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# AROIDEANA

*International Aroid Society, Inc.*

*Volume 38E*  
*No 2*  
*August 21, 2015*  
*ISSN 2310-0745*



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*Aroideana* ISSN: 0197-4033 ( Print ) 2310-0745 ( Online )  
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# Studies on Schismatoglottideae (Araceae) of Borneo XXXXVI: *Fenestratarum mulyadii*—A second species for a recently described genus

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## ABSTRACT

A second species of the recently established genus *Fenestratarum* is described, from Kalimantan Timur, Indonesian Borneo, as *Fenestratarum mulyadii*. This new species represents an over 600 km eastwards extension to the known range of the genus. *Fenestratarum mulyadii* is figured in colour, and compared to *Fenestratarum culum* in an identification key.

## KEY WORDS

Rheophytic, Kalimantan Timur, basalt

## INTRODUCTION

Shortly following approval and return of the proofs describing *Fenestratarum* (Boyce & Wong, 2014), a highly distinctive new species clearly assignable to *Fenestratarum* flowered in cultivation. It is described below.

KEY TO THE SPECIES OF *FENESTRATARUM*

1. Leaf blades linear, stiffly leathery, margins smooth; petiole and peduncle glabrous; spathe limb white . . . . . *F. culum*
- Leaf blades very narrowly oblong, softly leathery, margins strongly undulate; petiole and peduncle velvety; spathe limb green . . . . . *F. mulyadii*

***Fenestratarum mulyadii*** P. C. Boyce & S. Y. Wong, **sp. nov.** Type: Indonesian Borneo, Kalimantan Timur, Kutai Barat, Laham, Long Ma Au, Sungai Mahakam, 00°16'24.30"N 115°21'8.64"E, 14 Nov. 2014, *Mulyadi AR-5000* (holotype BO!; isotype SAR!).

**Diagnosis**

*Fenestratarum mulyadii* is distinguished from *F. culum* by the leaf blades with strongly undulate (vs smooth) margins, the velvety (vs glabrous) petioles and peduncles, and by the predominantly green spathe limb with more extensive fenestrations.

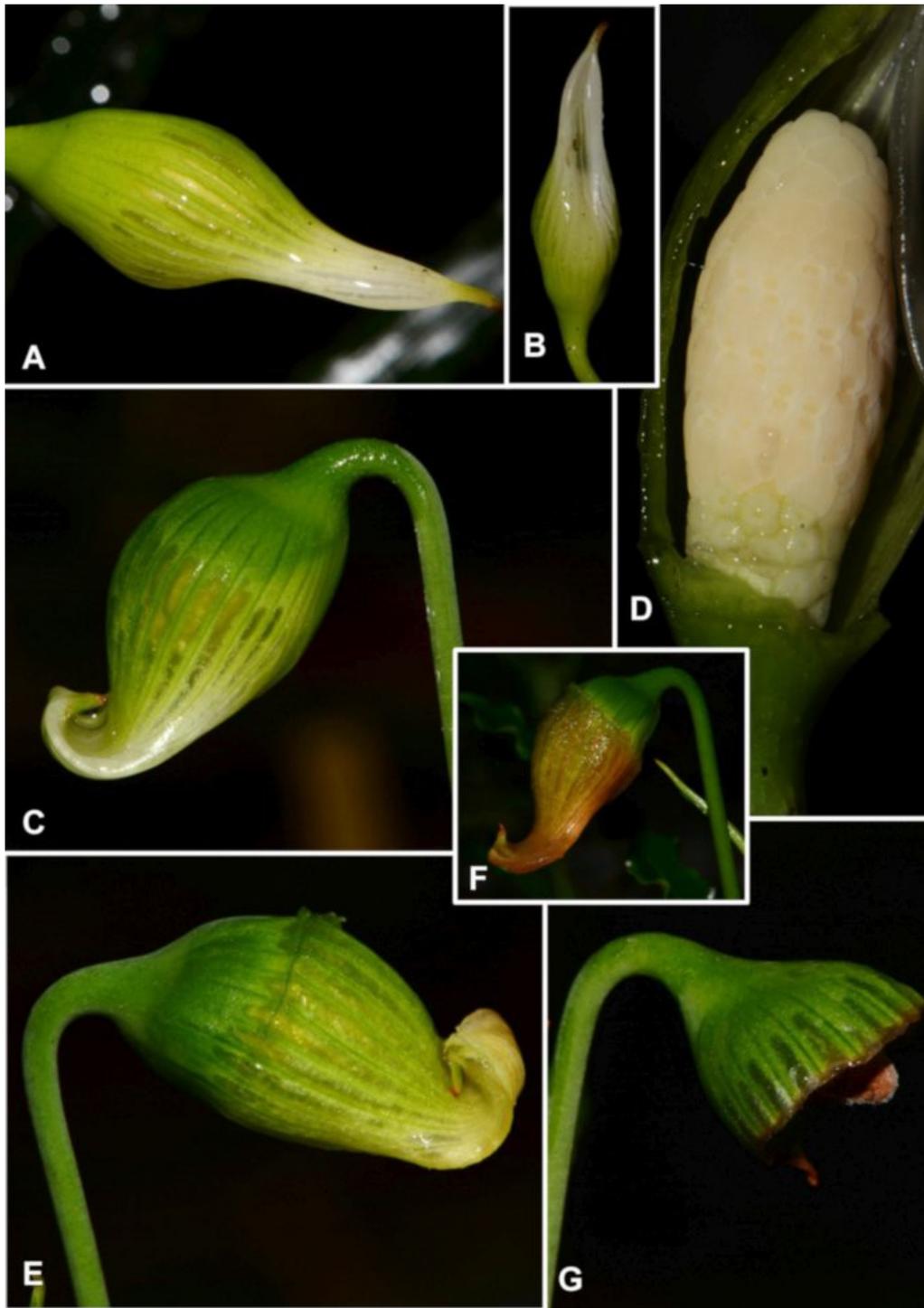
**Description**

Small obligate tufted rheophytes to ca. 15 cm tall. **Stem** compact, later elongating to ca 5cm, erect ca. 1 cm in diam., basally with copious strong roots and occasional stiff stilt-roots. **Leaves** many together, forming a neat rosette; **petiole** ca. 1.5 cm long, basal third broadly sheathing and swollen, ca. 3 mm wide, pale velvety green, remainder of petiole D-shaped in cross-section, dark velvety green; **petiolar sheath** with wings extended into a narrowly triangular ligular

caducous portion ca. 2.5 cm long; **blade** softly coriaceous, very narrowly oblong with margins strongly undulate 7–12 cm long × ca 8 mm wide, base cuneate, apex sub-acute and apiculate for ca 2 mm, adaxially deep velvety green, abaxially matte pale olive green; **midrib** abaxially and adaxially sharply prominent; **primary lateral veins** ca. 4 on each side, meeting at the tip and there coalescing to form the apiculate point; **secondary venation** forming an obscure tessellate pattern. **Inflorescence** solitary, but with up to four produced in sequence, alternating with solitary foliage leaves; **peduncle** slender, somewhat exceeding the leaves, ca. 7 cm long × 2 mm in diam., medium velvety green, uppermost part curving forward to hold the inflorescence at ca. 80° to the peduncle. **Spathe** ca. 2.7 cm long, ca. twice length of spadix; **spathe limb** broadly lanceolate with the lower part with large transparent areas separated by opaque green veins, terminally extended into a prominent white rostrum ca. 1 cm long, limb opening at pistillate anthesis by a ventral elliptic fissure with incurving margins, limb lower part of limb inflating at staminate anthesis and then caducous by deliquescence at junction with persistent lower part after staminate anthesis, falling in



**Figure 1.** *Fenestratarum mulaydii* P. C. Boyce & S. Y. Wong. **A–E.** Plants in habitat, Type locality. **A & E.** General view of plants in habitat. **B.** Flowering plant. **C.** Post anthesis plant. **D.** Fruiting plant. **A–E** from *AR-5000*. Images © Mulaydi. Used with permission.



**Figure 2.** *Fenestratarum mulyadii* P. C. Boyce & S. Y. Wong. **A & B.** Inflorescence at pistillate anthesis. Note fused lower spathe margins. **C.** Inflorescence at staminate anthesis. Note changes in spathe shape. **D.** Spadix at pistillate anthesis, nearside spathe artificially removed. **E.** Inflorescence at end of staminate anthesis, spathe limb starting to degrade and separate from persistent lower portion. **F.** Inflorescence post-anthesis; **G.** Persistent lower spathe shortly after shedding spathe limb. As fruits develop the peduncle straightens to present the slash-cup upwards. **A–G** from *AR-5000*. Images © P. C. Boyce.

a single but deliquescent piece together with the spent parts of the spadix; **lower spathe** with fully fused margins, forming an ellipsoid, later globose chamber during anthesis, dark green, persistent after anthesis and forming an erect 1 cm × 1 cm funnel-form structure subtending the developing fruits. **Spadix** sub-fusiform, 15–20 mm long × 5 mm wide; **pistillate flower zone** cylindrical, comprised of ca 3 spirals of flowers, narrower than remainder of spadix, accounting for slightly more than ¼ of spadix, ca 3 mm long × 4 mm in diam., with an incomplete row of squat polygonal glossy white staminodes at base; **pistils** crowded, sub-globose, ca. 1 mm in diam., very pale greenish white; **stigma** sessile, discoid, as wide as pistil, smooth with a central indentation, white; **sterile interstice** ca 1.5 mm long × 5–7 mm in diam., composed of a single row of polygonal staminodes, these 1 mm long × 0.5–1 mm wide, white; **staminate flower zone** wider than remainder of spadix, about ½ of entire spadix length, 5–6 mm long × 5–7 mm in diam., very pale creamy white; **staminate flowers** large, spirally arranged, each composed of two stamens, truncate, rhomboid from above, ca. 2 mm long × 1.5 mm wide; **thecae** set in pits on the top and bottom (with respect to the spadix axis) of each stamen separated by a conspicuous broad, slightly domed connective; **appendix** ca 2 mm long, tapering, obtuse; **appendix staminodes** squat rhomboidal, very pale creamy white. **Infructescences** erect. **Fruiting spathe** funnel-form, ca. 1 cm long × ca. 1 cm wide, dark green with a scar along rim; **fruits** obpyriform, ca 3 mm long,

stigmatic remain raised, darker green; **seeds** not seen.

**Distribution** — *Fenestratarum mulyadii* is so far known only from the Type locality.

**Ecology** — *Fenestratarum mulyadii* is rheophytic on mossy Neogene basalt river boulders under rather open perhumid lowland forest at ca 130m asl.

**Etymology** — The trivial epithet is for Mulyadi, the original collector of this and numerous other exceptionally interesting aroid species.

**Notes** — *Fenestratarum mulyadii* occurs over 600 km east of the only known locality of *Fenestratarum culum*, and on quite different (acid) geology. It is highly probable that additional novel *Fenestratarum* species occur between these range extremes, as likely as not highly localized and geologically obligated.

## ACKNOWLEDGEMENTS

This is part of an on-going research which is funded by the Ministry of Higher Education, Malaysia by the Exploratory Research Grant Scheme Vote No. NRGS/1089/2013-(03) and Fundamental Research Grant Scheme Vote No. FRGS/STWN10(01)985/2013(26). Biodiversity Centre are gratefully acknowledged.

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- Boyce, P. C. & S. Y. Wong. 2014. Studies on Schismatoglottideae (Araceae) of Borneo XXXXIII: *Fenestratarum culum* - A new genus and species from Kalimantan Barat, Indonesian Borneo. *Aroideana* 37E(2): 4–10.

# Studies on Schismatoglottideae (Araceae) of Borneo XXXXVII –*Aridarum ashtonii*, a new species from the Hose Mountains, and notes on *Aridarum burttii*

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## ABSTRACT

*Aridarum ashtonii* is described as a new species from highland sandstones of the Hose Mountains, Kapit, Sarawak, Malaysian Borneo. *Aridarum ashtonii* has previously been confounded by the authors with *Aridarum burttii*, a species occurring on lowland riverine shales. Notes on *Aridarum burttii* are given and the purported origins of the Type specimen questioned. *Aridarum ashtonii* and *A. burttii* are illustrated from living plants, and a key to the five species of

the *Aridarum Burttii* Complex is provided. Recognition of *A. ashtonii* takes *Aridarum* to 26 accepted, described species.

## KEY WORDS

Shale, sandstone, *kerangas*

## INTRODUCTION

During description of two new species of the *Aridarum Burttii* Complex (Wong et al.,

2012) a spadix was figured as *Aridarum burttii* Bogner & Nicolson (Wong et al., 2012: 266, **Figure 3**) determined on the basis that the plant originated from the Hose Mountains of Sarawak, from where the Type of *Aridarum burttii* was purported to have been collected (Bogner, 1979). At the time we harboured doubts privately as to the veracity of this determination, but with no better material to hand took a pragmatic approach.

Recently we had occasion to explore the Ulu (headwaters) of the Sungai (river) Engkari (Sarawak: Sri Aman, Lubok Antu), from where *Aridarum burttii* has also been collected (see Bogner & Hay, 2000: 189) and were fortunate to encounter significant populations of *Aridarum burttii* at every stage of flowering and thus were able to make extensive observations. It was soon

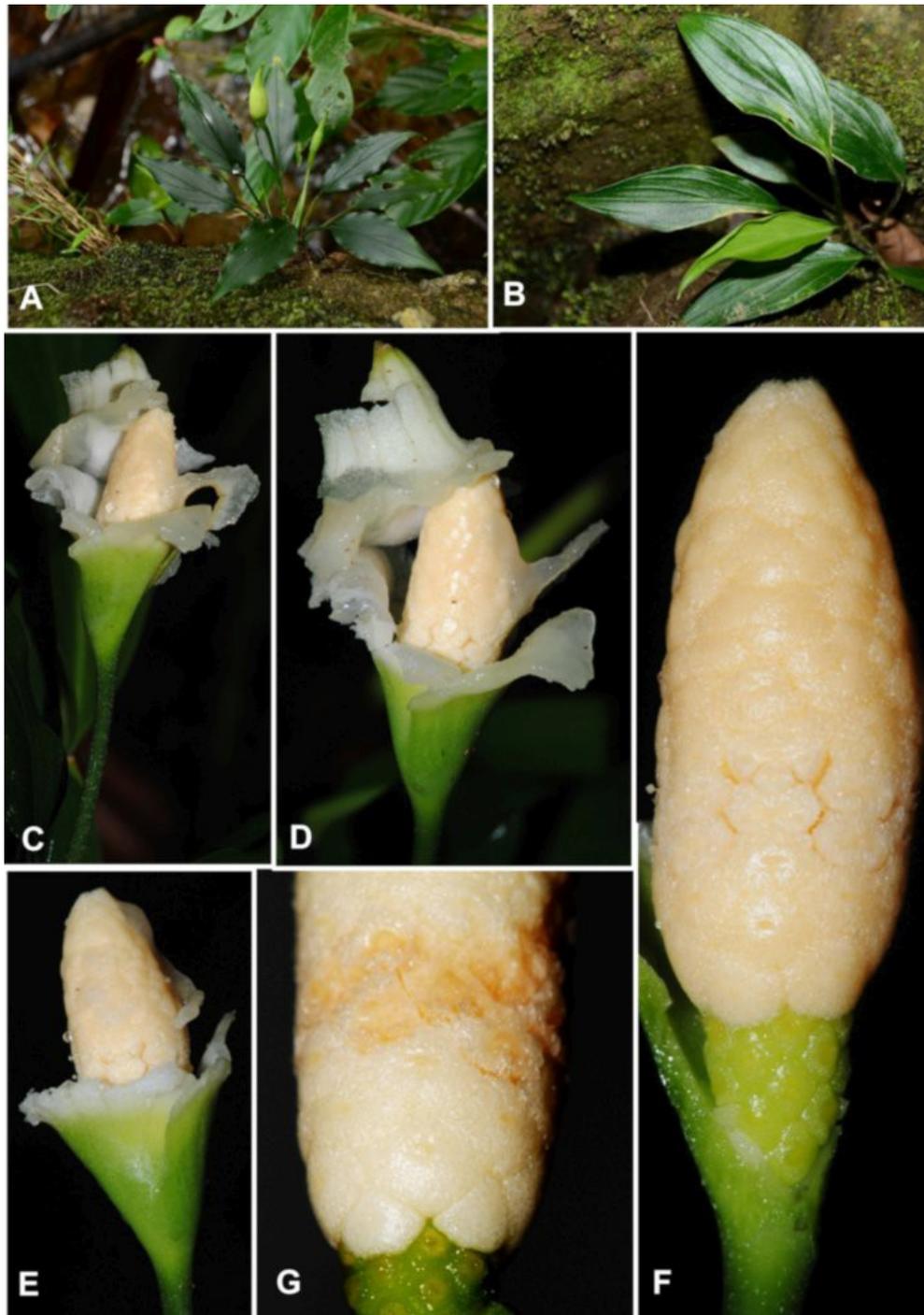
apparent that the Sungai Engkari plants match very closely the Type of *Aridarum burttii* [B. L. Burtt & A. M. Martin B 5116], and likewise differ considerably from the plant [AR-3726] figured as *A. burttii* in Wong et al., 2012. On return to Kuching re-examination of living and liquid preserved collections of AR-3726 established that not only were they not pertinent to *Aridarum burttii* neither did they match any described species of *Aridarum*. A search of SAR and of our photographic records of Herbarium material located specimens [P. S. Ashton S21256] matching our living plants from the Hose Mountains and we determined this to represent the same species.

We are describing this here as a new species of the *Aridarum* Burttii Complex – *Aridarum ashtonii* S. Y. Wong & P. C. Boyce.

KEY TO THE SPECIES OF THE *ARIDARUM BURTTII* COMPLEX

- 1. Pistillate flowers confined to two rows ± embedded in the spadix; inflorescence erect at anthesis . . . . . 2
- Pistillate flowers in several rows not embedded in the spadix; inflorescence nodding at anthesis . . . . . 3
- 2. Plants with rhizome creeping and rooting; leaf blades linear-lanceolate with prominently raised marginal veins; pistillate flower zone with a few vermiform staminodes at base. Lowlands, Kalimantan Barat . . . . . ***A. minimum***
- Leaf blades broadly elliptic, primary lateral veins prominently raised on both surfaces of blade; erect; pistillate flower zone with a few squat rhomboidal staminodes at the base. Higlands, Kapit, Sarawak . . . . . ***A. ashtonii***
- 3. Pistillate and staminate flower zones separated by a naked interstice equalling the staminate flower zone in length; staminodes few, cylindric-clavate, at base of staminate flower zone; stamens and appendix staminodes verrucate . . . . . ***A. kazuyae***
- Pistillate and staminate flower zones not separated by a naked interstice; staminodes at base of staminate zone absent or globose; stamens and appendix staminodes smooth .. 4
- 4. Stamen connective convex, distal rim rounded, smooth or slightly sulcate; staminodes at base of staminate flower zone absent or closely resembling staminate flowers; thecae horns long, stiff, arching. Kalimantan Timur . . . . . ***A. orientale***
- Stamen connective concave, distal rim serrate-dentate; staminodes at base of staminate flower zone globose; thecae horns rather soft, short, straight. C. Sarawak (Kapit) . . . . .  
 . . . . . ***A. burttii***

***Aridarum ashtonii*** S. Y. Wong & P. C. Boyce, **sp. nov.** Type: Malaysian Borneo, Sarawak, Kapit Division, Hose Mts, Mujong, Ulu [Sungai] Amau, Bukit Lumut, 900m asl, 18 Apr. 1964, *P. S. Ashton S21256* (holotype SING!; isotypes K!, L!, SAR!). **Figures 1 & 2.**



**Figure 1.** *Aridarum ashtonii* P. C. Boyce & S. Y. Wong. **A.** Flowering plant in habitat. **B.** Leaf blades showing the distinctive raised primary lateral veins. **C & D.** Inflorescence at staminate anthesis. **E.** Inflorescence at end of staminate anthesis. **F.** Spadix at staminate anthesis, spathe artificially removed. **G.** Detail of staminate flower zone (the darker median band) at staminate anthesis, spathe limb artificially removed. **A–E** from *AR-3726*. Images A & B © Mike Lo. Used with permission. Images C–G © P. C. Boyce.

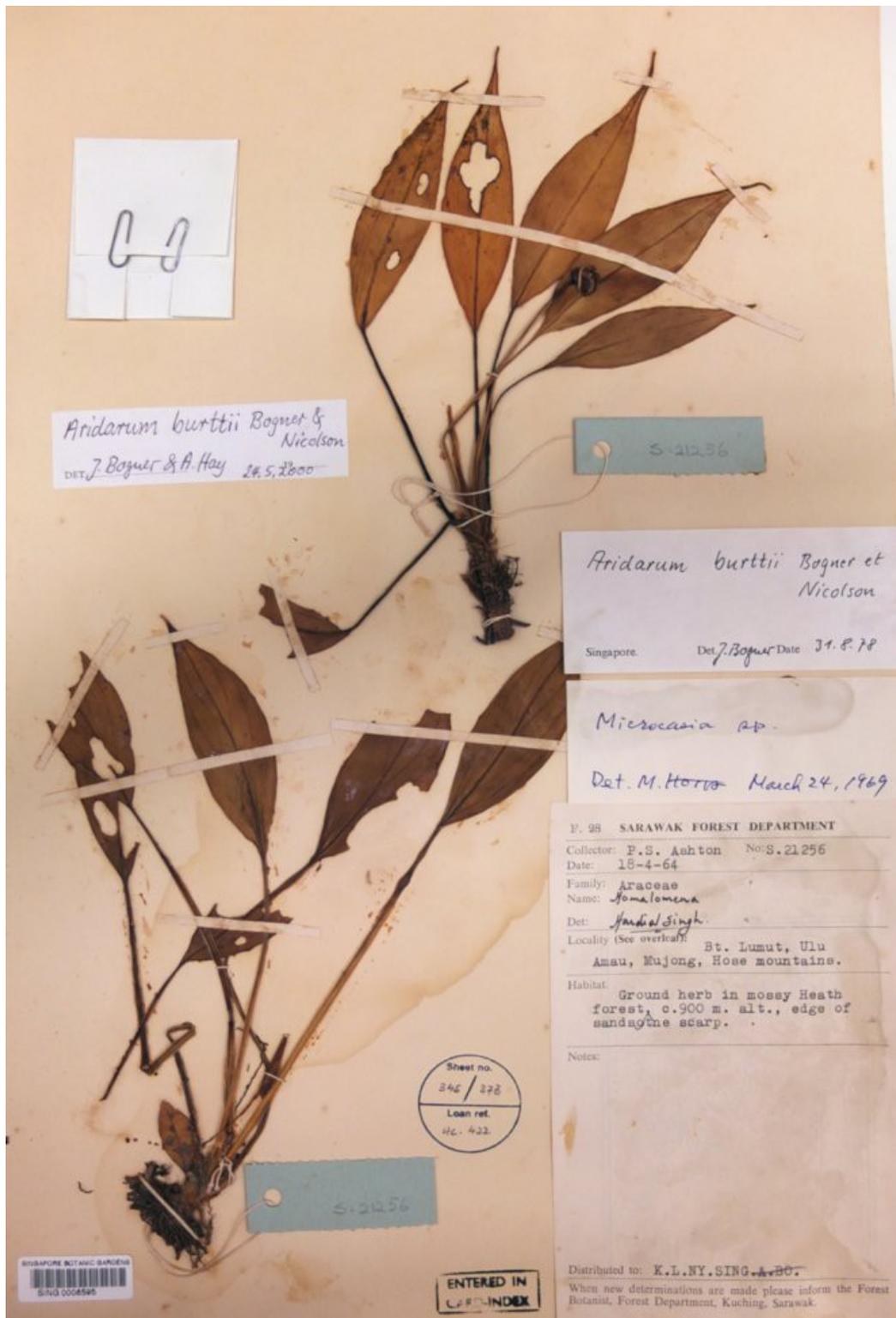


Figure 2. *Aridarum ashtonii* P. C. Boyce & S. Y. Wong  
Holotype specimen. P. S. Ashton S21256 [SING].

## Diagnosis

*Aridarum ashtonii* is readily distinguished from all other species of the *Aridarum Burtii* Complex by the combination of broad leaf blades, an erect inflorescence, staminate flowers reduced to two rows and embedded into the surface of the spadix, by the large, smooth appendix staminodes. By the much-reduced staminate flower zone and inflorescence erect at anthesis *Aridarum ashtonii* approaches *A. minimum*, although readily differentiated by the broadly elliptic (vs very narrow) leaf blades without primary lateral veins reduced to a single prominent marginal vein on each side, and the tufted (not creeping rhizomatous) habit. *Aridarum ashtonii* is a highland plant recorded from 900–1300m asl.

Small to medium-sized obligate rheophyte 10–20 cm tall. **Stem** somewhat condensed, sub-erect, later to ca 5 cm long, ca 1.5 cm in diam. **Leaves** up to 10 together, petioles erect with blades erect to slightly arching; **petiole** 6–17 cm long, 2–3 mm in diam., very weakly D-shaped in cross section, and weakly channelled dorsally, with the edges rounded, sheathing at the extreme base, medium green; **petiolar sheath** with wings extended into a narrowly triangular ligular portion 3–6 cm long, ligule soon deliquescing; **blade** rather stiffly coriaceous, elliptic, 4–11 cm long × 2–5.5 cm wide, base cuneate, apex acute, shortly acuminate and apiculate for ca 12 mm, adaxially semi-glossy medium green, paler abaxially; **midrib** abaxially and adaxially prominent; **primary lateral veins** 3–5 on each side,

diverging from the midrib at ca 30°, adaxially prominent, abaxially less so; **interprimary veins** very few, much less prominent than primaries and not visibly reaching the midrib or blade margins; **secondary venation** obscure; **tertiary venation** adaxially obscure, abaxially forming a slightly darker irregular reticulum. **Inflorescence** solitary, subtended by a 4–6 cm long, very narrowly triangular somewhat membranous cataphyll. **Peduncle** shorter than the petioles, 5–9 cm long, terete, medium green, inserted dorsal-obliquely on the spathe. **Spathe** broadly ovate, not constricted, ca 3 cm long; **lower part** salverform at anthesis, green, ultimately persistent through fruiting, **limb** glistening white, ca 2.5 cm long, apiculate for up to 5 mm, apicule distally green; limb gaping at pistillate anthesis, during staminate anthesis splitting into semi-concentric rings from the junction of the spathe limb and the persistent lower part, limb eventually falling to leave lower persistent part with a wide ragged margin of degrading tissue, this tissue then liquefying and leaving salverform persistent lower spathe with a scarred irregular rim. **Spadix** stoutly cylindrical-fusiform ca 2 cm long, ca 5 mm in diam.; **pistillate flower zone** comprising ca 1/6 of the spadix, obliquely inserted on peduncle, ventral side ca 2 mm long, dorsal side ca 3 mm long, with a few squat clavate white staminodes at the base; **pistils** subglobose, somewhat rhomboidal by compression, truncate, ca 1 mm in diameter, green; **stigma** sub-sessile, discoid, papillose, ca 2/3 the width of the ovary, greyish; **interpistillar staminodes** absent; **sterile**

**interstice** markedly wider than pistillate zone, ca 3 mm long; **interstice staminodes** large, rhomboidal, surface somewhat curved, ca 2 mm × 2 mm, waxy creamy white; **staminate flower zone** comprised of two whorls of flowers embedded into spadix, ca 1/6 of total spadix length, ca 2 mm long, medium dull yellow; **staminate flowers** each comprised of a single stamen, ± circular in plan view, with a suture between the thecae, comparatively large, ca 2.5 × 2.5 mm, connective smooth, centrally slightly impressed with the distal (with respect to spadix axis) margins forming narrow rim; **thecae** globose, each ca 1 mm long, displaced to the proximal (with respect to the spadix axis) side of the stamen with distal-pointing horns; **thecae horns** ca 0.3 mm long, stiff, directed upwards; **appendix** ca 1 cm long, comprising ca 2/3 of the entire spadix, bluntly tapering; **appendix staminodes** comprised of very densely-packed rhomboidal and partially coherent smooth staminodes, cream. **Fruiting spathe** very broadly salverform, ca 1 cm diameter, and 1 cm tall, pale to medium green with a ragged scar along the rim; **fruits and seeds** not seen.

*Ecology* — *Aridarum ashtonii* occurs on exposed sandstone river boulders and the margins of waterfalls, or on mossy boulders, under moist to perhumid lower montane heath forest (*kerangas*) on Oligocene sandstones between 900 and 1300 m asl.

*Distribution* — *Aridarum ashtonii* is known with certainty only from the Type locality on the NW flanks of the Hose Mountains

of Central Sarwak, and from Gunung Gelanggang at the SE extremity of the same range.

*Eponymy* — Named for Peter Shaw Ashton, a pioneer of understanding the dynamics of the tropical wet forests of SE Asia. Ashton's work in tropical botany began after taking his B.A. at Cambridge University in 1956 by being appointed Forest Botanist to the Brunei Government (1957–1962) during which time he completed his MA (Cantab) and PhD (Cantab). Between 1962–1966 Ashton was Forest Botanist to the Sarawak Government, before moving to Aberdeen University (1966–1978), and then to The Arnold Arboretum of Harvard University, where he was director 1978–1987, and remains to this day, now as Charles Bullard Professor of Forestry, emeritus Harvard University. Author of numerous publications on the dynamics of tropical forests, Peter Ashton is universally acclaimed for his work, notably on the dipterocarps.

*Additional specimens seen* — MALAYSIA: BORNEO: Sarawak, Kapit, Nanga Merit, Hose Mountains, Gunung Gelanggang, 02°06'0.00"N 113°49'0.00"E, 1300m, *Mike Lo AR-3726* (SAR); Kapit, Bukit Sampadai, Sungai Sampurau, Melinau, 14 Aug 1967, *I. Paie S. 25803* (K!, SAR!, US).

*Notes* — Within Sarawak, *Aridarum ashtonii* is in overall appearance most reminiscent of lowland *Aridarum burttii*, notably by the

leathery elliptic leaf blades with their prominently raised primary lateral veins. *Aridarum ashtonii* is readily distinguished from *A. burttii* by the much reduced staminate flower zone in which the flowers are embedded in the spadix, and by the large appendix clothed with smooth rhomboidal staminodes (vs appendix reduced and clothed with verruculate staminodes, often with the distal-most part naked).

The spadix of *A. ashtonii* is most similar to that of *A. minimum* (**Figure 3**), but these species may be differentiated as noted in the above Key and Diagnosis.

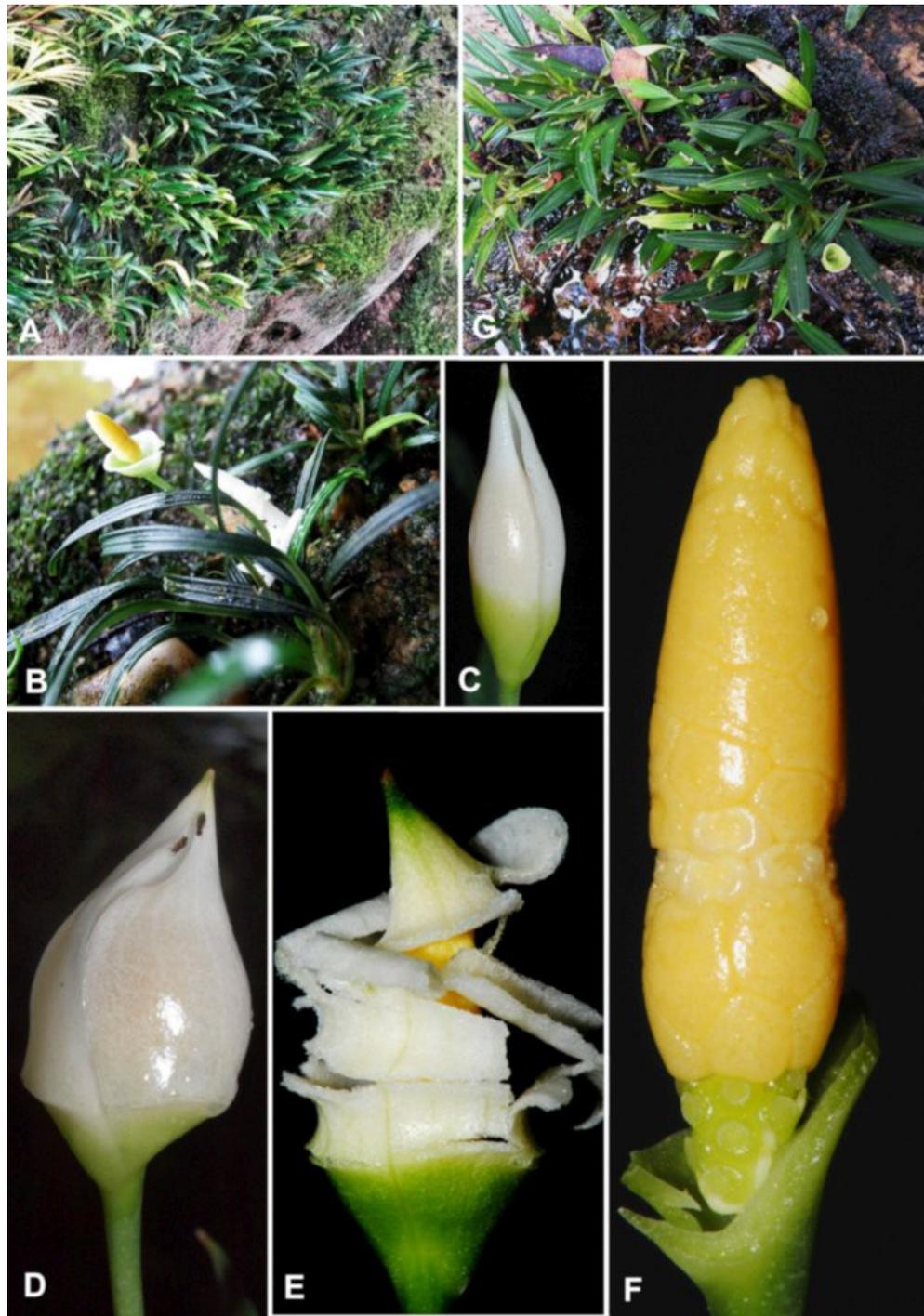
#### NOTES ON *ARIDARUM BURTTII*

As here defined *Aridarum burttii* (**Figures 4 & 5**) is a lowland species (extending to ca 400 m asl) restricted to riverine shales under lowland to hill mixed dipterocarp forest dominated by *Shorea oblongifolia*. *Aridarum burttii* is abundant along the Ulu Engkari, but absent from its junction with the Batang Ai reservoir, and for the first few kilometres of this river.

