (Makino) M. Hotta, Mem. Fac. Sci. Kyoto Univ., Ser. Biol. 4:

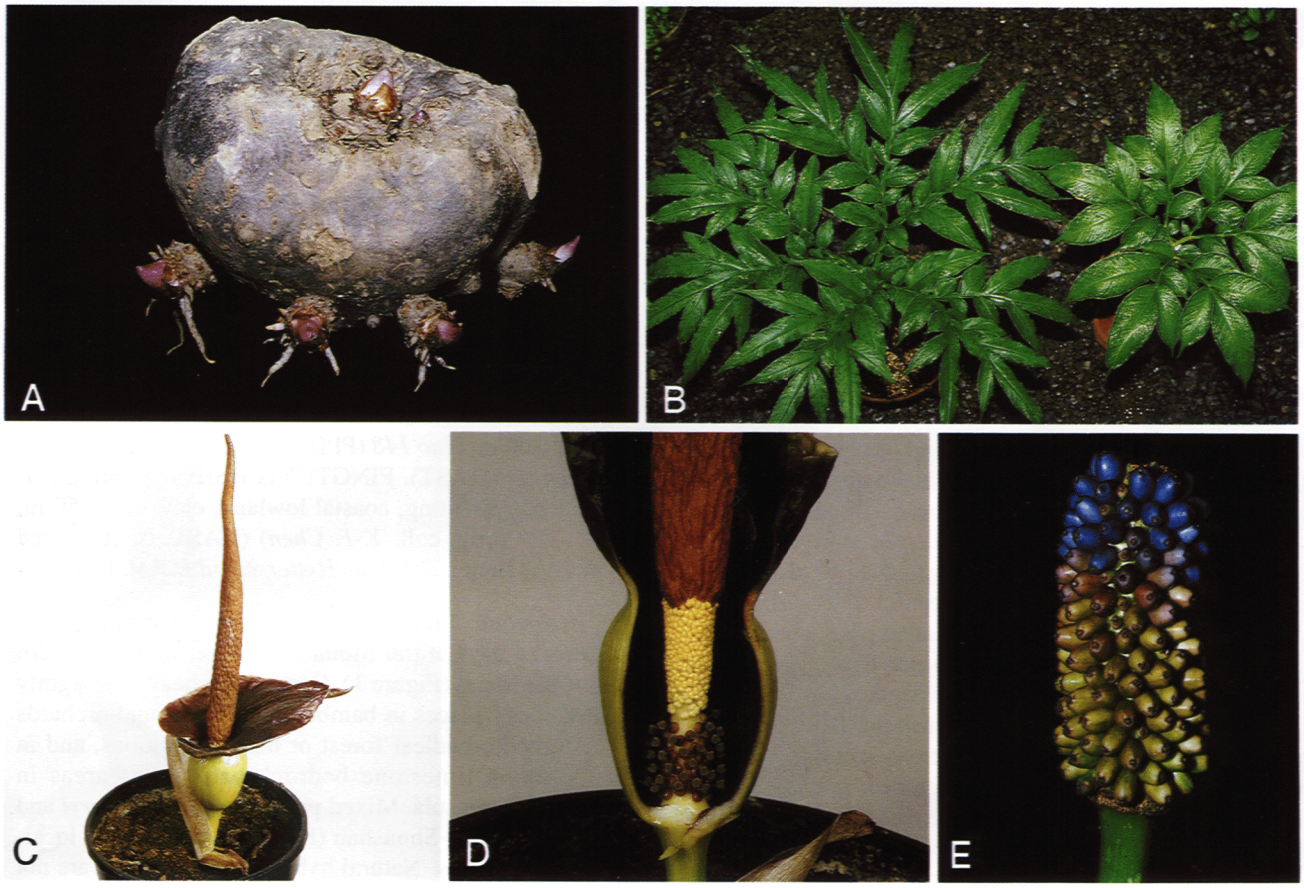


Figure 2. *Amorphophallus henryi*. **A**, tuber, showing sprouting, subglobose offsets (*Leu 964*); **B**, leaves seen from above (*Peng 15041*); **C**, inflorescence, habit (*Peng 7727*); **D**, inflorescence, dissected to show the lower part of the spadix (*Peng 7727*); **E**, infructescence, showing maturing berries (green via pale pink turning blue) (*Wang 1176*).

88. 1970, p.p. (only as to the synonym *A. henryi* N.E. Br.).—TYPE: Taiwan. Kaohsiung ('Takow'): Shoushan ('Ape's Hill'), in rocky situations, *A. Henry 776* (holotype: K; photograph, TAI; isotype: BM, E, MO, P, US). 台灣魔芋 Figure 2

Amorphophallus niimurai Yamam., J. Soc. Trop. Agric. 5: 346.1933; Liu and Huang, Quart. J. Taiwan Mus. 16: 130. 1963 ('*A. kimurai*'); Li, Shiao and Tseng, Acta Phytotax. Sin. 15(2): 93. 1977 (key, in Chinese); Li, Fl. Reip. Pop. Sin. 13(2): 87. 1979. —*Hydrosme niimurai* (Yamam.) S. S. Ying, Mem. Coll. Agric., Natl. Taiwan Univ. 30 (1): 31. 1990.—*A. hirtus* ('*hirta*') *sensu* Yamam. *non* N.E. Br., J. Soc. Trop. Agric. 5: 180. 1933.—TYPE: Taiwan. Kaohsiung ('Takao'), 1932, *Niimura s.n.* (holotype: TAI, flowered in Botanical Garden of the Taihoku Imperial University, May 1933).

Tuber depressed-globose, 3–11 cm in diam., 2–6 cm high, weighing up to 500 g, dark brown, seasonally producing several subglobose, offset tubers, these ca. 0.5–1 cm in diam. *Leaf* solitary; *petiole* smooth, 30–60 cm long, ca. 1–2 cm in diam. near the base, mid or dark green with several more or less oval or irregular, whitish spots, with or without numerous small white dots in between, surface dull or moderately glossy; *lamina* moderately or highly dissected, 30–100 cm in diam., rhachises narrowly winged; *leaflets* elliptic-ovate, elliptic or lanceolate, 4–26 cm long, 1.5–5.5 cm in diam., acuminate or elongate acuminate, upper surface mid or dark green, dull or glossy, margin at first reddish pink, later usually turning green or whitish, major veins strongly impressed, lower surface pale green. *Inflorescence* solitary, short peduncled; *peduncle* as petiole, 4–20 cm long, 0.8–1.5 cm in diam., lengthening in fruit; *spathe* campanulate, constricted between base and limb, broadly triangular-ovate, 9–23 cm long, 8–22 cm in diam., acute or obtuse, base strongly convolute, thick-walled, outside glossy pale green, with or without a purplish flush, with or without a few small paler spots, inside dark maroon, near the constriction dirty whitish or greenish-purple, limb horizontal, irregularly undulate, outside pale green with a variable pinkish-purplish hue, maroon near the margin, inside dark maroon, dull or glossy, near the margin greenish or pale purplish, venation strongly impressed, the base within densely covered with large, irregular verrucae. *Spadix* sessile, longer than spathe, 20–45 cm long, male and female zone contiguous or separated by a short (ca. 0.5 cm), (partly) sterile zone; *female zone*

