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SYSTEMATICS

Studies on Schismatoglottideae (Araceae) of Borneo XI: *Ooia*, a new genus, and a new generic delimitation for *Piptospatha*

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ABSTRACT. A new genus, *Ooia* S.Y. Wong & P.C. Boyce is erected from *Piptospatha sensu* Bogner & Hay with two species: *Ooia grabowskii* (Engl.) S.Y. Wong & P.C. Boyce and *Ooia kinabaluensis* S.Y. Wong & P.C. Boyce. *Ooia* is unique in the Tribe Schismatoglottideae owing to the persistence of the entire spadix axis through to fruit maturation and dispersal, with the entire axis remaining fresh and the non-female flowers sloughing away. Species of *Piptospatha sensu* Wong & Boyce are here delimitated to include only the Elongata Group, which as defined by Bogner & Hay includes the type species, *Piptospatha insignis* N.E. Br., but which is known only from the type, itself of imprecise origin.

Keyword: Araceae; Borneo; *Ooia*; *Ooia grabowskii*; *Ooia kinabaluensis*; *Piptospatha*; Schismatoglottideae.

INTRODUCTION

Based on molecular analyses of two plastid regions by the first author (Wong et al., 2010) and combined morphological analyses of the very distinctive inflorescence morphology, spathe senescence and dispersal mechanics, tribe Schismatoglottideae has been split into two tribes, with Philonotieae, representing the former neotropical '*Schismatoglottis*'. Apart from this, 4 new genera have been recognized, *Bakoa*, *Schottariella*, *Hestia*, and *Pichinia*, together with the resurrection of *Apoballis* (Boyce and Wong, 2008; 2009; Wong and Boyce, 2009; 2010a; 2010b). In addition to these changes, *Piptospatha sensu* Bogner and Hay (2000) is polyphyletic. Besides the removal of *Piptospatha lucens* into *Bakoa* (Boyce and Wong, 2008), it is concluded here that the *Piptospatha* Grabowskii Group is a separate genus based on molecular work.

An historical overview of *Piptospatha* was provided by Bogner and Hay (2000). The characters used by Bogner & Hay to set generic boundaries were essentially those of Hotta (1965; 1966; 1976), which outlined a genus having an inflorescence without a lower spathe/spathe limb constriction, seeds with micropylar appendages, staminate flowers lacking thecae horns, and a free ligular petiolar sheath. This generic circumscription is not supported by molecular phylogenetic study (Wong et al., 2010). *Piptospatha* sensu Bogner & Hay can now be said to comprise, based on the taxa sampled, three discrete monophyletic lineages; *Piptospatha* as understood here equates to the Elongata Group of Bogner & Hay while their Graboswkii Group comprises at least two lineages recognized here as the genera *Bakoa* (Boyce and Wong, 2008) and *Ooia*. Owing to field-time restraints several species moved to *Piptospatha* by Bogner & Hay (essentially taxa formerly included in *Hottarum* Bogner & Nicolson) have yet to be sampled for this study. The inclusion of these species in a planned extension to this study will quite likely further fragment *Piptospatha* sensu Bogner & Hay in such a way that it will in all probability be shown to comprise five lineages. An additional problem is that the type of *Piptospatha* is *P. insignis* N.E. Br., which is known only from a preserved cultivated plant ex Sabah, Malaysia and has never been re-collected. *Piptospatha insignis*' long-projecting anther connective makes it unique in the genus. Until this species is re-collected and sampled, it is better for the Elongata Group to remain in the genus *Piptospatha* pending further investigation and with the caveat that the type species may very well not be congeneric with other taxa currently (i.e., Bogner and Hay, 2000) assigned to the genus. Removal of *P. insignis* would render *Piptospatha* monospecific and would require that the Elongata Group be transferred to *Rhynchopyle* Engl., currently a generic synonym of *Piptospatha*.

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Key to genera of Schismatoglottideae and their principle subgeneric divisions in Borneo, Jawa and Nusa Tenggara

1a. Wings of petiolar sheath fully or almost fully attached to the petiole; seeds never with a micropylar appendage 2

1b. Wings of petiolar sheath extended into a free ligular portion; seeds sometimes with micropylar appendage 3

2a. Inflorescences on very slender peduncles, nodding at anthesis, peduncle at spathe insertion flexing 180˚ from vertical axis. Infructescences narrowly campanulate, nodding. Plants of podsols .....*Hestia*

2b. Inflorescences erect to nodding at anthesis, if nodding, then either peduncle massive, or peduncle at spathe insertion at most 45˚ from vertical axis. Infructescences fusiform with a constricted orifice, or if campanulate, then thick-walled and erect, never nodding. Plants of various substrates but never on podsols 4

3a. Modules monoeuphyllous, congested in a distichous arrangement; ligular sheath persistent..... ..... *Schismatoglottis insertae sedis*

3b. Modules polyeuphyllous and leaves never distichous; ligular sheath when present marcescent 5

4a. Spathe limb persistent into fruiting. Petiolar sheath usually fully deciduous; spadix interstice always present, invariably at least partly naked..... *Apoballis*

4b. Spathe limb deciduous during anthesis, or marcescent. Petiolar sheath persistent or marcescent; interstice where present always fully clothed with sterile flowers..... *Schismatoglottis* 13

5a. Spathe not constricted 6

5b. Spathe constricted 12

6a. Thecae of anther never with horn- or needle-like projections 7

6b. Thecae of anther each with a horn- or needle-like projection, although these sometimes visible only after female anthesis.....9

7a. Spadix almost completely adnate to spathe; male flowers mostly sterile with a narrow zone of fertile flowers exposed by the spathe opening; peduncle declinate during fruit maturation but twisting to become semi-erect at fruit maturity; spathe persistent into fruiting, and then at fruit maturity swiftly drying, reflexing and opening basally by tearing at peduncle insertion to expose fruits but remaining distally convolute and while in this situation clasping the spadix. Seeds with blunt micropyle.....*Bakoa*