For *Aridarum* species with reliable (which is to say field-based) observational data it is evident that all are localized in their distribution. This being the situation, the circumscription of *A. burttii* adopted here raises the distinct probability that the locality stated on the Type of *A. burttii* is in error. If *A. burttii* were indeed collected from the Hose Mountains it must have

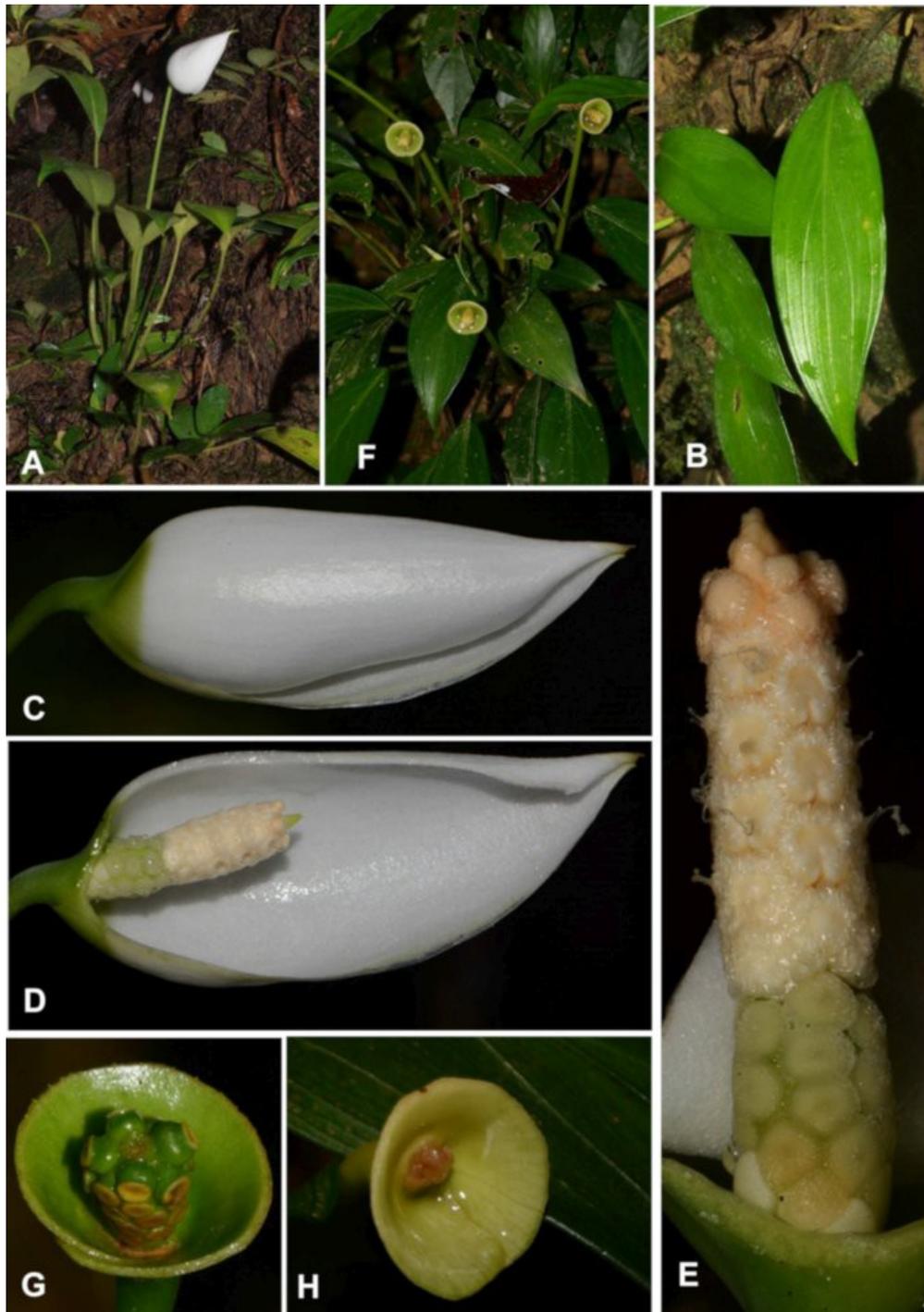
originated from well above our current confirmed upper altitudinal range recorded for the species, because all immediately surrounding areas of the Hose Mountains are between 600 and 1300 m asl, with many peaks of the actual range over 1800 m asl, and with the highest point (Bukit Batu) reaching 2028 m asl.

The protologue of *Aridarum burttii* cites *Burt & Martin 5116* (US) as the Holotype, although a search of the on-line database for US ([www.http://collections.nmnh.si.edu/search/botany/](http://collections.nmnh.si.edu/search/botany/)) failed to bring up the specimen, although Alice Tangerini's line work (Bogner & Nicolson 1991: 42, **Figure 1**) is present. Type material of *A. burttii* was prepared entirely from living material of *B. L. Burt & A. M. Martin B5116* cultivated at Royal Botanic Garden Edinburgh. Mark Newman (E) has been unable to locate a field-collected specimen of *Burt & Martin B5116* in E and (pers. comm.) stated that he "strongly suspect[ed] that *Burt [ & Martin] B5116* was a seed or rhizome sample which was accessed into the living collection of RBGE as number 19672479 (*vide* label on the E isotype – but see below) which flowered in 1968, at which time a herbarium specimen was made in the cultivated plant number series. The handwriting on the main label of the Edinburgh Isotype 'C5936' is Rosemary Smith's and it is very likely that she was also the collector." Assuming that the information on the E Isotype is correct, this implies that the material at US (if such exists) is also a cultivated collection, grown at E, raised from a seed or rhizome



**Figure 3.** *Aridarum minimum* H. Okada

**A.** Plants in habitat. **B.** Flowering plant in habitat. **C.** Inflorescence at onset of pistillate anthesis. **D.** Inflorescence at late pistillate anthesis. **E.** Inflorescence at end of staminate anthesis. **F.** Spadix, not reduced staminate flower zone (the narrower band ca 1/3 up the spadix) median band) at pistillate anthesis, spathe limb artificially removed. **A–F** from AR-3847. Images A & B, G © K. Nakamoto. Used with permission. Images C–F © P. C. Boyce.



**Figure 4.** *Aridarum burttii* Bogner & Nicolson

**A.** Flowering plant in habitat. **B.** Leaf blade showing the distinctive raised primary lateral veins. **C.** Inflorescence at pistillate anthesis. The spathe gapping is typical. **D.** Spadix at pistillate anthesis, nearside spathe artificially removed. **E.** Spadix at staminate anthesis, spathe limb artificially removed. Note the pollen strings. **F.** Fruiting plant in habitat. **G.** Sub-mature infructescence with associated splash-cup. **H.** Post-dispersal infructescence with splash-cup beginning to decay. **A–H** from *AR-5116*. Images © P. C. Boyce.



Figure 5. *Aridarum burtii* Bogner & Nicolson. Isotype specimen. B. L. Burt & A. M. Martin B 5116 [E]. The living collection accession number 67 2479 is wrong. It should be 67 2068.

collection with field number *Burt & Martin* 5116.

Rob Cubey, Plant Records Officer at Edinburgh Botanic Garden, kindly checked the garden's accession book for 1967. It turns out that the *Burt & Martin* B5116 field number correlated to 19672068, not against accession 19672479, is not as stated on the E Isotype. Mark Newman concludes "B5116 came in as a plant (probably rhizome) and was accessed as 19672068 (not 19672479). The accession number on the isotype at E is wrong. As I thought, there is no indication that Burt B5116 was ever a herbarium specimen. Despite this mislabelling (of the E Isotype) "I don't think this alters the fact that *B5116* was never a herbarium specimen, unless it is at US which is unlikely; Bill Burt would usually have deposited his top set at E.

In conclusion we speculate that the living plants from which the Type of *Aridarum burttii* were prepared were wrongly numbered, and did not originate from the Hose Mountains.

Bogner & Hay (2000) list four specimens determined to *A. burttii* but not belonging to that taxon. These are:

*P. S. Ashton* S. 21256 (= *A. ashtonii* S. Y. Wong & P. C. Boyce, **sp. nov.**);

*I. Paie* S. 25803 (= *A. ashtonii* S. Y. Wong & P. C. Boyce, **sp. nov.**);

*J. S. Burley et al.* 441B (= *Aridarum minimum* H. Okada);

*C. Ridsdale* PBU267 (= an undescribed species);

## ACKNOWLEDGEMENTS

This is part of on-going research funded by the Ministry of Higher Education, Malaysia by the Exploratory Research Grant Scheme Vote No. NRGS/1089/2013-(03) and Fundamental Research Grant Scheme Vote No. FRGS/STWN10(01)985/2013(26). The authors wish to extend their appreciation to Sarawak Forestry Corporation for facilitating fieldwork in Lanjak Entimau. Thanks to Nickson Robi, SFC, for logistical advice, and to Embahalbana Jangoh, Bada Ak Chendai, Augustine Kuas Ak Kenawang, and Ambau Ak Tajing ('Edwin') for their boating skills and hard work enabling our journey to Nanga Segerak. We wish also to express our gratitude to TR Bada Ak Chendai of Rumah Nanga Talong for the warm hospitality extended to us during our two stays at Nanga Talong. Thanks also to Mark Newman and Rob Cubey (Edinburgh Botanic Garden) for their valuable work in clarifying the history of the Type material of *Aridarum burttii*.

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# Studies on Schismatoglottideae (Araceae) of Borneo XXXXVIII – *Galantharum*, a new genus for the *Hottarum* Clade

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## ABSTRACT

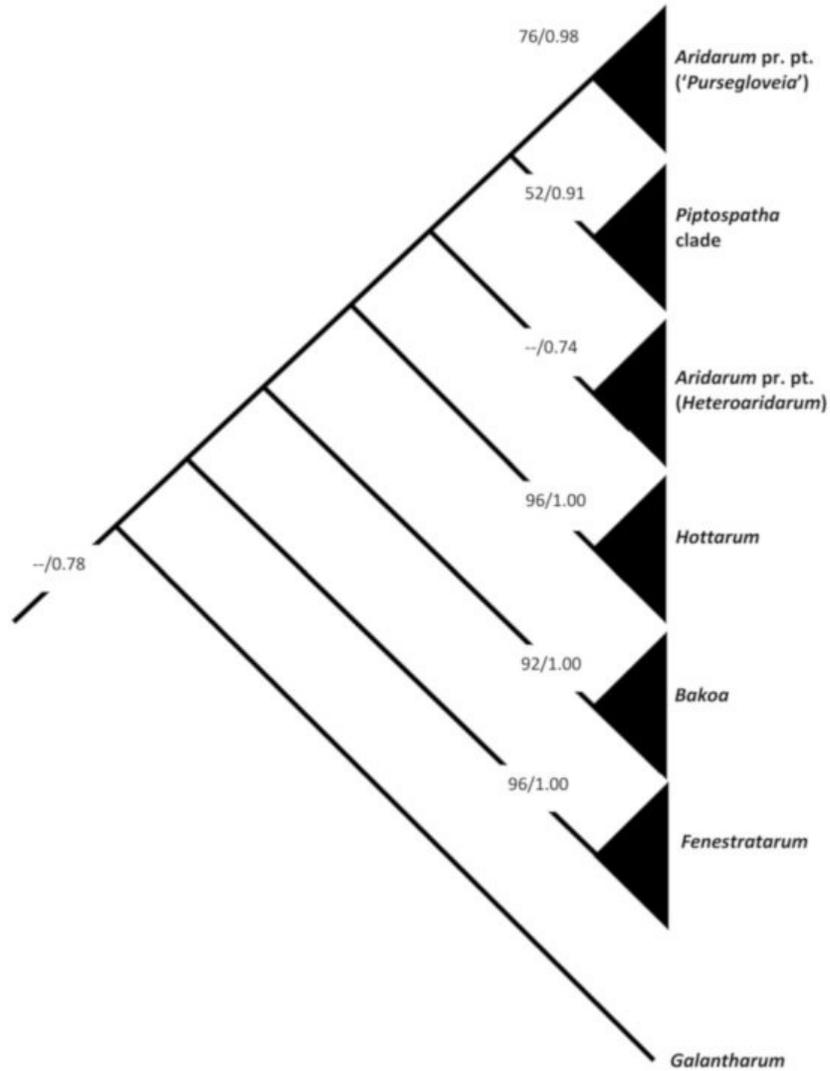
*Galantharum* is described as a new genus of Tribe Schismatoglottideae, with a single novel species, *Galantharum kishii*. Preliminary molecular analyses place *Galantharum* basal of a clade composed of *Fenestratarum*, *Bakoa*, *Hottarum*, two clades containing species currently assigned to *Aridarum*, and a clade of species presently included in *Piptospatha*.

## KEY WORDS

Rheophytic, molecular phylogenetic analyses

## INTRODUCTION

Field-based research of Schismatoglottideae on Borneo continues to reveal still more remarkable undescribed species, quite some number of which prove difficult to place into presently recognised genera based solely on their morphological



**Figure 1.** Schematic diagram of phylogenetic relationships of *Galantharum* to its immediate relatives in a partial clade of Tribe Schismatoglottideae as recovered by Low et al. (in prep.) based on data from one nuclear and one plastid DNA region. Figures at nodes indicate support values (Maximum Likelihood/ Bayesian Posterior Probabilities).

characteristics. In these instances additional data provided by molecular analyses is invaluable not only in assisting with generic placement and understanding relationships, but also modifying delimitation of genera themselves in a tribe where homoplastic events are rife (Wong, 2013; Low et al., 2015).

Here we describe a singular new species that can only be accommodated by the creation of a new genus, phylogenetically sitting at the base of a clade comprising *Fenestratarum* P. C. Boyce & S. Y. Wong, *Bakoa* P. C. Boyce & S. Y. Wong, *Hottarum* Bogner & Nicolson, two clades containing species currently assigned to *Aridarum* N. E. Br., and a clade of species presently included in *Piptospatha* N. E. Br. **Figure 1.**

***Galantharum*** P. C. Boyce & S. Y. Wong, **gen. nov.** Type species: *Galantharum kishii* P. C. Boyce & S. Y. Wong, **sp. nov.** **Figure 2.**

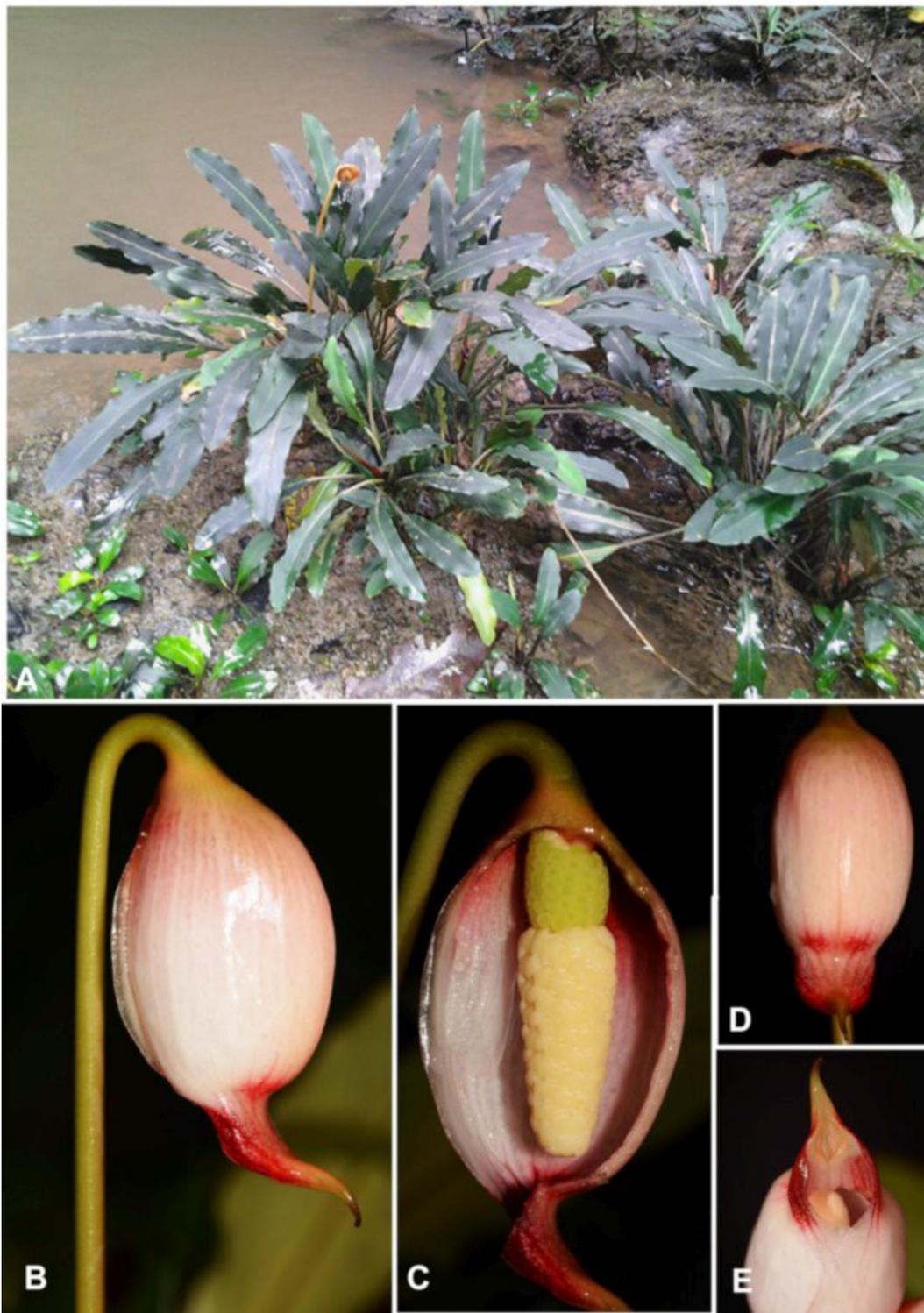
***Galantharum kishii*** P. C. Boyce & S. Y. Wong, **sp. nov.** Type: Indonesian Borneo, Kalimantan Utara, Bulungan Regency, Sekatak, 03°18' 35.3" N 116° 52' 50.6" E, 29 May 2013, *Mulyadi AR-4160* (holotype BO!; isotype SAR!).

### Diagnosis

*Galantharum* and its only species *Galantharum kishii* are diagnosed by the combination of a very strongly nodding (peduncle deflexed almost 180°) powerfully fragrant (vanilla) inflorescence with an

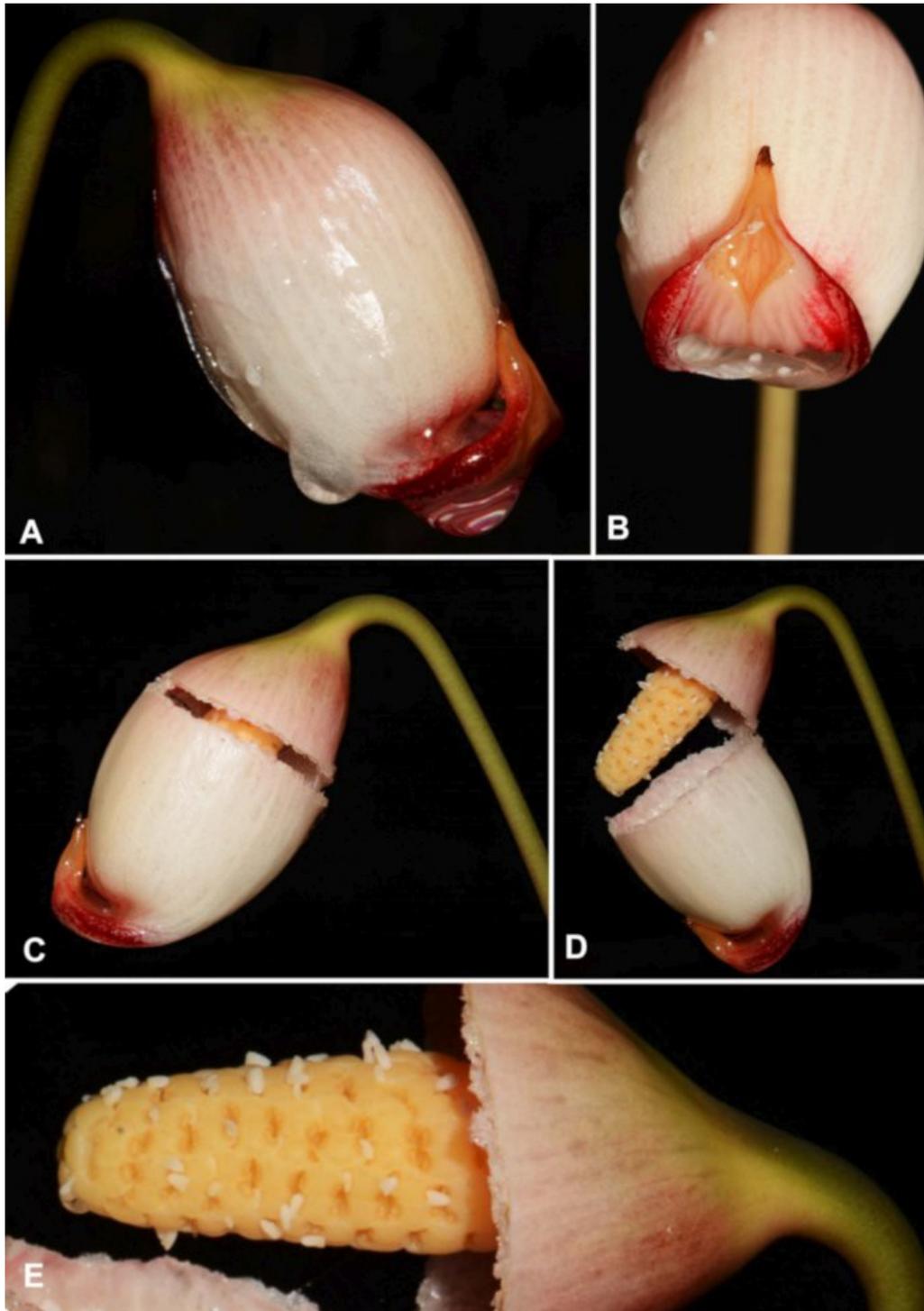
unconstricted spathe limb, spadix fertile to the tip, thecae in deep pits and lacking thecae horns, pollen released in oblong packages, basal-annular placentation, orthotropous ovules with a slender micropylar appendage, funnel-form splash-cups held erect by straightening of the distal portion of the peduncle, and indehiscent berries.

*Galantharum* is unique in the Schimatoglottideae by the extreme nature of the nodding of its inflorescences and by inflorescences producing a powerful vanilla-like smell at anthesis. *Galantharum* shares with *Fenestratarum*, *Hottarum* Bogner & Nicolson and *Bakoa lucens* (Bogner) P. C. Boyce & S. Y. Wong thecae set in deep pits. *Galantharum* differs from *Fenestratarum* by lacking a fenestrate spathe limb and by the much broader leaf blades without a basally pulvinate petiole. *Galantharum* differs from all *Bakoa* species by the caducous (vs persistent) spathe limb, and an erect splash-cup infructescence. *Galantharum* is additionally differentiated from *Bakoa lucens* by fleshy fruits (vs fruits drying to form a caryopsis), and from the remaining *Bakoa* species by indehiscent (vs dehiscent) berries. *Galantharum* is distinguished from *Piptospatha* by basal (vs parietal) placentation, and although sharing with *Piptospatha* a nodding inflorescence, the degree of the nodding is much heightened and furthermore the inflorescences of *Galantharum* are powerfully vanilla-fragrant. The only fragrant *Piptospatha* species are *Piptospatha perakensis* (Engl.) Ridl., *P. ridleyi* N. E. Br. ex Hook. f. occurring in Peninsular



**Figure 2.** *Galantharum kishii* P. C. Boyce & S. Y. Wong

**A.** Plants in habitat, Type locality. Note the post-anthesis inflorescence (spathe limb and spent part of spadix fallen). **B–E.** Inflorescence at pistillate anthesis. Note that the terminating rostrum is more-or-less straight. A–E from AR-4160. Image A © Mulyadi. Used with permission. Images B–E © P. C. Boyce.



**Figure 3.** *Galantharum kishii* P. C. Boyce & S. Y. Wong  
**A–B.** Inflorescence at staminate anthesis. Note the terminating rostrum is strongly reflexed. **C.** Inflorescence at staminate anthesis, spathe limb beginning to shed. **D.** Inflorescence at late staminate anthesis, spathe limb almost fallen. Note the pollen packages. **E.** Detail of the spadix, staminate anthesis. The oblong pollen packages are clearly visible. A–E from *AR-4160*. Images © P. C. Boyce.

Malaysia, with *P. perakensis* rather widespread and extending into southern Peninsular Thailand, and *P. ridleyi* occurring primarily in Johor, and *P. teijsmannii* P. C. Boyce & S. Y. Wong, which is restricted to two islands of the Riau Archipelago. All three of these West Sunda species smell of isoamyl acetate, not vanilla. From *Aridarum*, *Galantharum* diagnostically lacks thecae horns.

### Description

Small clumping rheophytic herb to 20 cm tall. **Roots** strong and adhering to bare, wet rocks, ca 1.5 mm in diam. **Stem** short, to 10 mm in diameter, obscured by leaf bases. **Leaves** many together, arching, forming a dense rosette; **petiole** 4–5 cm long, ca 2.5 mm in diam., bases clasping stem D-shaped in cross-section with the dorsal margins alate crispulate-hyaline and reddish, petiole minutely but distinctly scabrous, pale to rather deep olive green, usually reddish brown tinged; **petiolar sheath** with free ligular portion ca 4 cm long, marcescent and eventually deciduous, very deep brown; **leaf blades** narrowly oblanceolate, 6–14 cm long  $\times$  1–2.5 cm wide, margins undulate, base cuneate, apex acute with stout tubule ca 5 mm long, blades emerging rather bright medium green, maturing to medium semi glossy bluish green adaxially, paler abaxially; mid-rib slightly bluntly raised adaxially, rounded-raised and minutely scabrous abaxially, somewhat reddish-tinged; **primary lateral veins** ca 3 per side, parallel pinnate, impressed adaxially, slightly raised abaxially and tending to be red-flushed, at least on newer leaves; **interprimary lateral**

**veins** much weaker than primary laterals, visible as very slightly darker lines running parallel to the primary laterals and joining a moderately well-defined sub-marginal collecting vein. **Inflorescence** solitary, powerfully fragrant of vanilla at anthesis, spathe and spadix erect during early development, by anthesis deflexing to ca 170° to peduncle; **peduncle** 8–10 cm long, ca 2 mm in diam., minutely scabrous, pale reddish green. **Spathe** not constricted, glossy white with base tinged yellow-green, limb becoming slightly suffused pale pink, rostrum cherry-red shading to greenish, interior white with basal portion stained cherry-red, margins hyaline; **spathe limb** initially ellipsoid, inflating at anthesis to almost globose, limb falling at junction with persistent lower part during staminate anthesis, ca 3.5 cm long, base ca 1 cm wide, limb mid-way inflated to ca 2.5 cm, terminating in a ca 5 mm long rostrum with ca 6 ventral longitudinal ridges, rostrum initially straight, then (staminate anthesis) reflexing to become appressed against spathe limb. **Spadix** ca 20 mm long  $\times$  ca 5 mm in diam., base very slightly obliquely inserted onto spathe; **pistillate flower zone** cylindrical, ca 5 mm long  $\times$  ca 4.5 mm in diam. comprising ca 1/3 of spadix length, fertile to the base with two or three (ca 1  $\times$  1.2 mm) rhomboidal, flat-topped cream staminodes inserted basally; **pistils** cylindrical, truncate, congested, ca 0.7 mm diameter, lime green; **stigma** with a slight central depression, papillate, as wide as ovary, lime green, slightly darker centrally; **staminate flower zone** contiguous with and somewhat wider than pistillate zone,

fertile to tip, ca 15 mm long × ca 5 mm in diam., slightly tapering, apex blunt, pale creamy yellow; **staminate flowers** congested, composed of rather slightly irregularly paired stamens, stamen more or less oblong, with a conspicuous pit on each end, ca 0.5 mm wide × ca 0.8 mm long, connective convex; **thecae** lateral, set in pits, ca 0.3 mm; **pollen** shed in oblong packages ca 1.5 mm long. **Fruiting spathe** shallowly salverform, erect, ca 1 cm in diam., 1 cm deep in middle; **fruits** globose-ellipsoid, ca 2.5 mm long when ripe, medium green with brown stigma remnants, decomposing in the splash-cup into a slimy mass with seeds; **seeds** seed ca 2 mm long, 0.6–0.7 mm diam., narrowly ellipsoid, dark brown, slightly longitudinally ribbed, with a long curved translucent micropylar appendage 1.2–1.5 mm long, the appendages intertwined in the upper part of the berry.

Ecology — Growing in large clumps on mud-coated basalt stream rocks under open perhumid lowland forest between 95 and 300 m asl.

Distribution — Known from two localities ca 60 km apart.

Etymology — *Galantharum* is devised from Greek *gála* ‘milk’ + *ánthos* ‘flower’ + *Arum*, hence white-flowered aroid. This is intended as both a descriptive name and by way of allusion to the strongly nodding inflorescences that resemble, albeit quaintly, the flowers of the genus *Galanthus*

(Amaryllidaceae) –the Eurasian ‘snowdrops’.

The species epithet eponymy is for Hiroyuki Kishi, a collector and highly talented grower of tropical aquarium plants.

Other material examined — INDONESIA: BORNEO: Kalimantan Timur, Kabupaten, Malinau, Kecamatan Malinau Selatan (Loreh), Mt Sidi, 25 Nov. 2005, *Ni Putu Sri Asih s.n.*, cultivated in the Bali Botanic Garden (Kebun Raya Eka Karya Bali), Indonesian Institute of Sciences (LIPI).

Notes — *Galantharum kishii* is one of several novelties so far described from the species-rich basalts of Mt Sidi and nearby peaks (Kurniawan et al., 2011; Asih et al., 2012).

The molecular analyses upon which the above genus has been further resolved forms part of a PhD study of *Aridarum* by Low Shook Ling.

## ACKNOWLEDGEMENTS

This is part of an on-going research which is funded by the Ministry of Higher Education, Malaysia by the Exploratory Research Grant Scheme Vote No. NRGS/1089/2013–(03) and Fundamental Research Grant Scheme Vote No. FRGS/STWN10(01)985/2013(26).