cylindric or slightly conic, 1.5–4 cm long, 2–2.5 cm in diam. (incl. styles), flowers congested or all or partly, more or less remote; *male zone* more or less obconic, 1.5–3.5 cm long, 0.9–1.5 cm in diam. at the base, 1.5–2 cm in diam. at the top, flowers congested or the lower ones distant, free or fused in the upper part into low-angled spirals; *sterile zone* with variously transformed male flowers (staminodes), sometimes intermixed with a few sterile remnants of bisexual flowers, often accompanied by all possible transitional stages from the adjacent zones; *appendix* elongate fusiform, producing a smell of decaying meat or cow dung at female anthesis, 15–36 cm long, 1.4–2 cm in diam. near the base, 1.8–4 cm in diam. at one-third from the base, oval in cross-section, thin-walled and hollow after anthesis, top obtuse to acute, pale or dark brown, surface with regular or irregular, shallow, strongly wrinkled and/or with elongate depressions these in the basal half of the appendix with or without short, pale or dark purplish or whitish hairs (0.5–2.5 mm long). *Ovaries* depressed, circular or subcircular in cross-section, 2–3 (–4.5) mm diam, 1.5–3 mm high, base or the larger part greenish, the rest dark purple, 2-locular, one basal ovule per locule, funicle long, strongly coiled; *style* slender, 2–3 mm long, 0.8–1.2 (–1.5) mm in diam., brownish purple or blackish; *stigma* large, circular or oval in cross-section, 2 mm in diam., 0.8–1.5 mm high, 2–3 (–4) lobed, grayish purple, surface densely scabrate-papillate, lobes conic, obtuse. *Male flowers* consisting of (2–)3–6 stamens; *stamens* oval in cross-section, 2 mm long, 1.8 mm in diam., ivory white; *filaments* 1 mm long, basally connate; *anthers* 1 mm long, truncate or rostrate (elongation of connective); *connective* minutely verrucate, after anthesis more strongly rostrate by differential shrinking of the lateral sides of the anthers; *pores* apical, elongate prior to anthesis, oval at anthesis, opening by deepening of the lower margin, after anthesis more or less laterally displaced; *pollen* psilate. *Sterile flowers* (when present) between male and female zone of either pale green or purple hairs, up to 5 mm long, or reduced bisexual flowers, these consisting of a reduced pistil surrounded by several stamens. *Berries* elliptic, blue or violet, 1- or 2-seeded, 1.2–1.4 cm long, 0.8–ca.1.2 cm in diam., dried style remaining (ca. 3–4 mm long). *Seeds* ovate, ca. 1 cm long, ca. 7 mm in diam., one side flattened, coat grayish green, raphe distinct.

Additional specimens examined. **TAIWAN**. NANTOU HSIEN: Fengchiu, ca. 3.5–4 km SE of Hsinyi, on New Central Cross-Island Hwy # 21, road mileage sign 99 km, at Pishih Bridge, base of a rocky slope with scrubby vegetation/bamboo grove, elev. ca. 660 m, forming very large population in shaded rocky area that is full of leaf litters, *Peng 15041* (HAST). CHIAYI HSIEN: Tapu Hsiang, Chiayi Farm, near Szuwei Bridge, elev. ca. 250 m, *Peng 7108* (HAST); Fanlu Hsiang, Tsaoshan Village, en route to Lienyun Waterfall, *Peng 13456* (HAST). TAINAN HSIEN: Wushantou, Tachi, *Chen 94* (HAST; L, cultivated by W.L.A. Hetterscheid, as *Hetterscheid H.AM.085*); Taipingting, Shanhutan, elev. ca. 120–200 m, *Chen 513* (HAST; L, cultivated by W.L.A. Hetterscheid, as *Hetterscheid H.AM. 097*); same loc., Chen 514 (HAST); Liuchia, under bamboo forest, *Huang 10456* (TAI); Tungshan Hsiang, Kaoyuan, Chutoupai, Fuyikung Temple, elev. ca. 200 m, in bamboo plantation and orange orchard by Fuyikung Temple, lightly to heavily shaded places, *Wang 1176* (HAST). KAOHSIUNG CITY: Wanshoushan, elev. ca. 10–350 m, *Leu 964* (HAST; L, cultivated by W.L.A. Hetterscheid, as *Hetterscheid H.AM. 234*), same loc., on raised coral rock with broadleaf forest, scattered between 80 and 240 m alt., *Peng 15483* (HAST); Tsaishan, *Deng 585* (TNU), same loc., ca. 100 m alt., *Yang 2040* (TNU). KAOHSIUNG HSIEN: Liukuei Hsiang, Tsaitiehku ('Colorful Butterfly Valley'), elev. ca. 400 m, Chen 516 (HAST). PINGTUNG HSIEN: Machia Hsiang, Liangshan, elev. ca. 300 m, *Liao 148* (PPI); Liukuei, elev. ca. 150–200 m, *Chen 93* (HAST). PINGTUNG HSIEN: Kenting National Park, Shehting, coastal lowland, elev. ca. 0–50 m, *Peng 7727* (orig. coll. *Y.-F. Chen*) (HAST; L, cultivated by W.L.A. Hetterscheid, as *Hetterscheid H.AM. 084*);

Distribution. Endemic to Taiwan, at 20–660 m alt. to the west of the Central Mountain Range, in the southern half of the island (Figure 1). Common in heavily to lightly shaded rocky places in bamboo plantations and orchards or disturbed broadleaf forest or mixed situations, and in thin soils on limestone bedrock or in karst areas in Hengchun Peninsula. Mixed populations of *A. henryi* and *A. hirtus* occur in Shoushan (Kaohsiung city), type locality of both species. Natural hybrids between them are not found. Flowering Apr–May, fruiting May–Jul.

Notes. Except for the hairs on the spadix, *A. niimurai* is identical to *A. henryi*. This difference seems rather insignificant, the more so since observations of living plants by both authors show that the hairiness of the appendix varies greatly within a single clone.

