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Willdenowia
Annals of the Botanic Garden and Botanical Museum Berlin-Dahlem

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# Six new *Cryptocoryne* taxa (*Araceae*) from Kalimantan, Borneo

Version of record first published online on 23 November 2017 ahead of inclusion in December 2017 issue.

**Abstract:** Five new species and one new variety of *Cryptocoryne* (*Araceae*) from the Schwaner mountains (W Kalimantan) and the Müller mountains (W and C Kalimantan) are described. These new taxa makes a very interesting and unique addition to the genus *Cryptocoryne*. Two of the species have surprisingly low chromosome numbers: *C. bastmeijeri* with $2n = 14$ and *C. isae* with $2n = 10$. A key to the *Cryptocoryne* taxa of Borneo is provided.

**Key words:** *Araceae*, Borneo, chromosome numbers, *Cryptocoryne*, identification key, Kalimantan, Müller mountains, new taxa, rosette plants, Schwaner mountains

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## Introduction

The first thorough study of the genus *Cryptocoryne* Fisch. ex Wydler (*Araceae*) in Borneo was by the Italian botanist Odoardo Beccari in 1865 and 1867, surveying the species of Sarawak. He collected *C. ciliata* (Roxb.) Schott, *C. cordata* Griff. (that collection now referred to *C. cordata* var. *grabowskii* (Engl.) N. Jacobsen), and eight new species, which were subsequently described by Engler (1879) and elaborated on three years later (Engler 1883) (*C. auriculata* Engl., *C. bullosa* Engl., *C. ferruginea* Engl., *C. lingua* Engl., *C. longicauda* Engl., *C. pallidinervia* Engl., *C. spathulata* Engl. [now referred to *C. lingua*] and *C. striolata* Engl.). Brown (1880) described *C. caudata* N. E. Br. (now referred to *C. longicauda*) and Engler (1898) described *C. grabowskii* Engl. (now referred to *C. cordata* var. *grabowskii*), and a total of nine species were recognized in Borneo by the turn of the century. *Cryptocoryne grandis* Ridl. (now referred to *C. cordata* var. *grabowskii*) was described by Ridley (1905).

In 1970 J. Schulze (Schulze 1971) travelled around Sarawak and recollected Beccari's and Engler's nine species at the original localities and added a number of

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new localities. Starting in the 1970s, the work of H. C. D. de Wit (see, e.g., Wit 1971, 1990), Rataj (1975) and Jacobsen (1985) added another four currently accepted taxa to the *Cryptocoryne* flora of Borneo: the triploid *C. ciliata* var. *latifolia* Rataj (Rataj 1975), *C. edithiae* De Wit (now referred to *C.* ×*purpurea* nothovar. *borneoensis* N. Jacobsen & al.), *C. fusca* De Wit and *C. keei* N. Jacobsen. This increased the number of recognized taxa to 13, whereas another five taxa described by de Wit and Rataj are now considered to be synonyms of taxa already known for Borneo: *C. gracilis* De Wit (now referred to *C. striolata*), *C. pontederiifolia* subsp. *sarawacensis* Rataj (now referred to *C. ferruginea* Engl.), *C. tortilis* De Wit (now referred to *C. fusca*), *C. venemae* De Wit (now referred to *C. pallidinervia*) and *C. zonata* De Wit (now referred to *C. cordata* var. *grabowskii*).

Ipor & al. (2009) further surveyed the *Cryptocoryne* flora of Sarawak adding about 140 new *Cryptocoryne* localities to the previously known about 80 (Jacobsen 1985). At the beginning of the new millennium there were further surveys by H. Budianto, T. Idei, H. Kishi, Y. Sasaki, N. Takahashi and S. Wongso in Kalimantan (Indonesian Borneo), resulting in six additional taxa (*C. griffithii* Schott [a new record for Borneo], *C. ideii* Budianto, *C. noritoi* Wongso, *C.* ×*purpurea* nothovar. *borneoensis* N. Jacobsen & al., *C. uenoi* Y. Sasaki, *C. yujii* Bastm. and *C. zaidiana* Ipor & Tawan). During the next ten years another three taxa were added (*C. aura* Wongso & Ipor, *C.* ×*batangkayanensis* Ipor & al. and *C. ferruginea* var. *sekadauensis* Bastm. & al.) making a total of 23 recognized taxa on the island.

Recently an intensified investigation of Bornean *Cryptocoryne* has been undertaken, resulting in the discovery of several new taxa, especially in connection with surveying the Schwaner mountains and the Müller mountains, in which *C. aura* was described. Another six new taxa are described here (Fig. 1), increasing the total number of currently accepted *Cryptocoryne* taxa for Borneo to 30, with more than 500 documented records.