7b. Spadix either entirely free or only part of the female flower zone which is adnate to spathe; male flowers all fertile; peduncle erect (and then spathe limb caducous) or declinate (and spathe persistent) throughout the fruit dispersal; spathe limb either caducous early in anthesis or persistent until fruit maturity and then falling, still fresh, to reveal entire spadix and ripe fruits. Seeds with a pronounced, hooked, micropylar appendage 8

8a. Spathe limb caducous early in anthesis (generally between female and male anthesis); peduncle erect at fruit dispersal; fruiting spathe a funnel-form splash-cup; spent parts of spadix falling post fertilization to leave only the female flower zone sitting in the base of the splash cup; pistils connate into a syncarpium, or free but coherent..... .....*Piptospatha sensu stricto* (Elongata Group + type) excl. *Hottarum*

8b. Spathe limb persistent; peduncle declinate at fruit dispersal; fruiting spathe caducous prior to fruit dispersal, not forming a splash-cup; male and sterile flowers shedding post-anthesis to reveal an obscurely spirally-scarred spadix axis with the fertilized ovaries on a naked stipe revealed by the loss of subpistillar sterile flowers; pistils free.....*Ooia*

9a. Thecae with needle-like projection extending only after female anthesis; projection tipped with a weakly peltate ovate-triangular flap. Appendix composed of pistillodes..... *Schottariella*

9b. Thecae with a horn- or needle-like projection present prior to female anthesis; with the projection pointed and never associated with a terminal flap. Appendix, where present, composed of staminodes.....10

10a. Sterile interstice of spadix with flattened scale-like staminodes; anthers not excavated.....*Bucephalandra*

10b. Sterile interstice absent or with truncate staminodes; anthers nearly always with the top excavated (except *A. incavatum*)..... 11

11a. Thecae at each end of the anther (seen from above) .....*Aridarum* Sect. *Aridarum*

11b. Thecae adjacent on one side of the anther (seen from above) .....*Aridarum* Sect. *Caulescentia*

12a. Thecae of anther without horn- or needle-like projections; ovules on parietal placenta; seeds without a micropylar appendage.....*Schismatoglottis* Multiflora Group

12b. Thecae of anther, each with horn- or needle-like projections; ovules on basal placanta; seeds with a long, hooked micropylar appendage..... *Phymatarum*

13a. Stem pleionanthic.....14

13b. Stem hapaxanthic .....*Schismatoglottis* Calyptrata Group

14a. Petiole sheathing only at extreme base; each foliage leaf alternating with a cataphyll ..... *Schismatoglottis* Tecturata Group

14b. Petiole usually sheathing for at least a third of its length (rarely less); foliage leaves not alternating with cataphylls 15

15a. Inflorescence erect; spathe limb irregularly crumbling and breaking away at or after male anthesis; small to medium plants ..... *Schismatoglottis* Asperata Group

15b. Inflorescence nodding; spathe limb clasping the spadix and more or less marcescent after anthesis, finally falling with spent parts of spadix; massive pachycauls..... *Schismatoglottis* Corneri Group

Ooia S.Y. Wong & P.C. Boyce, *gen. nov.* —TYPUS: *Ooia grabowskii* (Engl.) S.Y. Wong & P.C. Boyce, *comb. nov.*
Figure 1

Herba rheophytica, foliorum petiolus in vaginum supra in pertem liberam longe-triangularis marcescenti productus. Apicem radix vivus cum gelinus viscosus et radix cum gemmae adventitiae numerosus coloniae faciens. Pedunculus floriferorum semierectus et inflorescentia nutans. Flores unisexuales nudi. Flores masculi pubescenti. Ovula pleura, orthotropa ad basim loculi inserta. Pedunculus fructiferorum declinatus. Spathae in fructiferorum infundibuliformis in toto persistens rostrum spathorum exceptus. Axis spadice fructiferorum in toto persistens, floribus non-femineus post anthesin cadens et axis spadice cicatriciferum relictans; ovariis libera.

Small to medium-sized evergreen herbs. Mucigel on root cap, adventitious shoots arising from the root. *Stem* erect or decumbent, usually more or less condensed. *Leaves* several; *petiole sheath* short with long, marcescent triangular ligule; *lamina* elongate-lanceolate to elliptic or oblonceolate, coriaceous, basally cuneate, apex with tubular mucro; primary lateral veins pinnate, running into distinct marginal vein, secondary laterals and higher order venation parallel-pinnate. *Inflorescence* solitary per module, emerging orthotropic, maturing campylotropic to anatropic during the onset of anthesis; *peduncle* subequal to or longer than petiole. *Spathe* stoutly ellipsoid, not constricted, persistent, pink, gaping at anthesis, apex cuspidate to acuminate. *Spadix* sessile with ± oblique insertion to shortly stipitate with the stipe adnate to the spathe, sometimes with a robust basal sterile zone (pistillodes) or absent; *female flower zone* cylindric; *pistils* free, ovary 1-locular, ovules many, placentae 2-4, basal; stigma ± sessile or elevated on a short style, usually as broad as ovary and more or less contiguous with adjacent ones; *male flower zone* contiguous with female flower zone, cylindric to ellipsoid, equal in thickness to female zone, obtuse; *stamens* crowded, minutely hairy to papillate, anthers truncate, connective ± flat; thecae oblong-ellipsoid, dehiscing by apical pore; pollen inaperturate, ellipsoid; appendix absent. *Infructescence* a cluster of free berries held within the persistent, finally disintegrating spathe; berry obovoid to subcylindric, small, green; seed elongate-ellipsoid to cylindric, with long, curved micropylar appendage, testa slightly costate, embryo elongate, endosperm copious.

Distribution. Malesia: Borneo, two species, *Ooia grabowskii* and *O. kinabaluensis*, both endemic.

Habitat. Obligate or facultative rheophytes, occasionally lithophytic, along streams and by waterfalls in lowland to lower montane rainforest. 50-2,300 m alt.