Hotta (1970) separated *A. niimurai* from *A. henryi* at the varietal level by treating it as a synonym of *A. hirtus* var. *hirtus*, while treating *A. henryi* as a synonym of *A. hirtus* var. *kiusianus* (Makino) M. Hotta, *comb. nov*. Hotta states that *A. kiusianus* Makino and *A. hirtus* differ only in the hairiness of the appendix and therefore merges them. Both species are near-related but they should be kept separate (*see* notes under *A. hirtus*). Hotta also implies that *A. niimurai* is intermediate between typical *A. hirtus* and *A. henryi* (as treated here). We do not agree with this statement, as *A. niimurai* greatly resembles *A. henryi*, except for the hairiness of the appendix, and does not resemble *A. hirtus* at all. *Amorphophallus henryi* and *A. hirtus* are readily distinguishable (*see* notes under *A. hirtus*).

Another implication of Hotta's treatment is that *A. henryi* and *A. kiusianus* represent the same taxon (*A. hirtus* var. *kiusianus*). We treat them as separate species. Compared to *A. kiusianus*, *A. henryi* has much longer and more slender styles, a larger stigma, a much broader and more strongly constricted spathe, a much shorter peduncle, a pale or dark brown appendix (blackish in *A. kiusianus*), and seasonally produced subglobose offset tubers (lacking in *A. kiusianus*). The entire inflorescence of *A.*

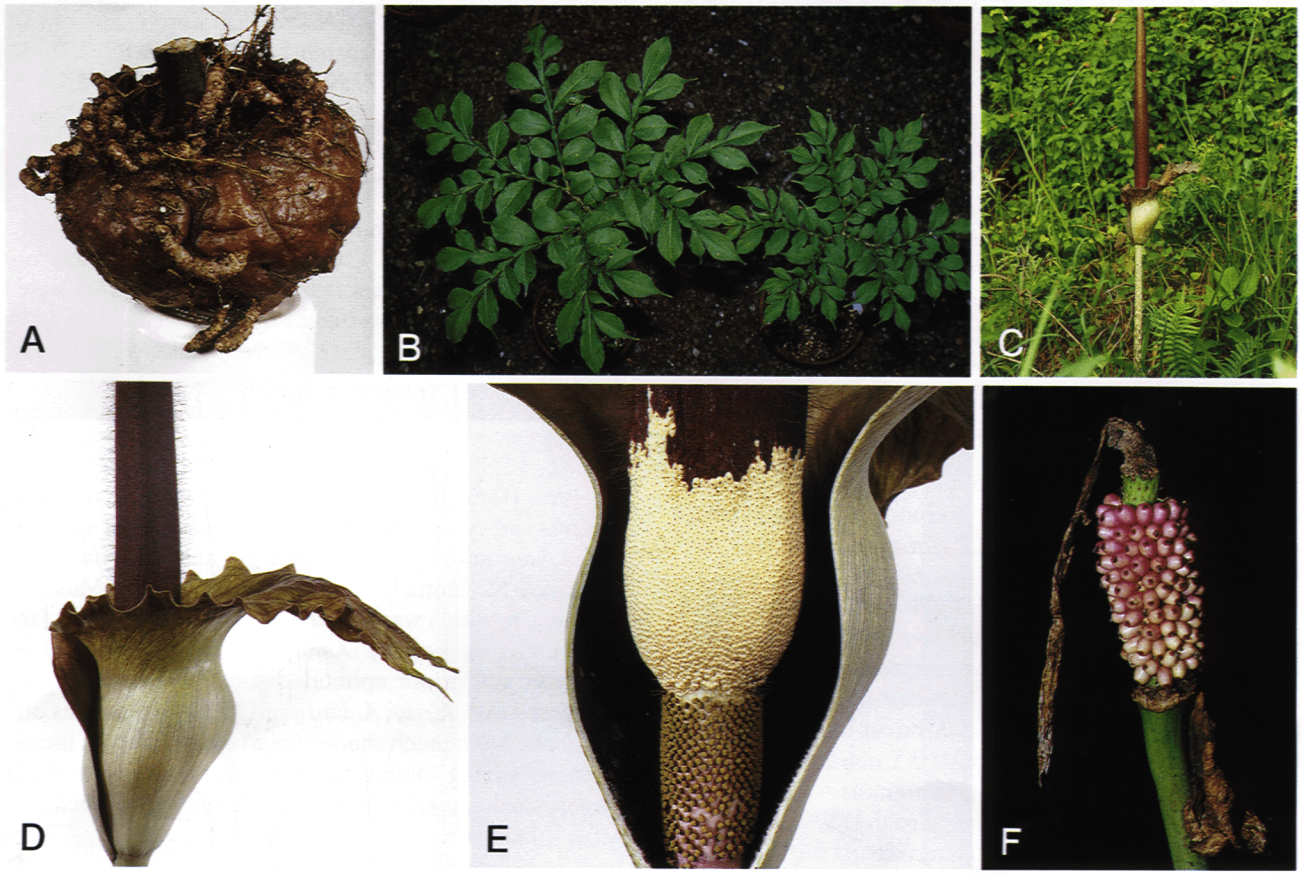


Figure 3. *Amorphophallus hirtus*. **A**, tuber, showing rhizomatous offsets (*Leu 516*); **B**, leaves seen from above (*Wang 1000*); **C**, inflorescence, habit (Leu 516); **D**, inflorescence, side view, detail showing hairy appendix (*Leu 516*); **E**, inflorescence, dissected to show the lower part of the spadix (*Leu 516*); **F**, infructescence, showing immature berries (before turning blue) (*Wang 1162*).

kiusianus is much more robust than that of *A. henryi*. Both species have a glabrous to more or less hirsute appendix, red margined leaflets and blue berries.

