

## **Studies on Schismatoglottideae (Araceae) of Borneo VIII: A Review of *Piptospatha elongata* in Sarawak**

WONG SIN YENG<sup>1</sup>, P.C. BOYCE<sup>2</sup> AND J. BOGNER<sup>3</sup>

<sup>1</sup>Faculty of Resource Science and Technology, Universiti Malaysia Sarawak,  
94300 Samarahan, Sarawak, Malaysia

<sup>2</sup>Forest Herbarium (BKF), The office of Forest and Plant Conservation Research,  
National Park, Wildlife and Plant Conservation Development, Chatuchak,  
Bangkok 10900, Thailand

<sup>3</sup>Augsburgerstrasse 43a, D-86368 Gersthofen, Germany

### **Abstract**

A review of *Piptospatha elongata* (Engl.) N.E. Br. in Sarawak is presented. The species is shown to comprise three morphologically and ecologically distinct taxa, two of which are new to science and herewith described as *Piptospatha impolita* S.Y.Wong, P.C. Boyce & Bogner and *P. viridistigma* S.Y.Wong, P.C. Boyce & Bogner. A new key to *Piptospatha* is presented and all species of the Elongata group are illustrated. Additionally, new observations on the morphologies separating the *Piptospatha elongata* Group and *P. grabowskii* Group *sensu* Bogner and Hay (2000) are presented.

### **Introduction**

Bogner and Hay (2000) provides a comprehensive and excellent revision of the Schismatoglottideae, including *Piptospatha* N.E.Br., for which six species are recognized in Sarawak. Since the publication, the first two authors have had the opportunity to undertake comprehensive field studies, and the first author in detailed molecular analyses of most of the presently recognized Sarawak species and this has produced a number of new observations resulting in the removal of *Piptospatha lucens* (Bogner) Bogner & Hay into a new genus (Boyce and Wong, in press) and compelling evidence that *P. elongata* (Engl.) N.E. Br. *sensu* Bogner and Hay (2000) is heterogeneous.

### ***Piptospatha elongata* Group**

The distribution and habitat data and a considerable portion of the description given in Bogner and Hay (2000) for *P. elongata* incorporates five or possibly more taxonomic elements. One of these elements is restricted to very hard sandstones in the coastal areas of Lundu (NW Sarawak) and

is here described as *Piptospatha impolita* S.Y.Wong, P.C. Boyce & Bogner. Another element is endemic to the Serian & Padawan areas as far NW as the Sungai Tegora (SE flanks of the Bungo range) and the southernmost Bau limestones and is usually (but not exclusively) associated with limestone. This element is also novel and is described as *Piptospatha viridistigma* S.Y.Wong, P.C. Boyce & Bogner.

### Key to *Piptospatha* species-

1. Spathe limb caducous; spadix above female flower zone shed directly after male anthesis; peduncle becoming erect and infructescence erect at fruit dispersal; fruits dispersing via 'splash-cup' mechanics ..... **(*P. elongata* group)** 2
1. Spathe limb almost fully persistent until fruit dispersal; spadix axis persistent until well after fruit dispersal; peduncle declinate and infructescence pendent at fruit dispersal; fruit dispersal various (mostly unstudied except for *P. grabowskii*) but not via 'splash-cup' mechanics ..... **(*P. grabowskii* group)** 11
2. Peduncle shorter than spathe; W Kalimantan ..... ***P. brevipedunculata***
2. Peduncle much exceeding the spathe ..... 3
3. Sterile interstice well-defined; NW Borneo ..... ***P. burbridgei***
3. Sterile interstice absent or not well-defined ..... 4
4. Connective extended into a pronounced elongate beak; Sabah ..... ***P. insignis***
4. Connective not raised above the thecae or shortly elevated and obtuse ... 5
5. Anthers pubescent to papillose ..... 6
5. Anthers glabrous ..... 8
6. Connective swollen; Peninsular Malaysia ..... ***P. ridleyi***
6. Connective not swollen ..... 7
7. Anthers in closely appressed regularly arranged pairs; Malay Peninsula and southern peninsular Thailand ..... ***P. perakensis***
7. Anthers (seen from above) irregularly arranged; E Kalimantan ..... ***P. manduensis***
8. Spadix usually with slightly narrowed sterile appendix (male zone rarely

- fertile to apex); petiole with narrow crispate wings distally; Sarawak .....  
 ..... *P. truncata*
8. Male zone fertile to apex; petiole without crispate wings; Sarawak,  
 Kalimantan ..... 9
9. Spadix bullet-shaped, the male portion tapering towards the apex;  
 lower part of male zone comprised of larger flowers, that may be sterile,  
 intermixed adjacent to the pistils with white staminodes; thecae broadly  
 excavated, the excavations of adjacent anthers forming a butterfly-shaped  
 depression; stigmas bright green; spathe at anthesis shading proximally to  
 distally from deep olive-green through very pale pink to medium pink, the  
 interior of the spathe tip rostrum with 5-7 conspicuous keels; persistent  
 fruiting spathe wide-flared; plants frequently limestone associated .....  
 ..... *P. viridistigma*
9. Spadix cylindrical; male flowers uniform throughout zone; thecae  
 longitudinally sulcate with the pores ventral and dorsal to the sulcae;  
 stigmas pink or dirty whitish. Spathe at anthesis shading proximally to  
 distally from deep plum purple through medium pink to deep pink, the  
 interior of the spathe tip rostrum with 2-3 conspicuous keels or keels  
 absent. Persistent fruiting spathe narrowly obconic; plants of sandstone  
 or granite ..... 11
10. Stigmas mid-deep pink; anthers with connective flat; spathe tip rostrum  
 almost straight or only weakly reflexed (*ca* 45°) relative to spathe axis at  
 anthesis, inside with 2-3 conspicuous longitudinal keels; plants exclusively  
 of granite ..... *P. elongata*
10. Stigmas dirty whitish; anthers with a short acute-triangular connective on  
 each side, spathe tip rostrum strongly reflexed (*ca* 130°) relative to spathe  
 axis at anthesis, inside without keels or these only very vaguely defined;  
 plants exclusively of sandstone ..... *P. impolita*
11. Female zone free, stigmas as wide as ovary, usually on a distinct style;  
 basal sterile zone partly adnate to spathe; widespread in Borneo .....  
 ..... *P. grabowskii*
11. Lower part of female zone adnate to the spathe; stigmas narrower than  
 ovary, sessile; NW Borneo ..... *P. kinabaluensis*

***Piptospatha elongata*** (Engl.) N.E. Br.

Curtis's Bot. Mag. 51, in descr. ad tab. 7410 (1895); Engl., Pflanzenr. 55  
 (IV.23Da): 124, fig. 75 (1912); Ridl., J. Bot. 51: 202 (1913); Bogner & Hay,  
 Telopea 9(1): 205 (2000). *Schismatoglottis elongata* Engl., Bull. Soc. Tosc.  
 Ortic. 4: 298 (1879). *Rhynchophyle elongata* (Engl.) Engl., Bot. Jahrb. Syst.