Notes. *Ooia* is unique in the tribe as so far observed by the persistence of the entire spadix axis through to fruit maturation and dispersal, with the entire axis remaining fresh, and the non-female flowers sloughing away; indeed this is unique in the family. The spathe of *Ooia* is persistent late into fruit development, at which point the extreme top margin and associated rostrum are shed, enlarging the spathe orifice to allow spent flowers to be shed from the persistent spadix and later to enable the mature fruits, which decompose at full ripeness, to be washed from the spathe *via* water turbulence. Such inflorescences are pendent and often with their tips submerged in water.

Ooia grabowskii has a distinct pistillode zone (up to $^1/_3$ of the spadix), but the sterile zone is absent in *O. kinabaluensis*. *O. kinabaluensis* is placed into this genus based on the spathe persistent into fruiting although it has not been observed whether the fruits are dispersed *via* turbulence. Placentation is basal in both species.

The spadix in *Ooia kinabaluensis* is sessile but shortly stipitate in all the observed specimens of *O. grabowskii*. The stamens are densely pubescent in *Ooia* and in *Piptospatha perakensis* (Engl.) Ridl. (West Malaysia and Southern Peninsular Thailand) as well.

The thimble-shaped root cap of *Ooia grabowskii* is covered with large amounts of mucigel. Adventitious shoots arise from the primary and lateral roots often in great quantity and are seemingly linked to colonization mechanics. This combination of characters has so far not been observed in the rest of the tribe.

Etymology. This genus is named after our student Mr Ooi Im Hin who has contributed outstanding data on the pollination biology of this tribe.

Ooia grabowskii (Engl.) S.Y. Wong & P.C. Boyce, comb. nov. Basionym: *Rhynchopyle grabowskii* Engl., Bot. Jahrb. Syst. 25: 20 (1898). Synonym: *Piptospatha grabowskii* (Engl.) Engl., Pflanzenr. 55 (IV.23Da): 125 (1912)—TYPE: INDONESIA. Southeast Kalimantan, Mindai-Pramassamalai hills, on rocks of waterfalls of the Pitanakan, 17 June 1882, *F. Grabowski s.n.* (holotype B!).