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# Studies on Schismatoglottideae (Araceae) of Borneo XXXIX – *Schismatoglottis antu*, a new species allied to *Schismatoglottis gui*

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## ABSTRACT

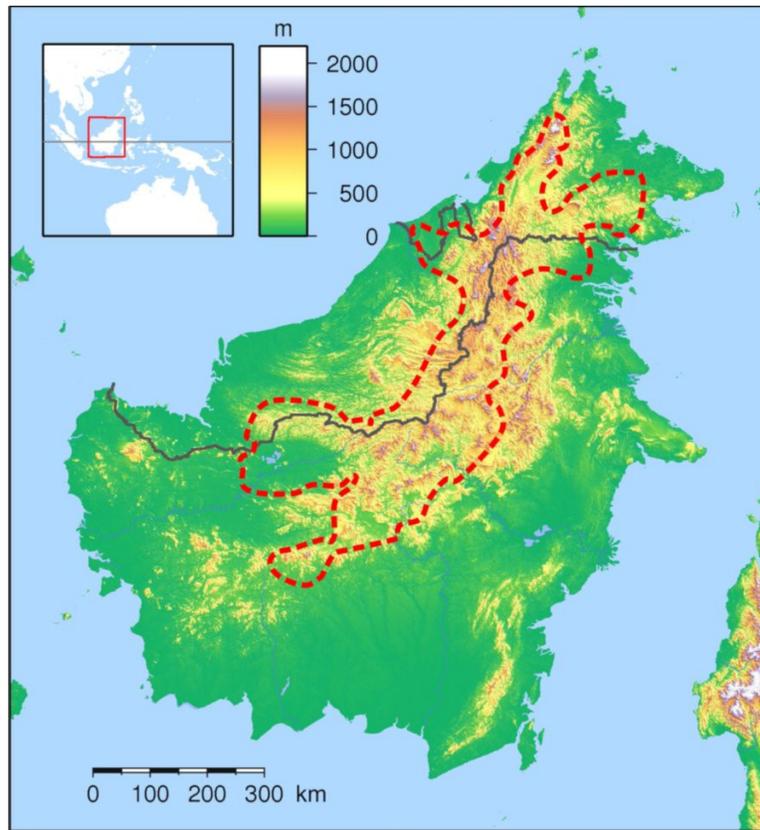
Ongoing fieldwork in the north western part of the “Heart of Borneo” has revealed a new species of *Schismatoglottis* allied to the recently described and enigmatic *Schismatoglottis gui* and *S. camera-lucida*. This novelty is here described and illustrated as *Schismatoglottis antu* S. Y. Wong & P. C. Boyce, **sp. nov.**

## KEY WORDS

Araceae, *Schismatoglottis*, Borneo, Malaysia, Indonesia, Sarawak, Kalimantan, Heart of Borneo.

## INTRODUCTION

The World Wide Fund for Nature’s “Heart of Borneo” initiative – [http://wwf.panda.org/what we do/where we work/borneo forests/](http://wwf.panda.org/what_we_do/where_we_work/borneo_forests/) – sets out to both protect and undertake research in an extensive area of Borneo (**Figure 1**). While a significant part of the HoB initiative



**Figure 1.** Map showing the extent of the ‘Heart of Borneo’ area. Wikimedia Commons.

focusses on animals, there is a plant element – [http://wwf.panda.org/what we do/where we work/borneo forests/about borneo forests/borneo animals/borneo plants/](http://wwf.panda.org/what_we_do/where_we_work/borneo_forests/about_borneo_forests/borneo_animals/borneo_plants/) – which agreeably includes flora other than carnivorous plants, horticulturally significant orchids, and giant-flowered holoparasites.

Aroid-focused fieldwork in the northern part of the HoB area has revealed numerous taxonomic novelties, some of them perplexing as to affinity (Boyce & Wong, 2014a), of which we are here describing a further absorbing species of the genus *Schismatoglottis*.

***Schismatoglottis antu*** S. Y. Wong & P. C. Boyce, **sp. nov.** Type: Malaysian Borneo, Sarawak, Sri Aman, Lubok Antu, Sungai Engkari, Nanga Segerak, Sungai Segerak, 01°24′53.3″N 112°00′15.6″E, 19 Mar. 2015, *Wong Sin Yeng, P.C. Boyce & Bada ak Chendai AR- 5183* (holo SAR!; iso SBC). **Figures 2 & 3A.**

### Diagnosis

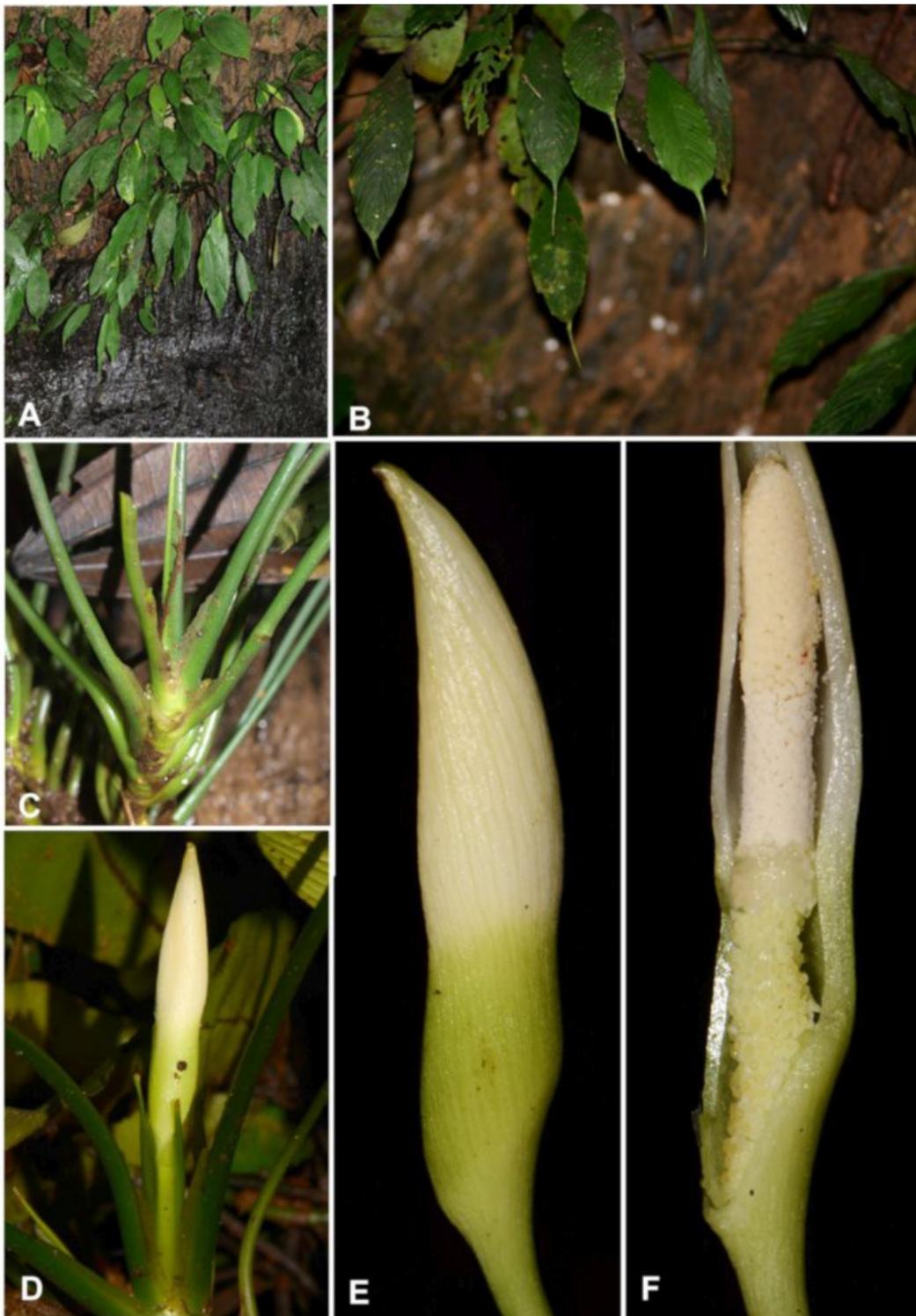
*Schismatoglottis antu* most closely resembles *Schismatoglottis camera-lucida* P. C. Boyce & S. Y. Wong and *S. gui* P. C. Boyce & S. Y. Wong. From *S. camera-lucida*, *S. antu* is diagnosed by the lower spathe opaque (not

translucent) at anthesis. Additionally the cylindrical (not fusiform) staminate flower zone, and blunt, bullet-shaped (not tapering) appendix are differential. *Schismatoglottis antu* may be distinguished by the solitary (not fascicled) inflorescences, and the cylindrical (vs obconic) staminate flower zone about equalling (vs half as long) as the appendix. From both *S. gui* and *S. camera-lucida* differs by the fully pendulous leaf blades with a very pronounced drip-tip.

### Description

Small, dense-clumping evergreen, facultative rheophytic herbs pendulous to ca 25 cm. **Stem** epigeal, elongated and rooting-ascending, terminal active portion densely leafy, older portions naked. **Leaves** pendulous, thinly chartaceous, ca 5 per module but modules very closely aggregated, subtended by a short, stiff **prophyll** ca 2 cm long, with the prophyll sheath wings hyaline and transparent; **petioles** up to 4.5 cm long, sheathing for ca ½ their length, ascending, petiole above the petiolar sheath carinate, the dorsal edges sharp, petiole glossy dark green, asperous; **petiolar sheath** persistent, margins hyaline, more-or-less transparent, open, decurrent; **blade** up to 25 × 5 cm, oblanceolate, base decurrent to weakly cuneate, apex broadly acute and extended into a ca 8 cm long drip-tip terminating in short tubular mucro, blades rich semi-glossy green adaxially, matte pale green abaxially; **midrib** conspicuous, shallowly impressed adaxially, rounded-raised abaxially; **primary lateral veins** about 15 per side, somewhat

impressed adaxially, raised abaxially; **interprimary veins** barely distinguishable from the primaries; **secondary veins** tessellate abaxially and darker than surrounding tissue. **Inflorescences** solitary; **peduncle** slender, ca 5 cm long × 2 mm wide, not emerging from the sheath during anthesis, extending during fruiting, pale green; **spathe** weakly constricted; **lower spathe** ellipsoid, ca 2 cm long × 5 mm wide, somewhat fleshy, pale green; **spathe limb** narrowly triangular, ca 4 cm long, acute, gaping very slightly at pistillate anthesis, weakly inflating during staminate anthesis to form a narrow slit the length mid-portion of the spathe limb, limb white, rostrum green, limb deliquescing post anthesis to the constriction, into a greenish white slime, lower spathe persisting. **Spadix** slightly shorter than the spathe, sessile, ca 5 cm long,; **pistillate flower zone** ca 1/3 the length of the spadix, ca 1.5mm × 4 mm, weakly obconic, strongly obliquely inserted on the spathe/peduncle; **pistils** rather lax, compressed-globose, ca 1 × 0.6 mm, creamy white; **style** very short, narrower than the ovary; **stigma** ca 1/2 width of the ovary, capitate, medium yellow, glossy-wet at pistillate anthesis; **interpistillar staminodes** reduced to a partial row of squat polygonal staminodes at the base of the pistillate zone; **interstice** ca 2 mm long, wider than the pistillate flower zone, covered with mushroom-shaped staminodes ca 1 mm diam., the tops rounded, dull white, becoming sticky-wet at staminate anthesis; **staminate flower zone** ca 7mm × 3mm, cylindrical, ivory; **staminate flowers** very densely arranged, 2-staminate, although



**Figure 2.** *Schismatoglottis antu* S. Y. Wong & P. C. Boyce. **A.** Plants in habitat, Type locality. **B.** Detail of the drip-tips. **C.** Petiole bases showing the persistent petiolar sheath and the asperous texture of the petiole. **D & E.** Inflorescence at pistillate anthesis. **F.** Inflorescence at staminate anthesis, nearside spathe artificially removed. All from Wong *et al.* AR-5183. Images: © P. C. Boyce.



**Figure 3.** Comparison of spadix of: **A.** *Schismatoglottis antu* S. Y. Wong & P. C. Boyce; **B.** *Schismatoglottis gui* P. C. Boyce & S. Y. Wong; and **C.** *Schismatoglottis camera-lucida* P. C. Boyce & S. Y. Wong. Image A: from Wong S. Y. *et al.* AR-5183; B: from Wong S. Y. & P. C. Boyce AR-3536; C: from Wong S. Y. & P. C. Boyce AR-3894. Images: © P.C.Boyce.

difficult to distinguish individual flowers; **stamens** globose, vaguely dumbbell shaped, connective embedded and  $\pm$  invisible; **thecae** opening by a tiny single pore; **appendix** ca 1 cm long, bullet-shaped, composed of irregularly oval staminodes, individually shallowly concave with a raised rim, ivory. **Infructescence** enclosed within a fleshy persistent spathe, the orifice of which is only slightly constricted and does not coincide with the spathe constriction, erect; **fruits** not observed.

Distribution — *Schismatoglottis antu* is so far known only from the Sungai Segerak and the joining Sungai Serjanggung where it is locally abundant but with individual populations scattered.

Ecology — *Schismatoglottis antu* occurs on very shaded riverside shale and earth banks under moist lowland gallery forest at ca 350 m asl.

Etymology — From the Iban language, *antu* – a ghost or demon. The species epithet was selected in mutual reference to Lubok Antu, the District in which falls the SW part of Lanjak Entimau Wildlife Sanctuary from where *S. antu* originates, and also by way of connotation to one of the two other most similar species: *Schismatoglottis gui*.

Notes — In spite of the discovery of this species, and the evident similarity of *S. antu*, *S. gui* (**Figure 3B**), and *S. camera-lucida* (**Figure 3C**), it is still far from clear to

which other species these three are related. As noted in Boyce & Wong (2014) molecular analyses are needed.

*Schismatoglottis gui* and *S. camera-lucida* are granite-restricted, the occurrence of *S. antu* on shales is another example of locally occurring species on specific geologies (see: Boyce & Wong, 2014b, c, d; Wong & Boyce, 2014a, b)

*Other material examined:* MALAYSIAN BORNEO. **Sarawak.** Sri Aman, Lubok Antu, Sungai Engkari, Nanga Segerak, Sungai Serjanggung, 01°24'45.5"N 112°00'19.4"E, 17 Mar 2015, *Wong Sin Yeng, P.C. Boyce & Bada ak Chendai AR-5162* (SAR); Sri Aman, Lubok Antu, Sungai Engkari, Nanga Segerak, Sungai Serjanggung, 01°24'46.5"N 112°00'18.5"E, 17 Mar 2015, *Wong Sin Yeng, P.C. Boyce & Bada ak Chendai AR-5167* (SAR).

## ACKNOWLEDGEMENTS

This is part of on-going research funded by the Ministry of Higher Education, Malaysia by the Exploratory Research Grant Scheme Vote No. NRGS/1089/2013-(03) and Fundamental Research Grant Scheme Vote No. FRGS/STWN10(01)985/2013(26). The authors wish to extend their appreciation to Sarawak Forestry Corporation for facilitating fieldwork in Lanjak Entimau. Thanks to Nickson Robi, SFC, for logistical advice, and to Embahalbana Jangoh, Bada Ak Chendai, Augustine Kuas Ak Kenawang,

and Ambau Ak Tajing ('Edwin') for their boating skills and hard work enabling our journey to Nanga Segerak. We wish also to express our gratitude to TR Bada Ak Chendai of Rumah Nanga Talong for the warm hospitality extended to us during our two stays at Nanga Talong.

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# Pollination ecology of two *Dieffenbachia* in French Guiana

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## ABSTRACT

The reproductive ecology of two species of *Dieffenbachia* (*D. seguine* [Jacq.] Schott and *D. paludicola* N.E. Br. ex Gleason) was studied at the Nouragues field station research in French Guiana. As in other known *Dieffenbachia*, the two studied species presented the classical cyclocephaline (dynastine scarab beetle) pollination system: Nocturnal anthesis with a strong odor, protogynous and short anthesis over 2 (3) days, female flowers being receptive on the first night and pollen being released on the second night. Inflorescences of *D. seguine* were visited by two species of scarab beetles (Cyclocephalini, Dynastinae): the dark brown *Cyclocephala rustica* and the black *Erioscelis proba*; while Inflorescences of *D. paludicola* were only visited by *Erioscelis proba*. Scarab beetles were efficient pollinators resulting in a high reproductive success even if some self-pollination can occur. Original data were gathered on flower and fruit

predation leading to pollen and seed loss but their effect of the reproductive success still needs to be quantified.

## KEY WORDS

*Dieffenbachia seguine*, *D. paludicola*, floral characters, fruit predation, mode of reproduction, reproductive success.

## INTRODUCTION

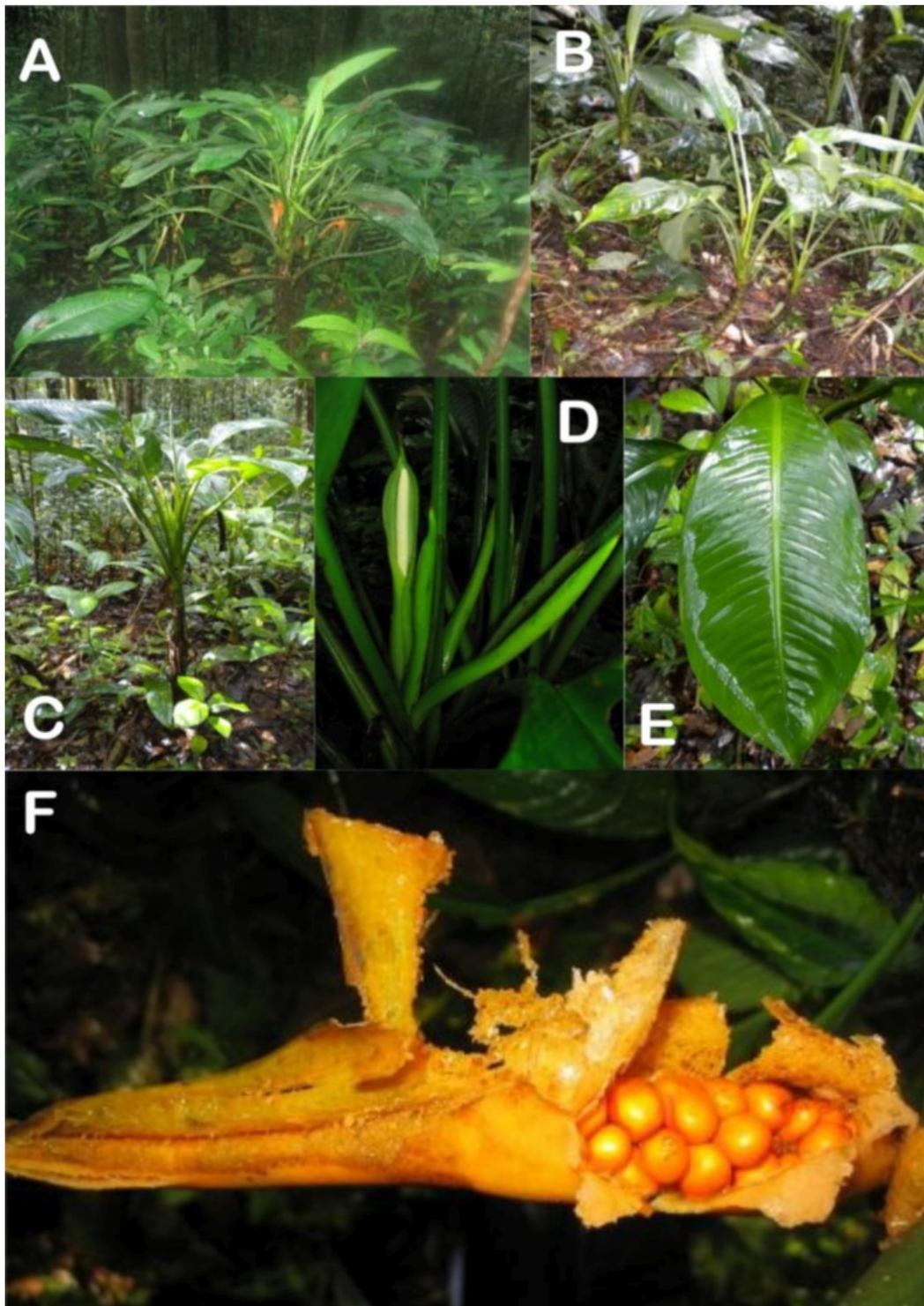
The genus *Dieffenbachia* is now included and basal with the genera *Bognera* and *Gearum* in the tribe Spathicarpeae as three non-geophyte genera within a geophytic tribe (Gonçalves et al., 2007; Cusimano et al., 2011; Maia et al., 2013; Chartier et al., 2014). The genus *Dieffenbachia* comprises 57 described species but a further 140 are estimated (Croat, 2004; Boyce & Croat, 2014). In French Guiana, only 5 species have been found plus a new undescribed

taxa (Croat 2011, **Figure 64**; Barabé & Gibernau, 2015). The inflorescence of *Dieffenbachia* is quite classical with female flowers (ovaries) located at the base of the spadix, male flowers at the apex and a short sterile zone in between. The male flowers consist of 4–5 connate stamens forming a synandrium with the anthers borne laterally below an apically truncated connective (Barabé & Lacroix, 2014). Beside the floral traits, *Dieffenbachia* also presents the classical cyclocephaline (dynastine scarab beetle) pollination system: Nocturnal anthesis with a strong odor, protogynous and short (over 2–3 days) anthesis, female flowers being receptive on the first night and pollen being released on the second or third night (see review Gibernau, 2015). Inflorescences of *Dieffenbachia* are also thermogenic but they seem to present only one thermogenic peak on the first night (female stage) contrary to many other cyclocephaline pollinated Araceae such as *Philodendron* species (Barabé & Gibernau, 2000). It is interesting to note that the thermogenic pattern of *Taccarum*, another genus of the Spathicarpeae tribe, also presents only one thermogenic peak during the female stage (Maia et al., 2013).

The pollination ecology and the reproductive success in natural populations has only been studied on 4 *Dieffenbachia* species: *D. oerstedii* and *D. nitidipetiolata* (reported as *D. longispatha*, Croat, 2004) in Costa Rica (Valerio, 1984; Young, 1986; Beath, 1999), *D. longispatha* in Panama (Beath, 1999) and *D. seguine* in Mexico (Cuartas–Hernández & Núñez–Farfán, 2006; Cuartas–Hernández et al., 2010). In

summary, beetle cross-pollination is necessary even if self-pollination can occur; pollinator density affects the reproductive success (high pollinator densities are negative); a given *Dieffenbachia* may be pollinated by several beetle species presenting different pollination efficiencies; and most of pollen dispersion is short range (to a close-by open inflorescence) leading to strong local structuration (see review Gibernau, 2015). The floral characters linked to pollination system have been studied on three species of *Dieffenbachia*, namely: *D. oerstedii*, *D. paludicola* and *D. seguine* (Chouteau et al., 2008; Gibernau et al., 2010; review Gibernau, 2015). The multivariate analyses showed that the three *Dieffenbachia* species are characteristics of beetle–pollinated aroids. In particular they present large stigma and pollen grains, but they have among the lowest numbers of both male and female flowers, and number of ovules (Chouteau et al., 2008; Gibernau et al., 2010).

This study presents original data on the pollination ecology and the reproductive success of two *Dieffenbachia* species growing in a primary lowland rainforest of French Guiana. The pollination ecology and reproductive success of one species, *D. seguine*, was studied in Veracruz Mexico (Cuartas–Hernández & Núñez–Farfán, 2006; Cuartas–Hernández et al., 2010), while the other species, *D. paludicola*, has never been documented before.



**Figure 1.** A. Habit of *D. seguine* growing over a large boulder with almost no soil. B. Young erecting ramet. C. Erect flowering plant. D. Sympodium of inflorescences with one open at pollination stage. E. Above view of a leaf. F. Mature infructescence with a dehiscent spathe exposing the ripe berries to seed dispersers.

## MATERIAL AND METHODS

### Studied Populations

The two *Dieffenbachia* species (*D. seguine* [Jacq.] Schott and *D. paludicola* N.E. Br. ex Gleason) were studied in French Guiana, at the Nouragues Research Station (<http://www.nouragues.cnrs.fr/spip.php?rubrique4>) in July 2006 with complementary data gathered in June 2009. *Dieffenbachia seguine* commonly grows on large stream boulders. The studied population was located on a boulders in the stream “Moteur” (Engine): GPS coordinates 04 - 05.196 N, 052 - 40.768 W (**Figure 1**). The second species, *D. paludicola*, is less common, growing in flooded deep soils. The studied population was growing along the sandy bank of the Nouragues stream, near a natural bridge (tree trunk): GPS coordinates 04 - 05.208 N, 052 - 40.741 W (**Figure 2**). A voucher specimen of *D. seguine* (Barabé & Gibernau 377) has been deposited at the Marie-Victorin Herbarium (Montreal, Canada). Several specimens of *Dieffenbachia* from the Nouragues research station (Inselberg camp) collected by different collectors are available at the IRD Herbarium (Cayenne, French Guiana); two were identified to the species, *D. seguine* (Cremers G. - - 10834) and *D. paludicola* (Cremers G. - - 10933).

### Plant Survey and Measures

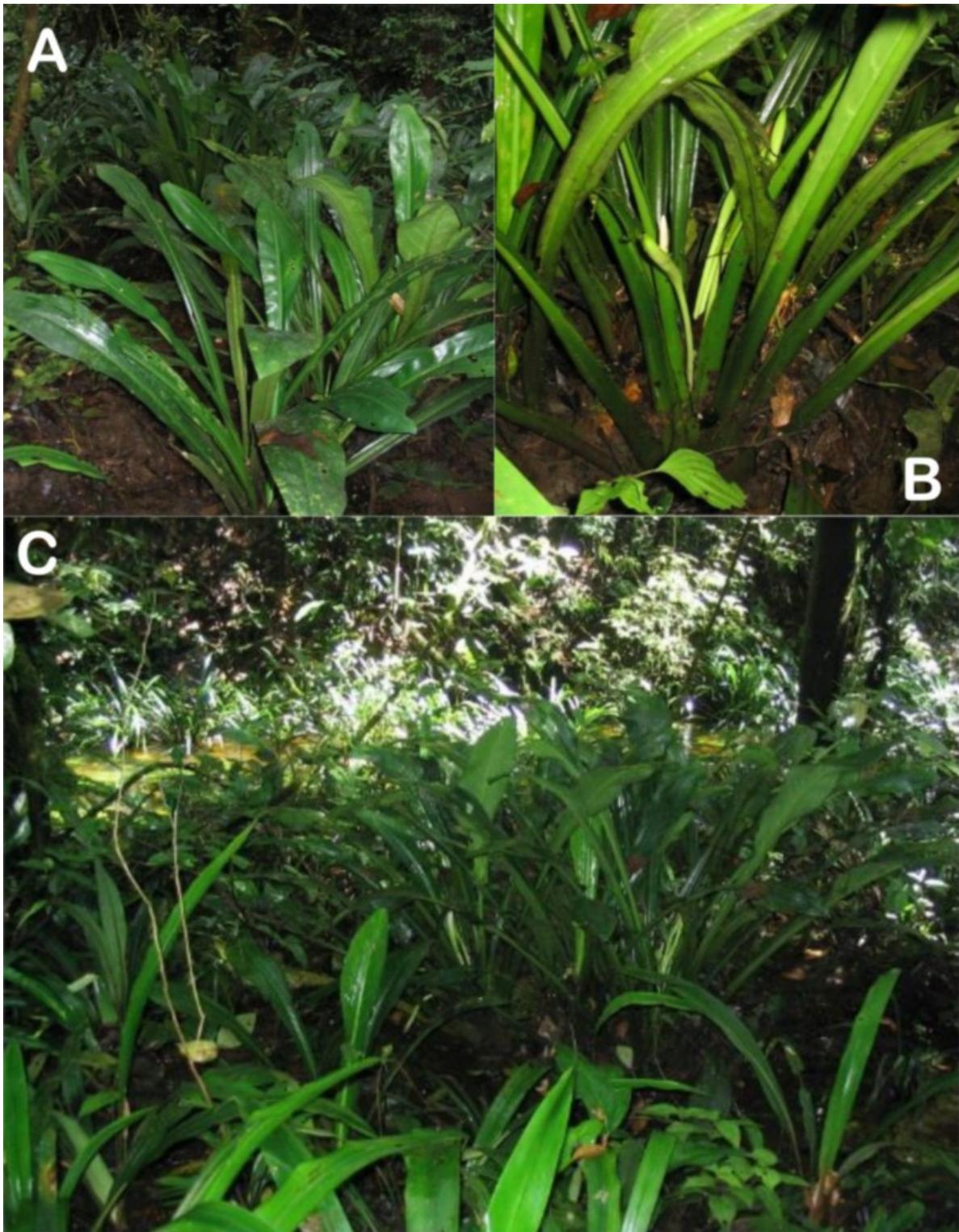
A total of 182 plants of *D. seguine* and 31 of *D. paludicola* were marked and labeled as reproductive or not. Vegetative traits (plant

height, number of leaves, stem diameter, petiole length, leaf blade length and width) and reproductive traits (number of inflorescences) were measured on 71 *D. seguine* and 30 *D. paludicola*, and the linear correlations among these characters calculated on 47 *D. seguine* and 30 *D. paludicola*.

### Reproductive Success

In addition, the reproductive success was surveyed on 39 individuals of *D. seguine* and 18 *D. paludicola*. Afterwards, reproductive characters, including spathe and spadix size, floral zones sizes (male, female and sterile), numbers of synandria, female and sterile flowers, were measured or counted on 27 inflorescences of *D. seguine* and 18 inflorescences of *D. paludicola*. Linear correlation analyses among these reproductive floral traits were performed on respectively inflorescences of 14 *D. seguine* and 18 *D. paludicola*. Finally, the floral sex ratio or maleness was calculated as the number of synandria / (number of synandria + number of female flowers). Thus it equals 1 when the inflorescence is totally male and approaches zero as it becomes more and more female.

For only *D. seguine*, berry production and seed set was also studied on 34 inflorescences. On 20 inflorescences visited by beetle pollinators, spatial variation of flower pollination probability was estimated by mapping the abortion or maturation of each ovary/berry. Seed set was calculated on 518 berries and seed weight measured on



**Figure 2.** A. Habit of *D. paludicola* with its characteristic long leaves. B. Detail of a flowered individual. The inflorescence is at female stage with the spadix protruding diagonally out of the spathe. C. The studied populations of *D. paludicola*, note the stream on the background.

298 seeds. Finally, the linear correlations among seed number and berry production or number of female flowers was tested on data from 18 inflorescences.

### **Inflorescence traits & Anthesis**

The inflorescence morphology (fusion spathe-spadix; opening orientation) was observed on 43 inflorescences of *D. seguine* and 16 of *D. paludicola*. However, the different phases of the anthesis was observed on *D. seguine* alone.

### **Insect Visitors**

During the flowering period, the number and species of insect visitors were surveyed in the early morning, before the insects from the previous day had left the pollination chamber. When insects were present, the insects were collected, fixed in 70% alcohol and later identified. In total, 80 inflorescences of *D. seguine* and 29 of *D. paludicola* were surveyed. Punctual observations of insect visitors were performed along the anthesis.

Scarab specimens were identified by Dr. Brett C. Ratcliffe (University of Nebraska, USA).

### **Thermogenesis**

The capacity of the spadix to increase its temperature was recorded in 2006 for both *Dieffenbachia* species: *D. seguine* (N = 14) and *D. paludicola* (N = 5). Temperatures were

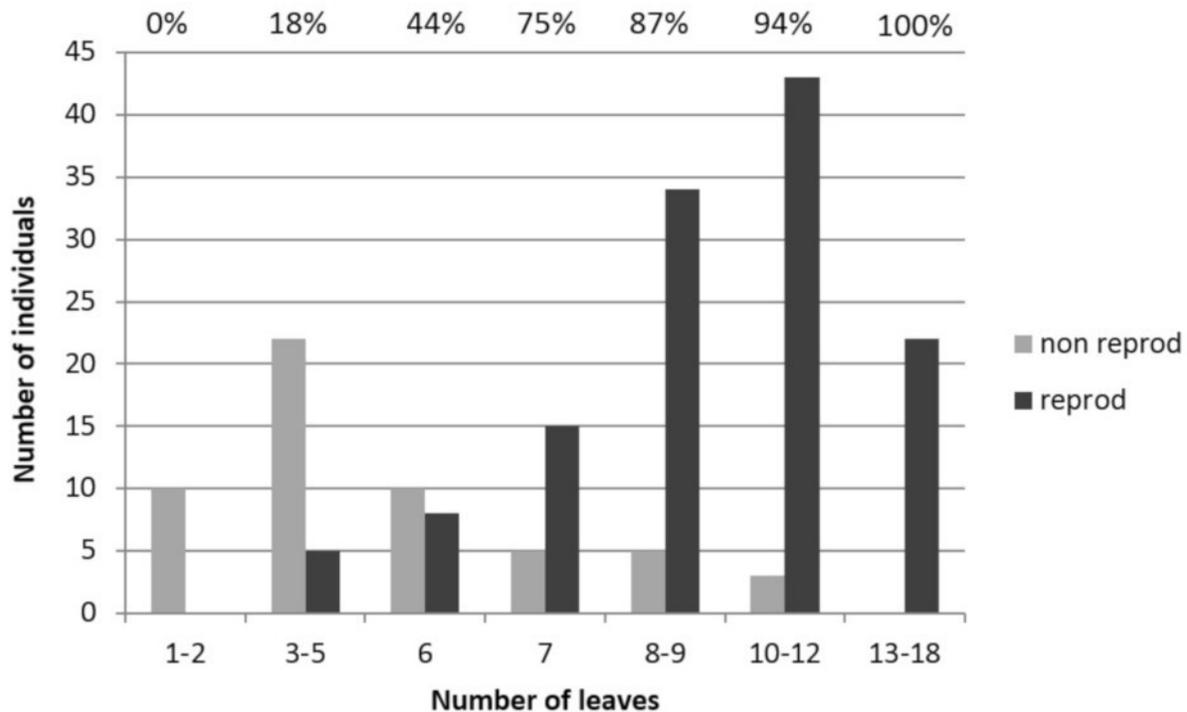
recorded during inflorescence opening. Temperatures of the spadix and the ambient air were recorded every 10 minutes with one Digi-Sense<sup>®</sup> DualLogR<sup>®</sup> thermocouple thermometers. One probe was inserted about 5 mm deep into the spadix in the middle of the male zone, the other recorded air temperature shaded below a leaf blade.