1: 184 (1881) & in Becc. , Malesia 1: 289, pl. 23, figs 3-15 (1882). – **Typus:** Malaysia, Sarawak, Kuching Division, Lundu, Gunung Gading, June 1867, *O. Beccari P.B. 2308* (holo, FI-B). **Plates 1A & 2.**

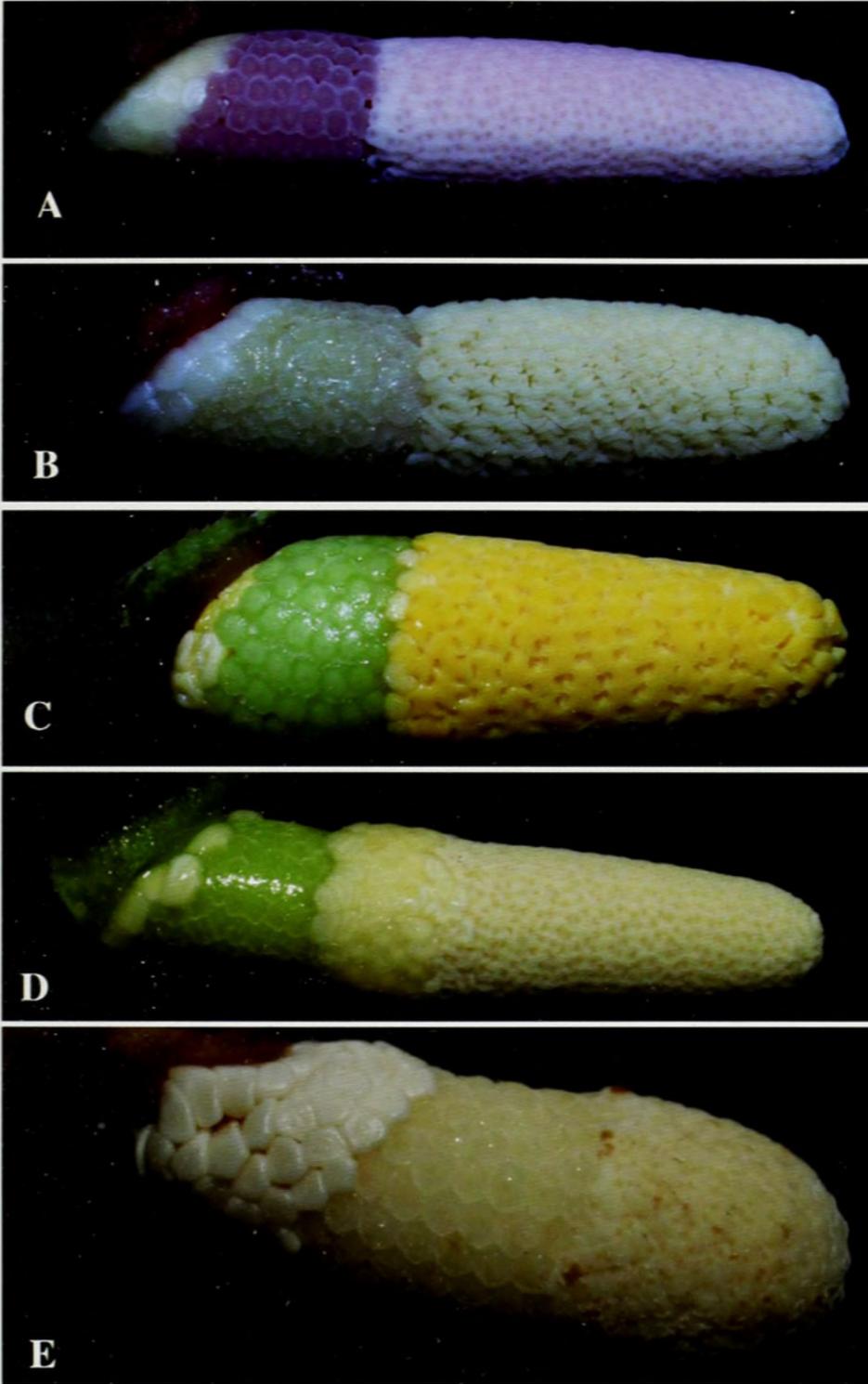
-*Schismatoglottis marginata* Engl., Bull. Soc. Tosc. Ort. 4: 298 (1879). *Rhynchopyle marginata* (Engl.) Engl., Bot. Jahrb. Syst. 1: 184 (1881) & in Becc. , Malesia 1: 288, pl. 23, figs 1-2 (1882). *Piptospatha marginata* (Engl.) N.E. Br., Curtis's Bot. Mag. 51. in descr. ad tab. 7410 (1895); Engl., Pflanzenr. 55 (IV.23Da) (1912) 125. - Type: Malaysia, Sarawak, no further data, *O. Beccari P.B. 3838* (holo, FI-B; iso, B).

-*Gamogyne pulchra* N.E. Br., Kew Bull. (1910) 197 & Curtis's Bot. Mag. 135 t. 8330 (1910). -Type: not designated (see Bogner and Hay, 2000: 205).