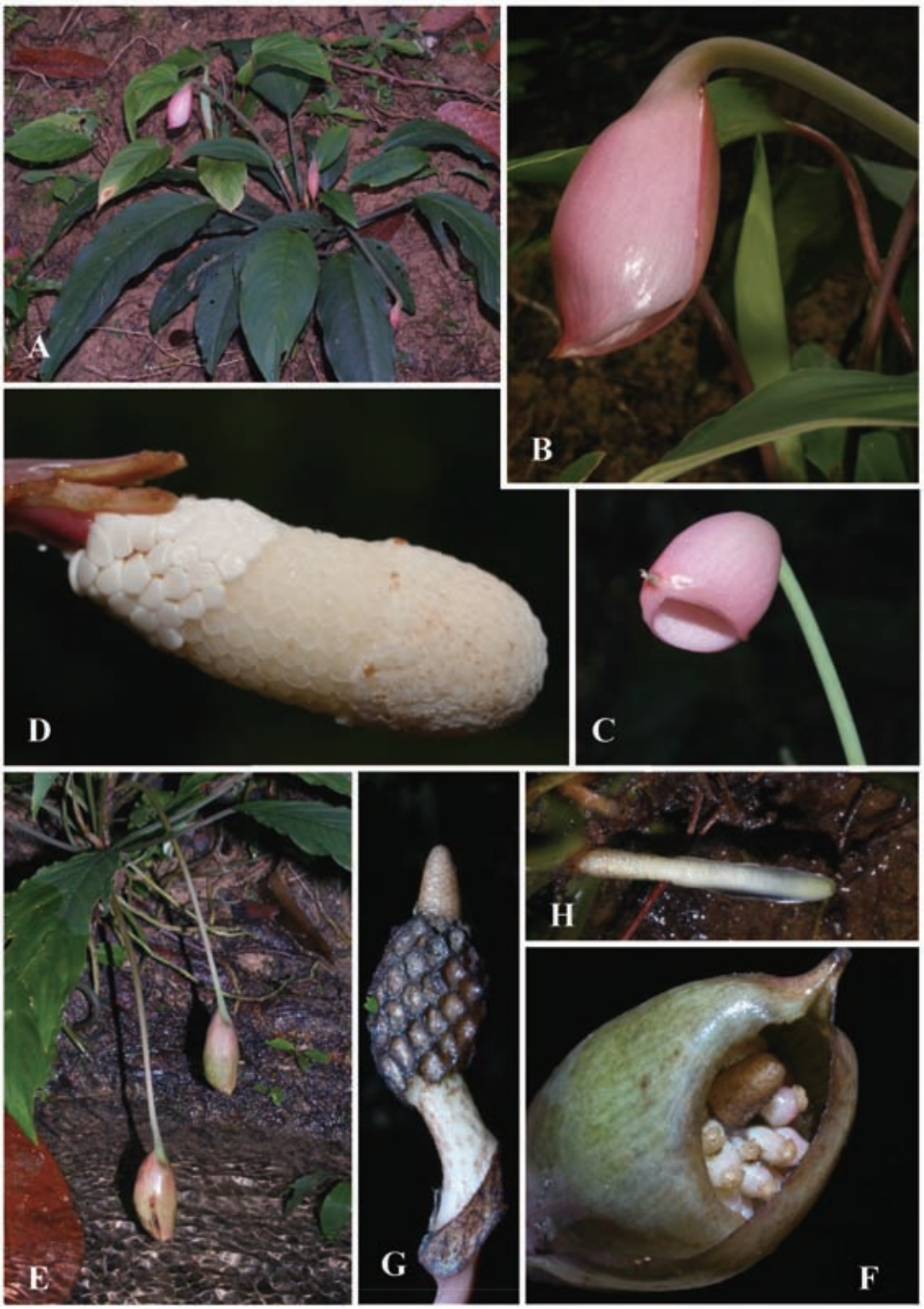

Figure 1. *Ooia grabowskii* (Engl.) S.Y. Wong & P.C. Boyce. A, flowering plant in habitat; B, inflorescence at female anthesis, side view; C, inflorescence at female anthesis, three quarter view, note the spathe tip rostrum; D, spadix at female anthesis with spathe artificially removed,. Note the large zone of pistillodes below the female flower zone and the pubescent male flowers, fertile to the tip of the spadix; E, fruiting plant in habitat with two almost mature infructescences on their declinate peduncles. Note the spathe almost totally persistent; F, infructescence nearing maturity. Note the separate ovaries contained inside the persistent spathe and the axis of the spadix revealed by the loss of the male flowers; the spathe rostrum has yet to be shed; G, Spadix post-fruit dispersal. Note that the spathe has been lost naturally to reveal the spadix axis with distinctive flower scars resulting from the shedding of ripe fruits, and weaker scars from the shedding of male and sterile flowers. The fruits were on the expanded part of the spadix; H, active root showing the mucigel cap.

Synonym: *Piptospatha havilandii* (Engl.) Engl., Pflanzenr. 55 (IV.23Da) (1912) 128.—*Rhynchopyle havilandii* Engl., Bot. Jahrb. Syst. 37 (1905) 125.—*Schismatoglottis havilandii* (Engl.) M. Hotta, Mem. Coll. Sci. Univ. Kyoto, Ser. B, 32 (1966) 233.—TYPE: MALAYSIA. Sarawak, Kapit Division, Rejang, Belaga, Nov 1892, *G.D. Haviland 2191* (holotype: BM!; isotypes: CAL, K!, SING!).

Rheophytic herb 20-50 cm tall. *Stem* c. 4-8 (-20) cm long, mostly condensed, occasionally more elongate with internodes to 1 cm long, 0.6-1.5 cm diam., roots strong, 2.5-4 mm thick. *Leaves* c. 4-8 together; *petiole* green to purple, 6-23 cm long, 2.5-3 mm diam., adaxially canaliculate, sheathing only at the very bottom of the base, the wings extended into a narrowly triangular ligular portion 5-10 cm long; blade narrowly elliptic to elliptic-oblong, 12-28 cm long × 4-10 cm wide, dull mid- to dark green adaxially, very rarely variegated in an irregular spattered pattern, abaxially paler, the base cuneate, the apex acute and apiculate for 2-3 mm; midrib prominent abaxially, adaxially somewhat impressed, sometimes abaxially purple, with 8-14 (-20) primary lateral veins on each side, more or less regularly alternating with lesser interprimaries and diverging at c. 45-60°; secondary venation abaxially fine, adaxially obscure; tertiary venation obscure. *Inflorescence* solitary (sometimes a few together but alternating with foliage leaves); peduncle 10-22 cm long, 2-3 mm diam., always shorter than the leaves, green to purple. *Spathe* ovoid-subcylindric, (2-) 3-5 cm long, 0.8-1.4 cm diam., apically beaked for 2.5-4 mm, persistent, rose pink to purple to brownish pink, more or less nodding at anthesis. *Spadix* (1.2-) 2.2-3 cm long, subcylindric to slightly clavate, shortly stipitate with the stipe adnate to the spathe, white to yellowish; *female flower zone* (0.3-) 0.5-1 cm long, 0.3-0.9 cm diam.; ovary ovoid, slightly angled, c. 1.4 mm diam.; stigma sessile to raised on a short style to 0.5 mm long, discoid, about as wide as the ovary, drying almost black; *interpistillar staminodes* absent from among the pistils, confined to a robust zone below the female flower zone of up to 6 oblique whorls; staminodes shortly stipitate, to 1.2 mm diam., irregularly polygonal, flat-topped with the centre usually somewhat impressed and the margins pale coloured (? with dried exudate); sterile interstice absent; *male flower zone* cylindric to ellipsoid, apically obtuse, fertile to apex; stamens crowded, mostly arranged in pairs, truncate, flat-topped, more or less rectangular from above, c. 1.1 mm across, minutely hairy on the upper surface especially at the margins; thecae opening through apical pores. *Fruiting spathe* ovoid-subcylindric, green to reddish green to greenish brown, obliquely erect, to 5 cm long, persistent then eventually more or less disintegrating; fruits in a dense cluster; berry broadly obovoid, crowded with old stigma remnant, 2-2.5 mm long, 2.8-3.2 mm diam.; seed subcylindric, 2.4-2.6 mm long, slightly ribbed, light brown with a transparent long curved micropylar appendage.

Distribution. Malesia: endemic to Borneo-Sarawak, W. Sabah, and scattered localities in Kalimantan.

Habitat. Obligate rheophytes in and beside streams and waterfalls over a variety of substrates including ultramafics & limestone etc.; lowlands to c. 2,000 m alt.

Note. The genus *Rhynchopyle* cannot be resurrected for *R. grabowskii* Engl. as the type for *Rhynchopyle* is *R. elongata* (Engl.) Engl. (≡*Piptospatha elongata*).