### **Flower & Fruit Predation**

For *D. seguine* only, flower damages were counted on 15 inflorescences, and fruit damages were quantified on 35 plants bearing a total of 61 infructescences. Insect observations were done regularly during the field survey and completed by infructescence dissections.

### **Mode of Reproduction**

The mode of reproduction was tested (on *D. seguine* only) by pollination experiments. In order to test the self-pollination capacity, 12 inflorescences were manually self-pollinated by brushing, with a paintbrush, freshly released pollen from an inflorescence (male stage) onto receptive stigmas (female stage) of another inflorescence of a same plant. Cross-pollination was also tested experimentally on 7 receptive inflorescences pollinated manually with pollen collected on a different plant. Apomixis, seed maturation without pollination, was tested on 11 bagged inflorescences on which male



**Figure 3.** Histogram of the numbers of reproductive and non-reproductive plants of *Dieffenbachia seguine* in each class of leaf number and values of the percentage of reproductive plants for each leaf class ( $N = 182$ ).

flowers were covered by tape to avoid pollen release.

Finally, experimental hybridization was tested on 5 inflorescences by pollinating manually female flowers of *D. seguine* with pollen of *D. paludicola*.

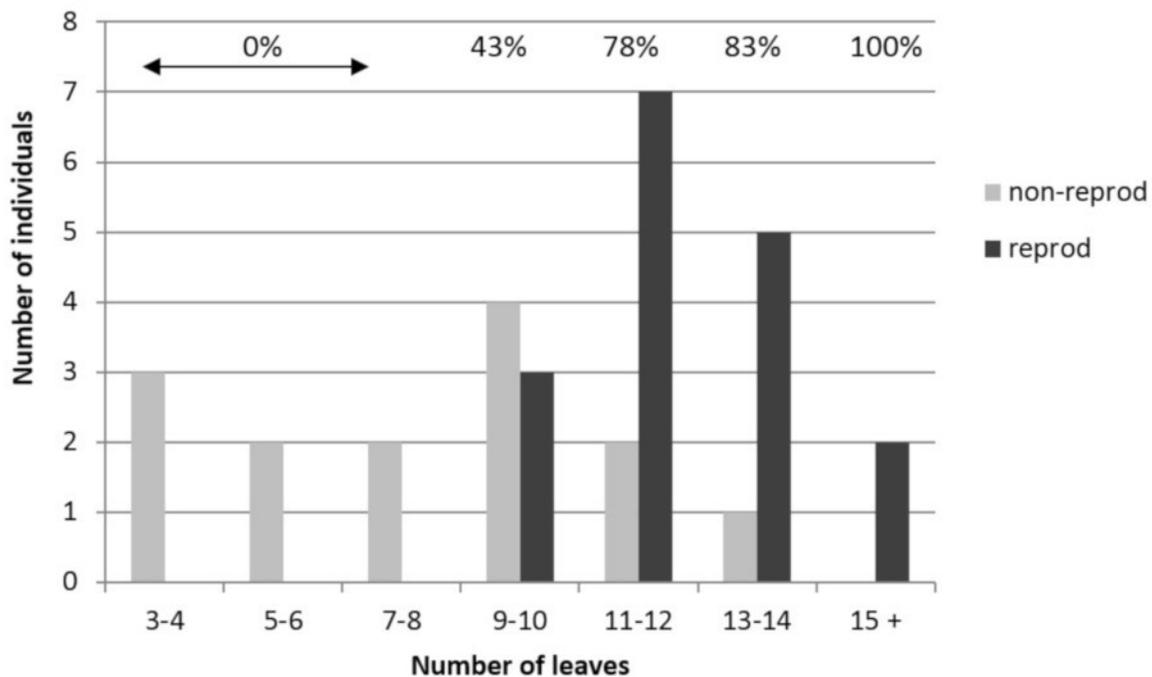
All the statistical analyses were performed with the statistical software Past 2.17 (Hammer et al., 2001). Data were log transformed for statistical analyses, slope comparisons were done by Analyses of covariance.

## RESULTS

### Non-Reproductive versus Reproductive Plants

#### *Dieffenbachia seguine*

Vegetative traits are presented on Table 1. The number of leaves were a good indicator of the plant vigor not only in terms of reproductive traits, the “threshold” value that represented about 50% of being reproductive seemed to be 6 leaves, but a few individuals with less than 6 leaves were observed also to be reproductive (see **Figure 3**). There was a significant positive



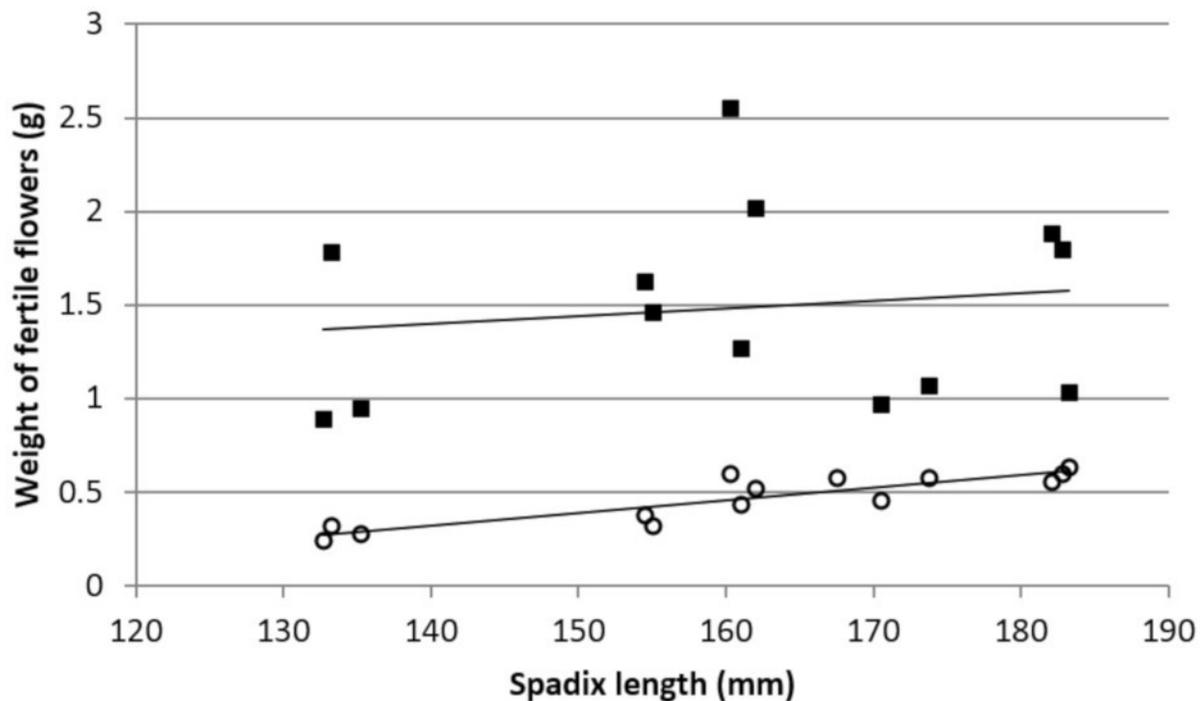
**Figure 4.** Histogram of the numbers of reproductive and non-reproductive plants of *Dieffenbachia paludicola* in each class of leaf number and values of the percentage of reproductive plants for each leaf class (N = 31).

linear relationship (N = 47) between the number of leaves and the number of inflorescences ( $Y = 0.775 X - 3.87$ ;  $r^2 = 0.64$ ;  $t = 9$ ;  $p < 10^{-5}$ ); between the number of leaves and the stem diameter ( $Y = 0.267 X - 1.13$ ;  $r^2 = 0.34$ ;  $t = 8.8$ ;  $p < 10^{-5}$ ) or the plant height ( $Y = 7.532 X + 53.78$ ;  $r^2 = 0.45$ ;  $t = 6.1$ ;  $p < 10^{-5}$ ).

### *Dieffenbachia paludicola*

Vegetative traits are presented on Table 1, note that the petiole is mainly inserted within the leaf sheath. The number of leaves appeared again to be a good indicator

of the plant vigor. There was a significant positive linear relationship between the number of leaves per plant and the length of the leaf blades ( $Y = 5.68 X + 59.3$ ;  $r^2 = 0.67$ ;  $t = 7.6$ ;  $p < 10^{-5}$ ). The probability of becoming reproductive was linked with the plant size represented for example by the number of leaves, the “threshold” value that represented about 50% of being reproductive seemed to be 9–10 leaves (**Figure 4**); but it’s also true with blade size. A blade length longer than 1.15 meters seemed also to be a threshold since none of the 13 individuals with shorter blades flowered and only 2 out of 18 individuals with longer blades didn’t flower.



**Figure 5.** Linear relationship between the spadix length (mm) and the weight (g) of the fertile flowers in *Dieffenbachia seguine*. The male flowers (synandria) are represented by black squares and the female flowers (ovaries) by open circles.

## Reproductive Success

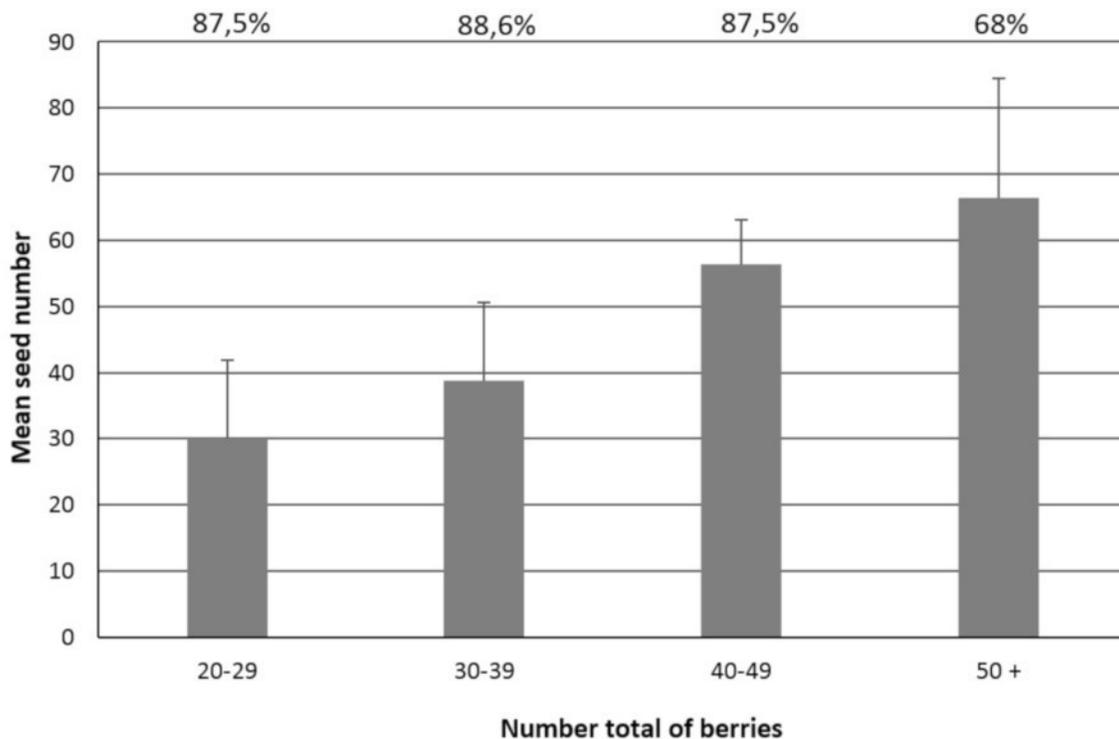
### *Dieffenbachia seguine*

A given reproductive plant could bear both inflorescences (actual flowering period) and more or less mature or aborting infructescences (previous flowering period). On 39 reproductive individuals, 27 (70%) had both inflorescences ( $2.15 \pm 1.03$ ) and infructescences ( $3.33 \pm 2.57$ ), 8 (20%) infructescences only ( $5.5 \pm 0.93$ ) and 4 (10%) only inflorescences ( $2.25 \pm 0.96$ ).

The inflorescence measures are presented in Table 2. There was a significant positive linear relationship between spadix length

and both the number of synandria and ovaries (respectively  $Y = X + 52.7$ ;  $r^2 = 0.20$ ;  $t = 2.16$ ;  $p = 0.04$ ;  $Y = 0.233 X + 6.58$ ;  $r^2 = 0.19$ ;  $t = 2.28$ ;  $p = 0.032$ ). The slopes were not different ( $F_{1,42} = 2.82$ ;  $p = 0.1$ ). The number of synandria varied from 145 to 255 and female flowers from 32 to 57 (Table 2); the mean ratio was 5 synandria for one ovary. The floral sex ratio didn't vary with the spadix size ( $r^2 = 0.001$ ;  $t = -0.05$ ;  $p = 0.96$ ).

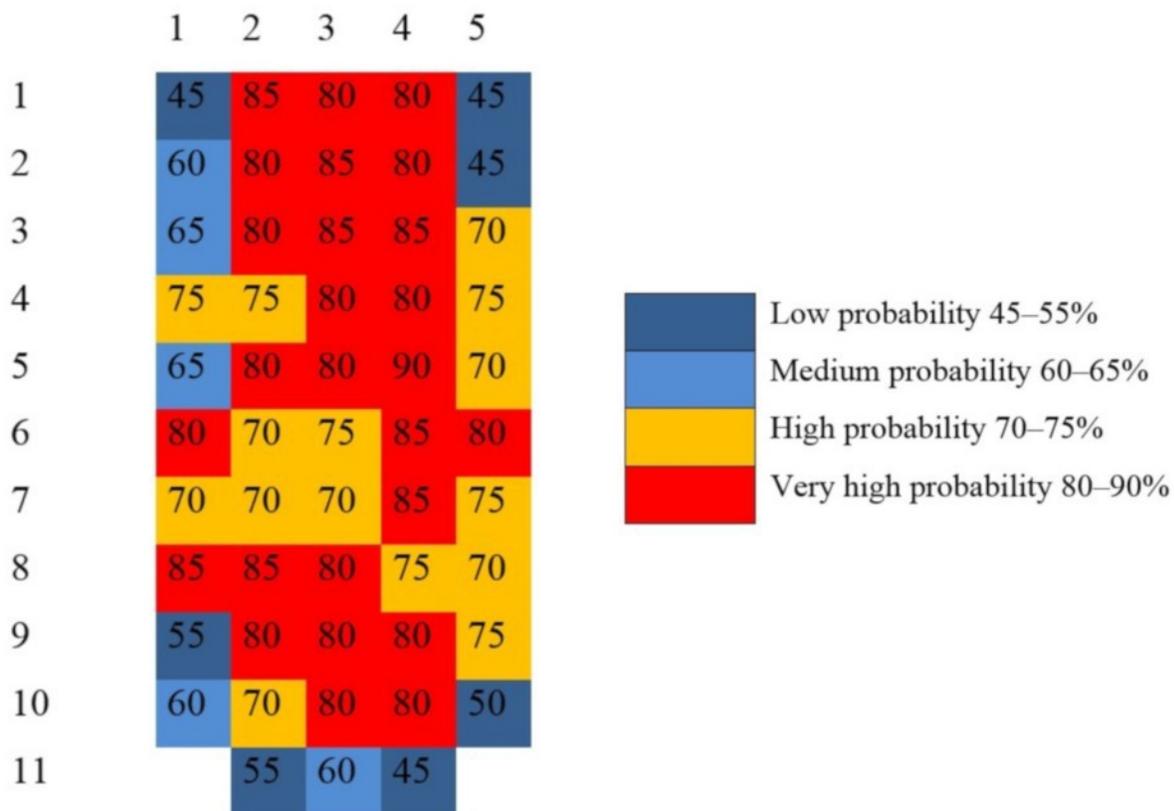
In terms of zone weights in relation to spadix size, the slopes of linear correlations were significantly different indicating a faster increase in the female zone ( $F_{1,25} =$



**Figure 6.** Histogram of the mean seed number ( $\pm$ standard deviation) per infructescence of *Dieffenbachia seguine* in each class of infructescence size (estimated by the total number of berries) and corresponding values of the percentage of berry maturation rate per infructescence (N = 33).

5.17;  $p = 0.03$ ; **Figure 5**). The total weight of the female flowers increased positively with the spadix size ( $Y = 0.0076 X - 0.766$ ;  $r^2 = 0.78$ ;  $t = 6.6$ ;  $p = 2.5 \times 10^{-5}$ ) whereas the total weight of the synandria didn't vary linearly with spadix size ( $Y = 0.028 X - 2.96$ ;  $r^2 = 0.02$ ;  $t = 0.5$ ;  $p = 0.63$ ) with a mean total weight of 1.5g. On the contrary, the total weight of female flowers increased from 0.25 to 0.64 g with spadix size (**Figure 5**).

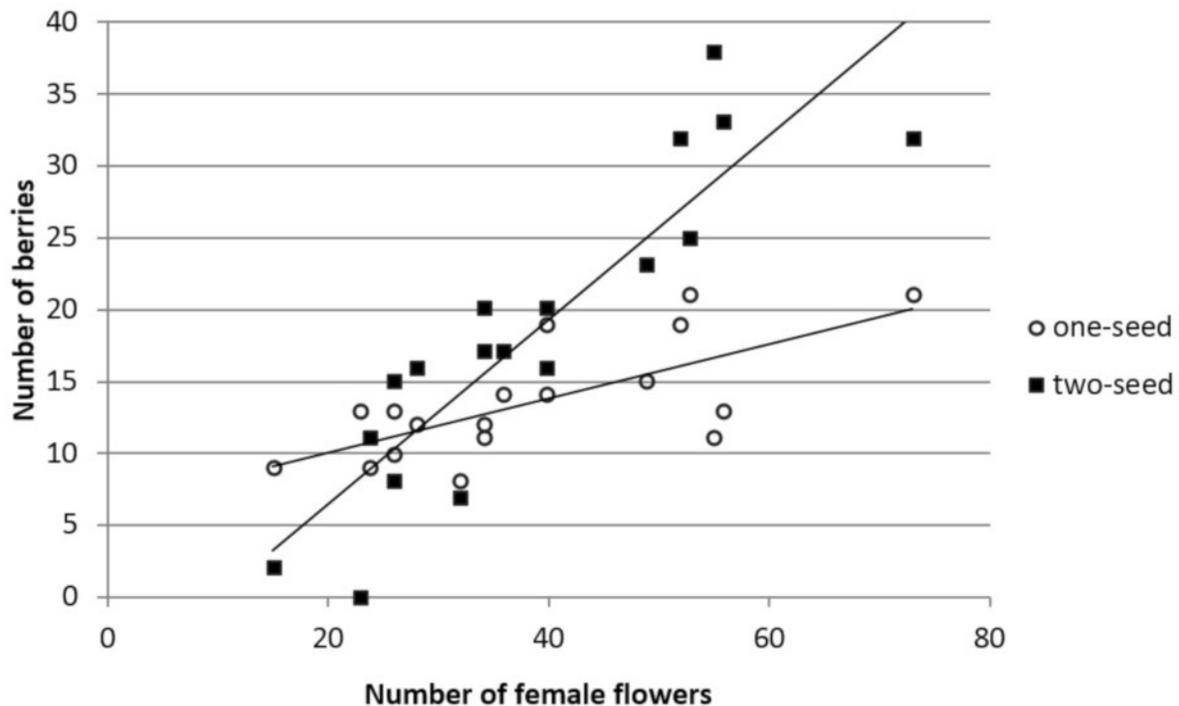
About the reproductive success (N = 38), the more inflorescences a plant produced the more infructescences it will mature ( $r^2 = 0.76$ ;  $t = 10.8$ ;  $p = 2.5 \times 10^{-5}$ ) suggesting a constant abortion rate of inflorescences/infructescences (36% of abortion representing an average of 1.2 inflorescence per plant). Within a given infructescence, the berry abortion rate per infructescence was not linearly linked to the size of the infructescence in terms of number of total berries ( $r^2 = 0.08$ ;  $t = -1.6$ ;



**Figure 7.** Schematic drawing of the female zone corresponding to the most frequent size observed with the probability for each ovary/berry location to be pollinated from an average of 20 infructescences of *Dieffenbachia seguine* visited by beetle pollinators. Row 1 represents the top of the female zone and row 11 the bottom. Columns 1 and 5 represent the margins of the female zone that are close to the spathe insertion on the spadix.

$p = 0.11$ ). But when considering it, in relation to classes of number of berries, it appeared that the percentage of non-developed berries remained constant ( $\sim 88\%$ ) for infructescences with less than 50 berries, and it drops to 68% for larger infructescences (**Figure 6**). Nevertheless, the mean number of produced seed per infructescence increased with the inflorescence size, estimated by the total number of female flowers (**Figure 6**). Moreover, the probability of flower

pollination in inflorescences visited by beetle pollinators varied according to its location within the female zone (**Figure 7**). The female flowers were schematically arranged in spiral over 4–5 columns and about 11 rows. The lowest and medium pollination probabilities (45–65%) were estimated for ovaries located on the four corner of the female zone and the basal-most row of female flowers (**Figure 7**). The flowers located in the central zone, medium rows and/or columns, presented



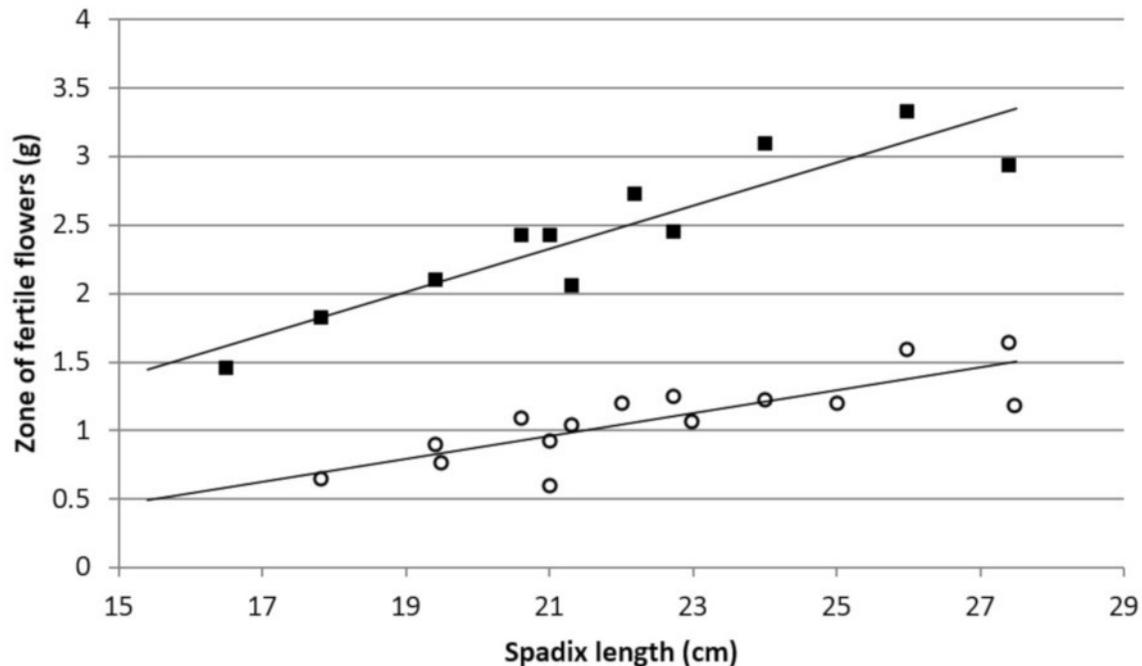
**Figure 8.** Linear relationship between the numbers of berries with one or two seeds in relation to the total number of female flowers (as an estimate of the spadix size) in *Dieffenbachia seguine*.

high or very high pollination probabilities (70–90%; **Figure 7**).

Developed berries belonged to four categories; those containing no seed, one, two or three seeds. Out of the 518 berries dissected, only one contained 3 seeds and 16 no seed. Hence, most berries contained one (46%) or two seeds (51%). Consequently, the total number of seeds was correlated to the number of berries ( $Y = 1.74 X - 7.86$ ;  $r^2 = 0.94$ ;  $t = 16.6$ ;  $p < 10^{-5}$ ). But most interestingly, the number of one-seed berries increased less ( $Y = 0.24 X + 3.11$ ;  $r^2 = 0.48$ ;  $t = 3.89$ ;  $p = 0.0013$ ) than

the two-seed berries ( $Y = 1.44 X - 18.79$ ;  $r^2 = 0.79$ ;  $t = 7.79$ ;  $p < 10^{-5}$ ) in correlation with the total number of female flowers (**Figure 8**). This slope difference was significant ( $F_{1,33} = 40.54$ ,  $p < 10^{-5}$ ).

Finally, the weight of seeds from one-seed berries ( $0.125 \pm 0.03$ g;  $N = 138$ ) was heavier than those from two-seed berries ( $0.107 \pm 0.03$ g;  $N = 151$ ), this difference being significant ( $t = 5.61$ ,  $p < 10^{-5}$ ). Too few seeds ( $N = 9$ ) from three-seed berries were available for performing a statistical test.



**Figure 9.** Linear relationship between the spadix length (cm) and the weights (g) of the fertile flowers in *Dieffenbachia paludicola*. The male flowers (synandria) are represented by black squares and the female flowers (ovaries) by open circles.

### *Dieffenbachia paludicola*

The inflorescence measures are presented in Table 2. There was a significant positive linear relationship between spadix length and both the number of synandria and ovaries (respectively  $Y = 7.03 X + 14.04$ ;  $r^2 = 0.67$ ;  $t = 5.67$ ;  $p = 3.4 \times 10^{-5}$ ;  $Y = 0.305 X + 3.79$ ;  $r^2 = 0.32$ ;  $t = 2.76$ ;  $p = 0.014$ ). The number of synandria varied from 128 to 200 and female flowers from 8 to 12 (Table 2); the mean ratio was 16 synandria for one ovary. The floral sex ratio increased linearly with the spadix size ( $r^2 = 0.33$ ;  $t = 2.82$ ;  $p = 0.012$ ) suggesting an increasing maleness

with an increase of the spadix size. This trend was clearly confirmed when looking at the masses allocated to both male and female zones (**Figure 9**). In terms of zone weights in relation to spadix size, the slopes of linear correlations were significantly different indicating a faster increase in the male zone ( $F_{1,23} = 7.494$ ,  $p = 0.012$ ). The total weight of the female flowers increased positively with the spadix size ( $Y = 0.101 X - 1.196$ ;  $r^2 = 0.68$ ;  $t = 5.2$ ;  $p = 1.65 \times 10^{-4}$ ) but at a lower rate (**Figure 9**) than the total weight of the synandria ( $Y = 0.172 X - 1.306$ ;  $r^2 = 0.84$ ;  $t = 6.8$ ;  $p = 7.95 \times 10^{-5}$ ).

## Inflorescence Traits & Anthesis

### *Dieffenbachia seguine*

The fusion of the spathe and the spadix could occur at three levels (N = 32): the bottom of the sterile zone (15.5%), the middle of the sterile zone (15.5%) or the bottom of the male zone (69%). The orientation of the spathe opening could be towards three main directions (N = 43): the stem (63%), one side (perpendicular to the stem, 32.5%), or the outside (opposite to the stem, 4.5%). In multi-flowered individuals, two inflorescences were never observed to be open at the same time.

The exact period of spathe opening was not precisely observed and should have taken place sometime during the night before the female phase or early in the morning, since on two occasions spathes were observed to be half open at 8:00 am. In the morning the upper spathe continued to open on  $\frac{1}{3}$  –  $\frac{1}{2}$  of its length. In the afternoon, half of the spathe was open, and stigmas were receptive. At 5:15 pm, a scarab beetle was once observed flying in zigzag around a receptive inflorescence. In the evening, the upper spathe opened widely increasing the opening of the constriction, the spadix tended to bend forward diagonally out of the spathe, and emitted its fragrance.

In the following morning (Day 2), the spadix was bending upward in more or less an erected position, no pollen was visible on the male flowers and beetles were present in

the pollination chamber, some copulating. The staminodes around the female flowers might be eaten, stigmas were no longer receptive. In late afternoon, around 5:00 pm, the pollen started to be released in the form of sticky strands by the anthers. Beetles remained in the pollination chamber, staminodes were eaten. In the evening, the constriction was less open, beetles flew away covered with the sticky pollen. In some individuals, the male zone was covered by Psychodid midges.

In the following morning (Day 3), the spathe was closing and only  $\frac{1}{4}$  –  $\frac{1}{3}$  of the upper spathe was open, some pollen was still present on the male flowers. The pollination chamber was narrow, in general empty of beetles but in two cases, beetles were still present. In the afternoon, the spathe was tightly closed around the erected spadix only the upper male zone was protruding out, no pollen was visible.

It appears that the anthesis cycle lasted 24 hours even if some pollen dispersion could occur on the third day (36 hours). “Young” infructescences were greenish and pendent, the closed pollination chamber was filled with a viscous liquid, the ovaries were green slightly enlarged with a mean diameter of  $3.04 \pm 0.19$  mm (N = 10).

### *Dieffenbachia paludicola*

Fusion of the spathe and the spadix could also occur at three levels (N = 16): the bottom of the sterile zone (44%), the

middle of the sterile zone (37%) or the bottom of the male zone (19%). Periodic observations suggested that the anthesis followed about the same sequence as *D. seguine*. On several cut inflorescences, pollen emission started at 1:30 pm but occurred mainly at 3:30 pm.

## Insect Visitors

### *Dieffenbachia seguine*

Inflorescences of *D. seguine* were visited by two species of scarab beetles (Cyclocephalini, Dynastinae): the dark brown *Cyclocephala rustica* and the black *Erioscelis proba* (Figure 10).

Out of the 80 inflorescences surveyed, 65 (81%) were visited by at least one scarab beetle. The mean number of pollinators was:  $2.86 \pm 1.43$  (range: 1–6). Out of the 151 scarab beetles observed, 121 were black (80%) and 30 brown. Out of 49 inflorescences checked, 32 (65%) contained only black beetles, 12 (25%) with both (black & brown) species and 5 (10%) with only brown beetles. In several occasions copulations on the spadix were observed among male and female of a given species; and in one occasion a black male and a brown female were *in copula*.

### *Dieffenbachia paludicola*

The studied population was only visited by one black species of scarab dynastid beetle, *Erioscelis proba* (Figure 10). Inside the pollination chamber of 29 inflorescences

visited, 79 beetles were counted (average:  $2.7 \pm 1.4$ , range: 1–6).

## Thermogenesis

### *Dieffenbachia seguine*

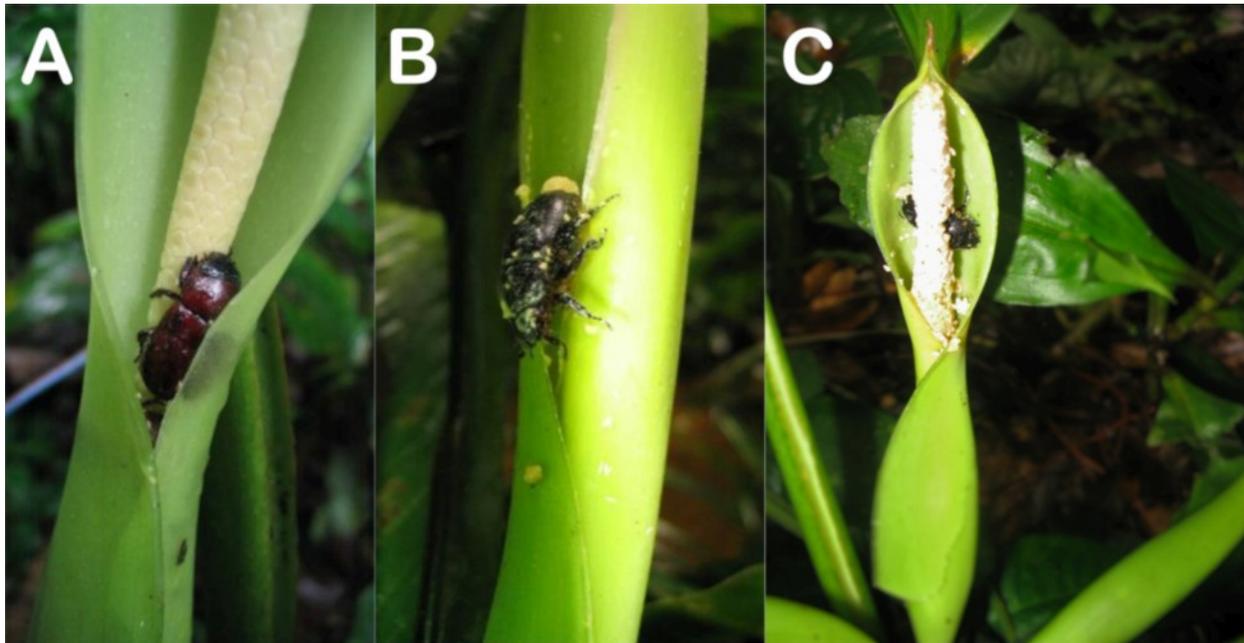
The thermogenic pattern of the spadix of *D. seguine* presented a major increase of temperature during the pistillate phase (Day 1) when stigma were receptive and almost no increase of spadix temperature on the following evening (Day 2) during the staminate phase and pollen emission.

