

Amorphophallus natolii (Araceae), a new species from limestone on Palawan, Philippines

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ABSTRACT. *Amorphophallus natolii* is described and illustrated as a new species from limestone hills near El Nido, Palawan island, Philippines. It differs most distinctly from other species of *Amorphophallus* with a densely hairy appendix by its much smaller size and dominant reddish pinkish colours of the spathe. A preliminary molecular analysis shows it to be in a basal position to a clade containing a few other species with similar appendices, to which it is also morphologically compared. It is certainly one of the most remarkable new discoveries in a genus containing ca. 200 species.

Keywords: Araceae; *Amorphophallus natolii*; Limestone flora; New species; Philippines; Palawan.

INTRODUCTION

Mr. Basil Natoli and his family roaming the area of the town of El Nido on the island of Palawan, Philippines, found a remarkable flowering *Amorphophallus* species occurring in very small humus pockets on a high limestone cliff above the town. The area lies on the west coast of Palawan and the town of El Nido which is bordered by a series of very steep limestone cliffs on top of which vegetation is found to grow in humus-rich deep cracks and shallow pockets. From photographs sent to three of the authors the *Amorphophallus* was recognized as a species new to science. Dried material collected by Andreas Wistuba was prepared for the CMUH herbarium (see below). Leaf parts were molecularly analysed by Cyrille Claudel, and compared to existing molecular information of *Amorphophallus*. From this a preliminary phylogenetic placement was made. The phylogeny of the *Amorphophallus* clade containing all species with hairs on the appendix was re-analysed based on *RbcL* and *MatK* in order to get a preliminary assessment of the homoplasy of this character. A key to the *Amorphophallus* species with hairs on the appendix is provided. The species description is based on the holotype specimen only. Additional statements on dimensions between brackets and in the discussion result from specimens seen on pictures only.

Other *Amorphophallus* species found on Palawan are *A. declinatus* Hett. (Taytay Bay: Hetterscheid, 1994), *A. palawanensis* Bogn. & Hett. (Underground River: Bogner and Hetterscheid, 1992) and *A. salmoneus* Hett. (Lagen Island: Hetterscheid, 1994), all are endemic.

NEW SPECIES

Amorphophallus natolii Hett., A. Wistuba, V.B. Amoroso, M. Medecillo & C. Claudel, spec. nov.—TYPE: PHILIPPINES. Palawan, above El Nido town, on limestone cliffs overlooking the town, in small pockets or deep cracks with organic detritus (humus), alt. 175-450 m, 14 Dec 2010, V.B. Amoroso s.n. (holotype: Central Mindanao University Herbarium, nr. CMUH 00007678). Plate 1a-d.

Diagnosis: The new species differs from other species with densely hairy appendices (*A. hirtus*, *A. longicomus* and *A. pilosus*) by its pinkish spathe colour (variously greenish to purplish in the other species; it differs from *A. hirtus* and *A. longicomus* by the absence of a distinct constriction of the spathe between base and limb. From *A. pilosus* it differs in lacking hairlike staminodes in the female zone of the spadix and in having a subglobose tuber instead of a vertically elongate one. From *A. longicomus* it differs additionally in having a short style.

Description: Seasonally dormant tuberous geophyte. Tuber depressed globose, 3-8 cm in diam., 2.5-6 cm high, dark or mid brown, producing a few globose offsets, these loosely attached to the main tuber. Cataphylls uniformly