## Material and methods

The present work is the result of a successful cooperation between the authors contributing various specialist inputs, viz. S.W. and I.B.I. with fundamental fieldwork and habitat information, K.R.M. and M.Ø. with cytological work, all authors with morphological and ecological information for taxon characterization, and J.D.B., H.B. and S.W. with cultivation and photographs (far from all contributed pictures are included). S.W., M.Ø. and N.J. initiated writing the main text, after which all authors took part in discussions and writing the manuscript.

The collections were made and herbarium material deposited as stated in the descriptions.

Chromosome numbers were determined at somatic metaphase of root-tips. Preparation of root-tips followed the protocol in Ørgaard & al. (1995), pre-treated in a water-saturated monobromenapthalene solution for four hours, then fixed in Clarke (3 : 1 absolute ethanol : glacial acetic acid) for four hours. The root tips were then washed in 5 °C citrate buffer (0.0021% citric acid and 0.0029% tri-sodium-citrate-dehydrate dissolved in demineralized water, adjusted to pH 4.6) and incubated in 37 °C enzyme solution (citrate buffer added 2% cellulose, Onozuka RS and 10% pectinase, Sigma P-5146) for 12 minutes. Root tips were then washed again in 5 °C citrate buffer for 30 minutes, placed individually in a drop of 45% acetic acid on a microscope slide and squashed. The slides were frozen in liquid nitrogen, the cover-slips were lifted off using a razor blade, and the slides were air-dried. The preparations were stained in DAPI (4´, 6-diamidino-2-phenylindole) solution (1µg $\mu l^{-1}$) for five minutes and mounted in citifluor (Citiflour Ltd.) before examination with a Zeiss Axioskop with appropriate filters for DAPI.

For the chromosome counting, plants were cultivated submerged or halfway emergent in an acid layer of leaf-litter soil.

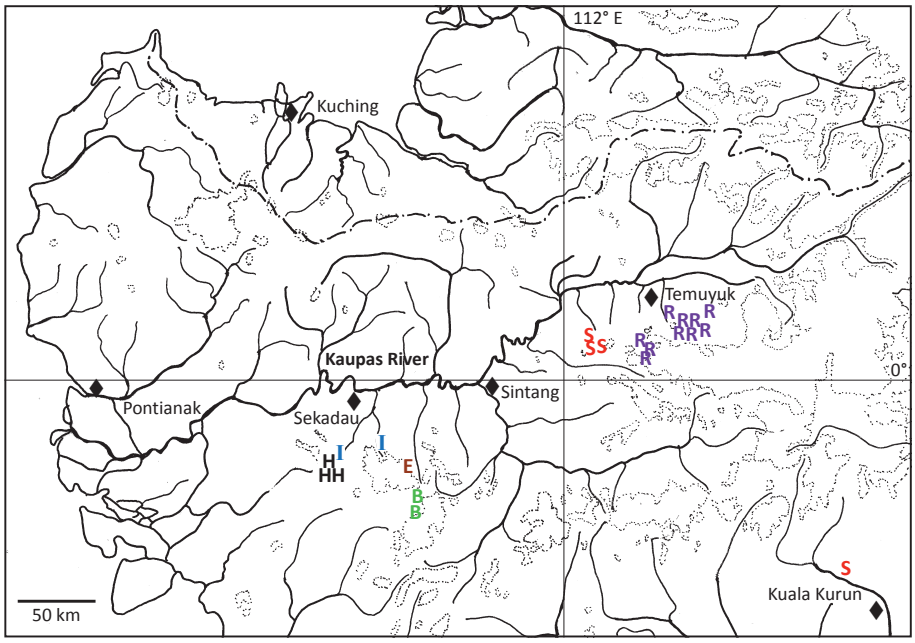



Fig. 1. Distribution map of the six new *Cryptocoryne* taxa from the Schwaner mountains and Müller mountains. Higher elevations are shown in dotted outlines. – B = *C. bastmeijeri*; E = *C. erwinii*; H = *C. yujii* var. *hendrikii*; I = *C. isae*; R = *C. regina*; S = *C. sahalii*.

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## Results and Discussion

### Habit and ecology

Vegetative propagation by subterranean stolons penetrating and colonizing the soil between the thin tree roots along a river bank or in forest floor pools is a characteristic associated with *Cryptocoryne*.

The habitats of most of the presently described taxa are small streams or creeks with slowly running water, or water seeping through larger areas of muddy flats in shady forest swamps. Such habitats are limited in number, and inhabited by only a few other plant species adapted to seeping water, muddy soil and low light intensity. In such places one often sees the *Cryptocoryne* populations as many-leaved rosettes throughout the forest swamps. In this kind of habitat reproduction by seed is important, while propagation by stolons is more limited. This noticeable seed propagation and single plant distribution is known from a few *Cryptocoryne* species in similar habitats, viz. *C. bogneri* Rataj (Sri Lanka; Jacobsen 1987a; Kasselmann 2003), *C. elliptica* Hook. f. (Peninsular Malaysia; Jacobsen 1987b), in some localities with *C. striolata* (Borneo), and most recently in populations of *C. aura* from the Schwaner mountains (Wongso & al. 2016).