During the pistillate phase, the thermogenic pattern started at the end of the afternoon around 5:00 pm (range: 4:09–6:06 pm) and lasted until about 11:00 pm (range: 9:16 pm–0:38 am). The maximum temperature difference occurred around 7:40 pm (range: 6:40–9:00pm) and the spadix temperature was around 25.2°C (range: 22.5–27.5°C). Consequently, the maximum temperature difference was moderate around 1.6°C (range: 0.8–2.7°C).

During the staminate phase, only 6 inflorescences (out of 12) presented some temperature difference between the spadix and ambient air; but the maximum of temperature differences were very low with a mean of 0.5°C (range: 0.3–0.9°C).

### *Dieffenbachia paludicola*

The thermogenic pattern of the spadix of *D. paludicola* was the same as for *D. seguine*.



**Figure 10.** Scarab beetle pollinators. A. *Cyclocephala rustica* “resting” over the synandria outside the pollination chamber. B. *Erioscelis proba* loaded with sticky pollen leaving an inflorescence (male stage) of *D. paludicola*. C. *E. proba* behind a spathe of *D. seguine* presenting chewed synandria.

During the pistillate phase, the thermogenic pattern started in the middle of afternoon around 3:20 pm (range: 2:30–4:12 pm) and lasted until about midnight 00:11 am (range: 10:53 pm–1:47 am). The maximum temperature difference occurred around 7:43 pm (range: 7:00–8:50pm) and the spadix temperature was around 27.4°C (range: 26.1–30°C). Consequently, the maximum temperature difference was notable around 4.3°C (range: 3.3–5.8°C).

During the staminate phase, 3 inflorescences (out of 4) presented some temperature difference between the spadix and ambient air; but the maximum of

temperature differences were low with a mean of 0.9°C (range: 0.7–1.3°C).

### Flower & Fruit Predation

#### *Dieffenbachia seguine*

Scarab pollinators usually ate the staminodes present in a row around the gynoecia (100%) and the sterile flowers (80%); but the synandria could also be damaged. Out of 15 inflorescences, 12 had some damaged synandria. The average proportion of damaged synandria was  $16.5 \pm 14\%$  (range: 3–50%), that represented an average of 31.5 synandria damaged out of

an average total of 212 (**Figure 11A**). In many damaged synandria, the pollen was lost, probably eaten, lowering the fitness of the plant. The scarab pollinators were not directly observed to damage the synandria; but since these damages occurred in visited inflorescences and appeared to be “continuous” with eaten sterile flowers, they are likely to have been done by the pollinators (**Figure 11A**).

Predation could also occur on the infructescences, the spathe could be gnawed in order to open a hole and get access to the berries that could be eaten (**Figures 11B**). On 35 plants bearing a total of 61 infructescences: 11 of them (18%) had a hole in the lower part of the spathe at the level of the female zone presenting several missing young berries (**Figure 11B**). The number of missing (eaten?) young berries was  $10.2 \pm 11.8$  (range: 1–39) knowing that the mean number of gynoecia per inflorescence was 44 (Table 2). Two infructescences presented a different predation with the upper spathe chewed out and the staminate zone more or less damaged in different parts (**Figure 11C**).

Finally, curculionids were also observed to damage many infructescences (47 out of 61; 77%), by making their typical holes in the spathe mainly on the upper part corresponding to the male flowers zone (**Figure 11D**). Such damages were never observed on inflorescences before or during the anthesis. Of the 47 infructescences attacked by curculionids, 29 (62%) were damaged only on the upper staminate zone;

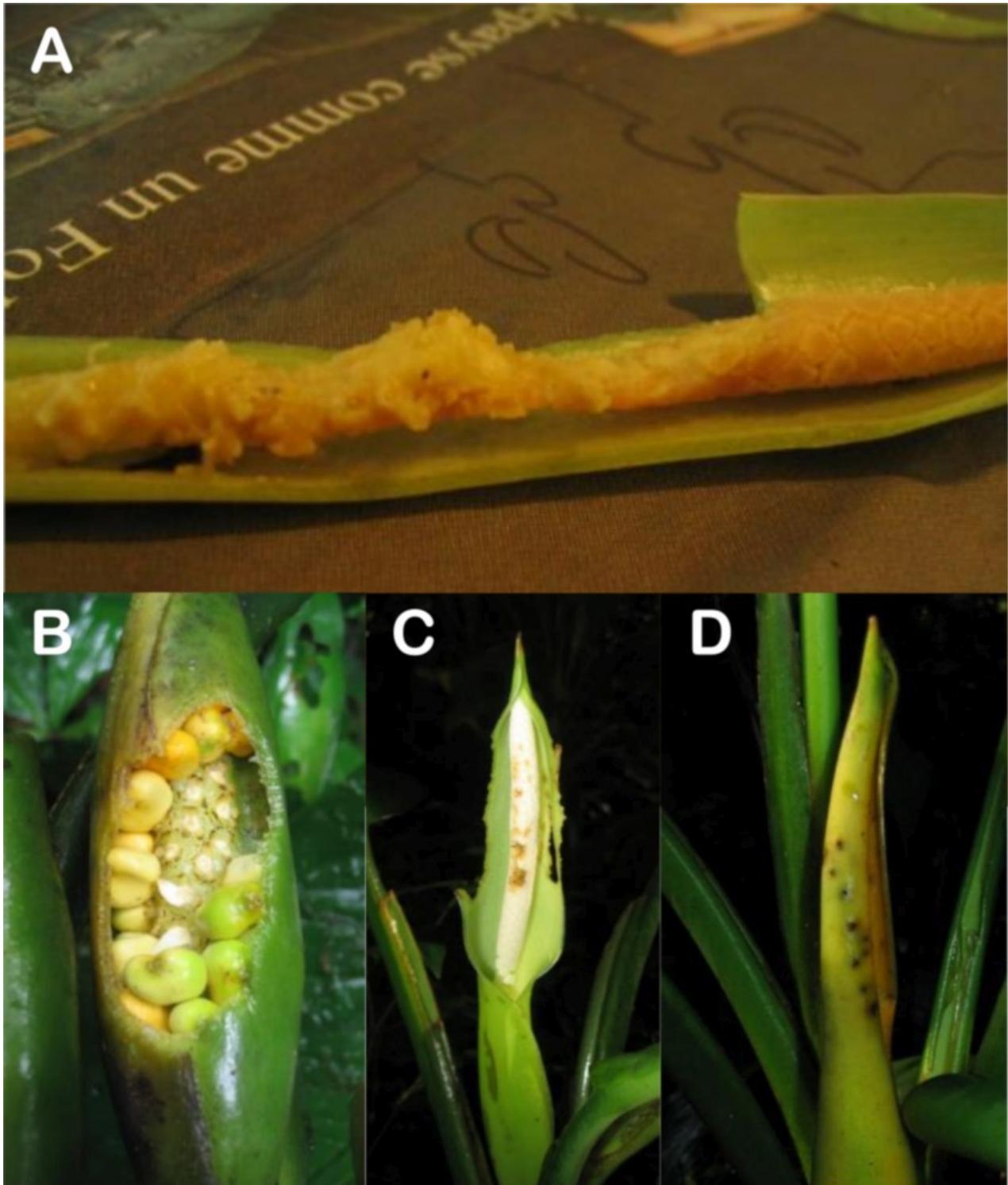
6 along the entire spathe; 6 on the upper half of the spathe (stamina + sterile); 5 on the staminate and gynoecia zones and 1 on the lower half of the spathe (sterile + female). In terms of the number of holes, 733 holes have been counted in total over the 48 spathes: 567 (77%) at the level of the staminate zone, 131 (18%) corresponding to the sterile zone and 35 (5%) to the female zone. In terms of the average number of attacks per spathe; the staminate zone presented  $14 \pm 13$  holes (range: 1–75); the sterile zone  $11 \pm 14$  (range: 1–50) and the female zone  $3 \pm 2$  (range: 1–7).

### *Dieffenbachia paludicola*

The beetle pollinators fed on the staminodes, these sterile flowers were all eaten in every visited inflorescence. Moreover synandria could also be eaten mainly those at the base of the male zone (contiguous with the sterile zone). The observed number of damaged synandria ranged from a few (5–6) at the base of the male zone up to the 4 basal rows of the male zone.

### Mode of Reproduction

The inflorescence visit rate by pollinating insects (see *insect visitors* section), the number of infructescences per plant and the proportion of pollinated berries per infructescence (see *reproductive success* section) were high suggesting an efficient mode of cross-pollination. Experimental pollination designs indicated that 7 out of 12 (58%) of the self-pollinated inflorescences started to



**Figure 11.** Different observed damages on inflorescences and infructescences of *Dieffenbachia seguine*. A. Sterile flowers and synandria eaten on one receptive inflorescence. B. Spathe chewed at its base and berries eaten on a young infructescence. C. Spathe chewed at its apex and synandria damaged on a receptive inflorescence. D. Spathe with marks (dark points) done by curculionids on an infructescence.

develop fruits. None of the 11 emasculated inflorescences (Apomixis) gave fruits. Six out of 7 (86%) hand-pollinated inflorescences developed fruits. Unfortunately all the infructescences were collected at the end of August at the end of our stay and were not mature, so no indication on the number of developing seeds or their viability could be tested.

From the five hybrid pollinations of female flowers of *D. seguine* with pollen of *D. paludicola*; 4 aborted and one appeared to start fruiting but it was collected too early in the maturing phase to be sure of its developing status.

## DISCUSSION

### Plant size and reproductive status

*Dieffenbachia* are terrestrial, evergreen chameophytes with long terminally erect stems (Gonçalves et al., 2007). Our result on the reproductive status in relation to plant size indicated that these two tropical species behave like geophyte temperate species such as *Arum*, *Arisaema* or *Helicodiceros* (Méndez, 2001; Vitt et al., 2003; Revel et al., 2012; Gibernau & Seymour, 2014). Plant vigor is related to reproduction, with small individuals being non-reproductive in contrast to larger ones (Revel et al., 2012). But contrary to the clear minimum size (threshold) found for the weight of the tuber in *Arum* or corm in *Arisaema* (Méndez, 2001; Vitt et al., 2003), the studied vegetative traits gave less

marked results (**Figures 3 & 4**) than for *Helicodiceros muscivorus* (Gibernau & Seymour, 2014). This is probably due to the fact that these vegetative traits are determined by many factors (resources, developmental, physiological, environmental) and not linearly linked to plant vigor, contrary to the tuber or corm weight which represents all the resource for developing the entire individual.

### Reproductive success and floral traits

In the studied population of *Dieffenbachia seguine*, 75% of the individuals were reproductive, and more than 80% of the reproductive individuals successfully reproduced (i.e., maturing infructescences). This fructification rate is high for both temperate and tropical Araceae (Young, 1986; Méndez & Diaz, 2001; Albre & Gibernau, 2008; Gibernau & Seymour, 2014). Now the individual probability for an inflorescences to successfully mature was lower 64%; but because each plant bear an average of 5 inflorescences (range: 1–12), it resulted in a high value of plant reproductive success. Another important parameter to estimate the reproductive success is the proportion of ovaries pollinated. This proportion was high, about 88%, for small- and medium-sized inflorescences (<50 berries) but decreased to 68% for large inflorescences (>50 berries; **Figure 6**). It is generally accepted that larger inflorescences are more likely to be pollinated and to develop infructescences than smaller ones (Revel et al., 2012). Apparently, this is not the case for *D. seguine*;

but several factors should be taken into account that may explain such discrepancy. Contrary to studied temperate aroids on this topic, *Dieffenbachia seguine* produce more than one inflorescence per flowering season (Revel et al., 2012; Gibernau & Seymour, 2014). Thus an integrative estimation of the reproductive success over the totality of inflorescences produced may be more appropriate. It can't be excluded that bigger inflorescences may attract more pollinators than smaller ones even in *Dieffenbachia*; but being visited by a higher number of pollinators is not always related to a better pollination. In *D. nitidipetiolata*, it has been shown that the probability of fruit set was a quadratic function of the number of visiting beetles with the highest probability for intermediate numbers of beetles and lower when beetles were too numerous (Young, 1988). Detrimental interactions among beetle pollinators when they are too numerous may represent more a kind of hindrance, leading to trouble in the pollination process (i.e. stigma access) rather than a better probability of pollination.

In *D. seguine*, the fact that the number of synandria and female flowers (**Figure 5**) increased at the same rate (same slopes) with an increase of the spadix size indicated that there was no bias in term of resource allocation to the male or female function in relation to an increase of the vigor. This result was also confirmed by the absence of correlation between the spadix size and the floral sex ratio, indicating no significant feminization of the inflorescence with an increase in the total size. Hence *Dieffenbachia*

*seguine* does not follow the size advantage model in terms of the variations of flower numbers. This inflorescence feminization has been shown to exist in some aroid species such *Arum italicum*, *A. cylindraceum* or *Arisaema triphyllum* (Gibernau & Albre, 2008; Barriault et al., 2010; Revel et al., 2012), but not in *Arum maculatum* or *Helicodiceros muscivorus* (Chartier & Gibernau, 2009; Gibernau & Seymour 2014). But when considering the weight of the flowers, the result is different. The weight of female flowers increased faster than the weight of synandria with an increasing spadix size. The weight of the synandria didn't vary linearly with spadix size with a mean weight of 1.5g; while the total weight of female flowers increased from 0.25 to 0.64 g with spadix size (**Figure 5**). Contrary to the number of flowers, the weight of the two flower types indicated a feminization of the inflorescence with its size increase, from 14 to 38% of the weight of the fertile flowers, even if the weight of synandria remained heavier than ovaries.

As for *Arum*, the pattern in reproduction investment is expected to be complicated in *Dieffenbachia* because an individual can produce several inflorescences. Difference of result between flower masses and numbers probably reflect that an increase in inflorescence size entails an increase relatively more important in flower size than in number (Mendez, 2001). The factors responsible for such increases are not the same according to the fertile zone. In fact, in *Dieffenbachia seguine*, the increase of the female zone may be due more to an increase

in the size of the female flowers than their number. The average ovary weight is related to spadix size ( $r^2 = 0.70$ ;  $t = 5.32$ ;  $p = 1.8 \times 10^{-4}$ ), increasing from 6.5 mg to 13.2 mg, but not the total number of ovaries ( $r^2 = 0.038$ ;  $t = 0.68$ ;  $p = 0.51$ ). On the contrary, the increase of the male flower zone is mainly due to an increase in the number of synandria. The average synandrium weight is not related to the spadix size ( $r^2 = 0.014$ ;  $t = 0.39$ ;  $p = 0.70$ ) neither to the total number of synandria ( $r^2 = 0.025$ ;  $t = 0.54$ ;  $p = 0.60$ ). So, large inflorescences increase the number of gametes, and thus their reproductive capacity. On the other hand, it is not known if the increase in the number of both male and female gametes is proportional or not (Gibernau & Albre, 2008; Revel et al., 2012).

### Pollination ecology & mode of reproduction

The two *Dieffenbachia* species studied presented classical floral traits and anthesis for cyclocephaline scarab beetle pollination: nocturnal anthesis with a strong odor, protogynous and short (over 2–3 days) anthesis, female flowers being receptive on the first night and pollen being released on the second or third night (Gibernau, 2015). The main pollinating scarab beetle in both species was *Erioscelis proba* since it was the exclusive pollinator of *D. paludicola* and the most abundant species (80%) in inflorescences of *D. seguine*. *Erioscelis proba* has been collected in Costa Rica from the inflorescences of *P. brevispathum* (Croat, 1997), and in French Guiana in

*Montrichardia arborescens* (Gibernau et al., 2003). The two populations studied were about 60 m apart (flight distance), not a great distance considering the flight capacity of scarab beetles. For example, in capture-recapture experiments of pollinators of *D. nitidipetiolata*, the mean flight distance *Erioscelis columbica* was 58 meters and 102 meters for *Cyclocephala amblyopsis* (Young, 1988). But the majority of recaptured beetles flew to the nearest inflorescence of *D. nitidipetiolata* from 2 to 80 meters, even if one beetle was tracked up to 1350 m away (Young, 1986; Beath, 1999). It's not known if individuals of *Erioscelis proba* had actually moved between the populations of the two species, it can't be ruled out. But experiments consisting of marking beetles with recapture data are needed in order to quantify the eventual flow of beetles between the populations of these two *Dieffenbachia* species. Even if there is a flow of beetles, it doesn't mean that hybridization occurs. In Araceae, scarab beetles are known to be attracted by some of compounds of the floral scent and thus able to distinguish species with different floral bouquets (Dötterl et al., 2012; Maia et al., 2012, 2013). Thus a comparison of the floral scent of these two *Dieffenbachia* species is needed to establish how olfactorily different are the two species. Whatever, the question remains if these two *Dieffenbachia* species are reproductively isolated (different flora scents discriminated by the beetles) or exchange some of their pollen (similar floral scents or plasticity in the beetle response). The hybrid pollination experiment showed that interspecific cross-

pollination is possible at least in one direction (pollen of *D. paludicola* on female flowers of *D. seguine*), but the viability of hybrid seedlings or the fertility of hybrid plants remain to be assessed. Since no obvious hybrid plants were observed in the field, the success of such crosses is doubted.

### **Reproductive success and fruit predation**

Nevertheless, scarab beetles appeared to be efficient pollinators as suggested by the unmanipulated fruit maturation of cross pollination, even if self-pollination resulted in mature fruits (58%). Now it is not known how common self-pollination is, and if it results in viable/fertile plants. Beetle pollination resulted in a high percentage of inflorescences visited (81%), a high number of infructescences per plant (~4) with a large number of pollinated berries per infructescence (84%). Surprisingly larger inflorescences (in term of number of flowers) were not better pollinated than smaller ones, in terms of developing berries; even if they finally produced more seeds. In *D. nitidipetiolata*, only larger inflorescences, in terms the number of male and female flowers, were visited by beetles, smaller ones been not visited (Young, 1990). In *Philodendron solimoesense*, a positive relationship was found between the inflorescence size and the number of attracted beetles (Gibernau et al., 1999). Our data doesn't allow testing the correlation between the inflorescence size and the number of pollinating beetles

attracted, but this result might be explained by three ways. The number of beetles is about the same whatever the inflorescence size resulting in the same pollination level whatever the number of female flowers. Hence the percentage of ovaries pollinated should decreased with an increasing total number of female flowers. Our result showed no linear trend but rather a threshold value around 50 female flowers. Second, bigger inflorescences do in fact attract more pollinating beetles as shown in a few other aroids, but an inflorescence crowded with beetles may be disadvantageous. As mentioned before, In *D. nitidipetiolata*, the highest probability of fruit set was for intermediate numbers of beetles, and lower when beetles were too numerous (Young, 1988), due probably to detrimental interactions among beetles and a worse pollination process. Thirdly, due to the relative sample size, when considering each size class apart, this observed trend may be fortuitous. In fact, one larger inflorescence (with 53 ovaries) was badly pollinated (22% of the ovaries) may be aberrant. If this data is discarded, then the percentage of berry maturation rate per infructescence is 76% for large inflorescences instead of 68%.

Floral herbivory has been observed during two stages in *D. seguine*. On inflorescences, synandria can be eaten up to 50% (mean: 16%) probably by the pollinating beetles but larvae cannot be ruled out. In Mexico, the inflorescences of *D. oerstedii* are the ovipositing and feeding site of *Beebeomyia tuxtlaensis* (Diptera, Richardiidae) and of an

unidentified drosophilid (Hernández-Ortiz & Aguirre, 2015). The eggs are oviposited along the edge of the spathe, once hatched the larvae enter under the spathe and feed mainly the upper male section and on the rachis, causing its decay; but female flowers could also be consumed (Hernández-Ortiz & Aguirre, 2015). Richardiid flies have also been recorded in Costa Rica on *D. nitidipetiolata* and *Anthurium* (Hernández-Ortiz & Aguirre, 2015). Richardiid flies have also been observed in inflorescences of *Taccarum* in addition to the beetle pollinators (Maia et al., 2013). Their larvae damaged anthers and ingested pollen. In most inflorescence (67%) infestation was limited (25–50 larvae) and only a few male flowers were damaged. In the few over-infested inflorescences (< 5%), containing more than 200 feeding larvae, damages were severe not only to the male zone of the spadix but also female flowers, and even the axial tissue of the spadix (Maia et al., 2013). If the damage from larvae have been observed, the effect on fruit production still needs to be quantified.

Damages were also observed on infructescences of *D. seguine*. The spathe was commonly damaged (77%) by curculionids and presented many small black holes oozing resin on the spadix (**Figure 11D**). It's not clear if this corresponded to nutritive or oviposition behavior of the insects, and if they reached the spadix. Even if they didn't directly affect the flowers, it can't be excluded that such damages may facilitate tissue infestation by bacteria, fungi... The effect of curculionids'

holes on the reproduction success need to be studied. Derelomine curculionids are known to be pollinators in some *Anthurium* species (Franz, 2007). Infructescence presented also bigger damages, the spathe being chewed out and young berries eaten (**Figures 11B & C**). The animal responsible for such damages was not observed, probably a small vertebrate, a rodent? If aroid fruit dispersion by animals has been somewhat documented (Barabé & Gibernau, 2015), fruit predation is rarely documented and might represent a new field of investigation.

In conclusion, the pollination and reproduction biology is now known from 5 species and 6 populations out of the 57 described *Dieffenbachia* species. The present study and recent works (Maia et al., 2013; Hernández-Ortiz & Aguirre, 2015) suggest that the insect community associated with inflorescences of *Dieffenbachia* may be more complex than just the pollinating beetles. Further ecological studies may reveal a more complex web of interaction centered on Aroid inflorescences than actually documented.

## ACKNOWLEDGMENTS

I wish to thank Patrick Châtelet, Philippe Gaucher and the staff of the Nouragues Research Station (CNRS, French Guiana), for commodities and technical help during the field sessions. I wish also to thank Derek Burch for constructive comments and corrections on the manuscript. This study was financed by a CNRS grant from

the Amazonie II program (APR – Nouragues) but also from an *Investissement d'Avenir* grant managed by the French *Agence Nationale de la Recherche* (CEBA, ref. ANR-10-LABX-25-01).

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**Table 1.** Comparison of plant morphology in terms of plant sizes, leaf and inflorescence numbers, and leaf sizes between *Dieffenbachia seguine* and *D. paludicola*.

	<i>D. paludicola</i>		<i>D. seguine</i>	
	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range
Sample size	N=30		N=71	
Number of leaves	10.5 $\pm$ 3.5	3–19	8.4 $\pm$ 3.6	1–19
Blade length (cm)	118.8 $\pm$ 20.6	70–152	44.6 $\pm$ 6.8	28–61
Blade width (cm)	17.2 $\pm$ 3.1	11.2–23.5	16 $\pm$ 2.3	10–22
Number of inflorescences	3.3 $\pm$ 3.4	0–9	2.8 $\pm$ 2.5	0–12
Number of inflorescences*	6.2 $\pm$ 1.8	3–9	4.1 $\pm$ 1.9	1–12
Stem diameter (cm)	–	–	3.2 $\pm$ 0.7	2–4.6
Petiole length (cm)	Within the sheath		27.2 $\pm$ 5.4	11–43
Sheath length (cm)	–	30–60	17.9 $\pm$ 3.4	9–27
Plant height (cm)	–	–	111.8 $\pm$ 19.2	69–148

\* Only on reproductive plants.

**Table 2.** Comparison of inflorescence morphology in terms of inflorescence sizes (spathe, spadix and floral zone lengths), numbers of the different type of flowers, and floral sex ratio between *Dieffenbachia seguine* and *D. paludicola*.

Sample size	<i>D. paludicola</i>		<i>D. seguine</i>	
	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range
	N=18		N=27	
Spathe length (cm)	23.14 $\pm$ 4.15	15.8–29.4	17.95 $\pm$ 2.03	14–21
Spadix length (cm)	21.79 $\pm$ 3.41	15.4–27.5	16.06 $\pm$ 1.59	13–20
Pollination chamber volume (cm <sup>3</sup> )	23.92 $\pm$ 9.76	7.86–39.63	23.25 $\pm$ 5.85	12.4–30.7
Female zone length (mm)	98.27 $\pm$ 18.41	58.8–125.8	62.57 $\pm$ 8.01	45.3–77
Male zone length (mm)	86.52 $\pm$ 13.59	63.9–108.8	77.41 $\pm$ 9.06	60–98
Sterile zone length (mm)	18.62 $\pm$ 7.82	8–35.4	18.14 $\pm$ 4.92	9–30
Number of female flowers	10.44 $\pm$ 1.04	8–12	43.8 $\pm$ 7.6	32–57
Number of male flowers*	167.39 $\pm$ 24.02	128–200	212.6 $\pm$ 34.3	145–255
Number of sterile flowers	2.17 $\pm$ 1.53	0–5	17.5 $\pm$ 12.6	2–42
Female flower diameter (mm)	7.5 $\pm$ 1.1	5.7–9.7	–	–
Floral sex ratio	0.94 $\pm$ 0.01	0.92–0.95	0.83 $\pm$ 0.03	0.75–0.88

\* synandria

**Table 3.** Berry production and maturation, and seed production per infructescence in *D. seguine*.

Sample size	<i>D. seguine</i>	
	Mean $\pm$ SD	Range
	N=34	
Berries per infructescence	40.64 $\pm$ 11.14	23–73
Pollinated (developed) berries	33.42 $\pm$ 10.5	12–53
% of pollinated berries	84 $\pm$ 18	23–100
Berries with no seed	0.80 $\pm$ 0.77	0–3
Berries with one seed	13.56 $\pm$ 4.03	8–21
Berries with two seeds	18.44 $\pm$ 10.75	0–38
Total number of seeds/infruct	50.61 $\pm$ 23.83	13–87

# Araceae of Parque Nacional Natural de Las Orquídeas, Colombia

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## ABSTRACT

A total of 16 new species of *Anthurium* are described as new to science: *Anthurium abajoense* Croat & A. Zuluaga, *A. alcogolloi* Croat, *A. blanquitense* Croat, *A. curtispindunculum* Croat, *A. dabeibaense* Croat, *A. elquincense* Croat, *A. espiranzaense* Croat & A. Zuluaga, *A. frontinoense* Croat & A. Zuluaga, *A. hempeanum* Croat, *A. juanguillermoi* Croat, *A. ovidioi* Croat, *A. pedrazae* Croat & A. Zuluaga, *A. paloense* Croat, *A. sneidernii* Croat, *A. tortuosum* Croat, and *A. triangulopetiolum* Croat.

## INTRODUCTION

Few areas in Colombia have created so much excitement as the region in

southwestern Antioquia Department between 300 and 3450 m with a life zone ecology ranging from *Premontane wet forest* to *Tropical wet forest* and *Premontane rain forest* life zones. Much of the region remains totally unexplored but certain areas in recent years have been explored by botanists. Botanical activity began actively with expeditions funded by the National Geographic Society and carried out by the Missouri Botanical Garden and the Universidad de Antioquia as well as the Jardín Botánico de Medellín. The expeditions included Dr. James Zarucchi, Dr. John MacDougal, Alan Brant, Alvaro Cogollo and others with the first set of material being deposited at HUA.



**Figure 1.** Map showing the location of Parque Nacional Natural de Las Orquídeas in Colombia.

The park occupies areas of three municipalities, Urrao, Frontino and Abriaquí. Access to the park is from the southwest via the city of Urrao reached from Medellín via Amagá and Bolombolo. Buses go as far as Caicedo and from there the park is reached only on foot or with horses or mules.

*Anthurium abajoense* Croat & A. Zuluaga, sp. nov. Type:

COLOMBIA. Antioquia: Municipio Frontino, Parque Nacional Natural de Las Orquídeas, Vereda Venados Abajo, Finca de Gabriel Montoya, a la margen derecha del Río Venados, 06°32'24"N, 76°19'10"W, 860–910 m, 23 July 2011, A. Zuluaga, P. Pedraza, J. Betancur, M. F. González, R. Arévalo, D. Sanin, J. Serna & A. Duque 776 (holotype, MO-6353107; isotype, COL). **Figures 2, 3.**

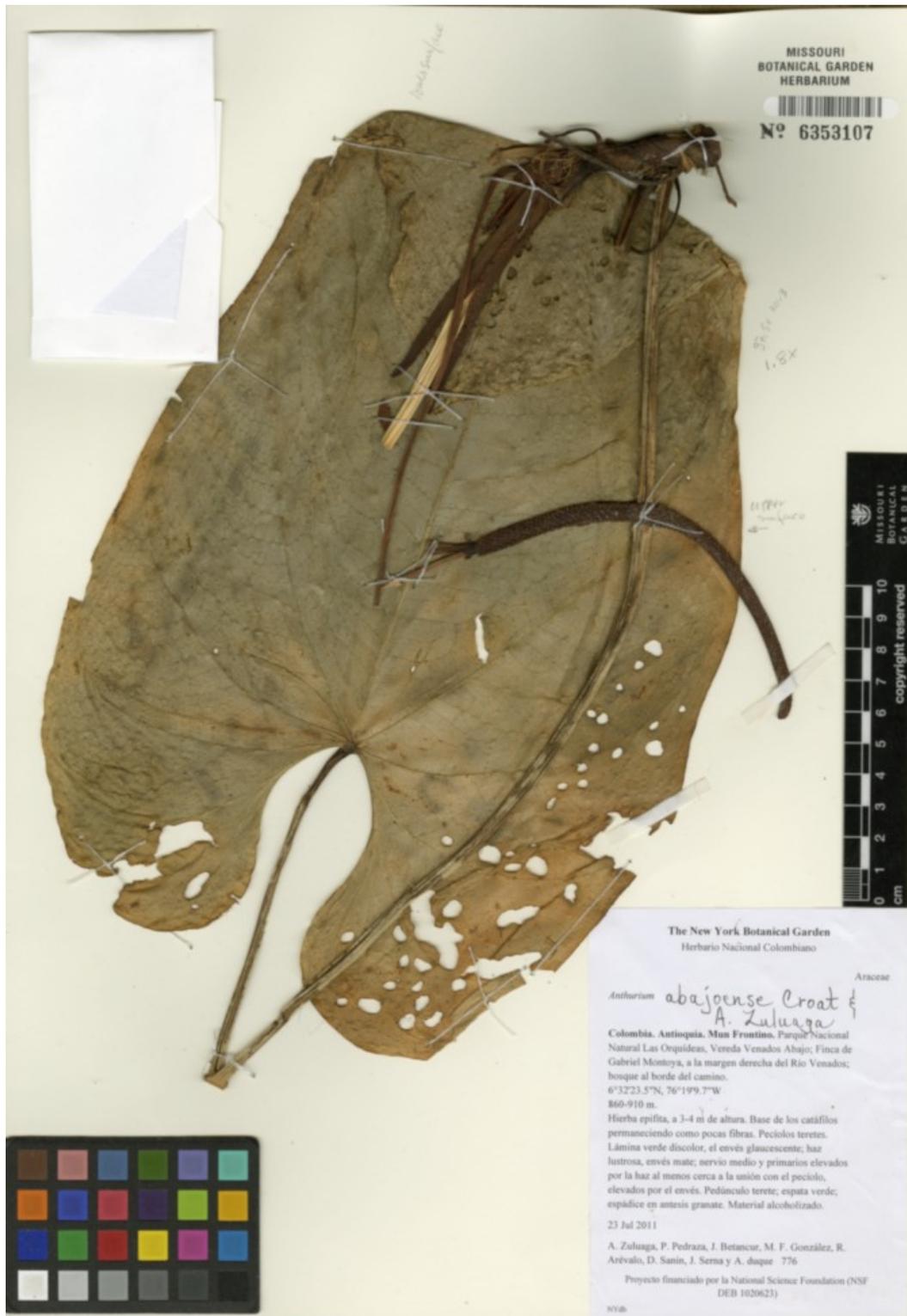
The species is a member of section *Cardiolonchium* characterized by its hemiepiphytic habit, short internodes, cataphylls persisting weakly as a few pale parallel fibers, a terete petiole, bicolorous narrowly ovate-sagittate greenish drying blades which are matte-subvelvety above, semiglossy below, a narrowly parabolic sinus, six pairs of basal veins, only the first pair of basal veins free to the base, the collective veins arising from the 1<sup>st</sup> pair of basal veins, as well as by the short peduncle, green reflexed spathe and the weakly tapered magenta spadix.

One of the collections, *Zuluaga 768*, differs from the holotype in drying a glossier, darker green, lacking the characteristic surface pustules of *Zuluaga 776*, and having 5(6) basal veins with only the 1<sup>st</sup> pair free to the base.