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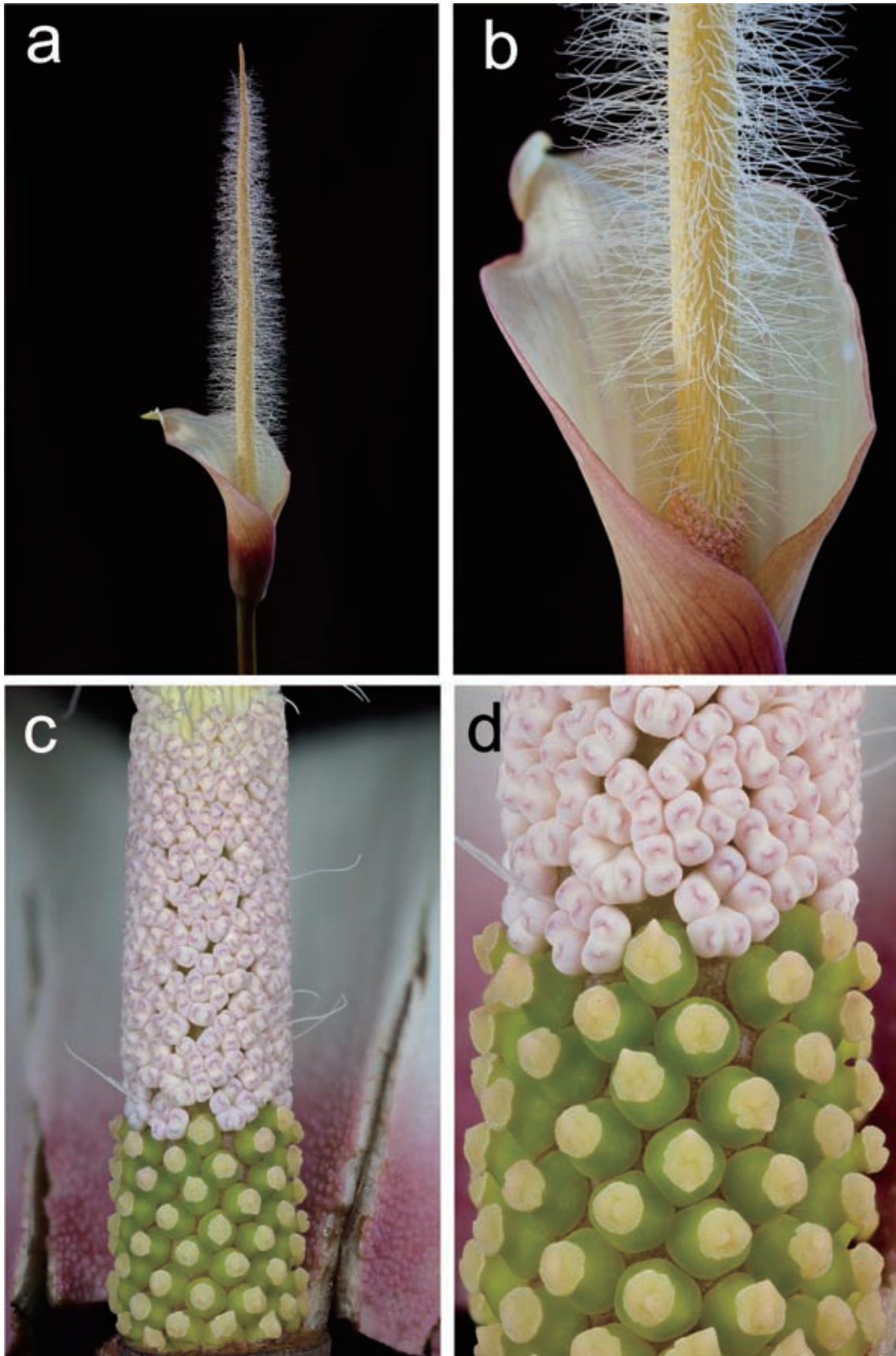


Plate 1. 1a: *Amorphophallus natolii*: habit of spathe and spadix; 1b: *Amorphophallus natolii*: spathe and lower part of spadix in detail; 1c: *Amorphophallus natolii*: lower part of spadix, showing female (below) and male zone (above), the latter with a few hairlike staminodes; 1d: *Amorphophallus natolii*: female zone (detail) showing shape of the pistils. All photographs by Andreas Wistuba.