The habitat types found in the lower foothills of the Schwaner mountains and the Müller mountains at altitudes of 50–200 m are generally different from most other *Cryptocoryne* habitats in Borneo (Fig. 1), although the widespread *C. striolata* is often found in the same regions in the Schwaner mountains. Similarly, several new species of *Bucephalandra* Schott (*Araceae*) (Wong & Boyce 2014), have been described from these mountains.

Before and after the turn of the millennium, the number of new discoveries of *Cryptocoryne* in Borneo was low. The considerable size of Borneo taken into consideration, it is possible that the number of *Cryptocoryne* species might well be far higher, thus being in line with the predictions given for *Bucephalandra* (Wong & Boyce 2014).

### Chromosome numbers

Chromosome numbers have proven to be an important taxonomic character in *Cryptocoryne* (Jacobsen 1977; Arends & al. 1982; Bastmeijer 2017). They form a dysploid series of reductions in numbers, and several taxa have a polyploid (euploid) series of additions as well (Table 1). The number $2n = 36$ is considered as a secondary basic number; reduction by fusions of chromosomes have taken place (dysploid series), a phenomenon also known from, e.g., palms (Dransfield & al. 2008) and grasses (Moore & al. 1995; Devos 2010). Dysploid chromosome series have also been recognized within the *Araceae* (Petersen 1989; Cusimano & al. 2012). Recently chromosome fusions have also been shown for *Typhonium* Schott (*Araceae*), in which new, low chromosome numbers have been reported (Wang & al 2002; Dao & al. 2007; Sousa & al. 2014).

Table 1. Presently known chromosome numbers of the genus *Cryptocoryne* exemplified by some of the representative species and morphological groups (names and numbers from the present investigation are in **bold**).

| |
|---|
| $2n = 36$ (& 54, 72) |
| *C. crispatula* Engl. and the narrow-leaved species from mainland Asia |
| *C. thwaitesii* Schott group, Sri Lanka |
| *C. lingua* Engl. and *C. zaidiana* Ipor & Tawan, Sarawak |
| $2n = 34$ (& 51, 68, 85, 102) |
| *C. cordata* Griff. and many others from the Malesian region, Vietnam and Philippines (e.g. *C. auriculata* Engl., *C. bangkaensis* Bastm., *C. dewitii* N. Jacobsen, *C. elliptica* Hook. f., *C. fusca* De Wit, *C. minima* Ridley, *C. noritoi* Wongso, *C. nurii* Furtado, *C. usteriana* Engl., *C. vietnamensis* I. Hertel & H. Mühlberg, *C. wongsoi* Ipor) |
| **$2n = 34$, *C. yujii*** var. ***hendrikii*** Wongso, W Kalimantan |
| $2n = 30$ |
| *C. longicauda* Engl., Johor, Sumatera and Borneo; *C. pontederiifolia* Schott, Sumatera; *C. villosa* N. Jacobsen, Sumatera |
| $2n = 28$ (& 42) |
| *C. beckettii* Thwaites ex Trimen group, Sri Lanka |
| **$2n = 28$, *C. regina*** Wongso & Ipor, W Kalimantan |
| The number $2n = 28$ has most likely evolved twice through two independent events (our interpretation based on the morphology and distribution of the species in question). |
| $2n = 26$ |
| *C. aura* Wongso & Ipor, W Kalimantan |
| **$2n = 26$, *C. erwinii*** Wongso & Ipor, W Kalimantan |
| $2n = 22$ (& 33) |
| *C. ciliata* (Roxb.) Schott, SE Asia |
| **$2n = 22$, *C. sahalii*** Wongso & Ipor, W Kalimantan |
| The number $2n = 22$ has most likely evolved twice through two independent events (our interpretation based on the morphology of the two species in question). |
| The numbers $2n = 33$, 66, 70, 72, 88, 90, 110 and 132 have been reported for *C. spiralis* (Retz.) Wydl. from India and, seemingly, do not cohere logically as they do within the other species groups; further study is needed. |
| $2n = 20$ |
| *C. hudoroi* Bogner & N. Jacobsen, *C. ideii* Budianto, *C. keei* N. Jacobsen and *C. striolata* Engl., Borneo |
| **$2n = 14$** |
| ***C. bastmeijeri*** Wongso, W Kalimantan |
| **$2n = 10$** |
| ***C. isae*** Wongso, W Kalimantan |

Chromosome numbers are shown associated with species groups and geographical distribution (Table 1).

### New taxa

***Cryptocoryne bastmeijeri*** Wongso, **sp. nov.** – Fig. 2–4. Holotype: Indonesia, W Kalimantan, Schwaner mountains, Ketapang Regency, S of Sekadau, 22 Sep 2015, *S. Wongso SW 1567* (BO; isotypes: C, L).