2. **Amorphophallus hirtus** N.E. Br. in Forbes & Hemsley, J. Linn. Soc., Bot. 36: 181.1903; Engler, Pflanzenr. IV (23C): 67. 1911; Yamamoto, J. Soc. Trop. Agric. 5: 346. 1933 (not as to p. 180 = *A. niimurai* Yamam.); Liu & Huang, Quart. J. Taiwan Mus. 16(3 & 4): 130. 1963; Huang, Fl. Taiwan 5: 801. 1978; Li, Shiao and Tseng, Acta Phytotax. Sin. 15(2): 93. 1977 (key, in Chinese); Li, Fl. Reip. Pop. Sin. 13(2): 86. 1979. TYPE: Taiwan. Kaohsiung Hsien ('Takow'), Shoushan ('Ape's Hill'), *Henry 1914* (holotype: K; isotype: MO). 密毛魔芋 Figure 3

Tuber globose or depressed-globose, 3–15 cm in diam., 2–9 cm high, weighing up to ca. 1500 g, whitish, turning grayish brown at exposure, seasonally producing numerous, thin, rhizomatous offset tubers, these up to 3 cm long and ca. 1 cm in diam. *Leaf* solitary; *petiole* 20–100 cm long, 1–2.5 cm in diam. at the base, turgid, smooth, dark green with numerous, tiny, blackish green spots or with larger, ± diamond-shaped, pale grayish-green spots, these filled with numerous, dark green, elongate dots; *lamina* 30–120 cm in diam., highly dissected, rhachises only in the distal half of the lamina winged, wings sinuous; *leaflets* ± obovate or elliptic-oval, 5.5–11 cm long, 2.5–4.5 cm in diam., elongate acuminate, ± succulent, upper surface dark emerald green with a pinkish-violet margin, venation on the upper surface impressed. *Inflorescence* solitary, long-peduncled; *peduncle* as petiole, 40–125 cm long, 1–4 cm in diam. at the base; *spathe* campanulate, constricted between base and limb, broadly triangular, 13–53 cm long, 12–45 cm in diam., acute, base strongly convolute, obliquely urceolate, thick-walled, outside pale green faintly flushed with purple or dark grayish green with numerous pale whitish green spots, the lower ones confluent, veins dark green, inside blackish maroon, covered with numerous shortly ridge-like, laterally compressed, fleshy warts, limb horizontally spreading or obliquely upturned, margin undulate, outside pale green flushed with purple-brown or dark grayish green with angulate, whitish green spots and margins dirty purple, without spots, inside maroonish flushed with green or with numerous small, rounded, sometimes confluent, whitish greenish spots, veins maroon. *Spadix* much longer than spathe, stipitate, 31–89 cm long, stipe 0.2–1 cm, male and female zone separated by a narrow, sterile zone; *female zone* slightly

obconic or cylindric, 1.6–6.5 cm long, 1.1–3.5 cm in diam. at base, 1.2–3.7 cm in diam. at the top, flowers lax; *male zone* urceolate, terete or slightly laterally compressed, upper margin straight or very irregular, 3–9 cm long, 0.9–3.7 cm in diam. at base, 2–7 cm in diam. at the top, flowers congested, in between some scattered, purple hairs; *appendix* very long conic, 25–73 cm long, 2–7 cm in diam. (base), entirely purple or with numerous, dirty greenish, small spots, emitting a strong smell of old socks or strong compost, top obtuse, surface with numerous, laxly disposed hairs, these directed perpendicular to the appendix axis, 0.2–1.5 cm long, purple, base not swollen, in shallow pockets in which a clear fluid is produced during female anthesis. *Ovaries* ± globose, 2.5 mm in diam., 2.5 mm high, circular in cross-section, more or less gradually tapering to the style, lower half white, upper half blackish maroon, 2-locular, one basal ovule per locule; *style* thick, 1 mm long, 1.5 mm in diam., maroon; *stigma* ± pyramidal, circular in cross-section, 2.5 mm in diam., 1.8 mm high, shallowly 2(–3)-lobed, lobes rounded, surface scabrate, pale olive-green; *male flowers* consisting of 3–6 stamens; *stamens* very shallowly hemispheric, 2 mm long, some of the uppermost stamens intermediate with the hairs on the appendix, carrying a short hair on the connective or reduced to a slightly concave, broad base, carrying a hair (staminode); *filaments* short, 0.5 mm long, connate; *anthers* ca. 1.5 mm long, 3–3.5 mm in diam., angulate in cross-section, top very shallowly rounded, ivory-white, producing a clear fluid from the top during female anthesis; *connective* brownish; *pores* apical, elongate, oval after anthesis; *sterile flowers* between male and female zone consisting of 1–7 staminodes, these consisting of a swollen, often depressed, white base and a purple hair of ca. 5–10 mm long. *Pollen* psilate.

Additional specimens examined. **TAIWAN.** CHANGHUA HSIEN: Kuaikuan, in fruit garden, 20 May 1991, *Chen s.n.* (TNU); Pakuashan, *Chang 6892* (TNU). CHIAYI HSIEN: Fanlu Hsiang, Tsaoshan village, en route to Lienyun Waterfall, elev. ca. 220–250 m, *Peng 15456* (HAST). TAINAN HSIEN: Hsinhua Forest Plantation, National Chung-Hsing Univ., elev. ca. 90 m, in grassy orchard, flowering plants ca. 1.5 m tall, *Leu 516* (HAST; L, cultivated by the first author, as *Hetterscheid H.AM.132A & B*); same loc., frequent in mango and longan orchards, in semi-shade to full sun on dry soil, peduncle with spadix up to 2.3 m high, *Wang 1162* (HAST), *Wang 10696* (TAI); Nanhsi Hsiang, watershed area of Tsengwen Dam, along a trail from bridge # 4, *Peng 13393* (HAST). KAOHSIUNG CITY: Tsaishan, *Deng & Chen 945, 947, 948, 949* (all at TNU); Wanshoushan, elev. ca. 150 m, in semi-shade to full sun on mt. slope facing ocean, frequent along trails and abundant in mango orchard, peduncle with spadix up to 2 m tall, *Wang 1000* (HAST), same locality, *Peng 15479* (HAST). KAOHSIUNG HSIEN: Maolin Hsiang, Shanping, elev. ca. 800 m, *Chen 525* (HAST); Alien Hsiang, Takangshan, *Liu 693* (HAST). PINGTUNG HSIEN: Paoli Forestry Station, *Deng 658* (TNU), *Yang 856* (PPI), *906* (PPI); Shantimen (San-te Men'), elev. ca. 300 m, *Hsu 40144* (TAI); Kenting, Tachienshihshan, under forest, elev. ca. 300 m, *Huang & Huang 13791* (TAI); Kenting Natl. Park, Tajienshihshan, on shady forest floor, elev. ca. 150 m, *Peng 7139* (HAST); Kuanshan, 5 km S of Hengchun, *Peng 7158* (HAST). TAITUNG HSIEN: Yenping Hsiang, Hungyeh village, secondary broadleaf forest, *Hu 2805* (HAST).

Distribution. Endemic to Taiwan, frequently found south of the Tropic of Cancer (Figure 3), in grassy orchards, plantations, moist valleys, or thin soils on limestone bedrock or in karst areas in partly shaded or fully exposed conditions in partly disturbed broadleaf forest, alt. 90–800 m. It occurs side-by-side with *A. henryi* in Shoushan (Kaohsiung city). Flowering May–Jun, fruiting Jun–Jul.