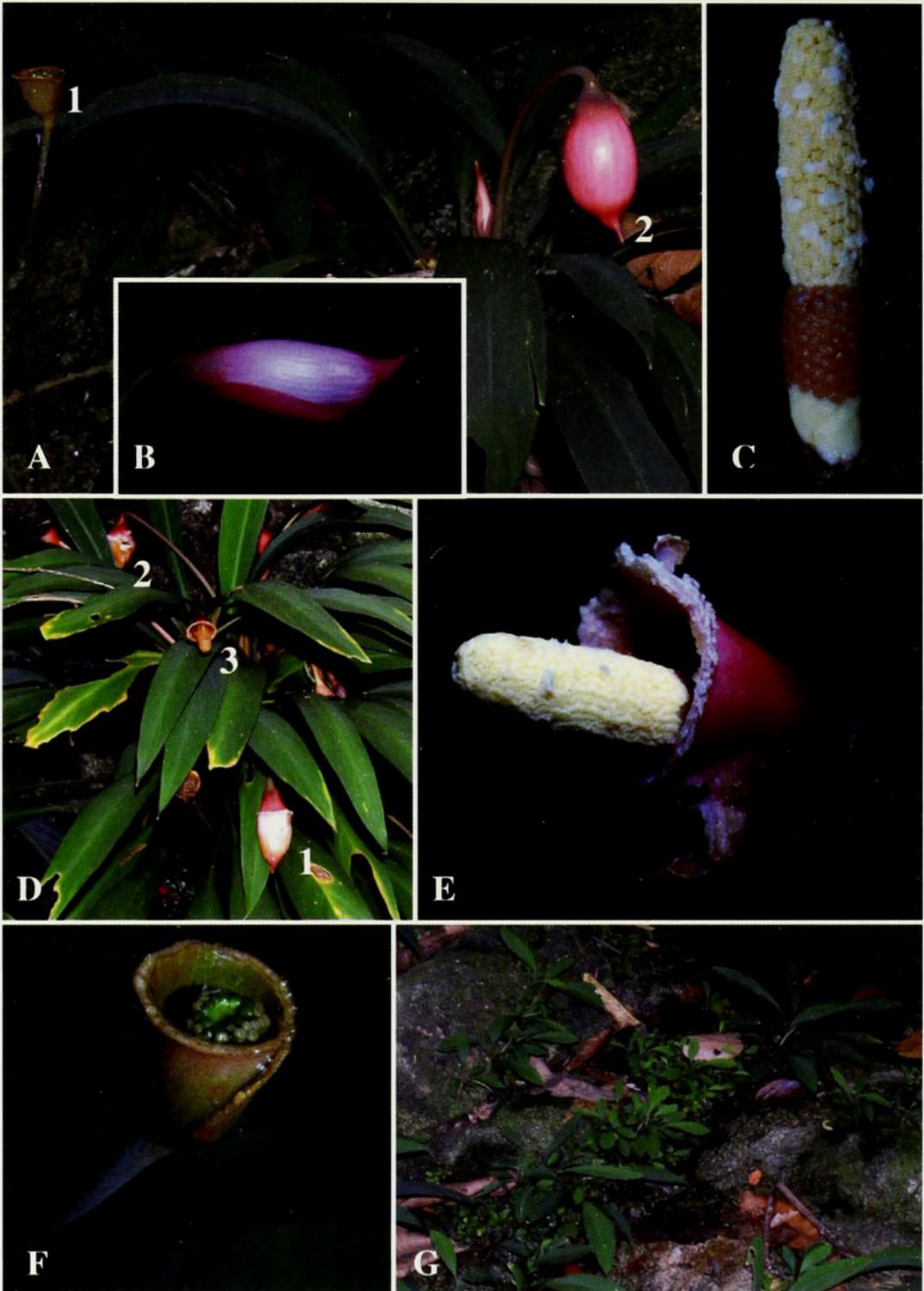
-*Piptospatha rigidifolia* Engl., Pflanzenr. 55 (IV.23Da): 127 (1912). - Type: Malaysia, Sarawak, Kuching Division, Lundu, Sept. 1905, *H.N. Ridley s.n.* (lecto, SING, selected by Bogner and Hay, 2000: 205).

?*Piptospatha angustifolia* Engl. ex Alderw., Bull. Jard. Bot. Buitenzorg III, 4: 193 (1922); Bogner, Pl. Syst. Evol. 142: 52 (1983). - Type: Indonesia, Kalimantan, *H. Hallier 614* (holo, BO), *prov. syn.*

Rheophytic **herb** 9-20 cm high. **Stem** condensed, 2–6 cm long, 0.5-1.1 cm diam., with robust pale green to more-or-less reddish-tinged roots 1.5-2 mm diam. **Leaves** several to 20 together; petiole 6-11 cm long, 1.5-2 mm diam., slightly canaliculate adaxially, sheathing only at the extreme base, the remainder of the sheath ligular, the ligules extended into a narrowly triangular, purple to reddish portion 3-5 cm long, this drying dark brown and not long-persisting; blade very narrowly elliptic to narrowly elliptic-oblong to oblanceolate, coriaceous, dark green adaxially, paler abaxially, 15-24 cm long × 1-3.5 cm wide, the base cuneate, the apex acute and tubular-apiculate for 2-3 mm; midrib robust, abaxially prominent, adaxially bluntly raised (fresh), impressed (dry), with (6-)7-10 primary lateral veins on each side, diverging at 35°-45° and more or less regularly alternating with lesser interprimary veins especially in the lower half of the blade; secondary venation adaxially more or less obscure, abaxially fine and dense; tertiary venation obscure. **Inflorescence** solitary to 2-3 together and then often alternating with foliage leaves; peduncle shorter than to equalling, rarely exceeding the length of the whole leaf, 11-22 cm long, 1.8-2.2 mm diam., purple to reddish. **Spathe** nodding at anthesis, subcylindric-obovoid, 3-4 cm long, apically rostrate for 3-4 mm, the rostrum conspicuously 2-3-keeled internally, straight at female anthesis but recurving up to 45° at the onset of male anthesis; spathe at anthesis shading proximally to distally from deep plum purple through medium pink to deep pink, inflating and the distal-most part opening at female anthesis, at the end of male anthesis the opening increasing by the reflexing of the terminal rostrum and then at late male anthesis the upper



**Plate 1.** Spadices of five Sarawak *Piptospatha* species. A. *Piptospatha elongata* showing the sinuate arrangement of the stamens and diagnostic pink pistils; B. *P. impolita*, note the carinate connectives and dirty white pistils; C. *P. viridistigma*, showing the butterfly-shaped excavated thecae and diagnostic green pistils. Note the neuter flowers below the fertile female flowers comprise centrally-depressed white pistillodes (positioned ventrally) and yellow staminodes (positioned dorsally); D. *P. burbidgei*, note the distinctive zone of staminodes separating the male and female flower zones; E. *P. grabowskii*, note the conspicuous zone of pistillodes positioned below the female flower zone, and the pubescent stamens.



**Plate 2.** *Piptospatha elongata* (Engl.) N.E.Br. A. Flowering plant in habitat. Of note is the noding inflorescence with almost straight rostrum (A2) and the erect infructescence (A1); B. Inflorescence at female anthesis. Note the almost straight rostrum; C. Spadix at male anthesis with spathe artificially removed. Note the pollen masses; D. Plant in habitat with inflorescences at a variety of anthetic stages: D1 = inter-anthetic period; D2 = onset of male anthesis; D3 = post anthesis; E. inflorescence during late male anthesis. Note the spathe limb is already shed and pollen has been released; F. Infructescence approaching maturity. Note the narrowly obconic persistent lower spathe; G. Seedlings in habitat.

third opening further before becoming caducous. **Spadix** cylindrical, more-or-less sessile, 2-2.5 cm long, 0.4-0.5 cm diam.; female zone cylindrical, 5-7 mm long, 5-7 mm diam.; ovary subcylindrical to subprismatic, ca 0.9 mm diam., mid-deep pink; stigma sessile, as broad as the ovary, thinly discoid, mid- to deep pink; staminodes confined to 1-3 irregular and somewhat oblique rows at the base of the female zone, truncate, more-or-less sessile, 0.7-0.9 mm diam., about as high as the pistils, ivory; male zone cylindrical, approximately equalling diam. of female zone, 1.3-1.7 cm long, apically obtuse; stamens crowded, more or less rectangular from above, glabrous, at anthesis longitudinally sulcate with the thecae pores dorsal and ventral to the sulcae, 1.2-1.4 mm across, connective flat, pale cream; pollen extruded in masses. **Fruiting spathe** narrowly funnel-shaped, erect, 1.2-1.5 cm diam.; berry obovoid, ca 3.5 mm long  $\times$  1.2-2 mm diam.; **seed** cylindrical, very slightly ribbed, 1.4-1.6 mm long, brown but outer integument translucent, with a long curved micropylar appendage rotting away in dispersed seeds.