*Diagnosis — Cryptocoryne bastmeijeri* differs from *C. auriculata* and *C. isae* by having up to 40 spreading

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green leaves, with a triangular-ovate blade, and by the short spathe limb. Its chromosome number of $2n = 14$ has hitherto not been recorded for *Cryptocoryne*.

*Description* — Aquatic to amphibious herbs, c. 10 cm tall. *Rhizome* thick, notched, with only a few thin stolons. *Leaves* 20–40 together in a rosette, spreading ± horizontally from upright petiole, 5–15 cm long; *blade* dark green, lighter green to purplish abaxially, triangular-ovate, 2–3 × 3–5 cm, smooth. *Cataphylls* whitish, c. 1.5 cm long 2-keeled, usually situated below soil surface. *Peduncle* 2–3 cm long. *Spathe* whitish outside in proximal part, distal ⅓ purplish; *kettle* cylindric, to 1 cm long, white inside, *flap* light yellowish; *tube* c. 0.75 cm long, white inside; *limb* purple to reddish, ovate, shortly pointed, forward obliquely twisted, to 1.5 cm long, surface with a few rounded protuberances, with an indistinct, darker collar, sometimes with a white line running distally from collar as a result of a folding of limb in young stage, red colour continuing in a more intensive hue a few mm into tube. *Spadix* c. 1 cm long, with usually 5 whitish *female* flowers with broadly ellipsoid to emarginate *stigmas* sometimes with a slight purplish tinge along margin; *olfactory bodies* yellow, irregular; *male flowers* 25–30, whitish yellowish. *Syncarp* on an up to 3 cm long peduncle, brownish purplish, lighter spotted, broadly ovoid, c. 1 cm wide, smooth, persistent stigmas clearly visible. *Seeds* with germinating embryo emerging c. ⅓ from distal end with c. 5 plumulary processes.




Fig. 2. *Cryptocoryne bastmeijeri*, rosette habit seen from above, with a spathe. – Photograph: 22 September 2015 by Hendrik.

importantly disseminates this information on his website (Bastmeijer 2017), thereby establishing contacts between enthusiasts worldwide.

*Remarks* — The embryo resembles that found in *Cryptocoryne aura* (Wongso & al. 2016) and *C. isae* S. Wongso by having the germinating embryo emerging c. ⅓ from the distal end with c. 5 plumulary processes.

The chromosome number of $2n = 14$ is a new number and unique within *Cryptocoryne*.

*Chromosome number* — $2n = 14$, reported here for *SW 1567*.

*Distribution* — As far as known endemic to W Kalimantan, Schwaner mountains, SW of Sintang, where it has been observed in one locality additional to the type locality.

*Ecology* — The type specimen was collected in a swamp forest streamlet with clear, slow-running water, with the leaves spreading over the mud and sand. Altitude range 175–200 m.

*Eponymy* — Named after Jan D. Bastmeijer, of Emmen, The Netherlands, who has for decades meticulously gathered information on *Cryptocoryne*, and most

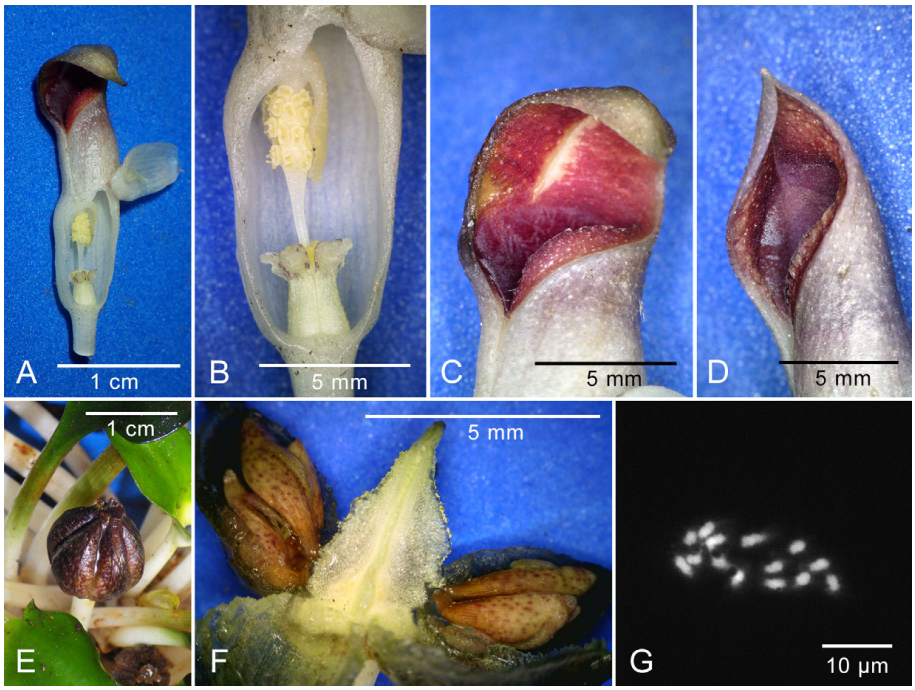



Fig. 3. *Cryptocoryne bastmeijeri* – A: spathe with kettle cut open; B: close-up of A with kettle cut open showing female flowers at base, sterile part of spadix, and male flowers at apex; C: spathe limb showing collar zone; D: smaller spathe limb with more upright limb surface; E: mature unopened syncarp; F: mature syncarp in longitudinal section showing position of seeds; G: chromosomes showing $2n = 14$. – Photographs: A–F by S. Wongso; G by K. R. Munk.