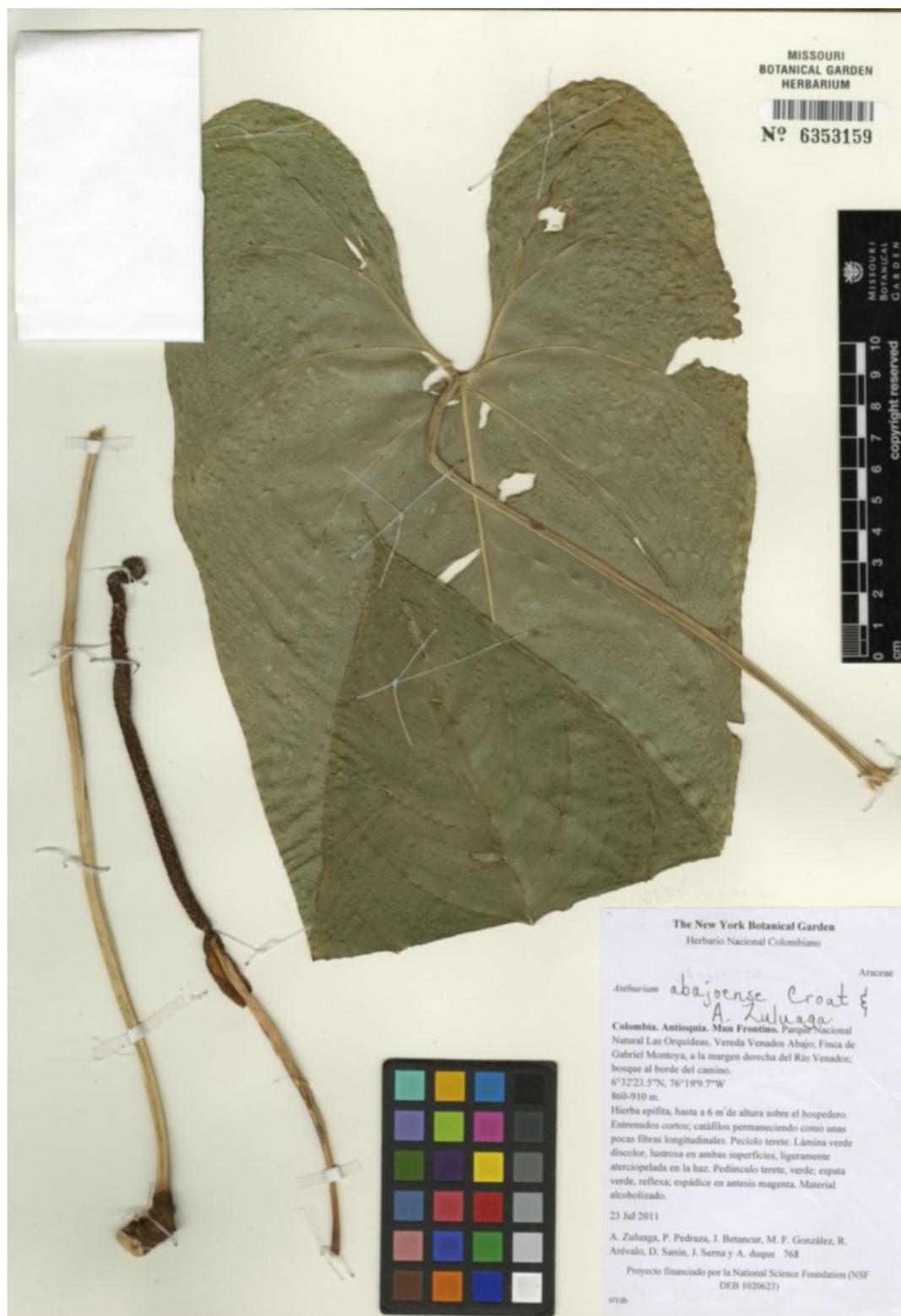
In the Lucid Anthurium Key, the species tracks to *Anthurium regale* Linden, a species which differs in having much larger leaves with prominently paler veins and a whitish spadix; *A. velutinum* Engl., differing in having the upper blade surface scabrid and all the veins on the lower surface prominulous; *A. coripatense* N. E. Br. ex Engl., which differs in having typically larger, more coriaceous blades with prominent tertiary veins and a more prominently stipitate, more typically cylindroid spadix and *A. incurvum* Engl., differing in having more broadly ovate blades to 1.1 times longer than broad, with the posterior ribs departing at ca. a 120°

angle (versus ca. a 50° angle for *A. abajoense*).

Hemiepiphyte; **internodes** short; **cataphylls** persisting as few longitudinal fibers. LEAVES 83.7–87.8 cm long with **petioles** terete, 45.6–46.6 cm long, drying 3–4 mm wide, grayish tan, deeply ribbed adaxially; **geniculum** moderately darker than petiole, finely striated, 2.4–3.1 cm long; **blades** ovate-sagittate, green bicolorous, glaucous on both surfaces, moderately coriaceous, 38.1–41.2 cm long, 18.9–20.6 cm wide, 1.5–2.2 times longer than broad, 0.84–0.88 times as long as petioles, abruptly acuminate at apex; **upper surface** glossy, drying semiglossy, densely granular, drying gray-yellow; **lower surface** matte, drying semiglossy, drying light gray-yellow; **anterior lobe** 29.0–31.9 cm long, 18.9–20.6 cm wide, with broadly convex margins, broadest below middle; **posterior lobes** 7.9–8.1 cm long, 10.2–10.9 cm wide, directed downward to turned somewhat inwards; **sinus** spatulate to narrowly parabolic, 8.4–9.1 cm deep, 3.1–3.6 cm wide; **midrib** elevated to at least the petiole, drying paler than upper surface, weakly acute above, moderately paler than lower surface, prominently round-raised below; **primary lateral veins** ca. 6 pairs, arising at a 52–59° angle, elevated to at least the petiole on upper surface, raised below, drying bluntly rounded, weakly raised above, narrowly rounded, moderately raised below, finely pale granular; **basal veins** 6(7) pairs, 1<sup>st</sup> pair, sometimes 2<sup>nd</sup>, free to base; **posterior ribs** nearly straight, 4.2–4.9 cm long, naked 1.7–2.7 cm; **tertiary veins**



**Figure 2.** *Anthurium abajoense* Croat & A. Zuluaga (Zuluaga 776). Herbarium type specimen showing leaf blade abaxial surface with a portion of the adaxial surface folded back, petiole and spathe with spadix and cataphylls.



**Figure 3.** *Anthurium abajoense* Croat & A. Zuluaga (Zuluaga 768) Herbarium specimen showing leaf blade abaxial surface with a portion of the adaxial surface folded back, petiole and inflorescence.

rounded, very weakly raised above, rounded, weakly raised below, moderately darker than upper surface; **collective veins** arising from 1<sup>st</sup> pair basal veins, running 3–6 mm from margin; **antimarginal vein** present, arising from lower basal veins. INFLORESCENCE with **peduncle** terete, green, 11.8 cm long, drying 3–6 mm diam., drying tan, finely ribbed in upper half, deeply sulcate in lower half; **spathe** green, reflexed, drying reflexed to reflexed-spreading, obovate-elliptic to at least 5.2 cm long, drying 1.4 cm wide, reddish brown, densely granular inside, moderately granular outside; **spadix** at anthesis garnet to magenta, drying dark brown, tapered, 13.1–14.2 cm long, 0.6 cm wide at base, 0.3 cm wide at apex, weakly stipitate; **stipe** 2 mm long, 3 mm diam.; **flowers** 6–8 visible per spiral, 0.7–1.1 mm long, 1.4–2.0 mm wide; **tepals** drying light red-brown in centers to dark brown around edges, drying granular, 1.0–1.3 mm wide, inner margin narrowly rounded to 2-sided, outer margin 2-sided to shield-shaped; **stamens** held at level of tepals, anthers 0.8–0.9 mm long, 0.4 mm wide, thecae weakly divaricate.

*Anthurium abajoense* is endemic to Colombia, known only from the type locality in Antioquia, Municipio Urrao, in the Parque Nacional Natural de Las Orquídeas at 860–910 m in a *Tropical wet forest* life zone (Holdridge, 1971).

The species is named for the type locality at the Vereda Venados Abajo.

*Paratype:* COLOMBIA. **Antioquia:** Municipio Frontino, Parque Nacional Natural de Las Orquídeas, Vereda Venados Abajo, Finca de Gabriel Montoya, a la margen derecha del Río Venados; 06°32'23.5"N, 76°19'9.7"W, 860–910 m, 23 July 2011, *A. Zuluaga, P. Pedraza, J. Betancur, M. F. González, R. Arévalo, D. Sanin, J. Serna & A. Duque 768* (MO).

***Anthurium alcogolloi*** Croat, **sp. nov.**  
 Type: COLOMBIA. Antioquia: Parque Nacional Natural de Las Orquídeas, camino a San Marcos, 06°33'N, 76°19'W, 950–1060 m, 6 June 1988, *A. Cogollo, J. G. Ramírez & O. Alvarez 3301* (holotype, MO-4241467; isotype, JAUM). **Figure 4.**

The species is tentatively placed in section *Polyneurium*, characterized by its moderately short, slender internodes, moderately elongated dark brown deciduous cataphylls, subterete petioles, brown-drying narrowly oblanceolate acuminate blades which are acute at the base, the collective veins arising from one of the lower primary lateral veins as well as by its long-pedunculate inflorescence with a stipitate brownish long, slightly tapered spadix. The type specimen has irregular black dots along the margin and midrib which may be fungal in origin.

*Anthurium alcogolloi* is seemingly most closely related to *A. blanquitense* Croat which occurs in the same habitats. That species differs in having greenish drying, more oblong-elliptic blades with the primary



**Figure 4.** *Anthurium alcogolloi* Croat (Cogollo 3301, MO sheet). Herbarium type specimen showing on left inflorescence and base of leaf blade abaxial surface with adaxial surface folded back; also showing on right leaf blade abaxial surface and base of adaxial surface folded back.

lateral veins on the lower surface more narrowly raised and acute, less prominently granular blades.

Epiphyte; **internodes** short, drying 0.5–1.4 cm diam.; **cataphylls** persisting intact, 2.7–6.3 cm long, drying reddish brown, sparsely pale short-lineate. LEAVES more or less erect, 50.3–66.7 cm long, averaging 59.9 cm long with **petioles** 12.4–30.7 cm long (averaging 20.6 cm), drying 2–5 mm diam., deeply sulcate, drying matte, yellowish tan to brownish tan, densely pale-speckled; **geniculum** 0.5–1.9 cm long, glossy, darker and slightly thicker than petiole, granular and sparsely glandular-punctate; **blades** narrowly oblong-elliptic, 27.2–54.3 cm long, 5.6–8.6 cm wide, (averaging 39.9 x 7.2 cm), 4.4–6.3 times longer than broad (averaging 5.4), 1.1–4.4 times as long as petiole (averaging 2.4), sometimes broadest above middle, abruptly acuminate (1.4–2.8 cm long) at apex, cuneate to broadly cuneate and somewhat inequilateral at base; margins concave near apex, straight midway; **upper surface** drying medium brown, glossy and subcoriaceous, sparsely glandular-punctate; **lower surface** drying red-brown, semiglossy and smooth, sparsely glandular-punctate; **midrib** weakly raised on upper surface, concolorous with upper surface, prominently rounded below, much darker and redder than lower surface, three lateral ribs; **primary lateral veins** 12–16 pairs, emerging at a 76–90° angle, markedly curved upwards, concolorous and faintly raised above, more prominent and narrowly raised, drying darker below; **collective**

**veins** arising from 1<sup>st</sup> pair of primary lateral veins, sometimes weakly loop-connected to primary lateral veins, 3–8 mm from margin. INFLORESCENCE erect, brown, with **peduncle** 19.2–25.2 cm long, drying 2–4 cm wide, terete, drying moderately sulcate, yellow-tan to brown-tan, moderately pale-speckled; **spathe** green, drying deep reddish brown, semiglossy, reflexed-spreading, 6.8–10.2 cm long, drying 0.5–0.8 cm wide, lanceolate, weakly tapered toward apex, abruptly acuminate, noticeably ribbed, densely dark-speckled; **spadix** cylindrical, scarcely tapered, 7.6–12.3 cm long, drying 4 mm wide at base, 2 mm wide at apex, weakly stipitate; **stipe** 3–4 mm long, 2 mm wide; **flowers** 3–4 visible per spiral, 1.6–1.9 mm long, 1.4–1.8 mm wide; lateral **tepals** 0.9–1.1 mm wide, inner margins broadly rounded, outer margins 2-sided; **stamens** apparently withdrawing beneath tepals after anthesis, anthers not seen. INFRUCTESCENCE with berries globose-obovoid, initially green but turning purple upon maturation.

*Anthurium alcogolloi* is endemic to Colombia, known only from the type locality in Antioquia Department in the Parque Nacional Natural de Las Orquídeas at 950–1060 m in a *Premontane rain forest* life zone.

The species is named in honor of Alvaro Cogollo who collected the type collection. Alvaro is an old friend, colleague and former field companion in Antioquia. Cogollo's career as a collector in Antioquia is renowned and he has developed the

herbarium collection at the Jardín Botánico in Medellín to be one of the finest in Colombia. It is a privilege to name this interesting new species in his honor.

*Paratypes:* COLOMBIA. **Antioquia:** Parque Nacional Natural de Las Orquídeas, road to San Mateo, vic. Quebrada San Mateo, 06°33'N, 76°19'W, 950–1060 m, 6 June 1988, *Á. Cogollo P. et al. 3301* (MO); Municipio, Florencia, Dirección este, Quebrada las Mercedes, 05°31'36"N, 75°02'26"W, 13 Oct 1992, *C. E. Barbosa 7942* (FMB).

***Anthurium blanquitense* Croat, sp. nov.**

Type: COLOMBIA. Antioquia: Municipio Frontino, Corregimiento Nutibara, Inspección Murri, Alto de Cuevas en la vía Nutibara-La Blanquita, Finca El Palmar, sitio El Llano, bosque pluvial primario, 06°40'N, 76°24'W, 2080 m, 16 Feb 1991, *R. Callejas, F. J. Roldán & M. V. Arbeláez 10050* (holotype, HUA-80249). **Figures 5, 6.**

The species is tentatively placed in section *Polyneurium* and is characterized by its usually epiphytic habit, internodes longer than broad, long yellow-brown cataphylls which persist intact at most of the upper nodes, subterete, weakly sulcate petioles, oblong-elliptic, narrowly caudate-acuminate, greenish drying blades with an acute to weakly attenuate base with the collective veins arising from one of the lower primary lateral veins as well as by the long-

pedunculate inflorescence with a green spreading narrowly long-attenuate spathe and the narrowly long-tapered purple-violet spadix with violet-purple early-emergent berries.

The species is closely related to *Anthurium testaceum* Croat & R. A. Baker from Costa Rica and Panama with which it has been confused. That species occurs at similar elevations, between 800 and 2000 m, but that species differs in having flowers with usually only 2 flowers visible in each spiral, whereas in *Anthurium blanquitense* there are usually 3–4 flowers visible per spiral. *Anthurium testaceum* also has leaf blades typically proportionately much longer or more noticeably lanceolate or narrowly ovate versus more nearly elliptic in *A. blanquitense*.

The correct sectional placement of species in this group has been dubious. In the treatment of the Araceae of Costa Rica (Croat & R. A. Baker, 1979), *A. testaceum* was placed in *Leptanthurium* whereas in the revision of *Anthurium* for Central America (Croat, 1983; 1986) the species was placed in section *Xialophyllum*. Now after studying many species in section *Polyneurium* from NW Ecuador where the section seems to be most greatly centered, it appears more likely that *A. testaceum* would be best placed in section *Polyneurium* until a definitive molecular study has been concluded.

Epiphytic, sometimes terrestrial; **internodes** short, 0.6–1.3 cm long, drying



Figure 5. *Anthurium blanquitense* Croat (Callejas 10050). Herbarium type specimen showing on left leaf blade adaxial surface with abaxial surface folded twice; also showing on right leaf blade abaxial surface folded over base of adaxial surface, stems, cataphylls and inflorescence at anthesis and post-anthesis.

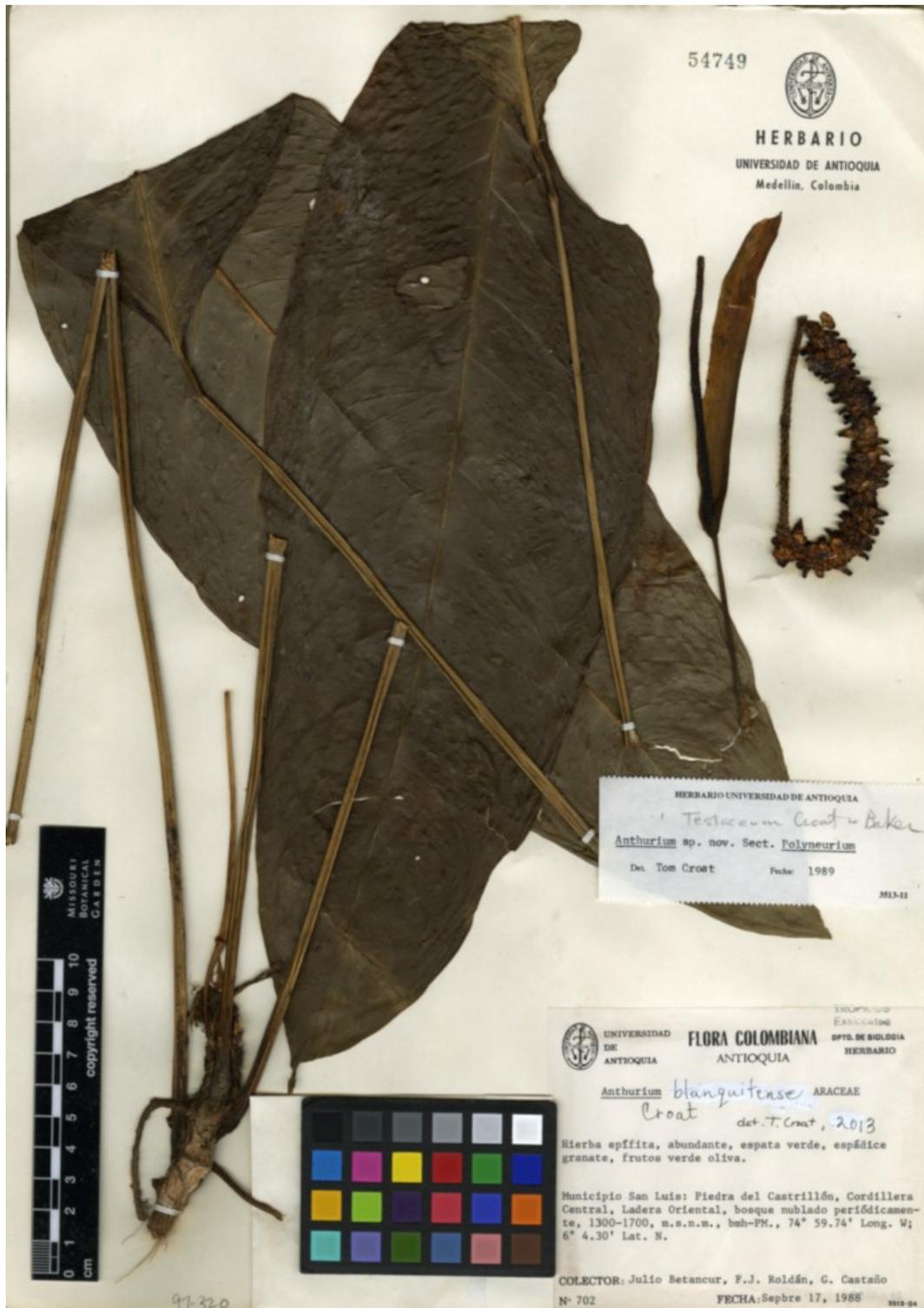


Figure 6. *Anthurium blanquitense* Croat (Betancur 702). Herbarium specimen showing on left leaf blade abaxial surface with base of adaxial surface folded back; also showing on right leaf blade abaxial surface, inflorescence and infructescence.

1.0–1.6 cm diam.; **cataphylls** 7.8–18.3 cm long, persisting intact, as fibers closer to base, ribbing rounded to acute drying reddish brown, matte, moderately pale-speckled, sometimes short-pale-lineate. **LEAVES** 65.9–80.3 cm long with **petioles** terete, 28.3–38.4 cm long (averaging 33.4 cm), drying 2–5 cm diam., yellowish tan, semiglossy, moderately sulcate, drying deeply sulcate with thin sometimes loosening marginal wings; **geniculum** 1.0–1.4 cm long, drying 4–6 mm diam., tannish green; **blades** ovate-elliptic, 37.1–41.9 cm long by 10.8–14.7 cm wide, (averaging 38.8 x 12.2 cm), 2.9–3.6 times longer than broad (averaging 3.2), 1.0–2.3 times longer than petiole (averaging 1.2), broadest midway to slightly below, abruptly acuminate at apex (acumen 1.2–4 cm, sometimes downturned), acute to cuneate at base, weakly inequilateral at base, drying thinly coriaceous to subcoriaceous; **upper surface** drying dark green to olive-green, glossy, surface smooth upon drying, minutely areolate upon magnification; **lower surface** drying medium gray-green, glossy, sparsely and minutely granular; **midrib** weakly raised and slightly rounded above, barely paler than upper surface, prominently rounded below, significantly paler than lower surface with lateral ribbing; **primary lateral veins** 14–18 pairs, departing midrib at a 43–54° angle, weakly and narrowly raised above, narrowly raised to acute below, slightly paler than upper surface, significantly paler than lower surface; **collective veins** arising from first few [3<sup>rd</sup>] primary lateral veins near base, weak loop-connecting primary lateral veins, 2–6 mm from margin, almost

indistinguishable above, drying weakly acute below. **INFLORESCENCE** erect; **peduncle** 47.7–51.9 cm long (averaging 49.8), drying 2–6 mm diam., terete, drying matte, yellowish tan, sulcus; **spathe** reddish adaxially, green at base and red towards apex abaxially, drying light brown to medium gray-brown, matte, erect-spreading, 4.7–11.2 cm long, 0.9–1.3 cm wide (averaging 9.4 cm x 1.0 cm), narrowly linear-lanceolate, minutely granular with the veins darker and raised upon drying, short-pale-lineate; **spadix** narrowly cylindrical to weakly tapered, 8.2–15.8 cm long, 2–3 mm diam. (averaging 11.5 cm long), violet to garnet, drying dark brown to medium red-brown; **flowers** 2–3 visible per spiral, 1.6–2.2 mm long, 1.2–1.5 mm wide; **tepals** drying light tan-red in centers to dark brown around edges, drying granular, 0.8–1.1 mm wide, inner margin broadly rounded, outer margin 2-sided to shield-shaped; **stamens** held at level of tepals, anthers 0.5–0.6 mm long, 0.3 mm wide. **INFRUCTESCENCE** 13.0–16.4 cm long, drying 0.9–1.3 cm wide with berries exerted (averaging 14.9 cm by 1.1 cm); **berries** violet-purple, drying yellow-tan at base darkening to brown at apex, drying 0.9 cm long by 0.4 cm wide, prominently protruded apex; **pericarp** short-pale-lineate.

*Anthurium blanquitense* is endemic to Colombia, known only from the type locality in Antioquia and Caldas Department at 1060–2080 m in a *Premontane rain forest* life zone.

The species is named for the type locality near La Blanquita in Antioquia Department in the Municipio Frontino.

*Paratypes:* COLOMBIA. **Antioquia:** Corregimiento Nutibara, cuenca alta del Rio Cuevas, 06°48'16"N, 76°14'51"W, 1790 m, 15 Apr 1987, *D. Sánchez S., C. Orrego, S. Sylva, Francisco J. Roldán, G. E. Martínez A., D. L. Restrepo & J. C. Betancur B. 1207* (MEDEL, MO); Piedra del Castrillón, Cordillera Central, Ladera Oriental, bosque nublado periódicamente, 06°04'N, 74°59'W, 1300–1700 m, 17 Sep 1988, *J. C. Betancur B. 702* (HUA, MO); 1900 m, 23 Nov 1986, *Sanchez 827* (MEDEL, MO).

***Anthurium curtipedunculum* Croat, sp. nov.** Type: COLOMBIA. Antioquia: Municipio de Frontino, region of Murri, road between Nutibara and La Blanquita, 19.2 km from Nutibara, 06°40'N, 76°26'W, 1560 m, 11 Feb 1989, *J. M. MacDougal, D. Restrepo, & D. S. Sylva 3944* (holotype, MO-3670529–30; 3670556). **Figures 7–9.**

The species is an unusual member of section *Belolonchium*, characterized by its hemiepiphytic habit (at 3 m), thick stem (5.5 cm diam.) with short internodes, cataphylls persisting as a network of pale closely arranged thin fibers, long-petiolate leaves (to 1.38 m), terete petioles which are much longer than the blades, narrowly ovate-cordate-sagittate brown-drying, abruptly acuminate blades with 8(9) pairs of basal veins, a single pair of free basal veins,

collective veins arising from the 5<sup>th</sup> pair of basal veins and mostly 1–3 mm from the margins as well as by the very short-pedunculate inflorescence with a hooding narrowly ovate-elliptic reddish spathe and the short-stipitate cylindroid dark purplish red spadix.

The unusually short peduncle on such a massive plant aids in recognition.

The sectional placement remains somewhat doubtful owing to intermediate characters depicting the section *Belolonchium* and section *Calomystrium*. While it has the fibrous cataphylls of section *Belolonchium* they are not the typical dark brown and conspicuous type usually found on *Belolonchium*. While it has short pale-lineations on the upper surfaces which are frequent for *Calomystrium*, they are exceedingly short and widely spaced and moreover lack the intact cataphylls so consistent for *Calomystrium*.

In the Lucid Anthurium Key the species tracks to *Anthurium bogotense* Schott, *A. cupreonitens* Engl. and *A. denudatum* Engl., all of which differ by having the anterior lobes markedly concave and with long-pedunculate inflorescences. *Anthurium bogotense* and *A. cupreonitens* also differ in having longer and more tapered spadices.

Hemiepiphyte to 3 m; stem 5.5 cm diam.; **internodes** short; **cataphylls** 19.5–26 cm long, drying as network of mostly aligned pale fibers, sub-manilla, with tiny fragments



**Figure 7.** *Anthurium curtipedunculum* Croat (MacDougal 3944). Herbarium type specimen (sheet 1) showing posterior portion of leaf blade abaxial surface with portion of the leaf blade adaxial surface folded over and inflorescence.



**Figure 8.** *Anthurium curtipedunculum* Croat (MacDougal 3944). Herbarium type specimen (sheet 2) showing portion of leaf blade abaxial surface with a portion of leaf blade adaxial surface folded back and stem with cataphyll.



Figure 9. *Anthurium curtipedunculum* Croat (MacDougal 3944). Herbarium type specimen (sheet 3) showing portion of leaf blade abaxial surface with inflorescence and cataphylls.

of brown epidermis. LEAVES 1.47 m long with **petioles** 1.38 m long, drying to 1.5 cm diam., sheathed to 6.2 cm, cylindrical, terete, smooth, drying light tan-brown and matte, weakly striated; **geniculum** 4.5 cm long; **blades** ovate-cordate-sagittate, 89.6 cm long, 57.0–63.0 cm wide, 1.57 times longer than broad, broadest at petiole attachment, 0.65 times as long as petiole, moderately coriaceous, abruptly acuminate and downturned at apex, prominently lobed at base; **upper surface** dark green, matte, drying dark brown, sparsely and minutely short-pale-lineate; **lower surface** moderately paler, glossy, drying weakly glossy, medium brown-gray-tan; **anterior lobe** 72 cm long, 59.8 cm wide, with weakly convex margins, broadest below middle; **posterior lobes** 29.7 cm long 20.5 cm wide, directed downward to turned somewhat inwards; **sinus** broadly hippocrepiform, 24.5 cm deep, 17 cm wide; **midrib** acute to narrowly rounded above, drying concolorous with surface, prominently and narrowly rounded to rounded below, drying noticeably darker than surface; **primary lateral veins** ca. 8–9 pairs, arising at a 48–56° angle, acute above, drying slightly lighter than surface, prominent and acutely rounded below, drying slightly darker than surface; **basal veins** 8(9) pairs, 1<sup>st</sup> pair free to base, 2<sup>nd</sup> pair coalesced to 1.4 cm, 3<sup>rd</sup> pair to 4.6 cm, 4<sup>th</sup> to 9<sup>th</sup> pair coalesced at 8.9 cm; **posterior rib** weakly rounded towards base, 12.4 cm long, naked to 8.2 cm; **tertiary veins** flat, darker than both surfaces; **collective veins** arising from 5<sup>th</sup> pair of basal veins, running 2–4 mm from margin. INFLORESCENCE with **peduncle** 2.0 cm

long, drying brown, coriaceous; **spathe** spreading, narrowly ovate, tapered with a long inequilateral acumen, to at least 13.1 cm long, drying 4.4 cm wide, dull red adaxially, light purplish red abaxially with traces of ivory, drying dark reddish brown adaxially, medium tan-brown abaxially, moderately granular, juvenile spathe narrowly long-acuminate, 8.3 mm long; **spadix** dark purplish red, drying dark brown, cylindroid, weakly tapered towards both ends, to 10.4 cm long, 1.8 cm diam., 1.3 cm wide at apex and base, stipitate; **stipe** 1 cm long, 3 mm wide; **flowers** 15–17 visible per spiral, 1.7–2.2 mm long, 1.6–2.0 mm wide; **tepals** drying dark brown, 0.9–1.3 mm wide, inner margin broadly rounded, outer margin 2-sided to 4-sided and broadly shield-shaped; **stamens** not yet emergent, but at apex seemingly mature, anthers 1.7 mm long, 0.6 mm wide, thecae parallel.

*Anthurium curtipedunculum* is endemic to Colombia, known only from the type locality in Antioquia Department in the region of Murri at 1560 m in a *Premontane rain forest* life zone.

The species epithet “curtipedunculum” is from the Latin “curtus” (short) and “pedunculus” (peduncle) referring to the very short peduncle.

*Anthurium dabeibaense* Croat, sp. nov.

Type: COLOMBIA. Antioquia: Municipio Frontino, Vereda San Andrés, vía Dabeiba-Fuema, 18–33

km, 76°40'N, 6°23'W, 960–1200 m, 23 Nov 1987, R. Callejas, R. Fonnegra, F. J. Roldán, A. L. Arbeláez 5841 (holotype, NY; isotype, HUA.

**Figure 10.**

The species is a member of section *Calomystrium* characterized by its terrestrial habit, persistent intact red-brown cataphylls, terete petioles, brown-drying ovate-cordate gradually long-acuminate blades with a narrowly parabolic sinus, 6 pairs of basal veins with 2 pairs of basal veins free to the base, a short posterior rib which is naked much of its length, collective veins arising from the first pair of basal veins as well as by its long-pedunculate, white lanceolate spathe and long-tapered white spadix.

The species perhaps more closely resembles *Anthurium modicum* Croat & Oberle which differs in having the collective veins arising from the lower pairs of basal veins, sparser, short pale-lineations and a more conspicuous and densely dark-speckled upper surface and a dark-punctate lower surface.

In the Lucid Anthurium Key the species tracks to *Anthurium nymphaeifolium* K. Koch & C. D. Bouché which differs in having much thicker and longer petioles, a wider spathe, and conspicuously dark-dotted leaves on the lower surface; *A. sanctifidense* Croat, differing in having blades which typically dry matte on the lower surface with collective veins usually much closer to the margin and with the upper surface much

more pale-lineate and *A. subcaudatum* Engl. differing in having a more V-shaped sinus and a cylindroid spadix.