rich pinkish brown. Leaf solitary; petiole 25-50 cm long, 1.3-2 cm in diam., smooth, entirely rich deep red, or green with an initial pinkish-purplish hue, the latter later turning all green, the lower part with tiny whitish or greenish speckles; lamina ca 70 cm wide, rhachises narrowly winged distal from the lowermost branchings; leaflets lanceolate, 4.5-15 cm long, 1.3-3.6 cm wide, narrowly acute-acuminate, upper surface dark green, lower surface pale green. Inflorescence solitary, developing shortly (but slowly) directly after leaf senescence; peduncle 8-30 cm long, ca. 8 mm in diam., pinkish red, grading upwards to dark olive green, or uniformly olive green; spathe elongate-triangular, 11-16 cm long, 3-10 cm wide, base convolute, base and limb not separated by a constriction, limb erect, base outside dark olive green or dark pinkish red, upwards grading to dark pinkish red or pale pink sometimes with a few whitish, orbicular spots, inside pinkish red with either a few, scattered, shallow warts or more densely set, thicker warts, limb erect, outside pale green or pale pink, to the sides flushed with reddish pink, with or without dark veins, inside white with or without a pale greenish flush, slightly transparent, margin straight or slightly sinuous, slightly flushed pale pink, top acute. Spadix sessile, longer than spathe, 18-25 cm long; female zone cylindrical, ca 1.6 cm long, 1.7 cm in diam., pistils adjacent, not congested; male zone cylindrical or slightly obconical, ca 2.8 cm long, 1 cm in diam., stamens congested, with occasional hair-like staminodes in between; appendix elongate, thin, conical, 13.6-18.5 cm long, 0.9-1 cm in diam. at the base (excl. staminodes), gradually tapering to the acute tip, surface densely set with long, thin hair-like staminodes with swollen bases. Ovary depressed, orbicular in outline, 2 mm in diam., 1.3 mm high, bright pale green, unilocular, with an incomplete wall between the locules, ovules 1 or 2; style thick, 0.8-0.9 mm long, 1 mm in diam., bright pale green, bifurcating; stigma deeply or shallowly bi(-tri)lobed, elliptical or suborbicular in outline, 1 mm in diam., 0.3 mm thick, lobes hemispheric or conical, erect or diverging, sometimes of unequal length, minutely verruculate, whitish. Male flowers consisting of 3-4 stamens; stamens ca 1.5 mm long, filaments ca 0.9 mm long, fused, white; anthers ca 0.5 mm long, subrectangular in outline, 0.8-1.2 mm in diam., whitish, pinkish around the pores, connective broad, pores slit-like. Upper male flowers deformed and showing all transitional forms to the staminodes present on the appendix. Staminodes on appendix hair-like, 0.3-1.3 cm long, thin, perpendicular to the spadix axis, white, base swollen but less so in upper staminodes, to absent, elliptical in outline, verruculose, dirty pinkish or cream. Fruiting part elongate (seen only on pictures), berries crowded; berries orange red, top truncated, stigma persistent.

Etymology. The species is named after Mr. Basil Natoli and his family, the original discoverers of the species.

Ecology and distribution. *Amorphophallus natolii* is only known from the type locality. It grows in exposed conditions in small, exposed humus pockets or in deep cracks on a limestone hill. This is not a unique situation

in *Amorphophallus*. Several species in Thailand, Vietnam and Laos, and on the island of Borneo, occur in similar conditions.

Taxonomic notes. Only three species of *Amorphophallus* are known to possess an erect, densely hairy, narrowly elongate conical appendix. These are *A. hirtus* N.E. Br. (Taiwan), *A. longicomus* Hett. & M.Serebryanyi (Vietnam), and *A. pilosus* Hett. (Vietnam). These three species carry the spathe and spadix on a very long peduncle, far outreaching the length of the spathe. In *A. natolii*, the peduncle may be shorter or equalling the spathe but may also be considerably longer (observations based on pictures only). Of these four species one (*A. pilosus*) has a massive, vertically elongate tuber, whereas *A. longicomus*, *A. hirtus* and *A. natolii* have a depressed globose tuber. In *A. hirtus* and *A. pilosus*, the style is short and this is shared with *A. natolii*, whereas *A. longicomus* has very long, slender styles. The colour of the adaxial surface of the spathe in *A. natolii* is near-unique in the entire genus, being a soft reddish pink to whitish pink. This colour is matched only by the abaxial surface of the spathe of *A. bulbifer* Roxb. (India), *A. muelleri* Bl. (N. India through Burma, Sumatra, Java to Timor), and *A. xiei* H. Li & Z.L. Dao (S. China), which are a phylogenetically closely-knit group of triploid species not closely related to any of the species discussed here, and *A. cicatricifer* Hett. (Thailand). The last species found in a similar basal position to the same clade as is *A. natolii* (see below). Both *A. hirtus* and *A. longicomus* share a strong constriction in the spathe between base and limb; this is lacking in both *A. natolii* and *A. pilosus*.