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Fig. 4. *Cryptocoryne bastmeijeri* – seeds at different development stages. A: showing five plumulary processes rolled up inside testa; B: plumulary processes have just unfolded by rupturing of testa; C: plumulary processes have unfolded completely and primary root has begun to emerge. – Photographs: S. Wongso.



Fig. 5. *Cryptocoryne erwinii* – habitat at type locality with halfway emergent plants, showing water at base of plants (one flowering specimen). – Photograph: 18 August 2015 by S. Wongso.




Fig. 6. *Cryptocoryne erwinii* – A, B: showing flowering plants from different angles and different ages; A: young spathe seen from side with recurved limb; B: older spathe seen from front with limb bent forward protecting tube exit. – Photographs: 18 August 2015 by S. Wongso.

***Cryptocoryne erwinii*** Wongso & Ipor, **sp. nov.** – Fig. 5–7.

Holotype: Indonesia, W Kalimantan, Schwaner mountains, Sintang Regency, S of Sekadau, 18 Aug 2015, *S. Wongso & I. B. Ipor SW 1560* (BO; isotypes: C, L).

*Diagnosis* — *Cryptocoryne erwinii* superficially resembles *C. lingua* in the leaves, but the leaf blade is more horizontally oriented, with the abaxial surface distinctly lighter than the adaxial one. The 6–9 cm long spathe is exceptional and differs from all other *Cryptocoryne* species in being white, with the distal part of the limb subulate and purple inside, first bent backward to upright, later bending forward over the white, widely expanded, funnel-shaped entrance, which lacks a collar. Its chromosome number of $2n = 26$ has hitherto only been reported for the recently described *C. aura*.

*Description* — Amphibious herbs 8–10 cm tall. *Rhizome* thick, stout, notched, with long, stout subterranean stolons. *Leaves* 5–10 together in a rosette, 6–10 cm long, *blade* spreading ± horizontally from upright petiole, green adaxially, lighter abaxially, ovate, to 3 × 6 cm, superficially smooth but with small rounded protuberances, base slightly cordate. *Cataphylls* greenish, to 2 cm long, 2-keeled. *Peduncle* 1–2 cm long. *Spathe* 6–9 cm long, red-brownish outside; *kettle* white inside, cylindric, with a broad constriction at middle, 1.5–2.5 cm long, *flap* white; *tube* 2–4 cm long, twisting after opening; limb subulate, 2–3 cm long, backward bent to upright at opening, next day bending forward, protecting opening of white, expanded funnel-cone-shaped tube opening (unusual tube opening may originate from a collar that has expanded and formed dilated opening). *Spadix* 1.5–2.5 cm long, with 4 or 5 white *female flowers* with broadly ellipsoid stigmas; *olfactory bodies* yellowish white; *male flowers* 30–40, yellowish; *appendix* white. *Syncarp* not observed.

*Chromosome number* — $2n = 26$, reported here for *SW 1560*.

*Distribution* — As far as known endemic to W Kalimantan, Schwaner mountains, Sintang Regency, SW of Sintang, where it has

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been found only at the type locality.

*Ecology* — The type specimen was collected in a small humus-rich muddy-peaty streamlet in a swamp forest, where the population was growing among tree roots. The habitat conditions indicate that the water flow is constantly low so that dead leaves accumulate to form a muddy-peaty, loose, organic substrate. Water parameters: pH 5.5, conductivity 25 µS/cm, temperature 25 °C. Altitude 60 m.

*Eponymy* — Named after Erwin Syahputra, who has a keen eye for plants, and discovered the habitat of this unique species.