Notes. Hotta (1970) recognized two varieties under *A. hirtus*—var. *hirtus* (to which *A. niimurai* was synonymized, *see* notes under *A. henryi*) and var. *kiusianus* (Makino) M. Hotta (based on *A. kiusianus* (Makino) Makino), to which was added *A. henryi* as a synonym (*see* notes under *A. henryi*). *Amorphophallus hirtus* and *A. kiusianus* are, in our opinion, distinct (*see* keys above). Compared to *A. hirtus*, *A. kiusianus* lacks rhizomatous offset tubers, has a much shorter (nearly absent) style, inconspicuous stigma lobing, much smaller stamens, a much feebler spadix in all its parts, and a glabrous or much less densely hairy appendix. The appendix is purple, 25–73 cm long in *A. hirtus* and blackish, 4–16 cm long in *A. kiusianus*.

3. **Amorphophallus kiusianus** (Makino) Makino, Bot. Mag. Tokyo 27: 244. 1913; Kitamura, Murata & Koyama, Coloured Ill. Herb. Pl. Jap. (Monoc.). 194. 1964 (in Japanese); Koyama in Ohwi, Fl. Jap. 255. 1965.—*A. konjac* K. Koch var. *kiusianus* Makino, Bot. Mag. Tokyo 25: 16. 1911.—*A. hirtus* N.E. Br. var. *kiusianus* (Makino) M. Hotta, Mem. Fac. Sci. Kyoto Univ., Ser. Biol. 4: 88. 1970, p.p. (not as to the synonym *A. henryi* N.E. Br.); Ohashi in Satake et al., Wild Fl. Jap. Herbaceous Pl.—Monocot. (incl. Dwarf Subshrubs) 1: 127, pl. 111. 1982.—TYPE: Japan. Kagoshima Pref., Shiroyama, 23 May 1879, *T. Uchiyama s.n.* (lectotype: TI, chosen by Hotta, 1970: 88; figured in Ohashi, Univ. Mus.Univ. Tokyo, Mater. Rep. 5, pl. 2. 1981). 東亞魔芋 Figure 4

Amorphophallus sinensis Belval, Bull. Soc. Bot. France 80: 98. 1933; Steward, Man. Vasc. Pl. Lower Yangtze Vall. China 499. 1958; Jiangsu Inst. Bot., Fl. Jiangsu 1: 328. 1976 (in Chinese); Li, Shiao and Tseng, Acta Phytotax. Sin. 15(2): 93. 1977 (key, in Chinese); Li, Fl. Reip. Pop. Sin. 13(2): 87. 1979 (in Chinese). TYPE: China. Jiangsu Prov.: Zose (25 km environ de Chang-hai) dans un endroit humide ou le soleil ne penetre jamais, *Belval 2111* (holotype: P).

Tuber depressed globose, up to ca. 20 cm in diam., up to ca. 12 cm high, no offset development. *Leaf* solitary; *petiole* smooth, up to ca. 80 cm long, ca. 4 cm in diam.,



Figure 4. *Amorphophallus kiusianus*. **A**, three plants, two sterile (showing leaves), and one in early stage of fruiting (*Liao 1262*); **B**, inflorescence, habit (*Peng 4724*); **C**, inflorescence, upper part, showing spathe and spadix (with glabrous appendix) (*Peng 4724*); **D**, inflorescence, upper part, showing spathe and spadix (with sparsely hirsute appendix) (Taipei Hsien, Peichatienshan, ca. 900 m alt., 18 May 1993, *K.C. Yang, s.n.*); **E**, inflorescence, dissected to show the lower part of the spadix (*Leu 1521*); **F**, infructescence, lower part with immature, pinkish berries, upper part with mature, blue berries (*Peng 15070*).

glossy, dirty olive green or grayish green, with narrowly elongate, oval or irregular whitish or very pale greenish spots and numerous tiny dark green dots; *lamina* ca.60–90 cm in diam., rhachises winged distal from the basal main branchings; *leaflets* elongate elliptic to lanceolate, 6–20 cm long, 3–4.5 cm in diam., moderately to long acuminate, margin undulate, upper surface bright green with a narrow pale violet margin. *Inflorescence* solitary, long peduncled; *peduncle* as petiole, 40–ca. 120 cm long (in fruit up to ca. 140 cm long), 1.5–4 cm in diam.; *spathe* triangular, base rounded, 9–25 cm long, ca. 4–13 cm in diam., shallowly or clearly constricted between base and limb, limb first oblique, then reflexing and bending downwards, margin reflexed or undulate, outside greenish pinkish or glossy dark purplish brown, with small, whitish spots, midrib and top occasionally green, margin greenish and with a narrow, reddish-violet marginal line, inside pale pinkish with a purplish base or entirely dark brown, or with a greenish margin, the latter sometimes flushed pinkish, sometimes medially pale green, with rounded, whitish spots, base outside dark green or dark greenish brown, with small, rounded whitish spots and blackish green veins, base within dark purple and with numerous, ± distant, conical warts, occasionally with small, whitish spots. *Spadix* ses-

sile or subsessile, shorter than, equal to or longer than spathe, 9–22 cm long; *female zone* slightly conic, 1–4 cm long, 0.5–2 cm in diam.; *male zone* cylindric or slightly obconic, 2.5–4.5 cm long, 0.5–2 cm in diam.; *appendix* fusiform-conic or elongate fusiform, 4–16 cm long, ca. 1–3 cm in diam. (near base), acute or obtuse, entirely blackish or with scattered, tiny green spots, glossy, smooth or with shallow depressions, base grooved, otherwise naked or with scattered, thin, violet-brown hairlike staminodes, emerging from the depressions, these up to ca. 1 cm long. *Ovaries* obovate, angulate in cross-section, ca. 2.5 mm high, ca. 2 mm in diam., bright pale green, bilocular, one basal ovule per locule; *style* nearly absent, ca. 0.2 mm long, ca. 1 mm in diam., bright pale green or dark brown, bifurcating at the apex; *stigma* shallowly bilobed, slightly oval in cross-section, ca.1.5 mm in diam., ca. 0.8 mm high, minutely papillate, pale greenish gray, lobes ± flattened or shallowly conic. *Male flowers* consisting of 4 (–5) stamens; *stamens* ca. 1.5 mm long, pale yellow; *filaments* ca. 0.5 mm long, entirely connate; *anthers* subtruncate or truncate, mostly subrectangular in cross-section, ca. 1.5–2 × 1 mm in diam., ca. 1 mm long, connective brownish, pores apical, elongate. *Staminodes* between male and female zone isolated or in groups of 2–4, or together with functional stamens as part of the lowermost male flowers, consisting of a highly reduced stamen and a long, brown hair on the connective, those on the appendix consisting of only a brown hair and each growing from a shallow depression. *Pollen* striate-areolate, released in strings. *Infructescence* with dried spathe-base sometimes remaining, cylindric, ca. 5–22 cm long, ca. 3–4.5 cm in diam.; *berries* rounded or oval, ca. 1 cm long, ca. 0.8–1 cm in diam., dried style remaining (1 mm long), two-seeded, glossy, at first bright green, then turning pinkish purple and finally bright deep blue; *seeds* oval in longitudinal section, one side flattened, rhaphe distinct, ca. 8 mm long, ca. 6 x 4 mm in diam., coat moderately glossy, black, minutely rugulose.