Other specimens examined. **MALAYSIA.** Sarawak: Kuching Division: Padawan, Puncak Borneo, trail behind Malesiana Tropicals Nursery to Hornbill Resort golf course maintenance kampong, 01°07’ 35.1”; 110°13’ 28.8”, 30 Sep 2003, *P.C. Boyce & Jeland ak Kisai AR-93.1* (SAR); Bau, Singai, Batu Taring, 19 Jun 2004 *P.C. Boyce, Jeland ak Kisai & Jipom ak Tisai AR-469* (SAR); Lundu, Jalan Lundu, Stunggang Ulu, 01°36’ 21.2”; 109°53’ 46.3”, 21 Sept 2005, *P.C. Boyce, R. Kneer & Jeland ak Kisai AR-1367* (SAR); Padawan, Kampung Sadir, 2 Feb 2006, *P.C. Boyce & Simon Kutuh ak Paru AR-1699* (SAR); Matang, Kubah National Park, Waterfall Trail, 01°35’ 40.2”; 110°10’ 45.9”, 28 Jul 2007, *P.C. Boyce, Wong Sin Yeng & Simon Maclean AR-2117* (SAR); Matang, Kubah National Park, Sg. Bungen, 01°36’ 30.9”; 110°11’ 35.0”, 28 Jul 2007, *P.C. Boyce, Wong Sin Yeng & Simon Maclean AR-2118* (SAR); *Ooi Im Hin OIH-18 (AR-2339)* (SAR); Bau, Bongo Range, trail to Tegora Mine, 01°19’ 41.5”; 110°09’ 19.0”, 8 Sep 2007, *P.C. Boyce, Wong Sin Yeng & Alexander Kocyan AR-2186* (SAR); 13th mile, Matang, *Brooke 9441* (L); *9471* (L); Padawan, Tibia Sapit, nr Sarawak/Kalimantan border, *Mamit S25875* (K, SAR); Kampung Sadir, c. 50 mi from Kuching, *Mamit S33367* (L, SAR); Ulu Sungai Sluba, Gunung Merubong, *Yii S 51388* (K, SAR). Sri Aman Division: Pantu, Gunung Gaharu, 01°03’ 11.1”; 110°52’ 55.8”, 21 July 6, *P.C. Boyce at al. AR-1923* (SAR); Lubok Antu, Batang Ai, Nanga Sumpa, Rumah Gumbang, Sungai Delok, 01°12’ 16.2”; 112°03’ 26.0”, 24 May 2008, *P.C. Boyce, Wong Sin Yeng & Jipom ak Tisai AR-2374* (SAR); Lubok Antu, Batang Ai, Nanga Sumpa, Sungai Pedali, 01°11’ 58.9”; 112°03’ 27.0”, 25 May 2008, *P.C. Boyce, Wong Sin Yeng & Jipom ak Tisai AR-2391*- (SAR); Lubok Antu, Batang Ai, Nanga Sumpa, Wong Ensalai, 01°11’ 51.0”; 112°03’ 39.9”, *26 May 08*, *P.C. Boyce, Wong Sin Yeng & Jipom ak Tisai AR-2417* (SAR); Lubok Antu, Sungai Delok, nr Nanga Sumpa, *Christensen 1200* (K); N slopes of Gunung Penrissen, *Jacobs 5005* (B, K, L). Sarikei Division: Sarikei, Ulu Sarikei, 01°55’ 05.4”; 111°29’ 35.8”, 7 Dec 2005, *P.C. Boyce, et al. AR-1580* (SAR); Sarikei, Ulu Sarikei, Rumah Nyuka, 23 Oct 2006, *P.C. Boyce & Wong Sin Yeng AR-2043* (SAR); AR-2043 (SAR); Sri Aman (‘Simanggang’), Tisak Sekarang, Ulu Sungai Panabun, *Paie S45112* (K, L, SAR); Sri Aman (‘Simanggang’), Sekarang, Kampung Entalau, Sungai Antu, *Paie S45158* (K, L, SAR). Kapit Division: Nanga Gaat, Rejang Wood Concession, Sungai Piat, 01°38’ 09.1”; 113°24’ 09.9”, 14 Oct 2003, *P.C. Boyce & Jeland ak Kisai AR-93.2* (SAR); Kapit, Pergunungan Hose, 02°14’ 47.2”; 113°41’ 24.9”, 22 Apr 2004, *P.C. Boyce & Jeland ak Kisai AR-294* (SAR); *AR-296* (SAR); Nanga Gaat, Rejang

Wood Concession, km 65 road to Camp Gahada, 01°42' 01.1"; 113°31' 14.8", 12 May 2004, *P.C. Boyce, Jeland ak Kisai & Jipom ak Tisai AR-371* (SAR); Nanga Gaat, Rejang Wood Concession, km 55 road to Camp Gahada, 01°44' 44.5"; 113°28' 32.3", 13 May 2004, *P.C. Boyce, Jeland ak Kisai & Jipom ak Tisai AR-390* (SAR); Belaga, km 10 Bakun-Bintulu-Miri road junction, 02°50' 51.7"; 114°01' 57.6", 11 Oct 2005, *P.C. Boyce, Jeland ak Kisai & Jipom ak Tisai AR-1414* (SAR); *AR-1422* (SAR); Kapit, Taman Rekreasi Sebabai, 01°56' 45.6"; 112°54' 16.8", 3 Apr 2009, *P.C. Boyce & Wong Sin Yeng AR-2430* (SAR); Teneong, *Brooke 9137* (L, SING); Sungai Kapit beyond Rumah Undut, *Chai S36010* (K, L, SAR); Gat, Upper Rejang R, *Clemens & Clemens 22131* (K); Kapit, Rejang, Kalong, *Haviland 3130* (SING); Balleh, Sungai Entawau, *Othman S41566* (L, SAR); Ulu Belaga, Ulu Sungai Sepako, *Othman et al. S43886* (K, SAR); Kapit, Sut, Sungai Bena, *Paie S41701* (K, L, SAR). Bintulu Division: Bintulu, Bukit Setiam, 02°59' 26.1"; 112°55' 54.4", 11 Aug 2004, *P.C. Boyce & Jeland ak Kisai AR-622* (SAR); Tau Range, Sungai Mayeng, *Purseglove 5298* (K, L, SING). Miri Division: Kelabit Highlands, around Pa Dalih, *Christensen 222* (K) & *604* (K); Kelabit Highlands, Batu Lawi, *Nooteboom & Chai 2305* (B, L, SAR); Merurong Plateau, Ulu Sungai Pesu, *Othman et al. S49116* (K). Limbang Division: Nanga Medamit, Mulu N.P., Melinau Gorge, 3 Oct 2007, *P.C. Boyce et al. AR-2300* (SAR); Bakelalan, *Brooke 10392* (L). SABAH: Pedalaman Division: Tenom District: Kaang, *Krispinus 120082* (K); Pensiangan District: Kampung Pun Batu, Bukit Pun Batu, *Lim et al. 1502* (SING). Tambunan District: Gunung Trusmadi, *Nooteboom 1389* (B, L) & *1417* (L). Pantai Barat Division: Tenom District, Ulu Senagong, *Boyce 1434* (K). Ranau District: Ulu Sungai Liwogu, *Amin et al. 123353* (K). Kota Belud District: Kinabalu, Sungai Liwagu, NE of Kundasing, *Allen AK66-34* (SING); Melangkap Kappa, NW side of Gunung Kinabalu, *Beaman et al. 8594* (K); Kota Belud District, Kinabalu, Ulu Liwagu & Ulu Mesilau, *Chew et al. 2501* (K, L, SING); Kota Belud District, Kinabalu, Kundusan, *Clemens & Clemens 29136* (GH, K, L, SING); Kota Belud District, Kinabalu, Dehobang River, *Clemens & Clemens 31876* (GH); Kampung Kiau Nuluh, *Jsimin Dianeh 461* (K); Kinabalu, Penibukan, Sg. Tahubang, *Nooteboom & Aban 1508* (B, K, L); Kinabalu, Bukit Burong trail, *Price 165* (K); Kinabalu NP, near park HQ, *Vermeulen & Chan 392* (L). **INDONESIA.** Kalimantan: Kalimantan Barat: Serawei, nr Djotta, *Winkler 330* (HBG, L). Kalimantan Timur: Wanariset, Long Sg. Barang, *van Valkenburg 1040* (K); Kalimantan Selatan: foot of G. Besar, Ratan Arai to Bato Kamba, *Murata 4250* (L).