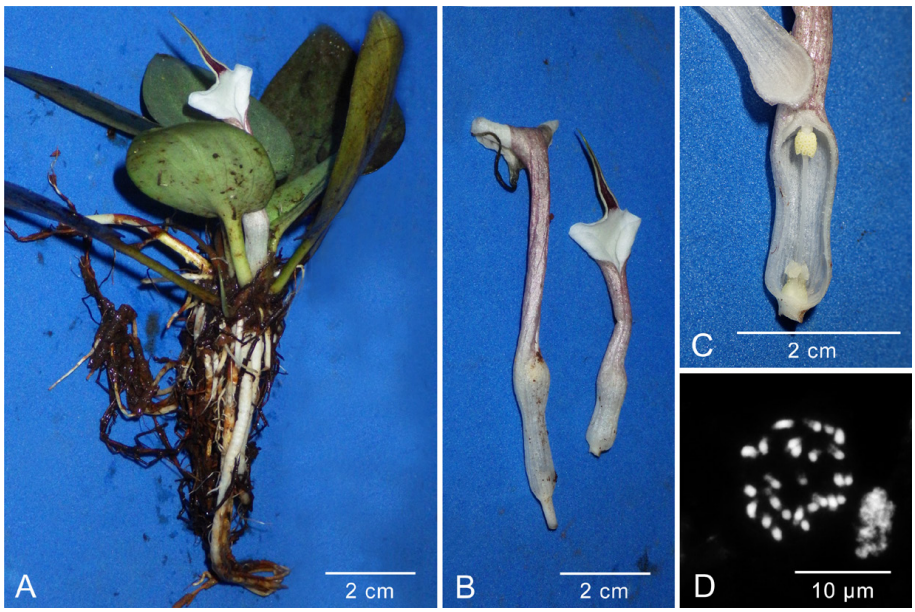



Fig. 7. *Cryptocoryne erwinii* – A: whole flowering plant showing habit; B: two spathes seen from back (older) and front (younger); C: opened kettle of younger spathe with lighter yellow male and female flowers; D: chromosomes showing $2n = 26$. – Photographs: A–C by S. Wongso; D by K. R. Munk.

*Remarks* — The colour and structure of the spathe of *Cryptocoryne erwinii* is unique, no other species having anything like the limb of this species. The chromosome number of $2n = 26$ is the same as that found in *C. aura*, but the morphology of the two species is very different.

***Cryptocoryne isae*** Wongso, **sp. nov.** – Fig. 8–10.
Holotype: Indonesia, W Kalimantan, Schwaner mountains, Sekadau Regency, S of Sekadau, 19 Aug 2015, *S. Wongso SW 1561* (BO; isotypes: C, L).

*Diagnosis* — *Cryptocoryne isae* usually has fewer than 10 upright leaves to 25 cm long, with a green, narrowly ovate, somewhat spongy blade, which could resemble *C. zaidiana*; the c. 6 cm long spathe has a short, forward obliquely twisted, purple limb with an indistinct, darker collar, whereas *C. zaidiana* has a long-tubed spathe with a broad, white, rugose limb and a purple throat. Its chromosome number of $2n = 10$ has hitherto not been recorded for *Cryptocoryne*.

*Description* — Amphibious herbs, c. 20 cm tall. Rhizome thick, firm, notched, with long, stout, subterranean stolons. *Leaves* usually less than 10 together in a rosette, 20–25(–30) cm long, *blade* erect-spreading from an upright petiole, dark green, lighter green abaxially, narrowly ovate, 2–3 × 5–10 cm, thick, softly spongy, smooth, margin entire, smooth or with fine crenulations. *Cataphylls* whitish brownish, c. 3 cm long, 2-keeled, usually reaching soil surface. *Peduncles* 1 or 2, to 8 cm long. *Spathe* c. 6 cm long, whitish outside in proximal



Fig. 8. *Cryptocoryne isae*, habitat at type locality with completely emergent plants on forest floor between other herbs and dead leaves. – Photograph: 19 August 2015 by S. Wongso.