Additional specimens examined. **CHINA**. JIANGXI PROV.: Suichuan Hsien, Chuchou, *Anon.* (Responsibility Team 236') *657* (PE); Zose, *Belval 2110* (P); Shanghai, *Kimura s.n.* (KYO). GUANGDONG PROV.: Hong Kong, Cap d'Aguilar, *Bodinier 742* (P); Patsinling, *Hu 12060* (A).

JAPAN. KYUSHU. Kagoshima Pref.: Kamocho, Airagun, *Hatusima & Sako 27021* (KYO); cult. orig., Bot. Gard. Tokyo Univ., *Hetterscheid H.AM.199* (L); cult. in Bot. Gard. Univ. Tokyo, *Murata s.n.* (KYO); Tarumizushi (cult. in Bot. Gard. Koishikawa, Tokyo), *Murata 11853* (TI); Iso, Yoshino, *Tashiro s.n.* (KYO); Nagasaki Pref., Fukue Island, *Tashiro s.n.* (KYO). SHIKOKU. Kochi Pref., Aki-gun, Ioki-mura; *Tagawa s.n.* (KYO).

TAIWAN. TAIPEI HSIEN: Sanhsia, Peichatienshan, en route from entrance to shelter, elev. ca. 520–600m, beside trail, under *Cryptomeria japonica* plantation or forest gap, scattered population found between 500 and 900 m alt., *Liao 346* (HAST); Sanhsia, along the mt. trail from Manyuehyuanshan Forest Recreation Area to Peichatienshan, by plantation of *Cryptomeria japonica*, elev. ca. 800 m, *Leu 1589* (HAST); Wenshan, Shihting, around Kankou, 27 May 1933, *Lin & Shen, s.n.* (TAI); Wulai, Szukanshui to Tatungshan, growing beside tea plantation in light shade, ca. 350–500 m alt., *Wang 1177* (HAST). TAICHUNG HSIEN: en route from Kukuan to Pahsienshan Forest Recreation Area, an herb ca. 50–60 cm high on roadside slope, *Chamaecyparis* plantation, elev. ca. 750–800 m, *Leu 1521* (HAST); Taiping Hsiang, Toupien village, scattered in betel nut plantation and litchi orchard in semi-shade to full sun, fruits green becoming red first, then turning purplish blue when matured, *Liu 135* (HAST). MIAOLI HSIEN: Shihtan Hsiang, Shihtan, margin of orange orchard, elev. ca. 250 m, *Leu 932* (HAST); same loc., orange plantation and secondary broadleaf forest, elev. ca. 150–200 m, on exposed slope by an orange plantation, rare locally, *Liao 1262* (HAST); same loc., *Peng 4724* (HAST); Shihtan Hsiang, Shihtan, W of Hsinfeng bridge, elev. ca. 300 m, by trail in mixed bamboo grove-orchard-broadleaf forest, found also in broadleaf forest gap, associated with *Lagerstroemia*, *Ardisia*, *Alocasia macrorrhizos*, and ferns, of rare occurrence, *Peng 15070* (HAST). NANTOU HSIEN: Luku Hsiang, Fenghuangku Birdhouse, on bamboo plantation floor, with very scarce herb layer, abundant locally, elev. ca. 700 m, *Liao 1264* (HAST); same loc., elev. ca. 830 m, common in bamboo plantation to the left of the entrance, in semi-shade to dense shade, fruits turning dark blue from pinkish red, *Wang 1207* (HAST). Exact locality unknown: plants originally collected from Taiwan by T. Shimizu in 1961, cultivated in Bot. Gard. Kyoto Univ., *Hotta 16210* (KYO).

Distribution. Southeastern China (provinces Jiangsu, Jiangxi, Zhejiang, Fujian, Guangdong), Japan (Amami-Oshima; southern Kiushiu including Satsuma, Kagoshima, Osumi, Yakushima, and Tanegashima; Shikoku, in Kochi Pref.) and Taiwan (in the northern half of the island [Figure 1]). In Taiwan found in shaded, semi-shaded, or sun-exposed places in plantations, orchards, or mixed bamboo-broadleaf forests at 150–900 m alt.; flowering Apr–Jun, fruiting May–Jul.

Notes. Makino (1911) first described this species as a variety of *A. konjac* K. Koch but later (1913) elevated it to species rank. The first author investigated the type of *A. sinensis* and additional specimens from mainland China and concluded that there are no consistent or relevant characters upon which this species can be separated from *A. kiusianus*. Compared to the Japanese representatives of *A. kiusianus* the Chinese mainland specimens show a paler-colored spathe and sometimes a spadix that clearly exceeds the spathe. From the Taiwan specimens they do not differ in any relevant character. Taiwan specimens more frequently posses a glabrous appendix. These differences do not warrant specific recognition of *A. sinensis*. In comparison with all other *Amorphophallus* species in Taiwan *A. kiusianus* is characterized by the extremely short style. Apomictic seed development has been observed in cultivation (pers. comm., Petra Malesevich, MO, 1994).