Terrestrial; **internodes** short, drying ca. 2.5 cm diam.; **cataphylls** 6.5 cm long, persisting intact, drying light red-tan-brown. LEAVES 76.9 cm long with **petioles** 40.6 cm long, drying 4–5 mm diam., terete, moderately sulcate, drying light to medium brown, matte and finely ridged; **geniculum** 3.2 cm long, drying brown-black, deeply sulcate; **blades** broadly ovate-cordate-sagittate, 36.3 cm long, 25.3 cm wide, widest ca. 1.5 cm above petiolar plexus, 1.4 times longer than wide, 0.89 times as long as petiole, moderately coriaceous, gradually long-acuminate (2.7 cm long), drying medium brown, matte, light green, drying light brown and semiglossy above; **upper surface** moderately very short-pale-lineate, minutely granular-ridged upon magnification; **lower surface** moderately to densely pale granular; **anterior lobe** 27.7 cm long, concave; **posterior lobes** 11–12 cm long, 9–10.9 cm wide, oriented downward and weakly inward, somewhat inequilateral; **sinus weakly** spathulate to parabolic, 8.2 cm long, 3.6 cm wide; **midrib** weakly rounded, drying slightly darker above, more prominent and darker below; **primary lateral veins** ca. 5 pairs, arising at a 39–46° angle, narrowly rounded, almost indistinguishable from interprimary veins above, darker than surface below; **tertiary veins** drying concolorous with surface, scarcely raised below; **collective veins** arising from 1<sup>st</sup> pair of basal veins, 4–8 mm from margin; **basal veins** 5(6) pairs, 1<sup>st</sup>



**Figure 10.** *Anthurium dabeibaense* Croat (Callejas 5841). Herbarium type specimen showing leaf blade abaxial surface with apex of adaxial surface folded back with inflorescence.

through 3<sup>rd</sup> pairs free to base, 4<sup>th</sup> & 5<sup>th</sup> pairs coalesced 7–10 mm; **posterior ribs** short, 1.2 cm long, weakly curved, naked to 5 mm. INFLORESCENCES with **peduncle** 32.1 cm long, drying 3 mm diam., drying moderately ribbed, deeply sulcate near base, dark brown, matte; **spathe** lanceolate, 11.7 cm long, to 2.3 cm wide below middle, spreading, white, drying dark brown, short-pale-lineate, moderately pale-granular; **spadix** long-tapered, stipitate 3 mm, 12.2 cm long and 6 mm wide at base and midway, 3 mm diam. near apex, white, drying dark brown, matte; **flowers** 7–8 visible per spiral, 2.2–2.6 mm long, 1.8–2.2 mm wide; tepals brown with sparse granules, lateral tepals 0.7–1.2 mm wide, inner margin weakly rounded, outer margin 2–3-sided to obtusely 4-sided; **stamens** held at the level of the tepals, 0.4 mm long and 0.6 mm wide, thecae divaricate. INFRUCTESCENCE not present.

*Anthurium dabeibaense* is endemic to Colombia, known only from the type locality in the Department of Antioquia, Municipio Frontino at 960–1200 m in a *Tropical moist forest* transition to *Premontane rain forest* life zone.

The species is named for the type locality along the road to Dabeiba in Antioquia Department.

***Anthurium elquincense* Croat, sp. nov.**

Type: COLOMBIA. Antioquia: Municipio Urrao, Vía Páramo de Frontino, El Quince, 22 Sep 1994,

2740 m, *E. Rentarúa et al.* 10591 (holotype, HUA-093644). **Figure 11.**

The species is a member of section *Tetraspermium* characterized by its terrestrial habit, elongated internodes which dry dark brown matte, densely pale-granular to short pale-lineate, cataphylls persisting semi-intact at the upper nodes, long-petiolate leaves, brown-drying, sharply sulcate reddish petioles, narrowly ovate-elliptic, brown-drying, short-cuspidate-acuminate leaf blades which are acute to narrowly rounded at base, reddish lower surfaces with a single pair of collective veins 4–6 mm from the margins and with a well-developed antimarginal vein as well as by long-pedunculate inflorescences with a red peduncle, a reddish erect-spreading spathe and a short narrowly cylindroid red spadix.

In the Lucid Anthurium Key the species tracks to *Anthurium licium* Croat & Oberle and *A. tonduzii* Engl., both of which differ in having broadly ovate blades; *A. subequans* Croat & Oberle, differing in having shorter, more ovate, more prominently acuminate blades which are glandular-punctate on the lower surface as well as a green spadix which turns dark purple; *A. caucanum* Engl., by its larger leaves (width of 6–20 cm), and

*A. cocornaense* Croat, differing by having much longer, proportionally more slender stems, proportionately more ovate, more prominently acuminate blades and a stipitate spadix.



**Figure 11.** *Anthurium elquincense* Croat (Rentería 10591). Herbarium type specimen showing on left leaf blade abaxial surface folded longitudinally covering leaf blade adaxial surface, two more leaf blades adaxial surface, inflorescence and cataphylls.

Terrestrial; **stems** elongated, moderately to densely pale lineate-pustular especially toward apex; **internodes** longer than broad, 1–2.7 cm long, 4 mm diam.; **cataphylls** 2.6–6.0 cm long, persisting intact, becoming weakly fibrous towards base in age, often prolonged into needlelike point, densely pale-granular. **LEAVES** more or less erect, 21.3–24 cm long; **petioles** C-shaped, 6.9–9.4 cm long, 1–2 mm diam., red, drying 1–2 mm diam., brown to tan-brown, broadly and sharply sulcate adaxially with obscure medial ridge towards base and sheath 3.4–3.6 cm long, sparsely glandular-punctate; **geniculum** difficult to discern; **blades** narrowly oblong-elliptic to narrowly ovate-elliptic, 14.4–15.8 cm long, 3.5–3.8 cm wide, 3.8–4.1 times longer than broad, 1.6–2.1 times longer than petiole, narrowly acute and sometimes downturned with a short, terete blackened apiculum ca. 1 mm long, acute to narrowly rounded and sometimes weakly inequilateral at base, drying brownish and weakly bicolorous, sub-coriaceous; **upper surface** drying matte, brown-gray, moderately glandular-punctate, obscurely short-pale-lineate, minutely dark-speckled upon magnification; **lower surface** reddish when fresh, drying tan-gray, semiglossy, sparsely glandular-punctate, moderate short-pale-lineate; **midrib** red when fresh, drying concolorous above, narrowly raised darker and narrowly rounded, drying with an acute medial rib; **primary lateral veins** 8–11 pairs, arising at a 55–60° angle, weakly raised and concolorous on both surfaces, scarcely more distinguishable than interprimary veins; **collective veins** 1 pair, arising from the lower primary lateral veins

ca. 6 mm from the base, 2–6 mm from the margin, more prominent than primary lateral veins; **antimarginal veins** present. **INFLORESCENCE** erect; **peduncle** 9.5–11.2 cm long, drying 1 mm diam., drying matte, dark reddish brown, deeply and finely ribbed, moderately pale-granular; **spathe** 2.4–2.8 cm long, 6–7 mm wide, narrowly lanceolate, erect-spreading, acute-acuminate at apex, red, drying red-brown, matte, prominently veined, densely granular adaxially; **spadix** stipitate, with stipe 2 mm long, 3.9 cm long, 3 mm diam., narrowly cylindroid, red, drying red-brown, gradually paler towards apex; **flowers** 4 visible per spiral, 1.8–2.1 mm long, 1.6–1.9 mm wide; lateral tepals 0.5–0.9 mm wide; inner margins broadly rounded to straight; outer margins 2-sided to broadly rounded; **stamens** held at level of tepals, contiguous; anthers 0.4 mm long, 0.6 mm wide; thecae ovate, slightly divaricate.

*Anthurium elquicense* is endemic to Colombia, known only from the type locality in Antioquia Department in the Páramo de Frontino at 2740 m in a *Montane rain forest* life zone.

The species is named for the type locality at El Quince in the Páramo de Frontino.

***Anthurium espiranzaense*** Croat & A. Zuluaga, **sp. nov.** Type: COLOMBIA. Antioquia: Municipio Frontino, Parque Nacional Natural de Las Orquídeas, Sector de Venados, Vereda Venados Abajo, sitio La

Esperanza, cuenca de la Quebrada Arenales, 06°32'6.8"N, 76°18'46.3"W, 880–920 m, 29 July 2011, *A. Zuluaga, P. Pedraza, J. Betancur, M. F. González, R. Arevalo, D. Sanin, J. Serna & A. Duque* 825 (holotype, MO-6353132; isotype, COL). **Figures 12, 13.**

The species is provisionally classified as a member of section *Decurrentia*, but is likely an undescribed new section characterized by its terrestrial habits, slender internodes, cataphylls deciduous when intact with only a few fibers persisting, subterete petioles, semiglossy bicolorous, gradually acuminate elliptic-ob lanceolate blades with the primary lateral veins scarcely more conspicuous than the interprimary veins, collective veins one pair arising from the base with both surfaces conspicuously granular upon magnification as well as by the erect long-pedunculate inflorescence with the peduncle several narrow-ribbed, spathe lanceolate green and spreading and spadix green becoming glaucous with the tepal becoming violet-purple in fruit with berries violet-purple.

In the *Lucid Anthurium Key* the species tracks to *Anthurium anchicayense* Croat, distinguished by its more coriaceous, more elliptic blades with more broadly spreading primary lateral veins, collective veins arising from one of the lower primary lateral veins and by the red berries and *A. guayaquilense* Engl., from a much lower elevation along the Gulf of Guayaquil in Ecuador distinguished by its longer yellowish spadix and white berries.

Terrestrial or hemiepiphytic (sometimes epiphyte with vine); **stem** terete; **internodes** short or 1–2 cm long, drying 0.7–10 cm diam. ; **cataphylls** 9.8–12.0 cm long, deciduous but with a few pale fibers persisting at base, intact at upper nodes, abruptly acuminate at apex (acumen 2 mm long), medium brown to translucent brown, matte, finely ribbed longitudinally, sparsely short-pale-lineate, moderately dark-pustular. LEAVES 24–39 cm long, averaging 36.7; **petioles** 8.4–11.7 cm long (averaging 10.3 cm), drying 3 mm diam., semi-terete, drying bilaterally flattened, dark brown, matte, sparsely short-pale-lineate, moderately dark granular; **geniculum** 0.9–1.3 cm long, drying 3 mm diam., faintly darker brown than petiole, deep ribbing, more densely granular than petiole, moderately short-pale-lineate; **blades** elliptic-ob lanceolate, 25.9–27.2 cm long, 7.9–9.6 cm wide (averaging 26.4 cm x 8.9 cm), 2.8–3.3 times longer than broad, 2.3–3.1 times longer than petiole, broadest above middle, gradually acuminate, 0.6–1.4 cm long, 0.5 cm wide midway, narrowly attenuated base, weakly inequilateral, green, bicolorous, new blades densely short-pale-lineate on both surfaces, conspicuously granular throughout; **upper surface** semiglossy, drying dark brown, semiglossy, densely granular, sparsely short-pale-lineate; **lower surface** semiglossy, drying medium brown to tan-brown, semiglossy, sparsely and irregularly granular (granules translucent reddish brown); **midrib** raised, triangular towards the apex, rounded at the base on upper surface, narrowly rounded on lower surface, drying very fine and weakly, narrowly raised on



Figure 12. *Anthurium espiranzaense* Croat & A. Zuluaga (Cogollo 3918). Herbarium specimen showing on left leaf blade adaxial surface with inflorescence, also showing broken portion of leaf blade abaxial surface.



Figure 13. *Anthurium espiranzaense* Croat & A. Zuluaga (Zuluaga 825). Herbarium type specimen showing on left broken portion of leaf blade, also showing on right leaf blade adaxial surface with inflorescence.

upper surface, concolorous, drying moderately ribbed, granular and short-pale-lineate near base on lower surface, darker than surface, (3–4), sparsely short-pale-lineate; **primary lateral veins** 14–16 pairs, departing midrib at a 38–45° angle, drying concolorous on both surfaces, drying faintly raised above, densely granular, weakly raised, narrowly rounded below; **interprimary veins** only slightly less prominent than primary lateral veins on both surfaces; **collective veins** arising from base, 4–8 mm from margin, narrowly raised, only faintly more prominent visibly than primary lateral veins, weakly rounded above, rounded to round-raised below. INFLORESCENCE with **peduncle** 22.6–30 cm long (averaging 27.1), drying 1–2 mm diam., drying medium brown, matte, terete, moderately sulcate with several slender ribs, moderately short-pale-lineate; **spathe** lanceolate, spreading, 4.3–6.5 cm long, 0.5–1.4 cm wide, green, with reddish veins adaxially, drying medium brown, with narrow ribs, densely granular adaxially, short-pale-lineate and granular abaxially; **spadix** 6.5–7.8 cm long, 2–5 mm diam., slightly tapered toward apex, green at anthesis, becoming glaucous, drying black-brown, stipitate (stipe 2 mm long, 3 mm diam.); **flowers** 3–5(7) visible per spiral, to 1.5–2.0 mm long, 1.2–1.4 mm wide; **tepals** becoming purple on infructescence, glossy black, sparsely white-granular, lateral tepals 0.9–1.3 mm wide, inner margins broadly rounded to weakly concave, outer margin 2-sided to broadly rounded; **stamens** withdrawn below the level of the tepals after anthesis; anthers 0.5 mm long, 0.5 mm

wide, thecae broadly ovate, moderately divaricate. INFRUCTESCENCE with berries violet-purple with a yellow base, yellow flowering, sparse arils with two yellowish seeds.

*Anthurium espiranzaense* is endemic to Colombia, known only from the type locality in Antioquia Department, Municipio Frontino at 880–920 m in a *Tropical wet forest* life zone.

*Anthurium espiranzaense* is named for the type locality in Sitio La Esperanza in Vereda Venados Abajo in the Parque Nacional Natural de La Orquídeas.

*Paratypes:* COLOMBIA. **Antioquia:** Municipio Frontino. Parque Nacional Natural de Las Orquídeas, Sector de Venados arriba, margen izquierda del Río Venados, 06°34'N, 76°19'W, 1060–1090 m, 24 July 1988, *A. Cogollo, J. G. Ramírez & O. Álvarez* 3460 (MO, JAUM); 12 Feb 1989, *A. Cogollo et al.* 3918 (MO).

***Anthurium frontinoense*** Croat & A. Zuluaga, **sp. nov.** Type: COLOMBIA. Antioquia: Municipio Frontino, Parque Nacional Natural de Las Orquídeas, Vereda Venados Abajo, Finca de Gabriel Montoya, along Río Venados, 06°32'23.5"N, 76°19'9.7"W, 860–910 m, 23 July 2011, *A. Zuluaga, P. Pedraza, J. Betancur, M. F. González, R. Arevalo, D. Sanin, J. Serna & A. Duque* 775

(holotype, MO-6353139; isotype, COL). **Figure 14.**

The species is a member of section *Xialophyllum* characterized by its terrestrial habit, elongated internodes, deciduous cataphylls, subterete weakly sulcate petioles, bicolorous, brown-drying ovate-elliptic-sagittate blades with a spatulate sinus, narrow posterior lobes, 5 pairs of basal veins, the 1<sup>st</sup> and sometimes the 2<sup>nd</sup> pairs free to the base, as well as by the slender, moderately long pedunculate inflorescence with a short green spadix and a slender, scarcely tapered green spadix.

In the Lucid Anthurium Key the species tracks to *Anthurium riocuevense* Croat which differs in having a parabolic sinus and with most of the basal veins free to the base; *A. leptocaulis* Croat differing in having a parabolic sinus and a greenish white to purple spadix; *A. pauciflorum* Croat, differing in having a parabolic sinus and a yellow spadix and *A. hutchisonii* Croat, differing in having the posterior lobes somewhat spreading and with the blades broadest across the base.

Terrestrial and subscandent; **internodes** drying light, grayish tan, matte, to 14.2 cm long, 0.4 cm diam.; **cataphylls** deciduous, not seen. LEAVES 20.6–21.8 cm long; **petioles** subterete, 18.2–18.6 cm long, 2 mm diam., weakly sulcate, drying moderately sulcate, red-brown, gradually darkening towards petiolar plexus; **geniculum** 0.7 cm long; **blades** ovate-

sagittate, 20.6–21.8 cm long, 13.4–14.8 cm wide, 1.5 times longer than wide, 1.1–1.2 times longer than petioles, abruptly acuminate at apex, prominently lobed at base, dark green, matte-subvelvety above, paler and weakly glossy below, drying dark brown above, yellow-brown below; **lower surface** drying weakly granular; **posterior lobes** 5.5–6.1 cm long, 3.8–4.5 cm wide, moderately unequal in size and shape, directed toward the base; **sinus** spatulate, 5.4 cm deep, 1.9 cm wide; **midrib** drying narrowly raised, concolorous above, rounded below, drying narrowly rounded, darker than surface; **primary lateral veins** 4–6 pairs, arising from the midrib at a 40–50° angle, flattened, concolorous, inconspicuous above, finely raised, drying darker than surface below, curving upward near margin; **basal veins** 5 pairs, 1<sup>st</sup>, sometimes 2<sup>nd</sup> pairs free to base; **collective veins** arising from 2<sup>nd</sup> pair of basal veins, loop-connecting to the primary lateral veins 3–5 mm from the margin. INFLORESCENCE 17 cm long; **peduncles** 12.4 cm long, 1 mm diam., green; **spathe** green, drying minutely granular, densely short-pale-lineate, narrowly lanceolate in shape, 6.2 mm long, 9.5 mm wide; **spadix** green, narrowly cylindroid, drying 4.7 cm long, 3.5 mm diam., drying brown-gray; **flowers** 4(5) per spiral, averaging 1.9 mm long, 2.2 mm wide, densely granular; lateral **tepals** 1.0–1.1 mm wide, inner margins broadly rounded, outer margins 2-sided to obtusely 3-sided, **stamens** held at level of tepals and covering style, 0.3 mm long, 0.6 mm wide;



**Figure 14.** *Anthurium frontinoense* Croat & A. Zuluaga (Zuluaga 775). Herbarium type specimen showing on left leaf blade adaxial surface with apex portion of abaxial surface folded down, also showing on right leaf blade adaxial surface with apex portion of abaxial folded back with inflorescences.

thecae divaricate. INFRUCTESCENCE with fruits green.

*Anthurium frontinoense* is endemic to Colombia, known only from the type locality in Antioquia Department, Municipio Frontino at 860–910 m in a *Premontane rain forest* life zone.

The species is named for the type locality in the Municipio Frontino in Antioquia Department.

***Anthurium hempeanum* Croat, sp. nov.**

Type: COLOMBIA. Antioquia: Municipio Frontino, Corregimiento Nutibara, cuenca alta del Río Cuevas, 06°51'N, 76°14'W, ca. 1000 m, 13 Apr 1987, D. Sánchez, C. Orrego, S. Sylva, G. Martínez, D. Restrepo, F. Roldan & J. Betancur 1124 (holotype, MEDEL). **Figures 15–18.**

The species is a member of section *Cardiolonchium* characterized by its terrestrial habit, large size, massive yellow-brown-drying cataphylls which remain intact except for the coarsely pale fibrous basal portion, the elongated petiole (to 1 m long) which dries deeply sulcate, narrowly ovate-sagittate, yellow-brown-drying blades with 9 pairs of basal veins, 2–3 pairs of which are free to the base, a well-developed, weakly curved posterior rib which is naked most of its length, the uppermost basal veins prominently branching, collective veins arising from 5<sup>th</sup> pair of basal veins and 2–4 mm from the margins as well as by the

green spathe, yellowish white long-tapered prominently elongated spadix and berries with a white base and red apex.

In the Lucid Anthurium Key the species tracks to *Anthurium angelopolisense* Croat, differing in having leaf blades drying grayish and epunctate above, yellowish gray-green below with the tertiary veins much less conspicuous; *A. argyrostachyum* Sodiro which differs in having a prominently constricted anterior lobe and a bluish green glaucous spadix; *A. chrysolithos* Croat & Oberle, differing in having much smaller blades (to 32 cm x 23 cm) with the collective veins usually arising from the 1<sup>st</sup> pair of basal veins and an inflorescence to only 6 cm long with berries solid red; *A. ramosense* Croat, differing in having the cataphylls deciduous more or less intact with only a few fibers at the base persisting, blades with more broadly rounded posterior lobes and the collective veins more distant from the margins (5–10 mm) and *A. silverstonei* Croat & Oberle differing in drying grayish green, having less prominent tertiary veins, and having denser dark punctations on the lower surface .

Terrestrial to 4 m; **internodes** short; **stem** drying to 3.5 cm diam.; **cataphylls** semi-intact, becoming coarsely pale fibrous at base, marcescent. LEAVES 1.01–1.11 m long with **petioles** terete, to at least 1 m, drying 1.7 mm diam., grayish tan, obtusely sulcate, drying sulcate on geniculum, densely pale granular; **blades** ovate-cordate-sagittate, to 100–111 cm long, 44–47 cm wide, 1.90–1.95 times longer than broad,



Figure 15. *Anthurium hempeanum* Croat (Sanchez 1124). Herbarium type specimen showing folded leaf blade with the adaxial surface on the outside.



Figure 16. *Anthurium hempeanum* Croat (Sanchez 1124). Herbarium type specimen showing peduncle and infructescence.



**Figure 17.** *Anthurium hempeanum* Croat (Sanchez 1124). Herbarium type specimen showing folded leaf blade with the adaxial surface of the posterior lobe on the outside.



**Figure 18.** *Anthurium hempeanum* Croat (*Sanchez 1124*). Herbarium type specimen showing cataphylls forming a netlike reticulum.

0.84–0.92 times as long as petioles, subcoriaceous, drying concolorous; **upper surface** matte, drying yellowish to greenish brown, smooth, sparsely dotted with dark yellow-brown glands, at higher magnification densely granular; **lower surface** drying semiglossy, yellowish brown, diffuse dark punctations, less conspicuously granular; **anterior lobe** 84–92 cm long, 44.3–47.2 cm wide, with margins weakly concave, broadest below middle; **posterior lobes** 28 cm long, 16.7 cm wide, directed downward to turned somewhat outwards; **sinus** broadly arcuate, 16.5–19.5 cm deep, 17 cm wide; **midrib** prominent, rounded on and concolorous to slightly paler than both surfaces, with granules along margins; **primary lateral veins** 22–24 pairs, arising at a 44–52° angle, weakly elevated on upper surface, flatly acute and concolorous, more prominent, acute on lower surface, concolorous, minutely granular along veins; **basal veins** 9 pairs, 1<sup>st</sup> pair free to base, 2<sup>nd</sup> pair coalesced to 1.5 cm, 3<sup>rd</sup> pair coalesced to 3.3 cm, 5<sup>th</sup> and 6<sup>th</sup> to 11 cm; **posterior ribs** nearly straight, 11 cm long, naked to 8 cm; **tertiary veins** prominulous, acute, less conspicuous on lower surface; **collective veins** arising from lowermost basal veins (6<sup>th</sup>–7<sup>th</sup> pairs), running 1–4 mm from margin. **INFLORESCENCE** with **peduncle** to at least 36.2 cm long, drying 0.9–1.3 cm diam., drying brown-tan, drying moderately ribbed; **spathe** green, reflexed, drying light reddish tan; **spadix** sessile, 54.8 cm long, 1.6 cm diam., 9 mm diam. at apex, whitish yellow, drying light to medium brown, tapered gently toward apex, post-anthesis; **flowers** 12–15 visible per spiral,

2.3 mm long, 1.5–1.8 mm wide; **tepals** sparsely pale granular; lateral tepals 1.3–1.4 mm wide, inner margin rounded, turned up against pistil, outer margin bluntly 2- to 3-sided; **stamens** dried, held at level of tepals, not contiguous, anthers 6 mm long, 4 mm wide, thecae oblong, parallel; **style** drying blackened, pistils emerging above tepals. **INFRUCTESCENCE** with white and purple berries.

*Anthurium hempeanum* is endemic to Colombia, known only from the type locality in Antioquia Department in the Municipio Fontino at 1000 m elevation in a *Premontane rain forest* life zone.

The species is named in honor of Volunteer Research Assistant, Mackenzie Hempe who spent the summer of 2012 working with the Araceae of the Parque Nacional Natural de Las Orquídeas in Antioquia. Mackenzie, a graduate of Lindbergh High School in St. Louis, entered Wellesley College in the fall of 2012. She is one of the most competent plant describers that I have had working with me and was able to observe and interpret even the most obscure detail of specimens.

*Anthurium juanguillermoi* Croat, **sp. nov.**

Type: COLOMBIA. Antioquia: Parque Nacional Natural de Las Orquídeas, Sector Calles, margin derecha del Río Calles, 06°31'N, 76°19'W, 1420 m, 25 Mar 1988, *A. Cogollo, J. G. Ramírez & O. Álvarez*

2571 (holotype, MO-4241470; isotype, HUA). **Figures 19, 20.**

The species is a member of section *Porphyrochitonium* characterized by its short internodes, persistent reddish brown cataphylls with frequent fragments of epidermis, long-petiolate dark-drying leaves with subterete petioles, elongated oblong-lanceolate gradually acuminate blades with the base usually acute to narrowly rounded at base with a single pair of collective veins arising from the base and 3–7 mm from the margin with the upper surface eglandular and the lower surface dark glandular-punctate as well as by the long-pedunculate inflorescence with a narrow green spreading spathe and a reddish or yellow spadix with red berries.

In the Lucid Anthurium Key the species tracks to *Anthurium deflexum* Engl. differing in having the leaves pendent from more or less erect petioles and a long-pedunculate inflorescence which much overtops the leaves. The species also resembles *Anthurium punctatum* N.E. Br., which differs in having 13–16 primary lateral veins and blades oblong-elliptic, drying matte to weakly glossy, tan-gray.

One of the specimens, *Cogollo 2568* differs in having sparsely scattered short-pale-lineate on its upper surface and in that all of the veins are less prominently raised yet darker than the type specimen.

Epiphytic, sometimes terrestrial, known to range from 1.7 and 2.3 m high in trees; **internodes** short, drying 0.8–1.7 cm diam.; **cataphylls** 4.7–8.3 cm long (averaging 6.5 cm), persisting as reddish brown fibers. LEAVES 19.0–73.5 cm long; **petioles** terete, 4.9–23.4 cm long (averaging 16.5 cm), drying 3 mm diam. midway 6 mm at base and on geniculum, matte, red-brown, finely ribbed, sometimes with 1–2 deep grooves; **geniculum** 0.9–1.8 cm long, drying 2–6 mm diam., darker and thicker than petiole; **blades** oblong-lanceolate, 14.1–50.1 cm long, 2.4–7.5 cm wide, (averaging 31.6 x 5.0 cm), 4.7–7.8 times longer than broad (averaging 6.3), 1.3–2.9 times longer than petiole (averaging 2.0), broadest below middle, gradually acuminate at apex (acumen ca. 1–2 cm, sometimes downturned), acute to narrowly-rounded, sometimes weakly inequilateral at base, thinly coriaceous to subcoriaceous, drying subcoriaceous on both surfaces; **upper surface** drying dark brown, weakly glossy, weakly granular; **lower surface** drying medium brown, semiglossy, raised glandular-punctate; **midrib** prominent and concolorous above, rounded to narrowly rounded, finely ribbed, darker than surface below; **primary lateral veins** appearing to be too numerous to count above and scarcely more prominent than interprimary veins above, 16–20(25) pairs visible below, departing midrib at a 42–56° angle, drying concolorous on each surface, narrowly raised below; **collective veins** arising near base, 3–7 mm from margin, drying weakly rounded above, acutely raised below; **antimarginal** veins present, 0.4 mm from



**Figure 19.** *Anthurium juanguillermoi* Croat (Cogollo 2568). Herbarium specimen showing on left apex of leaf blade adaxial surface folded over leaf blade abaxial surface, on right apex of leaf blade abaxial surface folded over leaf blade adaxial surface and inflorescence.



**Figure 20.** *Anthurium juanguillermoi* Croat (Cogollo 2571). Herbarium type specimen showing on left inflorescence, petioles and cataphylls, showing on right leaf blade base adaxial surface and leaf blade abaxial surface folded over and leaf blade apex folded up.

margin, slightly more conspicuous below. INFLORESCENCE erect; **peduncle** 18.8–46.1 cm long (averaging 34.2), drying 1–5 mm diam., green, drying matte, medium red-brown, granular; **spathe** narrowly linear-lanceolate, erect-spreading, 4.2–13.6 cm long, 0.6–1.2 cm wide (averaging 7.2 cm x 8 mm), green with a red center, drying dark brown, glossy and short-pale-lineate adaxially, matte abaxially; **spadix** weakly stipitate (stipe 1 mm long, 3 mm wide), 4.2–16.6 cm long, 3–7 mm diam. (averaging 10.6 cm x 5 mm), cylindroid, drying dark brown; **flowers** 5–7 visible per spiral, 1.9–2.3 mm long by 0.9–1.4 mm wide; lateral **tepals** 0.8–1.3 mm wide; inner margins broadly rounded; outer margins 2-sided; **stamens** held at level of tepals, anthers 0.3 mm long, 0.5 mm wide, thecae broadly ovate, weakly divaricate. INFRUCTESCENCE with berries purple to red at maturity.

*Anthurium juanguillermoi* is endemic to Colombia, known only from the type locality in Antioquia at 1420 m in a *Premontane rain forest* life zone.

The species is named in honor of Colombian botanist, Juan Guillermo Ramírez A. from the Jardín Botánico Joaquín Antonio Uribe in Medellín, Colombia. Juan is an excellent plant collector and assisted in the collection of the type specimen.

*Paratypes:* COLOMBIA. **Antioquia:** Amalfi, vereda Arenas blancas, 06°55'00"N, 074°55'00"W, 1100–1250 m, Apr 1994, R.

*Fonnegra G. et al. 4776* (HUA); Urrao, Parque Nacional Natural de Las Orquídeas, Sector Calles, margen derecha del Río Calles, 06°32'N, 076°19'W, 1420 m, 25 Mar 1988, *A. Cogollo P. et al. 2568* (JAUM, MO); *A. Cogollo P. et al. 2571* (JAUM, MO); Camino de Venados arriba hacia Calles, 06°34'N, 76°19'W, 1440 m, 25 July 1988, *A. Cogollo P. et al. 3491* (JAUM, MO); Vereda Calles, Bosque Nacional Natural de Las Orquídeas, Quebrada Honda, Inventario Permanente de bosque húmedo premontano, en el filo al NW de la Cabaña Calles, 06°29'N, 76°14'W, 1330 m, 10 Dec 1992, *J. Pipoly, III 16939* (MO); Inventario Permanente Bosque Pluvial Premontano, margen derecha del Río Calles, *A. Duque, F. Giraldo, W. Rodríguez, E. Álvarez, 06°32'N, 76°19'W, 1450 m, 26 Nov 1993, J. Pipoly, III 17152* (JAUM, MO); Río Calles, 1400–1500 m, 2 May 1995, *R. Fonnegra G. et al. 5481* (HUA); *R. Fonnegra G. et al. 5483* (HUA).

***Anthurium ovidioi*** Croat, **sp. nov.** Type: COLOMBIA. Antioquia: Parque Nacional Natural de Las Orquídeas, Sector Venados, margen derecha de camino hacia Venados arriba, 06°33'N, 76°19'W, 900 m, 7 June 1988, *A. Cogollo, J. G. Ramírez & O. Álvarez 3358* (holotype, FMB).

**Figure 21.**

The species is provisionally placed in section *Decurrentia* characterized by its epiphytic habit, slender stem with short internodes, pale green-drying deciduous cataphylls, short slender subterete petioles drying with a narrow sulcus, narrowly



Figure 21. *Anthurium ovidioi* Croat (Cogollo 3358). Herbarium type specimen showing on left leaf blade adaxial surface and on right two leaf blades abaxial surface.

oblong-linear, green-drying, long-acuminate blades which are more or less acute at the base with the collective veins arising from the lower primary lateral veins and with both surfaces drying conspicuously dark-granular, as well as by the long slender pedunculate inflorescence, the moderately broad, green spathe and a long-stipitate slender green spadix with no more than 2 flowers visible per spiral.

*Anthurium ovidioi* is closest to collection *Forero 5935* which differs in having much longer cataphylls, much larger blades with proportionately longer petioles to more than 18 cm long and blades with the collective veins arising from the base.

Epiphyte to 2.20 m; **roots** 1–2 mm diam., dark brown, deeply ribbed, scaled, few per node; **stem** to 12.8 cm, slender; **internodes** 0.5–2.2 cm long, drying (0.2)0.3–0.4 cm diam., subcoriaceous, ridged and fissured; **cataphylls** to at least 2.6 cm long, matte, short-pale-lineate, finely ribbed. **LEAVES** scattered along stem near apex; **petioles** subterete, 2.6–2.9 cm long (averaging 2.8 cm), drying 2 mm diam., light gray-green, matte, with narrow sulcus; **geniculum** 4–6 mm long, drying 1 mm diam., fairly indistinguishable from petiole aside from a dense layer of pale granules and being faintly darker; **blades** narrowly oblong-elliptic, 19.3–21.3 cm long, 1.9–2.0 cm wide, 8.7–9.3 times longer than broad, 5.9–7.2 times longer than petiole, broadest slightly above middle, caudate-acuminate, 1.5–1.8 cm long, 0.2 cm wide midway, weakly cuneate or acute at base, dark green and

weakly glossy above, drying weakly glossy, yellowish green-brown above, slightly paler and yellow-green below; **upper surface** minutely black-speckled and densely granular; **lower surface** sparsely black-speckled and densely olive-brown, densely and minutely granular; **midrib** concolorous, prominently round-raised toward base, flattening towards apex on upper surface to rounded and sparsely granular, prominently round-raised below and darker than surface, drying longitudinally ridged; **primary lateral veins** 14–16 pairs, departing midrib at a 42–56° angle, drying slightly darker and weakly raised on upper surface, slightly raised and faintly lighter than lower surface; **collective veins** arising from lower primary veins, 1–3 mm from margin, more prominent than primary lateral veins, drying bluntly raised above, rounded below; **antimarginal veins** present, 0.3 mm from margin, barely visible above, bluntly rounded below. **INFLORESCENCE** green and erect; **peduncle** to 7.1 cm long, drying 6 mm diam., pale tannish green, matte, ridged longitudinally, with fine striations between; **spathe** ovate, 1.8 cm long, 6 mm wide, green, densely granular inside, short-pale-lineate mostly outside; **spadix** stipitate 6 mm, 2.3 cm long, 2.3 mm diam., cylindroid-tapered, drying black-brown; **flowers** 1–2 visible per spiral, 2.3 mm long and wide, tepals dark purplish and subglaucous, with sparse pale cellular inclusions, lateral tepals to 0.9 mm wide; inner margins narrowly rounded to obtusely 2-sided; outer margin broadly rounded or obtusely 3–4-sided; **stamens** not yet emergent, anthers yellow, 0.4 mm long, 0.7

mm wide, drying amber, thecae slightly divaricate. INFRUCTESCENCE with berries violet-purple at maturity.