*Other specimens seen:* BORNEO. **Sarawak**, Kuching Division, Lundu, Sungai Sebako, 14 Apr 1984, *Dayang Awa & Paie S.46973* (K, KEP, L, SAN, SAR); Lundu, Kampung Sebako, Sungai Sebako, 01° 43' 18.9"; 109° 42' 53.8", 3 Feb 2005, *P.C. Boyce & Jeland ak Kisai AR-989* (SAR + spirit); Lundu, Gunung Gading, trail to waterfalls, 01° 41' 28.3"; 109° 50' 43.6", 14 Nov. 2006, *P.C. Boyce & Wong Sin Yeng AR-2052* (SAR + spirit); Lundu, 2 May 1954, *Brooke 8410* (L, SAR); Lundu, Gunung Gading, 19 Jul 1963, *Chai S.18484* (GH, K, L, SING); Lundu, Gunung Gading, Oct 1929, *Clemens & Clemens 21924* (GH, K, SAR); Lundu, Gunung Gading, *Foxworthy 326* (SAR, SING); Lundu, Sebuluh, 21 Jan 1989, *Othman Ismawi et al. S.62244* (K, L, KEP, MO, SAN, SAR); *ibid*, 15 Aug 1990, (K, KEO, L, SAN, SAR); Lundu, Gunung Pueh, Sungai Batu, 2 Mar 1989, *Othman Ismawi et al. S.56652* (K, KEP, L, SAN, SAR, US); Lundu, Gunung Pueh, Sungai Batu, 2 Oct 1974, *Mamit S.35218* (K, L, SAN, SAR, US); Lundu, Gunung Gading, *Micholitz s.n.* (SING); Lundu, Gunung Gading, 19 Sep 1955, *Purseglove & Shah P.4534* (K, L, SING); Lundu, Gunung Gading, 16 Aug 1960, *Sinclair & bin Tassin 10365* (E, K, L, SAR, SING); Lundu, Sematan, Pueh, close by Pueh mulberry plantation (Silkworm Farm), 7 Feb 1996, *S.Teo & Awg Enjah, S.68066* (K, KEP, SAR); Lundu, Gunung Gading, Sungai Sebuluh, 14 Jun 1991, *Yahud et al. S.61955* (K, KEP, SAR, US); Lundu, Kampung Pasir Ulu, Sungai Pasir Ulu, *Yahud et al. S.61925* (K, SAR); Lundu, Gunung Gading, 26 Mar 1980, *Yii Puan Ching S.42018* (L, SAR, US).

*Habitat:* Rheophytic on granite rocks in lowland to lower hill forest in light to medium shade. 10-400 m asl.

*Distribution:* Borneo, Sarawak, Kuching Division, endemic to the Lundu area, centred on Gunung Gading. It is quite likely also present in adjacent Kalimantan but we have not been able to re-examine the Kalimantan Barat specimens cited by Bogner and Hay [*Church et al.* 2787 (K); *Nieuwenhuis* 432 (B) and *Winkler* 798 (HBG)]; by the vague locality data that accompanies these specimens we are unable to place them adjacent to the Sarawak distribution of *P. elongata* or *P. viridistigma*.

*Notes:* *Piptospatha elongata* as here defined is endemic to the Lundu area centred on Gunung Gading where it is restricted to granite substrates. It is readily separated in flower from the other *elongata* Group *Piptospatha* in west Sarawak (*P. viridistigma* and *P. impolita*) by the combination of a cylindrical spadix, unexcavated thecae, mid- to bright pink stigmas, a spathe tip rostrum conspicuously 2-3-keeled internally, and remaining straight or reflexing by only *ca* 45° during anthesis, flat anther connectives and the spathe at anthesis shading deep plum purple proximally through medium pink to deep pink distally and, in fruit, by the narrowly obconic persistent lower spathe.

From *P. impolita*, *P. elongata* is readily distinguished by the mid- to dark pink stigmas, the spathe tip rostrum conspicuously 2-3-keeled internally and remaining straight or reflexing by only *ca* 45° during anthesis, and the flat anther connectives.