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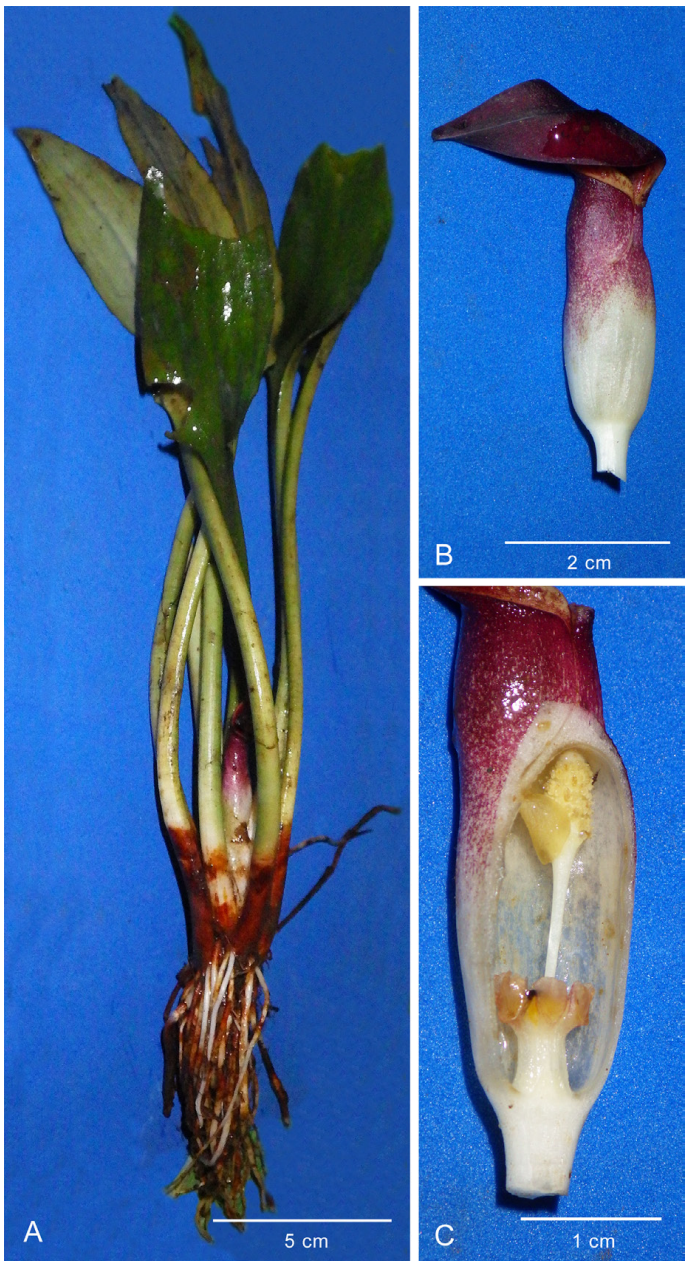



Fig. 9. *Cryptocoryne isae* – A: habit of plant showing short spathe; B: limb of whole spathe showing obliquely forward-bent limb; C: cut-open kettle showing female flowers, naked portion of spadix and male flowers above. – Photographs: 19 August 2015 by S. Wongso.

part, distal ½ purplish; *kettle* ovate-cylindric, slightly constricted below level of male flowers, to 2.5 cm long, white inside, *flap* light yellow; *tube* c. 1 cm long, white inside; *limb* forward obliquely twisted, to 3 cm long, purple with an indistinct, darker collar, rather smooth, red colour continuing a few mm into tube. *Spadix* to 3 cm long, usually with 5 whitish *female flowers* with broadly ellipsoid to emarginate stigmas with a slight purplish tinge along stigmatic margins; *olfactory bodies* yellow, rounded; *male flowers* 30–40, yellowish. *Syncarp* ovoid with persistent stigmas. *Seeds* with germinating embryo emerging c. ⅓ from distal end with c. 5 plumulary processes.

*Chromosome number* — $2n = 10$, reported here for *SW 1561*.

*Distribution* — Probably endemic to W Kalimantan, Schwaner mountains, Sekadau Regency, S of Sekadau, where it has been observed in one locality besides the type locality.

*Ecology* — The plants that provided the type specimens were found among other herbs emerging from low-lying forest floor in the upper, drier areas near a stream with a loamy, muddy substrate; the long petiole may be an adaptation to tree leaf accumulation rather than to deep water or substrate sedimentation. The short spathe on a short peduncle situated between the proximal parts of the petioles indicates that plants are always emergent during the flowering season at this site.

A second known locality is reported SW of the type locality. This locality has a higher water level; the peduncle is longer (more than 6 cm). Unfortunately, this site will be opened for agriculture soon. The type locality was also somewhat disturbed, with only secondary forest present. Altitude 125 m.

*Eponymy* — Named after Isa Bin Ipor, of UNIMAS, who has studied the *Cryptocoryne* species of Sarawak for many years and more recently has joined explorations for species in Kalimantan.

*Remarks* — Chromosome number $2n = 10$. This surprisingly low number is new in *Cryptocoryne*. Comparable low chromosome numbers have recently been recorded in the SE Asian *Araceae* genus *Typhonium* (Wang & al. 2002; Dao & al. 2007; Sousa & al. 2014).

***Cryptocoryne regina*** Wongso & Ipor, **sp. nov.** – Fig. 11–13.
Holotype: Indonesia, W Kalimantan, Müller mountains, Kapuas Hulu Regency, S of Temuyuk, 20 Aug 2015, *S. Wongso & I. B. Ipor SW 1563* (BO; isotypes: C, L).

*Diagnosis* — *Cryptocoryne regina* resembles *C. auriculata* in having leaves with a green to pinkish marbled, triangular-ovate, somewhat spongy blade, but the spathe limb differs in being obliquely twisted, whitish to purple, with an indistinct, lighter collar zone. Its chromosome number is $2n = 28$, a number that has previously been reported for the *C. beckettii* Thwaites ex Trimen group from Sri Lanka.