MOLECULAR DATA

The molecular phylogeny of *Amorphophallus* is currently being reconstructed by Wilbert Hettterscheid and Cyrille Claudel (Claudel and Hettterscheid, in prep.). It was decided to insert a preliminary molecular phylogenetic analysis using PAUP (Swofford, 2003), executed by Cyrille Claudel, to get some grip on the phylogenetic position of *A. natolii*, because of its hairy appendix, an otherwise quite rare character in *Amorphophallus*. Other species with hairs on the appendix, either densely or shallowly, or occasionally occurring in a species or consistently, are *A. aberrans* Hett., *A. cirrifer* Stapf, *A. cruddasianus* Prain ex Engl., *A. henryi* N.E. Br., *A. hirtus*, *A. kiusianus* (Makino) Makino, *A. lanuginosus* Hett., *A. laoticus* Hett., *A. longicomus*, *A. macrorrhizus* Craib, *A. napiger* Gagn. and *A. pilosus*. In a recent molecular analysis (Sedayu et al., 2010) some of these species (*A. cirrifer*, *A. henryi*, *A. hirtus*, *A. lanuginosus* and *A. laoticus*) were included and all turned out to be part of one clade called the Continental Asia I - clade.

The PAUP analysis was based on two markers (*rbcL* and *matK*) with available data of about 120 *Amorphophallus* species incl. all species mentioned above. The partial consensus tree shown here is pre-published from a paper in preparation (Claudel et al., in prep.) and is only meant

to illustrate the phylogenetic relationship of the species described here in relation to other species with hairlike staminodes on the appendix. Therefore only the Continental Asia-I clade is shown as this is the only clade containing species with hair-like staminodes on the appendix. The complete protocol and analysis of the entire genus will be published soon. The dataset of this analysis contained 3015 characters, of which 1491 characters were constant, 414 variable characters were parsimony-uninformative and 1110 were parsimony-informative. The settings used were as follows: gaps treated as “missing”; starting tree(s) obtained via stepwise addition; TBR; branches collapsed (creating polytomies) if maximum branch length is zero; trees unrooted.

The analysis reveals all species mentioned above with hairs on the appendix to belong to an expanded Continental Asia-I clade (relative to Sedayu et al., 2010) but *A. natolii* to be almost basal to it, *A. hirtus* being the actual basal species (see Figure 1). This preliminary result would indicate that the densely hairy appendix is a basal character of the Continental Asia-I clade whereas the species with a less densely hairy appendix and those with occasionally occurring hairs on the appendix, are in a more derived position. No further conclusions are made here as to the functionality of the staminodes. This will await a more robust analysis including more morphological characters optimized on the phylogeny of the entire genus.

Detailed observations by the first author clearly indicate the hairs to be derived from functional anthers and that they are to be regarded as staminodes. The appendix of *Amorphophallus* (and probably nearly all Araceae) is of staminal origin (the latter therefore being a huge syntaminodium), and thus this is not a surprising observation. The allusion created by the hairs to mammal skin may be part of a pollinator deceit syndrome, well-known to other *Amorphophallus* species (Hettterscheid, in prep.) and the Mediterranean *Helicodicerus muscivorus* (L. f.) Engl. (Kite, 2000; Seymour et al., 2003; Angioy et al., 2004). Then again, it may also be a mechanism to keep pollinators from successfully climbing out of the spathe via the spadix during female anthesis, in order to secure maximum pollination chances. The scent during female flowering is reminiscent of freshly cut wood (W. Suarez, Philippines, pers. comm., verified by Claudel). This is a new type of scent reported for the genus (Kite and Hettterscheid, 1997; Kite et al., 1998) and does not seem to support a cadaver-imitation syndrome.