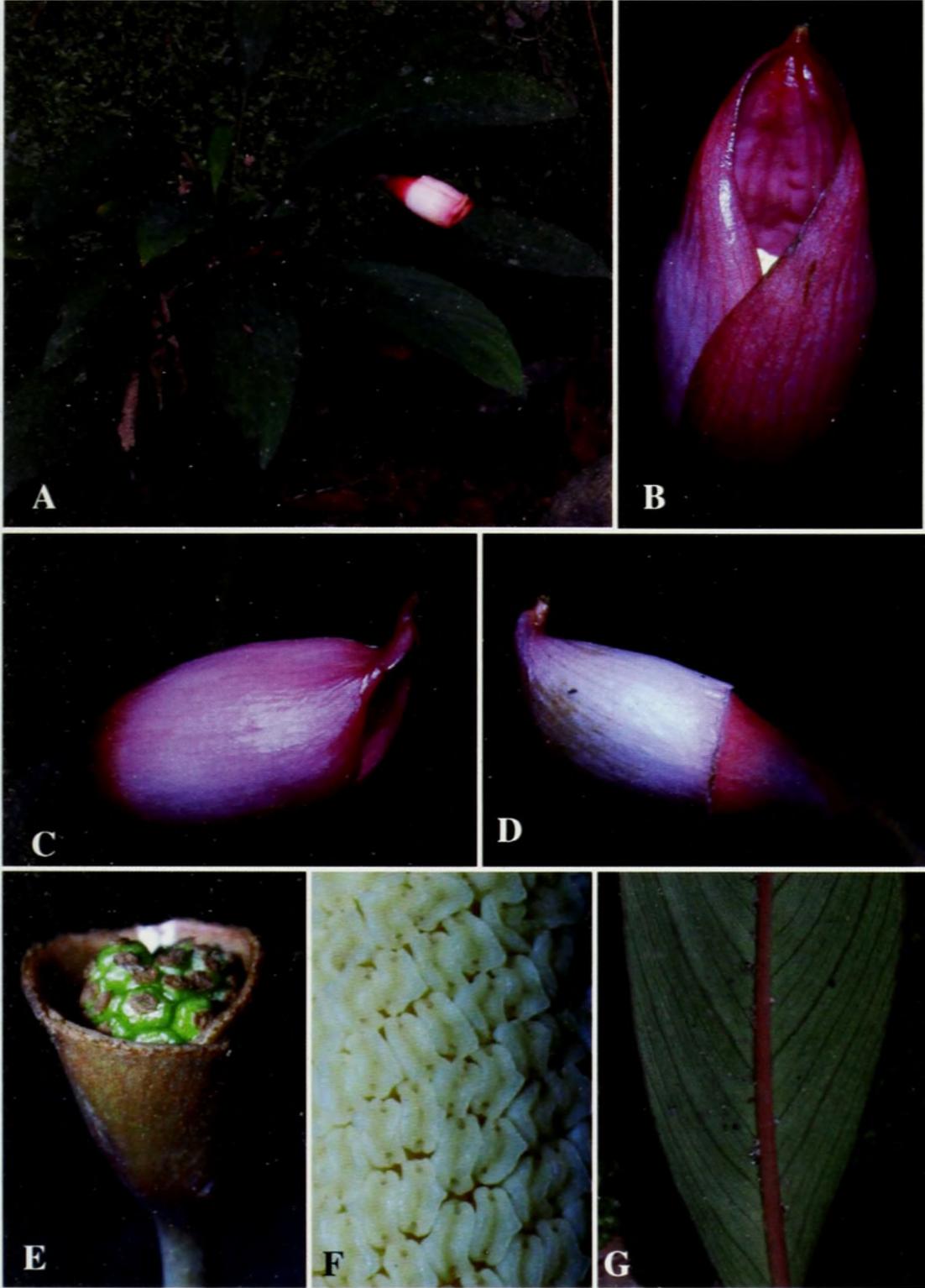
*Piptospatha elongata* is immediately separated from *P. viridistigma* by a cylindrical (vs. bullet-shaped) spadix, longitudinally sulcate unexcavated thecae, 2-3 (vs. 5-7 keels) on the interior of the spathe tip rostrum and a narrowly obconic (vs. wide flared) persistent lower spathe. The pollen of *P. elongata* (and *P. impolita*) is released en masses whereas that of *P. viridistigma* is extruded in strings.

*Piptospatha elongata* is restricted to granite, whereas *P. viridistigma* is mainly, although not exclusively, found on limestones.

***Piptospatha impolita*** S.Y.Wong, P.C. Boyce & Bogner, *sp. nov.*

*A* *Piptospatha elongata affinis, sed carinae intus spathorum nullis (vs. 2-3), rostrum spathorum valde reflexis (dum 130°) at staminis connectivo acute producto differt.* – **Holotypus:** Malaysia, Kuching, Lundu, Sempadi, Sg. Limau, Bukit Kankar, 25 Aug 2007, P.C. Boyce, Wong Sin Yeng & Jipom Tisai AR-2141 (SAR, + spirit). **Plates 1B & 3.**

Rheophytic **herb** 9-11 cm high. **Stem** condensed, 1-4 cm long, 0.5-0.9 cm diam., with slender pale green 0.5-1.5 mm diam. **Leaves** several to 10 together; petiole 2-6 cm long, 1-1.5 mm diam., very slightly canaliculate adaxially, sheathing only at the extreme base, the remainder of the sheath



**Plate 3.** *Piptospatha impolita* S.Y.Wong, P.C. Boyce & Bogner. A. Flowering plant in habitat; B. Inflorescence at late female anthesis. Note that the orifice of the spathe lacks keels; C. Inflorescence at late female anthesis; D. Inflorescence at onset of male anthesis with spathe limb beginning to shed; E. Infructescence at mid-maturity. Note that the persistent lower spathe is broadly narrowly obconic; F. Detail of male flower zone just prior to male anthesis showing the sulcate stamens and lateral, beaked connective; G. Detail of leaf lamina abaxial venation.

ligular, the ligules extended into a narrowly triangular, purple to reddish portion 2-3 cm long, drying dark brown and moderately long-persisting; blade very narrowly elliptic to narrowly elliptic-oblong to oblanceolate, thinly coriaceous, matte medium-green adaxially, paler to slightly dull-pink flushed abaxially with the mid-rib and occasionally main venation markedly reddish, 6-13 cm long  $\times$  0.5-1.5 cm wide, base cuneate, apex acute and tubular-apiculate for 2-3 mm; midrib robust, abaxially prominent, adaxially bluntly raised (fresh), impressed (dry), with (6-)7-10 primary lateral veins on each side, diverging at *ca* 35° and more or less regularly alternating with lesser interprimary veins; secondary venation adaxially more or less obscure, abaxially fine and dense; tertiary venation obscure. **Inflorescence** solitary to 2-3 together and then alternating with foliage leaves; peduncle shorter than to equalling, the whole leaf, 9-14 cm long, 1-2 mm diam., purple to reddish. **Spathe** nodding at anthesis, subcylindric-obovoid, 2-3 cm long, apically rostrate for 3-4 mm, the rostrum internally smooth or with *ca* 2 very ill-defined keels, straight at female anthesis but recurving strongly by up to 130° at the onset of male anthesis; spathe at anthesis shading proximally to distally from deep plum purple through medium pink to deep pink, inflating and the distal-most part opening at female anthesis, at the end of male anthesis the opening increasing by the reflexing of the terminal rostrum and then at late male anthesis the upper third opening further before becoming caducous. **Spadix** cylindrical to very weakly, 1.5-2 cm long, 0.4-0.5 cm diam.; female zone cylindrical, 5-7 mm long, 5-7 mm diam.; ovary subcylindric to subprismatic, *ca* 0.9 mm diam., dirty whitish; stigma sessile, as broad as the ovary, thinly discoid, dirty whitish; staminodes confined to 1-2 irregular and somewhat oblique rows at the base of the female zone, truncate, more or less sessile, 0.7-0.9 mm diam., about as high as the pistils, ivory; male zone weakly fusiform, isodiametric to female zone, 1.3-1.7 cm long, apically obtuse; stamens crowded, more or less rectangular from above, glabrous, at anthesis longitudinally sulcate with the thecae pores dorsal and ventral to the sulcae, 1.2-1.4 mm across, connective short acute-triangular, pale cream; pollen extruded in masses. **Fruiting spathe** narrowly funnel-shaped, erect, 1-1.3 cm diam.; berry obovoid, *ca* 2.5-3 mm long  $\times$  1.5-2 mm diam.; **seed** cylindrical, 1.4-1.6 mm long, brown but outer integument translucent, with a short curved micropylar appendage rotting away in dispersed seeds.