Ooia kinabaluensis (Bogner) S.Y. Wong & P.C. Boyce, comb. nov. Basionym: *Hottarum kinabaluense* Bogner, Pl. Syst. Evol. 145: 161 (1984). Synonym: *Piptospatha kinabaluensis* (Bogner) Bogner & A. Hay, Aroideana 9(1): 216 (2000).—TYPE: MALAYSIA. Sabah, Pantai Barat Division, Kota Belud District, S slope of Mt. Kinabalu, E tributary of Sungai Mesilau, at old trail between Mesilau Cave and Janet's Halt, 7 Sep 1963, *S. Collenette 21634* (holotype L!; isotype K!).

Diminutive to moderately robust herb 10-50 cm tall. *Stem* condensed, 1-10 cm long, 0.4-1.5 cm diam., sometimes reddish. *Leaves* few together; *petiole* 2.5-30 cm long, 0.9-3 mm diam., sheathing only at the extreme base, the wings extended into a narrowly triangular ligular portion 2-16 cm long; blade coriaceous, narrowly elliptic to ovate, 3-21 cm long × 1.3 -9.5 cm wide, the base cuneate, the apex acute to shortly acuminate and apiculate for 1-4 mm; midrib robust, abaxially somewhat prominent, with (3-) 4-12 primary lateral veins on each side, in very robust specimens more or less regularly alternating with lesser interprimaries, diverging at c. 60°; secondary venation fine, adaxially more or less obscure; tertiary venation forming a faint tessellate reticulum abaxially. *Inflorescence* solitary; peduncle 4-18 cm long, slender. *Spathe* 1.6-2 cm long (to 3.2 cm in fruit), reddish, persistent, held more or less erect, more or less obovoid, apiculate for 1-4 mm. *Spadix* 1.5-1.8 cm long, obliquely adnate to the spathe at the base; female zone 6-8 mm long, c. 3 mm diam.; pistils 1-1.2 mm high, c. 0.6-0.8 mm diam.; ovary ellipsoid, with basal placentation; stigma sessile, discoid, slightly narrower than the ovary, c. 0.5 mm diam.; interpistillar staminodes absent from within, below or above the female zone; interstice absent; male zone 0.9-1 cm long, more or less ellipsoid, apically obtuse; stamens crowded, truncate, elongate to more or less rectangular from above, papillate, 0.8-0.9 mm across. *Fruits* completely contained within the persistent spathe; berry depressed-globular 2-4.5 mm diam., crowned by old stigma remains; seed elongate, 2-3 mm long, brown, longitudinally ribbed, with a curved long translucent micropylar appendage up to twice the length of the seed.

Distribution. Malesia: endemic to North West Borneo.

Habitat. Facultatively rheophytic, lithophytic or terrestrial in shade; 750-2,300 m alt.

Notes. *Ooia kinabaluensis* is placed into this genus based on its spathe being wholly persistent into fruiting and on its basal placentation.

For a long time it was believed that *O. kinabaluensis* was very locally endemic on Kinabalu. However, in recent years several collections, some of which had been long overlooked, have revealed that the species is widespread in eastern Sabah and also disjunct at Bukit Pagon, Brunei/Sarawak border.

Other specimens examined. **BRUNEI.** Temburong District: Gunung Retak, *Johns 6743* (BRUN, K); Amo, headwaters of Temburong R, NE of Gunung Retak, *Sands et al. 5375* (K). SABAH: Kota Bulud Division: Ranau District: Mesilau ('Mosilou'), *Amin 123519* (K); Kundasang, nr Golf Course, *Madani 111616* (K); Above upper edge of Mt Kinabalu Golf Course site nr E Mesilau River, *Beaman et al. 7473* (K); Gunung Kinabalu, Eastern Shoulder, *Chew et al. 708* (K, L); Kinabalu, Silau Basin, *Furtado sub Clemens & Clemens 29135* (K, L, SING); Kinabalu, Marai Parai, *Clemens & Clemens 32290* (GH,

L); Kinabalu NP, Park Headquarters, *Edwards 2162* (K); Kinabalu, Kundasang by the Liwagu R., *Furtado s.n.* (SING); Nr HQ of Kinabalu NP, *Ogata 11083* (L).