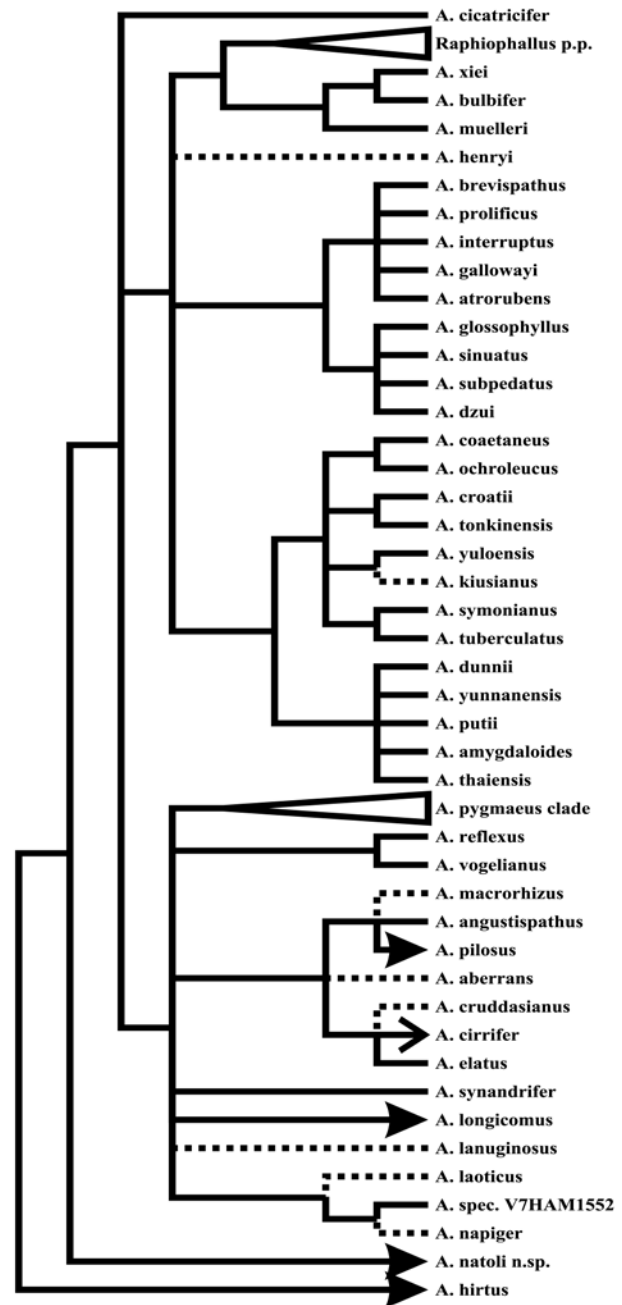


Figure 1. The Continental Asia-I clade of *Amorphophallus*, showing in colour all species with hairs on the appendix. Solid arrows: the species with the appendix densely covered with staminodes. open arrow: the one species with always loosely set staminodes on the appendix (*A. cirrifer*). dotted branches: the species with occasionally staminodes on the appendix.

KEY TO AMORPHOPHALLUS SPECIES WITH HAIRS ON THE APPENDIX

Hairlike staminodes developing on the appendix is known to occur in 13 species of *Amorphophallus*, incl. *A. natolii*. In 8 of these (*A. aberrans*, *A. cruddasianus*, *A. henryi*, *A. kiusianus*, *A. lanuginosus*, *A. laoticus*, *A. macrorhizus* and *A. napiger*) the staminodes are not always present or even rare. The key only works for specimens with staminodes and is based on inflorescences only.

1a: appendix densely set with hair-like staminodes.

- 2a: style short (ca. 1 mm long).
 3a: spathe outside green with whitish spots, limb inside purple with white or pale purple spots, appendix and hairs dark brown, spathe constricted between base and limb, fruits blue. (Taiwan, endemic) *A. hirtus*
 3b: spathe outside base uniformly pinkish red, limb uniformly whitish or with a pinkish hue, appendix off white, hair-like staminodes white, spathe not constricted, fruits red. (Philippines, Palwan, endemic) *A. natolii*
- 2b: style distinct (2-4 mm long).
 4a: female zone with numerous hair-like staminodes, tuber elongate. (Vietnam, endemic)..... *A. pilosus*
 4b: female zone without hair-like staminodes or a few at the top, tuber depressed globose. (Vietnam, endemic).....
 *A. longicomus*
- 1b: appendix with scattered hair-like staminodes, or only a few near the base.
 5a: male zone with a very dense clothing of hair-like staminodes. (C. Vietnam, endemic) *A. lanuginosus*
 5b: male zone without hair-like staminodes or only few.
 6a: style distinct, long (2-4 mm long).
 7a: peduncle longer than spathe, spathe limb held erect, pressed against the appendix, appendix far outreaching the spathe, fruits yellowish or white, tuber vertically elongate, narrow. (Lao, endemic)..... *A. laoticus*
 7b: peduncle shorter than spathe, spathe limb held horizontal, fruits blue, tuber subglobose. (Taiwan, endemic)
 *A. henryi*
- 6b: style indistinct or short (0-1 mm long).
 8a: spathe limb inside purple with white or pale purple spots, held oblique or horizontal.
 9a: peduncle longer than spathe, appendix erect, female zone without hair-like staminodes. (Taiwan, eastern China & south Japan) *A. kiusianus*
 9b: peduncle shorter than spathe, appendix usually strongly horizontal, top often pointing upwards, surface always with scattered hairlike staminodes, female zone with numerous hair-like staminodes. (C. Thailand, endemic)..... *A. cirrifer*
- 8b: spathe limb inside uniformly purple or pale green, erect, tuber vertically elongate.
 10a: female zone with numerous hairlike staminodes with bulbous bases. (C. and N. Thailand, endemic)....
 *A. aberrans*
 10b: female zone without staminodes.
 11a: pistils crowded, outline prismatic, stigma shallowly or deeply lobed, spathe limb inside always pale green, tuber thick, not or rarely with a few branches.
 12a: appendix base narrower than male zone. (N. Thailand, endemic) *A. macrorrhizus*
 12b: appendix base as thick as or thicker than male zone. (N. Thailand, Burma)... *A. cruddasianus*
 11b: pistils more or less widely spaced, outline oval or suborbicular, stigma entire, spathe limb inside uniformly purple (rarely) or pale green, tuber very narrow, often branching. (Thailand, Cambodia, Vietnam)..... *A. napiger*