*Other specimen seen:* BORNEO. **Sarawak**, Kuching Division, Lundu, Sempadi, Sg. Limau, Bukit Kankar, 01°39' 44.2"; 109°59'56.5", 26 Mar 2004, *P.C. Boyce & Jeland ak Kisai AR-269* (SAR + spirit).

*Habitat:* Rheophytic on very hard sandstones in seasonally dry, but perhumid, lowland and lower hill forest between 50-150 m asl.

*Distribution:* Borneo, Sarawak, Kuching Division, endemic to the Lundu area along the coast.

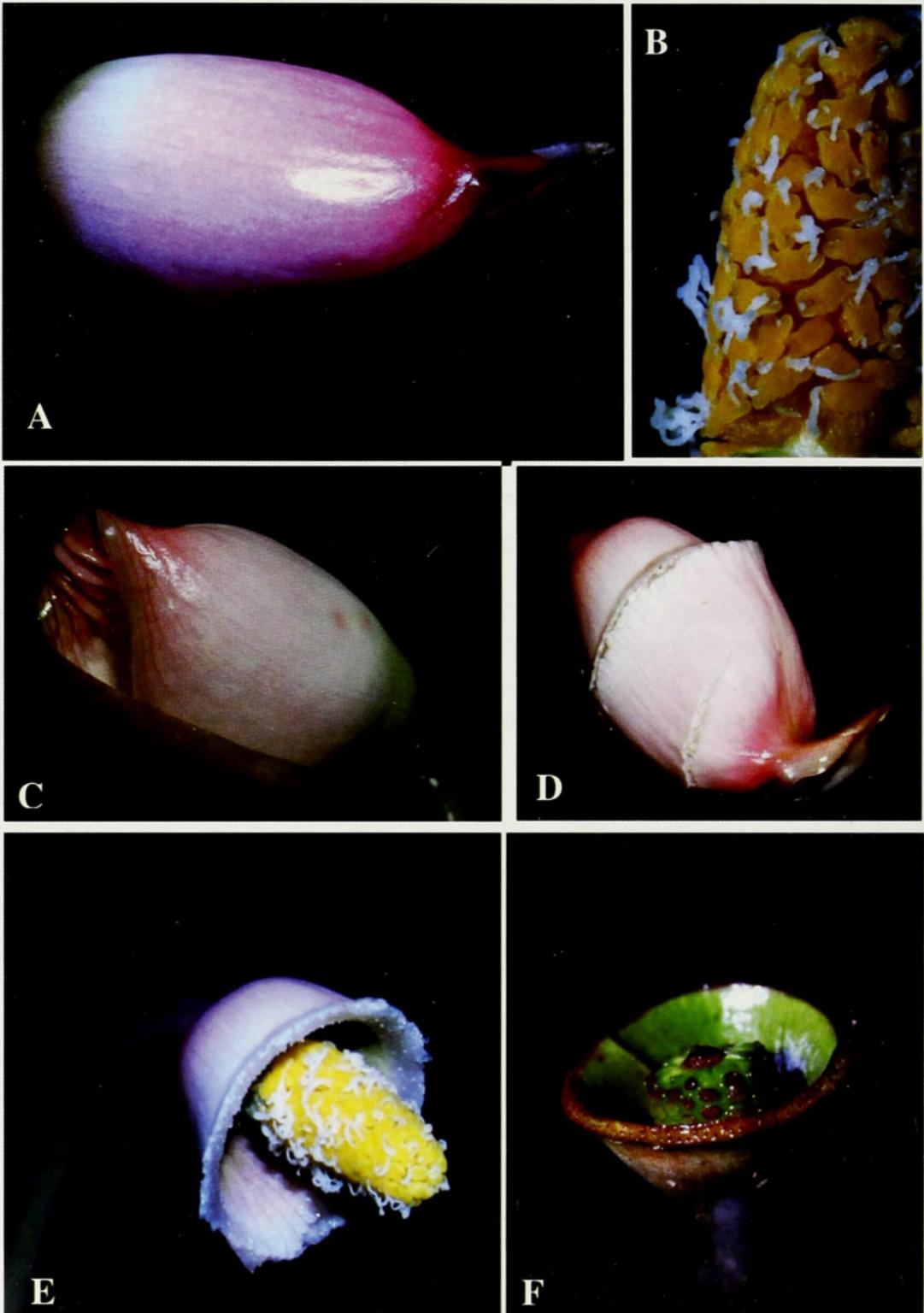
*Notes:* *Piptospatha impolita* is most similar to *P. elongata*, but readily distinguished by the anthers with a short acute-triangular connectives (one on each side of the stamen and held parallel to the longitudinal sulcae), the spathe tip rostrum without internal keels, or the keels only very weakly defined, and the rostrum becoming strongly reflexed (*ca* 130° vs. 45°) relative to spathe axis at anthesis, and the dirty whitish pistils and stigmas.

*Etymology:* from the Latin (*impolitus* - unpolished) in reference to leaf lamina markedly matte adaxially.

***Piptospatha viridistigma*** S.Y.Wong, P.C. Boyce & Bogner, *sp. nov.*

*Ab alli* *Piptospatha gregis elongatae borneensibus combinatio spadice conoideo, antherae excavates, excavatio papilio similis, spathae intus distalis 5-7 carinae instructa et spathae fructiferorum cyathiformis differt.* – **Holotypus:** Kuching Division, Siburan, Kampung Giam, Air Terjun Giam, 01° 19' 11.2"; 110° 16' 11.4", 7 Feb 2006, P.C. Boyce, Jeland ak Kisai & Wong Sin Yeng AR-1687 (holo, SAR + spirit). **Plates 1C & 4.**

Rheophytic **herb** 16-40 cm high. **Stem** condensed, 2-6 cm long, 0.8-2 cm diam. with robust more or less reddish-tinged roots 1.5-2.5 mm diam. **Leaves** several to 15 together; petiole 6-15 cm long, 1.5-2.5 mm diam., D-shaped in cross-section, minutely aperous, sheathing only at the extreme base, the wings extended into a narrowly triangular purple to reddish ligular portion 5-8 cm long drying dark brown; blade very narrowly elliptic to narrowly elliptic-oblong to oblanceolate, coriaceous, dark green adaxially, paler abaxially, 10-24 cm long × 1.5-3.5 cm wide, the base cuneate, the apex acute and apiculate for 2-3 mm; midrib robust, abaxially prominent, adaxially impressed, with (6-)7-10 primary lateral veins on each side diverging at 35-45° and more or less regularly alternating with lesser interprimary veins; secondary venation adaxially more-or-less obscure, abaxially fine and dense; tertiary venation obscure. **Inflorescence** solitary; peduncle shorter than to equalling, or rarely exceeding the length of the whole leaf, 11-24 cm long, 1.8-2 mm diam., purple to reddish, minutely asperous. **Spathe** nodding at anthesis, subcylindric-obovoid, 3-4 cm long, apically beaked for 3-4 mm, spathe at anthesis shading proximally to distally from deep olive-green through very pale pink to medium pink, the interior of the spathe tip rostrum with 5-7 conspicuous keels, opening in the upper third, then the upper part caducous. **Spadix** the bullet-shaped, with the male portion tapering towards the apex, anthers with the thecae broadly excavated, and the excavations of