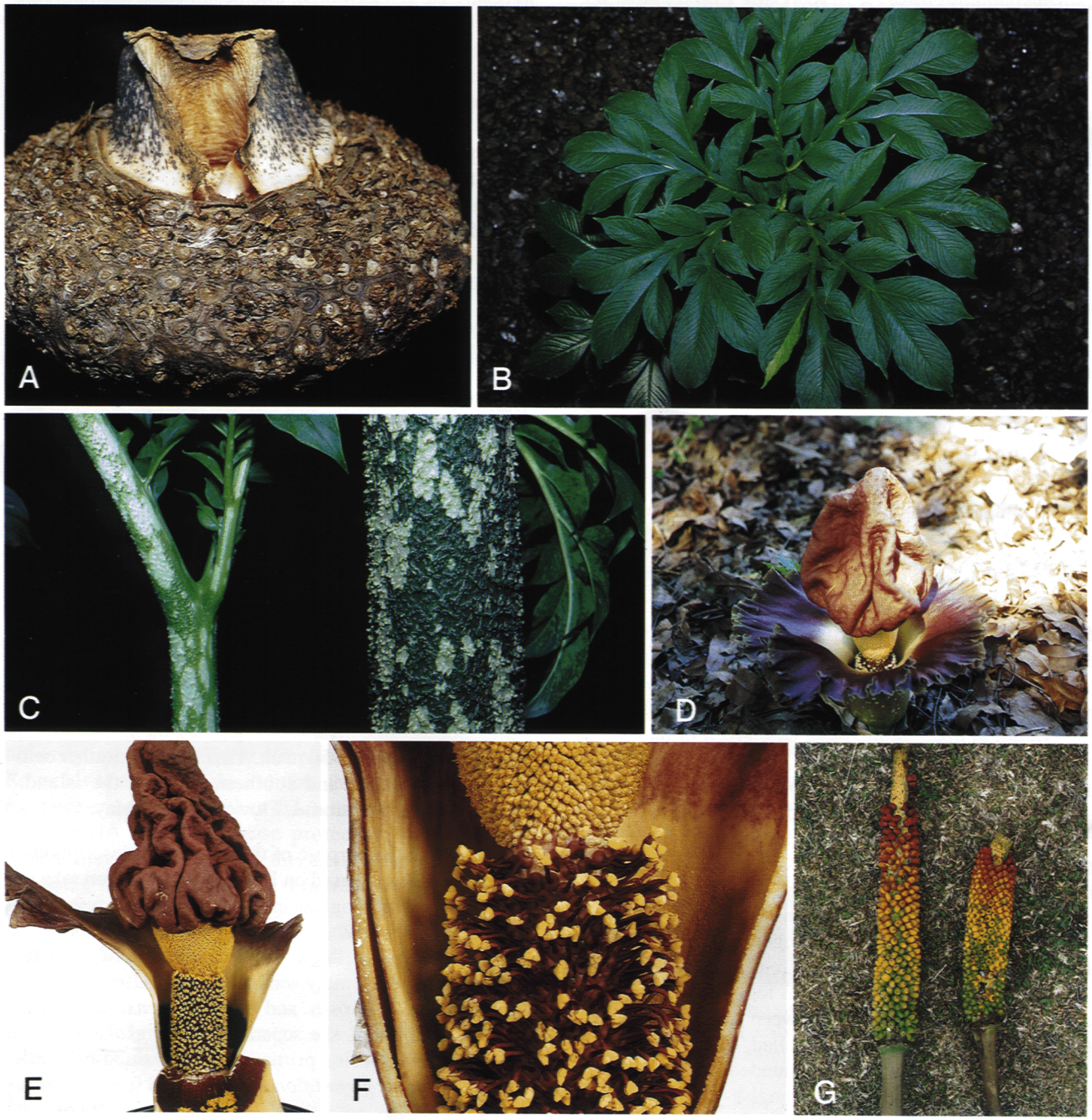


Figure 5. *Amorphophallus paeoniifolius*. **A**, tuber, showing thickened, annulate rootscars (subglobose offsets not as yet developed) (*Lin 495*); **B**, leaf, seen from above (*Leu 989*); **C**, portion of sterile plants, showing strongly scabrate-verrucate surface of the petioles (*Lin 491*); **D**, inflorescence, habit (*Lin 491*); **E**, inflorescence, dissected to show the entire spadix (cult. origin, Leiden Bot. Gard., *H.AM. 022-A*); **F**, inflorescence, dissected to show the lower part of the spadix, showing, among other things, the long styles (cult. origin, Leiden Bot. Gard., *H.AM. 041-A*); **G**, infructescences, showing berries maturing from green, via yellow to red (Sumatra, 1993, *Hetterscheid s.n.*).

4. **Amorphophallus paeoniifolius** (Dennst.) Nicolson, Taxon 26(2/3): 338. 1977.—*Dracontium paeoniifolium* Dennst., Schl. Hort. Ind. Mal. 13, 21, 38 (*paeoniaefolium*'). 1818—TYPE: Rheede tot Draakestein, Hort. Ind. Mal. 11: plate 19 (Mulenschena'). 1692. 疣柄魔芋 Figure 5

Amorphophallus campanulatus Decne. (*non* (Roxb.) Blume, 1837, based on *Arum campanulatum* Roxb., *nom. illeg.*), Nouv. Ann.Mus. Paris, ser. 3, vol. 3: 166. 1834.—TYPE: Indonesia, Timor, *Gaudichaud s.n.* (holotype: P),

Amorphophallus virosus N.E. Br., Gard. Chron., New Ser. 23: 759. 1885; Hooker, f., Bot. Mag., t. 6978. 1888; Li, Fl. Reip. Pop. Sin. 13(2): 89. 1979.—TYPE: Thailand, *H. G. Smith s.n.* (holotype: K, orig. coll. by Bock).

Amorphophallus gigantiflorus Hayata, Icon. Pl. Formos. 6: 101. 1916; Liu & Huang, Quart. J. Taiwan Mus. 16: 130. 1963; Huang, Fl. Taiwan 5: 800. 1978; Li, Shiao and Tseng, Acta Phytotax. Sin. 15(2): 93. 1977 (key, in Chinese); Li, Fl. Reip. Pop. Sin. 13(2): 89. 1979.—*Hydrosme gigantiflorus* (Hayata) S. S. Ying, Mem. Coll. Agric., Natl. Taiwan Univ. 30 (1): 31. 1990.—TYPE: Kareikosho, Takunansha, May 1914, *S. Yuki s.n.* (holotype: TI).

Amorphophallus bangkokensis Gagnep., Not. Syst. 9(1–2): 117. 1940; Gagnepain in Lecomte, Fl. Gen. Indoch. 4(2): 1160. 1942; Li, Fl. Reip. Pop. Sin. 13(2): 91. 1979.—TYPE: Thailand, Bangkok, *Kerr 12824* (holotype: K).

The foregoing synonymy pertains mostly to names appearing in the Fl. Reip. Pop. Sin.; for a more extensive synonymy, *see* Nicolson, 1987.