LITERATURE CITED

- Angioy, A.-M., M.C. Stensmyr, I. Urru, M. Puliafito, I. Collu, and B.S. Hansson. 2004. Function of the heater: the dead horse arum revisited. *Proc. R. Soc. Lond. B (Suppl.)* **271**: 13-15.
- Bogner, J. and W.L.A. Hettterscheid. 1992. Notes on the genus *Amorphophallus* (Araceae) - 1. Three new species from tropical Asia. *Blumea* **36**: 467-475.
- Hettterscheid, W.L.A. 1994. Notes on the genus *Amorphophallus* (Araceae) - 2. New species from tropical Asia. *Blumea* **39**: 237-281.
- Kite, G.C. 2000. Inflorescence odour of the foul-smelling Aroid *Helicodieros muscivorus*. *Kew Bull.* **55**: 237-240.
- Kite, G.C. and W.L.A. Hettterscheid. 1997. Inflorescence odours of *Amorphophallus* and *Pseudodracontium* (Araceae). *Phytochemistry* **46(1)**: 71-75.
- Kite, G.C., W.L.A. Hettterscheid, M.J. Lewis, P.C. Boyce, J. Ollerton, E. Cocklin, A. Diaz, and M.J. Simmonds. 1998. Inflorescence odours and pollinators of *Arum* and *Amorphophallus* (Araceae). In S.J. Owens and P.J. Rudall (eds.), *Reproductive Biology*. Royal Botanic Gardens Kew, pp. 295-315.
- Sedayu, A., M.C.M. Eurlings, B. Gravendeel, and W.L.A. Hettterscheid. 2010. Morphological character evolution of *Amorphophallus* (Araceae) based on a combined phylogenetic analysis of *trnL*, *rbcL* and *LEAFY* second intron sequences. *Bot. Stud.* **51**: 473-490.

Seymour, R.S., M. Gibernau, and K. Ito. 2003. Thermogenesis and respiration of inflorescences of the dead horse arum *Heliconia muscivora*, a pseudothermoregulatory aroid associated with fly pollination. *Funct. Ecol.* **17**: 886-894.

Swofford, D.L. 2003. PAUP Phylogenetic Analysis Using Parsimony Version 4. Sinauer Associates, Sunderland, Massachusetts.

菲律賓巴拉望島石灰岩天南星科新種魔芋：
Amorphophallus natolii

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本文報導菲律賓巴拉望島 El Nido 附近石灰岩山丘發現之新種魔芋— *Amorphophallus natolii*，並加以描述與繪圖。此新種之肉穗花序之附屬器密被長毛，與其它一樣具有密毛附屬器之魔芋的主要不同在於形狀甚小，且佛焰苞明顯為紅 - 粉紅色。初步的分子分析顯示此新種位於與數種其它具有類似的附屬器同一支系的基部位置；本文對這些物種亦進行形態比較。可以說此新種為具有大約 200 種植物的魔芋屬最重大發現之一。

關鍵詞：天南星科；*Amorphophallus natolii*；新種；菲律賓；巴拉望島；石灰岩植物。