**Plate 4.** *Piptospatha viridistigma* S.Y.Wong, P.C. Boyce & Bogner. A. Inflorescence at female anthesis; B. Detail of spadix at male anthesis. Note the extruded pollen in strands; C. Inflorescence at late female anthesis. Note the conspicuous keels at the orifice of the spathe; D. Inflorescence at onset of male anthesis with spathe limb beginning to shed; E. Inflorescence at late male anthesis with spathe limb shed. Note the copious pollen strands; F. Infructescence at mid-maturity. Note that the persistent lower spathe is broadly funnel-form.

adjacent anthers forming a butterfly-shaped depression, and the diagnostic bright green stigmas and pistils, 2-2.5 cm long, 0.4-0.5 cm diam.; female zone fusiform, 5-7 mm long, 5-7 mm diam.; ovary subcylindric to subprismatic, *ca* 0.9 mm diam.; stigma sessile, as broad as the ovary, thinly discoid; interpistillar staminodes absent from among the pistils; neuter organs (an admixture of staminodes and pistillodes) confined to 1-2 irregular and somewhat oblique rows at the base of the female zone, staminodes truncate and centrally-depressed positioned ventrally, white, pistillodes truncate or weakly convex, positioned dorsally, yellow, all more or less sessile, 0.7-0.9 mm diam., about as high as the pistils; sterile interstice comprised of one complete row of white staminodes and 1-2 rows of the lowermost male flowers larger than the fertile flowers and apparently sterile; male zone stoutly fusiform-cylindric, isodiametric with female zone, and often with a distinct ledge at the base that truncately-overhangs the female zone, 1.3-1.7 cm long, apically obtuse; stamens crowded, truncate, the connective not raised, more-or-less rectangular from above, glabrous, 1.2-1.4 mm across, thecae excavated, adjacent thecae excavations forming a butterfly-shaped depression, deep yellow; pollen extruded in strings. **Fruiting spathe** broadly funnel-shaped, erect, 1.2-1.5 cm diam.; berry obovoid, *ca* 3.5 mm long  $\times$  1.2-2 mm diam.; **seed** cylindric, very slightly ribbed, 1.4-1.6 mm long, brown but outer integument translucent, with a long curved micropylar appendage which rots away in old seeds.

*Other specimens examined:* BORNEO. **Sarawak**, Kuching Division, Padawan, Bukit Manok, 01° 12'; 110° 18', 1 Apr 2004, *P.C. Boyce, Jeland ak Kisai & A. Shafreena AR-14* (SAR, + spirit); *ibid*, 18 Mar 2004, *P.C. Boyce, Jeland ak Kisai & A. Shafreena AR-250* (SAR, + spirit); Siburan, Kampung Giam, Air Terjun Giam, 01° 19' 11.2"; 110° 16' 11.4", 7 Feb 2006, *P.C. Boyce, Jeland ak Kisai & Wong Sin Yeng AR-1687* (SAR, + spirit); Bau, Bongo Range, trail to Tegora Mine, 01° 19' 41.5"; 110° 09' 19.0", 8 Sept. 2007, *P.C. Boyce, Wong Sin Yeng & Alexander Kocyan AR-2185* (SAR, + spirit); Bau, Gunung Lanyang, 11 Apr 2001, *Julia S., et al. SBC 2683* (SAR, SBC); Padawan, Gunung Gayu, 1° 12' 52"; 110° 19' 59", 14 Dec 1995, *Kato et al.* (SAR); Padawan, Stabut, 16 Jan 1970, *Mamit S.29953* (A, BO, E, K, L, MEL, SAR); Padawan, Jalan Kampung Annah Rais, hot springs, 12 Jan 1996, *Mohizah et al. S. 66820* (K, KEP, L, SAN, SAR, US); Padawan, Kampung Sadir ('Sadil'), Mini Hydro Station, *Yii Puan Ching S.51335* (K, SAR); Gunung Siruruh, Sarawak/Kalimantan border, 21 Sep 1987, *Yii Puan Ching S. 55240* (K, KEP, L, SAN, SAR, US). Sarawak, Samarahan Division, Serian, Sungai Ranchan ('Renchang'), Feb 1963, *Ashton S.21298* (K, L, SAR, SING); Tebakang, ('Tabakang'), Bukit Alak, *Awa & Paie S.45730* (K, SAR); Serian, Pichin, Umon Murut, Tiab Belanting, 01° 08' 03.7"; 110° 27' 00.3"S, 22 Jun 2005,

*P.C. Boyce, Jeland ak Kisai & A. Shafreena AR-1256* (SAR, + spirit); Serian, Pichin, Bung Biringan, 28 Oct 2004, *P.C. Boyce & Simon Kutuh ak Paru AR-733* (SAR, + spirit); Serian, Mongkos, Kampung Batuh Mawang, Labak Ebang, Utak Samat, 5 Jan 2006, *P.C. Boyce & Simon Kutuh ak Paru AR-1658* (SAR, + spirit); Serian, Gunung Niyat, Ulu Sungai Majat, 27 Feb 2002, *Jemree & Enjah S. 85506* (K, KEP, L, SAN, SAR); Serian, Ranchan Falls, 26 Feb 1993, *Lai Chak Teck, Rantai et al. S. 66046* (K, KEP, SAR); Gunung Sirang, nr Sarawak/Kalimantan border, *Mamit S.35875* (L, SAR).

*Habitat:* Rheophytic, usually on limestone, occasionally on sandstone (*pers. obs.*) or basalt (fide *Ashton S.21298*) along small forest streams and waterfalls in light to medium shade, 100 – 350 (950) m asl.

*Distribution:* Borneo, Sarawak, Kuching & Samarahan Divisions, endemic to the Serian & Padawan areas as far NW as the Sungai Tegora (SE flanks of the Bungo range) and the southernmost Bau limestones. As with *P. elongata* it is very likely that *P. viridistigma* extends into adjacent Kalimantan but we have not been able to re-examine the Kalimantan Barat specimens cited by Bogner and Hay (2000).