Tuber globose or depressed-globose, up to 25 cm in diam., up to ca. 20 cm high, dark brown, root-scars thickened, annulate, seasonally producing few or many offset tubers, these globose or shortly cylindric. *Leaf* solitary or occasionally two on one tuber; *petiole* ca. 55–200 cm long, ca. 2–8 cm in diam. at the base, pale green or dark green with numerous, large and small, oval-elliptic, whitish-green spots, surface strongly scabrate-verrucate, verrucae elongate; *lamina* 80–200 cm in diam., rhachises winged almost to the base; *leaflets* obovate, oblong, oval or elliptic, acuminate, 6–15 cm long, 3–13 cm in diam., veins impressed. *Inflorescence* solitary, short peduncled; *peduncle* as petiole, ca. 3–15 cm long, ca. 3–5 cm in diam., slightly less verrucate, greatly lengthening in fruit (up to 100 cm); *spathe* campanulate, extremely broadly triangular, obtuse or acute, ca. 20–30 cm long, ca. 25–40 cm in diam., moderately constricted between base and limb, base strongly convolute, very thick-walled, outside pale green or brownish with a few whitish, rounded spots, inside maroon, near the constriction dirty orangish-yellowish or pale green, limb horizontally spreading, collar-shaped, strongly undulate, outside dirty brownish-purplish with some pale spots, inside glossy dark maroon, sometimes with a glaucous sheen, base within densely verrucate, verrucae large, irregular. *Spadix* sessile, equalling or longer than spathe, 20–40 cm long; *female zone* cylindric, 5–15 cm long, ca. 2.5–8 cm in diam. (incl. styles), flowers congested or slightly remote; *male zone* strongly obconic, the upper part roofed against the broad base of the appendix, 2–8 cm long, 1.5–6.5 cm in diam. at the base, 3–10 cm in diam. at the top, flowers congested; *appendix* irregularly globose-conic, up to ca. 20 cm long, up to ca. 20 cm in diam. at the base, top obtusish, surface irregularly, shallowly or deeply folded, minutely verrucate, pale or dark purplish brown. *Ovaries* depressed or depressed-globose, 4–5 mm in diam., ca. 2.5 mm high, circular in cross-section, base white, rest maroonish, 2–3-locular, one basal ovule per locule; *style* very long and slender, 8–10 mm long, 1.5 mm in diam., maroon; *stigma* large, capitate, laterally compressed, ca. 4 x 2.5 mm in diam., ca. 3 mm high, 2–3 (–4)-lobed, lobes conic, obtuse, surface pale yellowish-white, densely verrucate-scabrate. *Male flowers* consisting of 4–6 stamens; *stamens* narrowly elongate, ca. 5 mm long, 1.5–2 mm in diam., ivory white; *filaments* extremely short, ca. 0.2–0.5 mm, connate; *anthers* narrowly elongate, ca. 4.5–5 mm long, top truncate; *pores* apical, elongate; *pollen* orange, exine smooth.

Additional specimens examined. **TAIWAN.** PINGTUNG HSIEN: Chaochou, broadleaf forest, 15–20 m alt., *Deng & Chen 445* (TNU); Chaochou, 'Vacation World', elev. ca. 50 m, *Leu 989* (HAST); same loc., *Yang & Lin 22142* (PPI); 'Vacation World', ca. 3 km S of Chaochou on Pingtung-Oluanpi Hwy, forest floor of *Swietenia macrophylla* plantation, thickly covered by *Swietenia* leaves, *Lin 491* (HAST).

Distribution. Amorphophallus paeoniifolius is the most widespread species in the genus, ranging from Madagascar to the Polynesian Islands. Because it has been widely cultivated as a root crop, it is not certain that its presence on Taiwan is part of its original natural distribution. It does not appear to be common in Taiwan; there have been confirmed collections only in Hengchun Peninsula in Pingtung Hsien, southernmost Taiwan (Figure 1), on the forest floor in plantations, ca. 15–50 m alt. That it is ". . . Rather common in the central and southern parts of the island." (Huang, 1978) is doubtful. Flowering Apr–May.

Notes. For the purpose of this paper, the description of *A. paeoniifolius* is based on Hayata (1916) and on selected additional morphological information from a few specimens from Taiwan and elsewhere. It should be noted that in *A. paeoniifolius*, the dimensions of parts of the inflorescence are extremely variable. Li (1979) retains *A. gigantiflorus*, *A. virosus*, and *A. bangkokensis* as separate species. In the key, she separates *A. bangkokensis* from the other two species primarily by the smooth petiole. *Amorphophallus gigantiflorus* is separated from *A. virosus* primarily by having a three-lobed stigma (vs. two-lobed in *A. virosus*). Other characters mentioned by Li that separate the species, e.g. shape of the appendix and colors of the spathe, vary highly in *A. paeoniifolius* (to which all three mentioned species belong). Also, the lobing of the stigma is variable in this species, being either 2- or 3-lobed. The degree of roughness of the petiole is equally variable, and may vary considerably in one individual over the years. W.L.A. Hetterscheid studied *A. paeoniifolius* over its entire distribution range and found it to be extremely variable, but found no arguments to separate infraspecific taxa, let alone maintain the many species' that have been recognized separate from *A. paeoniifolius*.

A comprehensive morphological account of this species will be published by W.L.A. Hetterscheid as part of

the revision of the species of *Amorphophallus* for the Flora Malesiana account of the Araceae.

The most widespread and commonly cited name for this species is *A. campanulatus*. The epithet *'campanulatus'* and its proper author-citation is very confused (*see* Nicolson, 1977 for a clarification of the confusion).

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魔芋屬植物（天南星科）研究 4.台灣自生種類之分類訂正

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本研究對台灣自生之魔芋屬 (*Amorphophallus*) 植物進行分類訂正，確定台灣共有四種，其學名分別爲 *A. henryi* N.E. Br.（台灣魔芋），*A. hirtus* N.E. Br.（密毛魔芋），*A. kiusiamus* (Makino) *Makino*（東亞魔芋）及 *A. paeoniifolius* (Dennst.) Nicolson（疣柄魔芋）。前二種特產台灣；東亞魔芋則爲本研究首次報導的台灣新記錄植物。本研究將台灣植物誌記載爲特有種的雷公統 (*A. gigantiflorus* Hayata) 及疏毛蒟蒻 (*A. nimurai* Yamam.) 分別歸併爲疣柄魔芋（廣泛分布於馬達加斯加至玻里尼西亞群島間）及台灣魔芋（台灣特產種）之異名；中國大陸產的疏毛魔芋 (*A. sinensis* Belval) 則歸併爲東亞魔芋（分布於中國大陸東南省分、台灣以及日本南部的九州、四國）。本研究除對上述植物進行分類處理、提供檢索表、完整之性狀描述、引證標本、彩色圖幅外，並討論植物地理及演化親緣關係。

關鍵詞：魔芋屬；蒟蒻；天南星科；地理分布；台灣；植物分類。