Piptospatha N.E. Br. *sensu* S.Y. Wong & P.C. Boyce.— TYPE: *Piptospatha insignis* N.E. Br., Gard. Chron. 11: 138 (1879). Cult. RBG Kew ex Malaysia, Sabah, without further locality (orig. coll. *Burgidge 95*), *N.E. Brown s.n.* (holotype: K!; isotypes: BM!, FI-B!).

Figure 2

Small to medium-sized evergreen herbs; *Stem* erect or decumbent, usually more or less condensed. *Leaves* several; *petiole sheath* short with long, marcescent ligule; *lamina* elongate-lanceolate to elliptic or oblonceolate, coriaceous, basally cuneate, apex with tubular mucro; primary lateral veins pinnate, running into distinct marginal vein, secondary laterals and higher order venation parallel-pinnate. *Inflorescence* solitary per module, emerging orthotropic, maturing (prior to the onset of anthesis) anatropic; peduncle subequal to or longer than petiole (rarely very short - *P. brevipedunculata*). *Spathe* stoutly ellipsoid, not constricted, usually pink, lower part persistent and cup-like, upper part slightly gaping at anthesis, caducous, cuspidate to acuminate. *Spadix* sessile with oblique insertion, pistillodes at the base (sometimes intermixed with staminodes in *P. viridistigma*); *female zone* cylindric; *pistils* connate into a synandrium, or free but cohering to neighbouring ones, ovary 1-locular, ovules many, placentae 2-4, parietal; stigma ± sessile, usually as broad as ovary and more or less contiguous with adjacent ones; *male zone* contiguous with female, cylindric to ellipsoid, equal in thickness to female, obtuse; *stamens* arranged in pairs or irregular, free, compressed, anthers truncate, connective ± flat or expanded apically or with conical beak (*P. insigni*s) overtopping thecae; *thecae* oblong-ellipsoid, dehiscing by apical pore; *pollen* inaperturate, ellipsoid, small to medium-sized (mean 25 μm), exine psilate; *appendix* absent (present in *P. brevipedunculata*, short, reduced to a few terminal sterile stamens). *Infructescence* a cluster of berries subtended by the obconic spathe base, or held within the entirely persistent spathe, spadix above fruiting portion degrading and shed entirely soon after fertilization; *berry* obovoid to subcylindric, small, green, either fused into a syncarpium (most species), or free but cohering to adjacent berries (*P. insignis*); seed numerous, elongate-ellipsoid to cylindric, with long, curved micropylar appendage, testa slightly costate, embryo elongate, endosperm copious.

Distribution. West Malesia: 5 core species + 6 satellite species (see discussion below). Demography is currently: Malay Peninsula (2 species: *P. perakensis,* also extending to southern Thailand & *P. ridleyi* N.E. Br. ex Hook. *f.*). Borneo (4 species: *P. insignis, P. elongata*, *P. impolita*, *P.* and *P. viridistigma*).

Habitat. Obligate rheophytes along streams and by waterfalls in lowland to lower montane rainforest areas.

Notes. Piptospatha is defined by the shedding spathe limb, erect splash cup, parietal placentation, fruits either fused into a syncarpium (most) or free but cohereing (*P. insignis*), and the presence of micropylar appendage on the seed. There are only five species which fit into this new definition of *Piptospatha*: *P. elongata* (Engl.) N.E. Br., *P. impolita* P.C. Boyce, S.Y. Wong & Bogner, *P. ridleyi* and *P. viridistigma* P.C. Boyce, S.Y. Wong & Bogner; Wong et al., 2009 (the *Piptospatha elongata* complex) and, the type of the genus: *P. insignis*.

Piptospatha brevipedunculata (H. Okada & Y. Mori) Bogner & A. Hay, *P. manduensis* Bogner & A. Hay, and *P. truncata* (M. Hotta) Bogner & A. Hay are best recognized only provisionally as belonging to *Piptospatha*, i.e., "satellite" species, until new collections make it possible to be clearer about their relationship. *Piptospatha brevipedunculata* has a white spathe throughout anthesis, which is not observed in the core *Piptospatha,* and it is also one of the two species in the genus with the presence of an appendix in the spadix. The micropylar appendage is transparent, and placentation basal. The peduncle is much shorter than the petiole which is unique in *Piptospatha*. It is suspected that this species might not be closely related to *Piptospatha*.

Piptospatha manduensis, is superficially similar to *Ooia grabowskii,* based on its hairy stamens, the male zone fertile to the apex, and in the more robust zone of staminodes below the female zone. However, Bogner and Hay (2000) mentioned that it has a half caducous upper spathe. Study of the type specimen by the second author suggests that the abscission of the spathe limb was not a natural occurrence; so it might be a misleading observation. This species is maintained in *Piptospatha* at the moment based on the spathe abscission. Post anthesis spadix degradation is unknown.

Piptospatha truncata is the type of the genus *Hottarum* but has yet to be included in this study because of a lack of living material for molecular analysis. Placentation in *P. truncata* is basal, and an appendix is present.

Former *Hottarum sarikeense* Bogner & M. Hotta (treated as *Schismatoglottis* by Bogner and Hay, 2000), and an additional novel species, fall outside the *Schismatoglottis* clade (Wong et al., 2010), and thus it appears possible that *Hottarum* may require resurrection. More work is needed, including analyses of the type of *Hottarum* (*H. truncatum* (M. Hotta) Bogner & Nicolson).

Piptospatha perakensis is distributed throughout Peninsular Malaysia through to Southern Thailand and is distinctive with its green spathe which changes to white during male anthesis. The species, along with Peninsular Malaysian *P. ridleyi* is currently being studied (Ooi in prep.).

Piptospatha remiformis Ridl., treated as a doubtful species by Bogner and Hay, 2000, has yet to recollected. It was described based on the inadequate fruiting material.