*Anthurium ovidioi* is endemic to Colombia, known only from the type locality in Antioquia Department in the Parque Nacional Natural de Las Orquídeas at 900 m in *Premontane rain forest* or *Tropical wet forest* life zones.

The species is named in honor of Ovidio Alvarez who has worked for 28 years as a park ranger at Parque Nacional Natural de Las Orquídeas. Ovidio knows the park well due to his many years of dedication there, and he often serves as an assistant to botanists collecting at the park, as he did in the case of this expedition which collected the type specimen which bears his name.

***Anthurium pedrazae*** Croat & A. Zuluaga, **sp. nov.** Type: COLOMBIA. Antioquia: Municipio Urrao, Corregimiento La Encarnación, Vereda Calles Abajo, Parque Nacional Natural de Las Orquídeas, camino entre páramo El Almorzadero y poco antes de la cabañas de Calles, 06°32'20"N, 76°14'51" W, 1100–1300 m, 31 July 2011, A. Zuluaga, P. Pedraza, J. Betancur, M. F. González, R. Arévalo, D. Sanín, J. Serna & A. Duque 838 (holotype, MO-6353146; isotypes, COL, NY). **Figures 22, 23.**

The species is an unusual member of section *Calomystrium* characterized by its

elongated internodes which dry grayish and semiglossy, cataphylls persisting mostly intact, terete petioles which are longer than blades, narrowly ovate-sagittate brownish drying, narrowly acuminate blades with a spatulate sinus, 6 pairs of basal veins with two pairs free to the base and the collective veins arising from the lowermost pairs of basal veins as well as by the moderately long-pedunculate inflorescence, red ovate erect cucullate spathe and the briefly stipitate cylindroid spadix that is much shorter than the spathe.

In the Lucid Anthurium Key the species tracks to *Anthurium atramentarium* Croat & Oberle, differing in having a purplish spathe and greenish to yellowish spadix; *A. nymphaeifolium* and *A. yarumalense* Engl., differing by having short internodes, thicker blades with a broader sinus and a much longer tapered spadix.

Hemiepiphyte or terrestrial and subscandent; stems erect to sprawling; **internodes** brown-gray, to 14.9 cm long, drying 8–9 mm diam., drying brownish gray, moderately to deeply sulcate, semiglossy, sometimes with fine striations; **cataphylls** 10.8 cm persisting at upper nodes, intact with some fibers, finally deciduous, drying medium to dark reddish brown. LEAVES with **petioles** 20.0–37.5 cm long (averaging 30.6 cm), drying 0.5 cm diam. at base, 0.2 cm diam. at blade, terete, moderately sulcate, drying matte, light to medium red-brown, short-pale-lineate; **geniculum** 1.8–2.5 cm long, drying concolorous to slightly darker than petiole, fairly inconspicuous;



**Figure 22.** *Anthurium pedrazae* Croat & A. Zuluaga (Zuluaga 838). Herbarium type specimen showing on left leaf blade adaxial surface, showing on right leaf blade adaxial surface with inflorescence.



Figure 23. *Anthurium pedrazae* Croat & A. Zuluaga (Betancur 14935). Herbarium specimen showing on left leaf blade adaxial surface with inflorescence, showing on right leaf blade adaxial surface.

**blades** narrowly ovate-sagittate, 20.4–29.7 cm long, 9.8–13.7 cm wide (averaging 25.2 cm by 11.7 cm), widest from 0.4–2.8 cm above petiolar plexus, 1.6–2.6 times longer than wide, 0.54–1.2 times as long as petiole, discolorous, glossy above and glossy grayish green below, drying mid to light brown above and light brown below, semiglossy above and glossy below, acuminate and downturned at apex (acumen 1.8–2.1 cm long); **upper surface** densely short-pale-lineate, sparsely granular; **lower surface** moderately to densely pale granular; **anterior lobe** 18.6–23.9 cm long (averaging 20.7 cm); **posterior lobes** 6.2–7.3 cm long, 4.4–5.6 cm wide (averaging 6.5 cm by 4.9 cm), oriented down and weakly inward; **sinus** spatulate to weakly parabolic, 4.9–6.5 cm long, 1.8–2.4 cm wide (averaging 5.6 cm by 2.1 cm); **midrib** elevated and narrowly rounded, drying round-raised and concolorous to slightly darker with medial rib (almost winged near the base) above, drying prominently elevated, darker and thicker below with multicolored granules; **primary lateral veins** elevated and acute, 8–12 pairs, arising at a 44–60° angle, drying roundly elevated, slightly darker above, moderately darker below; **tertiary veins** drying concolorous and narrowly rounded above, drying narrowly raised and slightly darker below; **collective veins** arising prominently from 1<sup>st</sup> pair basal veins, loop-connected to 2<sup>nd</sup>, 3<sup>rd</sup> (4<sup>th</sup>) pairs basal veins, 2–5 mm from margin; **antimarginal vein** lacking; **basal veins** 5–6 pairs, 1<sup>st</sup> and 2<sup>nd</sup> pairs free to base, 3<sup>rd</sup> pair coalesced to 9 mm, 4<sup>th</sup> pair coalesced 7 mm; **posterior rib** short, only weakly curved, 1.1–1.5 cm long,

naked to 6–8 mm. INFLORESCENCES erect; **peduncle** green to garnet, 6.5–14.8 cm long, drying 2 mm diam., drying obtusely sulcate abaxially, more sharply sulcate adaxially, medium red-brown and matte; **spathe** 5.2–8.1 cm long, to 4.4 cm wide above center, spreading, garnet-red, drying dark red-brown, short-pale-lineate outside, densely granular within; **spadix** white, stipitate 2 mm, 2.0–4.1 cm long and 6–7 mm wide midway, cylindroid, drying red-brown; **flowers** 6–8 visible per spiral, 1.4–1.8 mm long, 1.8–2.4 mm wide, tepals brown, sometimes shield-shaped, lateral tepals 0.6–0.9 mm wide; inner margin broadly rounded; outer margin 2-sided or more commonly 3-sided, sometimes 4-sided; **stamens** held at the level of the tepals, 0.3–0.4 mm long and 0.5–0.7 mm wide, thecae parallel. INFRUCTESCENCE not present.

*Anthurium pedrazae* is endemic to Colombia, known only from the type locality in Antioquia Department, Municipio Urrao in the Parque Nacional Natural de Las Orquídeas at 1100–1850 m in a *Premontane wet forest* life zone.

The species is named in honor of Colombian botanist, Paola Pedraza who assisted in collecting the type specimen. Paola is a graduate of City University, New York and is now conducting research as the Assistant Curator for the Institute of Systematic Botany at the New York Botanical Garden. Paola is a specialist on the family Ericaceae.

*Paratype:* COLOMBIA. **Antioquia:** Municipio Urrao, Corregimiento La Encarnación, Vereda Calles, Parque Nacional Natural de Las Orquídeas, camino Calles-La Encarnación, después de la confluencia de Río Polo y el Río Calle y antes del Río San Pedro, Sitio La Quiebra, 06°30'31"N, 76°14'W, 1600–1850 m, 31 Jan–2 Feb 2011, J. Betancur, P. Pedraza-Peñalosa, M. F. González, G. Giraldo, F. Gómez, A. Duque & J. Serna 14935 (COL, MO).

***Anthurium poloense* Croat, sp. nov.** Type: COLOMBIA. Antioquia: Municipio Urrao, Corregimiento La Encarnación, Vereda Calles, Parque Nacional Natural de Las Orquídeas, camino Calles-La Encarnación, después de la confluencia del Río Polo y el Río Calle y antes del Río San Pedro, Sitio La Quiebra, 06°30'31"N, 76°14'W, 1600–1850 m, 31 Jan–2 Feb 2011, J. Betancur, P. Pedraza-Peñalosa, M. F. González, G. Giraldo, F. Gómez, A. Duque & J. Serna 14843 (holotype, NY-01395310; isotype, COL). **Figure 24.**

The species is a member of section *Calomystrium* characterized by its terrestrial habit about as long as broad or slightly longer than broad, persistent intact cataphylls, subterete petioles, ovate-sagittate brown-drying acuminate blades with a parabolic sinus, anterior lobe with margin straight or weakly concave, 5–6 pairs of basal veins, 1(2) basal veins free, the base and collective veins arising from the 4<sup>th</sup> pair

of basal veins and 1–2 mm from the margin, long-pedunculate inflorescence, green lanceolate-elliptic spreading spathe and narrowly long-cylindroid stipitate green spadix. Also characteristic is the sparsely glandular-punctate and sparsely short-pale-lineate upper blade surfaces and the densely glandular-punctate lower surfaces.

*Anthurium poloense* is similar to *A. obtusilobum* Schott but that species differs in having thicker blades that dry more gray-brown above and have more prominent short pale lineations, have a spadix cream-colored and are more thickly cylindroid.

In the Lucid Anthurium Key the species tracks to *Anthurium hoffmannii* Schott which differs in having the collective veins arising from the 1<sup>st</sup> pair of basal veins; *A. johnmackii* Croat & Oberle, differing in having a more narrowly triangular blade with narrower, more elongate somewhat spreading posterior lobes and *A. modicum*, differing in having blades drying more pale yellow-brown with the upper surface densely and minutely dark-speckled above but lacking dark glandular punctations.

Terrestrial; **stem** drying 9 mm diam., dark brown with reddish tinge; **internodes** short; **cataphylls** 5.1–13.6 cm long, persisting intact, drying medium to light brown, short-pale-lineate, sparsely black-punctate. **LEAVES** 65.8–71.4 cm long with **petioles** 40.1–43.2 cm long, drying 2–4 mm diam., matte, medium brown, densely pale-granular, sparsely black-punctate;



**Figure 24.** *Anthurium poloense* Croat (Betancur 14843). Herbarium type specimen showing on left leaf blade abaxial surface covered by leaf blade adaxial surface with inflorescence.

**geniculum** ca. 5 mm long, slightly thicker than petiole, concolorous with petiole and midrib, sparsely black-punctate; **blades** ovate-sagittate-cordate, 25.2–28.7 cm long, 20.1–20.9 cm wide, 1.28–1.35 times as long as broad, 0.6 times as long as petiole, gradual acuminate at apex, subcoriaceous; **upper surface** drying dark brownish gray, matte, coriaceous, very sparsely short-pale-lineate, moderately pale-granular, sparsely dark-punctate; **lower surface** drying medium brown, semiglossy, densely dark-punctate; **anterior lobe** 19.4–20.3 cm long, weakly concave upper margins, lobe broadest 2.5 cm above petiolar plexus; **posterior lobes** 9.7–10.3 cm long, 7.4–7.8 cm wide, directed downward; **sinus** broadly parabolic, 7.3–7.5 cm deep by 5.1–5.4 cm wide; **midrib** weakly raised on upper surface, acute and concolorous to upper surface, more prominent below, rounded and darker than lower surface; **primary lateral veins** 8–10 pairs, arising from the midrib at a 48–62° angle, narrowly rounded above and concolorous to upper surface, narrowly rounded below and darker than lower surface; **basal veins** 5(6) pairs, 1<sup>st</sup> and 2<sup>nd</sup> pairs free to base, 3<sup>rd</sup> pair coalesced to 1.8–1.9 cm, 4<sup>th</sup> and 5<sup>th</sup> pairs coalesced to 3.1–3.3 cm, 6<sup>th</sup> pair coalesced to 2.5–2.7; **posterior rib** 3.1–3.6 cm long, naked to 2.4–2.8 cm, weakly curved; **collective veins** arising from 5<sup>th</sup> basal vein, persisting 1–2 mm from margin, concolorous to and level with upper surface, darker than and narrowly rounded on lower surface. INFLORESCENCE with **peduncle** green, drying light to medium brown, to 2 mm diam., matte; **spathe** to 5.8 cm long, drying

to 1.4 cm wide, lanceolate-elliptic, green, drying reddish brown, densely pale granular; **spadix** to 7.3 cm long, 4 mm diam., cylindroid with minimal tapering at base, stipitate, green, drying dark brown; **stipe** 1.2 cm long, 2 mm diam.; **flowers** 7–8 visible per spiral, 1.6–1.9 mm long, 1.9–2.1 mm wide; **tepals** 1.8–2.0 mm wide, inner margins broadly rounded to straight, outer margins 2-sided, with edges concave, drying medium to dark brown, densely granular; **stamens** not fully emergent, anthers 0.7 mm long by 0.7 mm wide, thecae weakly divaricate.

*Anthurium poloense* is endemic to Colombia, known only from the type locality in the Municipio Urrao at 1600–1850 m in a *Premontane rain forest* life zone.

The species is named for the type locality near the Río Polo in the Municipio Urrao.

***Anthurium sneidernii* Croat, sp. nov.**

Type: COLOMBIA. Antioquia: Urrao Municipio, Parque Nacional Natural de Las Orquídeas, Vereda Calles, margen derecha del Río Calles, 06°32'N, 76°19'W, 1350 m, *J. Pipoly, III, W. Rodríguez & O. Álvarez 18020* (holotype, MO-4603571; isotype, COL). **Figure 25.**

The species is a member of section *Porphyrochitonium* characterized by its abundance in the understory, terrestrial habit, short slender internodes, persistent red-brown cataphyll fibers, moderately



**Figure 25.** *Anthurium sneidernii* Croat (Pipoly 18020). Herbarium type specimen showing leaf blades adaxial surface with inflorescence and cataphylls.

elongated C-shaped petioles which dry deeply and narrowly sulcate, narrowly lanceolate-elliptic narrowly acuminate blades which are gray-brown above and grayish yellow-brown below, midrib narrowly acute above, primary lateral veins scarcely more prominent than the interprimary veins which are numerous and close, collective veins that are very close to the margins as well as by the inflorescence that is much shorter than the leaves with a slender peduncle, and a green spathe and spadix.

In the Lucid Anthurium Key the species tracks to *Anthurium caloveboranum* Croat which differs in having much longer oblong-elliptic blades that are up to 5 times longer than broad; *A. cartiense* Croat, differing in having larger blades, obtuse to rounded at base which are epunctate on the upper surface, more remote collective veins, more prominent and more primary lateral veins; *A. crassilaminum* Croat, differing in having much larger (4.5–8 cm wide), more coriaceous blades with collective veins more remote from the margins and a proportionately shorter petiole; *A. gracililaminum* Croat, differing by having much longer, more slender, less bicolorous blades to 6.5 times longer than wide which are more narrowly long-acuminate with more remote collective veins and *A. verrucosum* Croat & D. C. Bay, differing in having cataphylls 4.5–15 cm long and in a net-like reticulum, longer petioles (9–38 cm long), broadly oblong-elliptic blades (24–57 cm long x 5–19 cm), collective veins 36 mm

from the margins and larger inflorescences (peduncle 19–54 and spadix 1.5 cm long).

Terrestrial, sometimes climbing to 2 m; **internodes** 1–2 cm long, drying 1.0–1.6 cm diam.; **cataphylls** 2.4–5.2 cm long (averaging 3.6 cm), pinkish, drying reddish brown, persisting as fibers near base, sometimes intact at apex, darker red with veins prominently round-raised where intact. LEAVES 17–40 cm long (averaging 29 cm); **petioles** 8.1–19.6 cm long, drying 1–2 mm diam. (averaging 12.5 cm x 1.3 mm), often weakly C-shaped, terete, ribbed, sometimes with 1–2 narrowly deep grooves, matte, tannish grey-brown, sparsely dark-glandular-punctate, sometimes sparsely pale pustular; **geniculum** 0.8–2.6 cm long, drying 1–3 mm diam., darker and thicker than petiole, dark brownish black, more sparsely dark glandular-punctate than petiole, more densely pale-pustular when present; **blades** narrowly lanceolate-elliptic, 11.2–22.8 cm long by 2.6–7.4 cm wide, (averaging 17.3 x 5.0 cm), 2.7–4.3 times longer than broad (averaging 3.6), 0.98–1.9 times longer than petiole (averaging 1.5), broadest at middle, narrowly acuminate at apex (acumen 0.6–1.6 cm) narrowly cuneate, sometimes weakly inequilateral at base, base arching away from petiole, drying thinly chartaceous on both surfaces; **upper surface** drying gray-brown, matte, densely minute-black speckled upon strong magnification; **lower surface** drying grayish yellow-brown, semiglossy, raised glandular-punctate; **midrib** prominent and narrowly rounded above, weakly raised and only slightly rounded below, concolorous to both

surfaces; **primary lateral veins** 16–20 pairs, scarcely more prominent than interprimary veins on both surfaces, departing midrib at a 52–62° angle, drying concolorous to and rounded on both surfaces, slightly more prominent below; **collective veins** arising from base, 1(4) mm from margin, drying narrowly rounded above, nearly inconspicuous below. INFLORESCENCE erect, greenish yellow; **peduncle** 10.3–29.7 cm long (averaging 34.2), drying ca. 1 mm diam., drying sulcate, finely ribbed, green, drying tannish grey-brown, matte, moderately to densely pale granular, sparsely dark glandular punctate; **spathe** 1.6–3.4 cm long, 3–6 mm wide (averaging 2.5 cm x 4 mm), narrowly linear-lanceolate, erect-spreading to reflexed-spreading, greenish yellow, drying dark grayish brown to dark reddish brown, matte, sparsely short-pale-lineate and moderately pale granular adaxially, moderately short-pale lineate and densely granular abaxially; **spadix** 2.3–5.9 cm long, 1.5–8 mm diam. (averaging 3.5 cm x 2 mm), narrowly cylindroid, sometimes slightly C-shaped, drying medium to dark brown, stipitate (stipe 2–3 mm long x 1 mm wide); **flowers** 2–3 visible per spiral, 1.4–2.2 mm long by 1.3–2.0 mm wide; **tepals** densely granular, lateral tepals to 1.0–1.2 mm wide; inner margins narrowly rounded to 2-sided; outer margin sharply 2-sided; **stamens** not yet emergent. INFRUCTESCENCE with **berries** ca. 4 mm, red at maturity, subglobose; **seeds** yellowish, drying brownish yellow, 3 mm long x 2 mm wide x 1 mm thick.

*Anthurium sneidernii* is endemic to Colombia, known only from the type locality in Antioquia Department, Municipio Urrao in the Parque Nacional Natural de Las Orquídeas at 1459–1470 m in a *Premontane rain forest* life zone.

The species is named in honor of Danish botanist Kjell Von Sneidern who collected the first collection of this species. Von Sneidern emigrated to Colombia from Sweden in the 1920's where he became the country's leading ecologist and ornithologist.

*Paratypes:* COLOMBIA. **Antioquia:** Municipio Urrao, Corregimiento La Encarnación, Vereda Calles, Parque Nacional de Las Orquídeas, finca de Alfonso Pino, en la divisoria de aguas entre las quebradas La Virola y El Bosque, noroccidentale de la cabaña de Calles, 6°31'35"N, 76°15'50"W, 1450–1470 m, 27 Jan 2011, J. Betancur, P. Pedraza-Peñalosa, M. F. González, G. Giralado, F. Gómez, A. Duque & J. Serna 14765 (MO); Margin derecha del Río Calles, 1300 m, 06°32'N, 76°19'W, 21 Feb 1989, A. Cogollo 4158 (COL); Margin derecha del Río Calles, 1280 m, 06°32', 76°19'W, 2 June 1988, A. Cogollo 3153 (COL). **Caldas:** La Selva, Cordillera Occidental, Vertiente Occidental, 1600–1900, 25 July 1945, K. Von Sneidern 5250 (F).

*Anthurium tortuosum* Croat, **sp. nov.**  
Type: COLOMBIA. Antioquia:  
Municipio de Urrao, road between

Urrao and Caicedo, 18 km NE of center of Urrao, in stream, 06°23'N, 76°03'W, 2570 m, *J. M. MacDougal, F. J. Roldán & J. Betancur 4266* (holotype, MO-4369937–39: isotype, JAUM).

The species is a member of section *Belolonchium* characterized by its terrestrial habit, abundance in ravines and canyons, persistent reddish brown cataphyll fibers, subterete sulcate petioles drying reddish brown, narrowly ovate-sagittate, gradually acuminate blades with the anterior lobe shallowly concave, 8 pairs of basal veins, one pair free to the base, well-developed posterior ribs which are naked veins throughout most of its length, as well as by the long-pedunculate inflorescence, green hooding spathe, narrowly cylindroid reddish spadix with early-emergent pistils.

*Anthurium tortuosum* is most similar to *A. castanae* Croat, which differs in having blades semiglossy below with the areoles of the surface sparsely granular as well as by having the tertiary veins thicker than broad and only sparsely covered with tortuous scabrid scales. In contrast, *Anthurium tortuosum* has blades with the lower surface matte with the surface somewhat areolate as well as by having the tertiary veins more round-raised and more prominently granular-squamate on the entire circumference of the veins and by having the scales paler and more granular).

In the Lucid Anthurium Key the species tracks to *Anthurium bogotense* Schott, differing

in lacking any scabrid veins on the lower surface; *A. floridaense* Croat from western slopes of the Cordillera Central, differing in having the major veins on the lower surface merely ribbed, not at all scarious.

Terrestrial; **internodes** short; **cataphylls** persisting as reddish brown fibers. LEAVES 215 cm long with **petioles** 145.3 cm long, drying to 0.4–1.1 cm diam., smoothly sulcate, drying medium tan-brown and matte, weakly striated; **geniculum** 5.9 cm long, withered, darker than petiole; **blades** ovate-sagittate, to 69.7 cm long, 49 cm wide, 1.42 times longer than broad, 0.48 times long as petiole, coriaceous, gradual acuminate, rugose-bullate; **upper surface** dull, drying dark brown, matte, smooth; **lower surface** drying medium brown, semiglossy, smooth; **anterior lobe** to 52.2 cm long, to 49 cm wide, with convex margins to 33.6 cm above petiolar plexus where margins are weakly concave for 10 cm, broadest at petiolar plexus; **posterior lobes** to 23.6 cm long, to 17.2 cm wide, directed downward to turned inwards; **sinus** broadly hippocrepiform, to 17.7 cm deep and to 12.2 cm wide; **midrib** acute to narrowly rounded above, drying concolorous with surface, prominently round-raised below, drying faintly lighter than lower surface; **primary lateral veins** ca. 11–14 pairs, arising at a 44–58° angle, weakly cuneate above, drying faintly lighter than surface, prominent and narrowly round raised below, drying slightly lighter than surface; **basal veins** 9(10) pairs, 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> pairs free to base, 4<sup>th</sup> pair coalesced to 4.7 cm, 5<sup>th</sup> to 9<sup>th</sup> pair coalesced at 9.4 cm, acute

to level with upper surface, rounded below, concolorous with upper surface, lighter than lower; **posterior rib** weakly rounded towards base, to 9.8 cm long, naked to 4.4 cm; **tertiary veins** flat above, rounded below, concolorous with upper surface, lighter than lower surface; **collective veins** arising from 3rd pair of basal veins, running 1–4 mm from margin. INFLORESCENCE with **peduncle** 59.7–86.1 cm long, reddish, drying medium reddish brown, deeply sulcate; **spathe** broadly lanceolate, tapered to apex and base, 10.7–12.3 cm long, drying 3.6–4.5 cm wide, green, drying medium tannish brown, gradual lightening towards apex, veins raised both adaxially and abaxially, densely granular abaxially; **spadix** 13.6–16.3 cm long, 1.2–1.8 cm diam., tinged dull red, drying dark brown, cylindroid, weakly tapered to both ends; **flowers** 11–12 visible per spiral, 1.9–2.3 mm long, 1.1–1.4 mm wide; lateral **tepals** 0.9–1.4 mm wide, inner margins narrowly rounded, outer margins sharply 2-sided; **stamens** held just above tepals, anthers 0.9 mm long, 0.7 mm wide, thecae slightly divaricate.

*Anthurium tortuosum* is endemic to Colombia, known only from the type locality in Antioquia Department at 2570 m in a *Lower Montane rain forest* to *Lower Montane wet forest* life zone.

The specific epithet “tortuosum” comes from the Latin “tortuosus” (meaning bent or twisted in different directions) referring to the tortuous scales on the veins on the lower blade surfaces.

***Anthurium triangulopetiolum* Croat, sp. nov.** Type: COLOMBIA. Antioquia: Urrao Municipio, Parque Nacional Natural de Las Orquídeas, Vereda Calles, Inventario Permanente, margen derecha del Río Calles, 06°32'N, 76°19'W, 1350–1450 m, 7 Dec 1993, J. Pipoly, III, W. Rodríguez & O. Álvarez 17876 (holotype, MO-04588723; isotype, JAUM). **Figure 26.**

The species is a member of section *Porphyrochitonium* as characterized by its short internodes, persistent reddish brown cataphyll fibers, triangular petioles equal to or longer than the blades, narrowly ovate to elliptic dark brown-drying blades which are acute to rounded and apiculate at apex and attenuate at the base with the collective veins arising from or very near the base as well as by the long-pedunculate inflorescences with the spathe green to violet-purple and reflexed-spreading, the green to violet-purple spadix and the berries which are white at the base and violet-purple at the apex.

Some of the paratypes have some differences worth mentioning. *Cogollo 3002* differs slightly from the type specimen in having more oblong elliptic blades, drying lighter gray-brown, having a longer acumen, proportionately longer cataphylls, and darker pustules on both surfaces. *Pipoly 17341* differs in having a red spathe, pink peduncle, and fewer pustules along the petiole. *Cardenas 3258* differs by its proportionately thicker and shorter blades,



Figure 26. *Anthurium triangulopetiolum* Croat (Pipoly 17856). Herbarium type specimen showing on left leaf blade abaxial surface covered partially by adaxial surface on right with inflorescence and cataphylls.

longer petioles and peduncles, and by having the upper surface drying a deeper red.

The species appears to be closest to *Anthurium dnyeri* Croft which differs in having proportionately shorter petioles, proportionately narrower, more oblong-elliptic blades and lavender-white berries.

In the Lucid Anthurium Key the species tracks to *Anthurium brevipes* Sodiro, differing in having narrowly oblanceolate, long-acuminate blades; *A. langendoenii* Croft & D. C. Bay from Bajo Calima in Colombia, differing in having obovate blades with no more than 13 primary lateral veins and a pale yellow-green to cream spadix; *A. spatulifolium* Sodiro from the western slopes of the Andes in Ecuador, differing in having much narrower, oblanceolate blades and *A. vallense* Croft differing in having a much longer, more prominently networked cataphyll.

Epiphyte or terrestrial; **internodes** short, drying 1.3–1.7 cm diam.; **cataphylls** 6.6–15.3 cm long (averaging 10.3 cm), drying red-brown, persisting densely fibrous. LEAVES 31.2–60.8 cm long (averaging 45.75 cm) with **petioles** 12.3–30.6 cm long (averaging 21.9 cm), 3–9 mm diam., drying matte gray-brown, sharply triangular, deeply sulcate, moderately pustular; **geniculum** darker than petiole, densely pustular, 1.2–1.6 cm long; **blades** ovate, sometimes ovate-elliptic, arched, 17.8–30.2 cm long, 5.9–20.9 cm wide (averaging 23.9 x 12.8 cm), 1.4–3.2

times longer than wide (averaging 2.0), broadest below midway, 0.9–1.5 times longer than petiole (averaging 1.2), subcoriaceous, drying discolorous, with thin hyaline margin, narrowly rounded at apex with short acumen or obscure apiculum, attenuate at base; **upper surface** drying semiglossy, red-brown, sparsely glandular-punctate, raised, sparsely pustular (white to light yellow), densely pale-granular; **lower surface** drying lighter, glossy, densely glandular-punctate (the glands weakly raised), moderately to densely pustular (white to light yellow), especially along midrib, usually minutely dark-specked throughout surface upon magnification; **midrib** prominent on both surfaces, narrowly rounded above, slightly darker than surface, broadly rounded near apex, slightly angular midway, more bluntly prominent towards base, darker than surface; **primary lateral veins** ca. 18–21 pairs, arising at a 58–68° angle, paler than surface above, darker than lower surface below, inconspicuously raised above, slightly indistinguishable from interprimary veins, bluntly raised below, scattered with pustules and minutely granular upon magnification; **interprimary veins** concolorous to surface above and below, raised almost equal to primary lateral veins on upper surface, weakly raised on lower surface; **collective veins** arising from the base, 4–8 mm from the margin, weakly raised above, sharply below, concolorous with primary lateral veins on both surfaces; **antimarginal veins** present, slightly more visible on upper surface than lower. INFLORESCENCE erect, **peduncle** 9.6–27.6(–43.4) cm long

(averaging 19.1 cm), 2–8 mm diam. (averaging 4 mm), 2.1–6.3 times longer than spathe (averaging 4.9), sharply sulcate, finely ribbed, drying red-brown, moderately darker along ribs; **spathe** 3.7–4.6 cm long (averaging 4.1 cm), 2–7 mm wide (averaging 5 mm), green to purple, drying deep red-brown, reflexed-spreading-rolled; **spadix** cylindroid, weakly stipitate, 3–4 mm diam., 7.1–13.7 cm long (averaging 11.1 cm), drying to 3–9 mm wide (averaging 6 mm), purple, drying dark brown; **flowers** 3–4 visible per spiral, 2.8–3.6 mm long, 1.2–2 mm wide, tepals matte with white to yellow-brown granules; lateral tepals 1.4–2.3 mm wide, inner margins broadly rounded to straight, outer margins 2-sided to weakly 3-sided; **stamens** barely emerging above tepals at anthesis, then retracting; anthers ca. 0.2 mm long, 0.4 mm wide, thecae broadly divaricate. **INFRUCTESCENCE** greenish white berries, with purple.

*Anthurium triangulopetiolum* is endemic to Colombia, known only from the type locality in Antioquia Department, Urrao Municipio at 1340–1550 m in *Lower Montane rain forest* and *Tropical wet forest* life zones.

The species epithet “triangulopetiolum” is from the Latin “triangulo” (triangular) and “petiolum” (petiole) referring to the triangular-shaped petiole.

*Paratypes*: COLOMBIA. **Antioquia**: Parque Nacional Natural de Las Orquídeas, Sector Calles, margen derecha del Río Calles, 06°32'N 076°19'W, 1320–1390 m, 24 Mar

1988, *A. Cogollo P. 2529* (JAUM, MO); Sector Venados, 06°33'N, 76°19'W, 800 m, 3 Apr 1988, *A. Cogollo P. 3002* (JAUM); Sector Calles, 06°33'N 076°19'W, 1250–1375 m, 31 Mayo 1988, *Á. Cogollo P. 3111* (JAUM); En el filo NW de la Cabaña de Calles, 06°32'N, 76°19'W, 1450 m, 1 Dec 1993, *A. Cogollo P. 7649* (JAUM, MO); Quebrada La Bironda, 06°31'N, 76°19'W, 1300–1500 m, 3 Apr 1992, *D. Cárdenas L. & E. Álvarez 3258* (MO); Quebrada Honda, Inventario Permanente, en el filo al NW de La Cabaña Calles, Parcela W, subparcelas W 2–W 3, 06°29'N, 76°14'W, 1340 m, 7 Dec 1992, *J. Pipoly, III 16683* (MO); Inventario Permanente Bosque Pluvial Premontano, margen derecha del Río Calles, 06°32'N, 076°19'W, 1450 m, 26 Nov 1993, *J. Pipoly, III 17153* (JAUM, MO); Zona limitrofe con bosque nublado, 1450–1500 m, 29 Nov 1993, *J. Pipoly, III 17341* (MO).

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MISSOURI  
BOTANICAL GARDEN  
HERBARIUM



Nº 4241465



upper surface  
short pale-linate

TROPICOS  
E欣欣calatae

HERBARIO JARDIN BOTANICO JOAQUIN ANTONIO URIBE (2014)

FLORA DE COLOMBIA

ANTIOQUIA  
Municipio Frontino

Parque Nacional Natural "LAS ORQUIDEAS Sector Calles, margen derecha del río Calles y de la quebrada "El Guaguo".  
Alt. 1390-1420 m.s.n.m. 6°32'N, 76°19'W.

ARACEAE  
*Anthurium spiranzaense* Croat, 2013  
Croat.

Herbáceo voluble, terrestre, flores amarillentas, bráctea verde.

Colector Alvaro Cogollo, Dayron Cárdenas & Ovidio Alvarez  
No. 3918 Fecha: Febrero 12 de 1989  
Colección financiada por: INDERENA y Fundación Jardín Botánico JOAQUIN ANTONIO URIBE.