*Notes:* *Piptospatha viridistigma* is readily differentiated from *P. elongata* and *P. impolita* by the bullet-shaped spadix, with the male portion deep yellow (*vs.* pale cream) tapering towards the apex, the anthers with the thecae broadly excavated with the excavations of adjacent anthers together forming a butterfly-shaped depression, and the diagnostic bright green pistils (from whence the trivial epithet is derived) and stigmas. Other characters include the minutely puberulent petioles and peduncle, pollen extruded in strings (*vs.* masses) and the spathe at anthesis shading proximally to distally from deep olive-green through very pale pink to medium pink. In fruit the persistent fruiting spathe is wide-flared rather than narrowly conical.

Sterile plants of *P. viridistigma* are very similar to *P. elongata*, although the uniformly minutely asperous petioles (D-shaped in cross-section) and longer persistent petiolar sheath are stable morphologies to differentiate *P. viridistigma* from *P. elongata*. To date *P. elongata* has never been collected away from granite.

Despite the long standing obfuscation with *P. elongata* we believe that the closest morphologically similar species is probably *P. burbidgei* (N.E.Br.) M.Hotta based on the presence of a sterile interstice comprised of the lowermost male flowers being larger than the fertile flowers and apparently sterile and intermixed with a complete row of white staminodes (and thus morphologically similar to the staminodal interstice that is diagnostic of *P. burbidgei*) and also the bullet-shaped spadix. However, it must be noted that

vegetatively *P. burbidgei* is quite different in appearance to *P. viridistigma* (indeed different to all other Sarawak *Piptospatha*) and that the apparent similarities in the inflorescences may well be an evolutionary parallel or convergence.

*Etymology*: from the Latin for green (*viride*) and *stigma* in allusion to the strikingly green coloured stigmas.

### **Additional elements included in *P. elongata sensu Bogner and Hay (2000)***

Other elements cited by Bogner and Hay (2000) as belonging to *P. elongata*, but which need to be excluded, or for which doubt exists are:

*Nicolson 1264* (K+photo, L+photo, SAR+photo, US+photo), Kuching Division, Matang FR, 10 mi W of Kuching, is unequivocally *P. grabowskii* (Engl.) Engl.

*Argent et al. 692* (L) from "Miri Division ('4th Divn'), Gunung Mulu NP, Sungai Lansat", is referable to *P. burbidgei*. The first two authors have undertaken extensive fieldwork in the lowlands of Mulu, including the Sungai Lansat, and are confident that *P. elongata* is not present in the area (nor, indeed, anywhere in NE Sarawak), whereas *P. burbidgei* is a common species on the exposed shales throughout the Mulu area, including on the Sungai Lansat.

*McDonald & Ismail 3615* (GH) from "Kalimantan Timur, Bulungan ('Pujungan') Distr., Kayan-Mentarang Reserve,..." may belong to either *P. burbidgei* or *P. manduensis* Bogner & A.Hay, or be referable to a novel taxon but requires re-examination. We are confident that by the considerable geographical disjunction that it is not referable to any species dealt with in detail in this paper.

The depauperate *Hullett s.n.* (SING) collection from Sri Aman Division, Lingga, Batu Gajah, is interesting in that it may be referable to the very poorly known *P. remiformis* Ridl., the type of which is missing but originates from Lingga. At present Lingga is notably under-collected but, based on the few aroids so far gathered from there, harbours an intriguing mixture of otherwise highly localized west Sarawak endemics including *Aridarum nicolsonii* Bogner & M.Hotta and *A. crassum* S.Y.Wong & P.C. Boyce. However, neither of these species in their main distribution occur in the same locality nor on the same geology as *P. elongata*. The Lingga area needs to be

extensively investigated before a confident identification can be made.

### **Informal Groups**

One of the significant contributions in the Bogner and Hay (2000) *Piptospatha* account is the proposal of two groups, the *P. elongata* Group and the *P. grabowskii* Group defined by the persistence or otherwise of the spathe limb into fruiting. We have observed a suite of additional characters that further reinforce the morphological and perhaps phylogenetic validity for these two groups.

#### **Elongata Group**

The spathe limb is caducous during anthesis as reported by Bogner and Hay (2000). Based on our observations, spathe limb senescence begins mid-way through the period of male anthesis, when the somewhat soft-textured limb degrades and becomes increasingly fragile, while at the same time abscising from the leathery and persistent funnel-form lower spathe. By the end of male anthesis the inflorescence is comprised of an erect to sub-erect peduncle and a nodding spathe/spadix from which the spathe limb is already shed and the spadix is still intact. With the completion of male anthesis, providing that the female flowers have been successfully fertilized, the spadix above the female zone is shed – if fertilization has not been successful the entire spadix decays and is shed. The shedding of the distal portion of the spadix is accompanied by the peduncle becoming more or less erect and the axis at the attachment of the spathe twisting so as to bring the funnel-form lower spathe orthotropic to the peduncle; in such a posture the lower spathe later functions as a ‘splash-cup’ dispersal unit. At or shortly after the spathe being brought vertical, the lower spathe perceptibly thickens and turns green.

#### **Grabowskii Group**

Bogner and Hay (2000) defined the Grabowskii Group by (in successfully pollinated inflorescences) the spathe limb persistent throughout and after anthesis with only the very distal-most portion decaying. We are able to add to these observations and confirm that the spathe persists, with the very distal-most portion decaying only after anthesis, until during fruit dispersal at which point the spathe abscises at the junction of the peduncle and is lost along with the dispersing fruits. Other notable differences in the Grabowskii Group are that the inflorescence post-anthesis is declinate by deflexing of the lower part of the peduncle and also the spadix is persistent until post-dispersal, the spent male flowers and various neuter structures are shed, but the axis remains even after the fruits and persistent spathe have been shed. Based on on-going research it appears that the shedding of the distal-most

part of the spathe serves to enlarge the opening at the end of the now much thickened spathe and is perhaps associated with facilitating the shedding of the spent male flowers and neuter organs. It also appears that the spadix axis is perhaps involved with fruit dispersal mechanics but more observations are needed to confirm this. Whatever the outcome of studies on these morphological interactions, it is clear that fruit/seed dispersal mechanics of the *Elongata* and *Grabowskii* groups is fundamentally different.

### **Pistillodes & Staminodes**

Bogner and Hay (2000) noted several instances in *Piptospatha* where it was not possible from dried and alcohol-preserved material to unequivocally assign neuter organs as staminodes or pistillodes, in particular with regard to such neuter organs situated below the female flower zone (i.e., basal-most on the spadix). We have been fortunate to observe a large number of fresh inflorescences of five species that are indigenous to Sarawak; based on these observations we are confident that the lowermost organs in *P. grabowskii* (Plate 1E), *P. elongata* (Plate 1A), *P. impolita* (Plate 1B) and *P. burbidgei* (Plate 1D) are pistillodes, while those present in *P. viridistigma* are comprised of pistillodes and a few staminodes (see Plate 1C).

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