Piptospatha burbidgei (N.E. Br.) M. Hotta is distinguished by its prominent interstice of pistillodes and basal placentation. It has usually extremely fine primary vena-

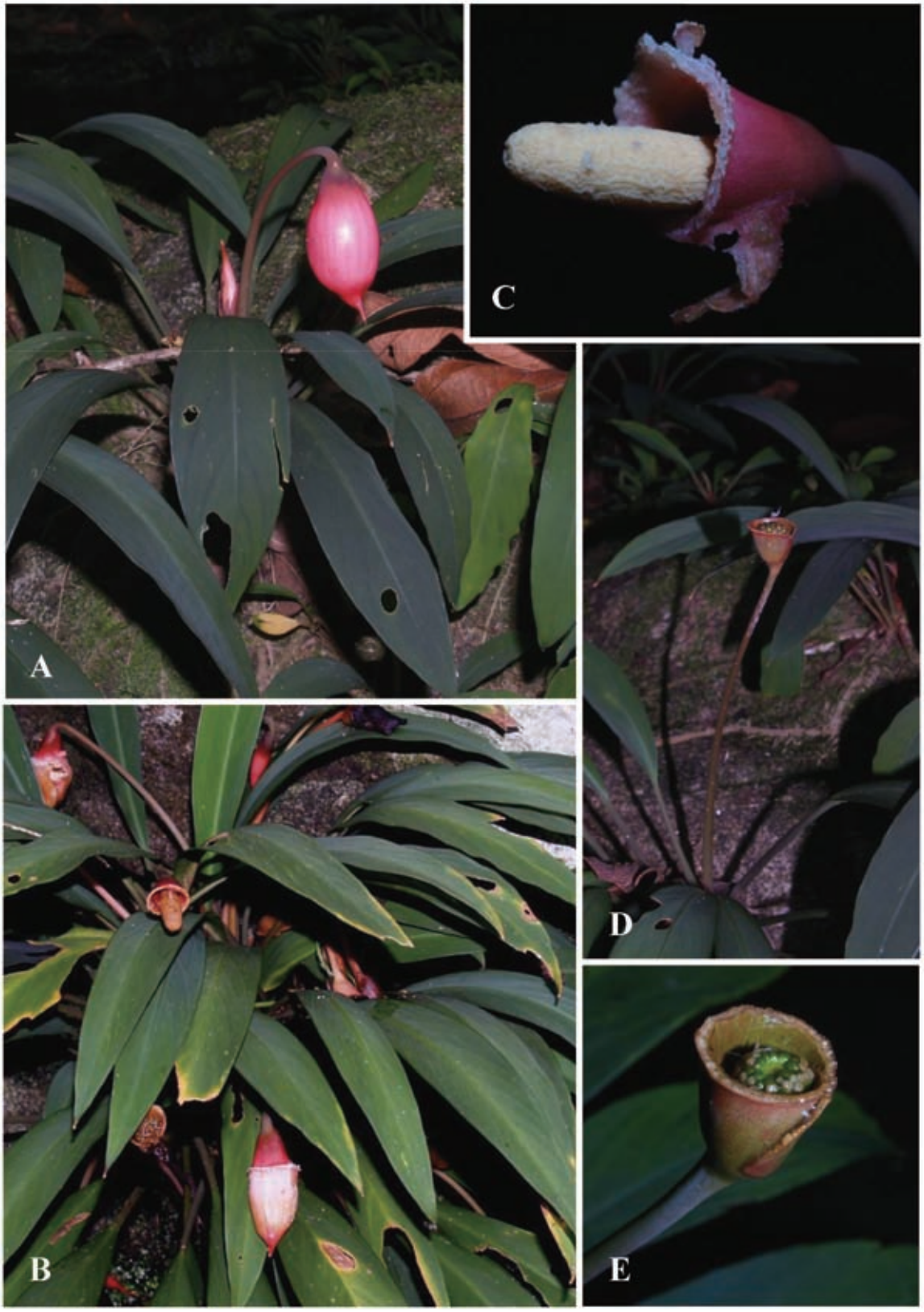

Figure 2. *Piptospatha elongata* (Engl.) N.E. Br. A, flowering plant in habitat, the inflorescence is at female anthesis; B, plant in habitat with inflorescence at male anthesis, spathe limb of nearest inflorescence just beginning to abscise; inflorescence in middle post anthesis, spathe limb almost shed but spadix still present; inflorescence at rear left hand side late male anthesis, spathe limb almost shed; C, inflorescence at male anthesis, note the spathe limb shed to leave a persistent cup-like lower spathe; D, plant in nearly mature fruit; note the erect peduncle and persistent lower spathe forming a splash-cup; E, splash-cup formed by persistent lower spathe; note the fruits connate into a syncarpium.

tion, and the petiole is shorter than the lamina; the spadix is very shortly stipitate with the stipe being more or less free, not or hardly adnate to the spathe; the stigma are coarsely papillate (at anthesis) and laterally contiguous; the interstice is sterile, and the stamens are almost flat-topped and glabrous.

Bogner and Hay (2000) viewed the interstice of the *P. burbidgei* appendix as composed of staminodes, but based on our observations of fresh inflorescences, these structures are pistillodes. However, ontogenetic work needs to be carried out to confirm this.

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婆羅洲天南星科落檐族之研究XI：新屬 *Ooia* 與 *Piptospatha* 屬之重新界定

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本文報導的婆羅洲天南星科落檐族新屬 *Ooia* 係由 Bogner & Hay 界定的 *Piptospatha* 屬獨立出來，包含 *Ooia grabowskii* 與 *O. kinabaluensis* 兩個物種。*Ooia* 屬與其它落檐族植物明顯有別之處在於佛焰花序軸宿存，整個花序軸至果實成熟與散播時期仍保持新鮮，僅非雌性花會脫落。*Ooia* 屬僅包含 *Piptospatha* 屬內由 Bogner & Hay 所定義、包含模式種 *Piptospatha insignis* 的 Elongata Group，但該模式種植物僅模式標本爲人所知，確切產地不詳。

關鍵詞：天南星科；婆羅洲；*Ooia*；*Ooia grabowskii*；*Ooia kinabaluensis*；*Piptospatha*；落檐族。