*Description* — Amphibious herbs, variable in height, 6–10(–15) cm tall depending on locality. *Rhizome* thick, stout, notched, with long, subterranean stolons. *Leaves* up to 8 together in a rosette, erect-spreading from up-

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right petioles, 10–23 cm long (longer in more submerged plants), *blade* dark green to lighter brownish (reddish) opalescent, with darker green markings, lighter green abaxially, ovate to narrowly ovate, 2.5–3.5 × 8–12 cm, somewhat thick and softly spongy, smooth. *Cataphylls* whitish to greenish distally, c. 3 cm long, 2-keeled, usually situated below soil surface. *Peduncle* 1–3 cm long. *Spathe* 6–11 cm long, whitish outside in proximal part, above kettle becoming silvery to purplish; *kettle* ovate-cylindric, 2–3.5 cm long, white inside, *flap* light yellow; *tube* 1–2 cm long, white inside; *limb* upright or backward bent to forward obliquely twisted, 2–3 cm long, smooth adaxially, silvery white to reddish or with a reddish margin, collar zone distinct, silvery white to white or with a reddish tinge. *Spadix* to 3.5 cm long, with 5–7 greenish *female flowers* with broadly ellipsoid to emarginate stigmas; *olfactory bodies* whitish, irregularly rounded; *male flowers* 40–70, yellowish. *Syncarp* not observed.

*Chromosome number* — 2*n* = 28, reported here for *SW 1563*; and additional collections *SW 1562* and *SW 1573*.

*Distribution* — Endemic to W Kalimantan, Müller mountains, Kapuas Hulu Regency, S of Temuyuk.

*Ecology* — Streams and rivers, where it may occupy sandbanks in smaller streams or river banks in larger streams or rivers. It tends to be found in sites near or just above the lower water level, in which it is able to maintain itself tightly woven in between tree roots. Water parameters at the type locality: pH 6.6, conductivity 37 µS/cm, temperature 26 °C. The substrate is a sand and loam mix and the habitat resembles that of *Cryptocoryne auriculata* from Sarawak.

At a second locality (*SW 1562*), a little further toward the west, the water parameters were: pH 6.3, conductivity 44 µS/cm, temperature 25 °C. The plants at the second locality were growing on a sandbank in the middle of a smaller stream and the plants and inflorescences were slightly larger than at the type locality, and the leaves were completely green.

More than ten localities have been recorded, so the distribution of this species comprises more diverse habitat conditions. For example, it is also found on the banks of larger rivers with strong current and fluctuating water level (*SW 1563*). Altitude range 50–75 m.

*Etymology* — The specific epithet *regina*, which is Latin, meaning queen, refers to the commercial trade name

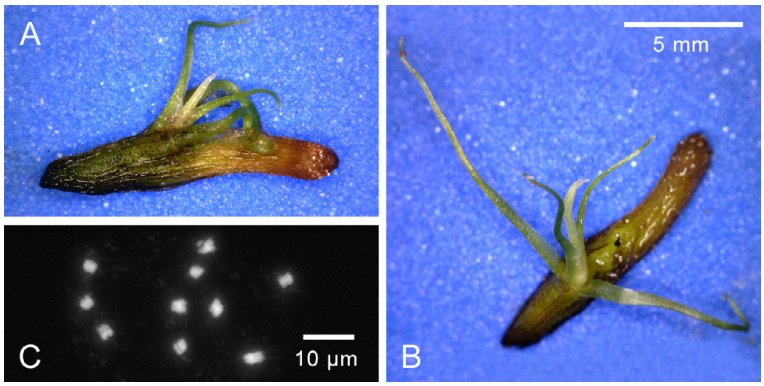



Fig. 10. *Cryptocoryne isae* – A: seeds showing five plumulary processes emerging from middle of seed; B: seed showing five plumulary processes unfolded; C: chromosomes showing 2*n* = 10. – Photographs: A, B by S. Wongso; C by K. R. Munk.



Fig. 11. *Cryptocoryne regina*, habitat on stream bank at type locality with plants growing along a gradient from emergent to submerged. – Photograph: 20 August 2015 by S. Wongso.

'Silver Queen', a plant with a bright silvery spathe limb.

*Remarks* — Chromosome number 2*n* = 28, a number previously reported for the *Cryptocoryne beckettii* group from Sri Lanka (Arends & al. 1982; Jacobsen 1977), but this number has most likely evolved twice, and does not indicate close relationship.

Variation in leaf-size and colour is found at different localities; at present it is not known to what extent this variation is genetically based.

***Cryptocoryne sahalii*** Wongso & Ipor, **sp. nov.** – Fig. 14–16.

Holotype: Indonesia, C Kalimantan, Müller mountains, Gunung Mas Regency, NW of Kuala Kurun, 4 Apr 2015, *S. Wongso & I. B. Ipor SW 1509*, cultivated as *B 1631*, 24 Sep 2017 (BO).

*Diagnosis* — *Cryptocoryne sahalii* resembles *C. griffithii*, but has many more (20–30 vs 10) green to purple, rounded, cordate leaves in a rosette; the limb of the spathe is purple (to yellowish), upright to recurved in the distal

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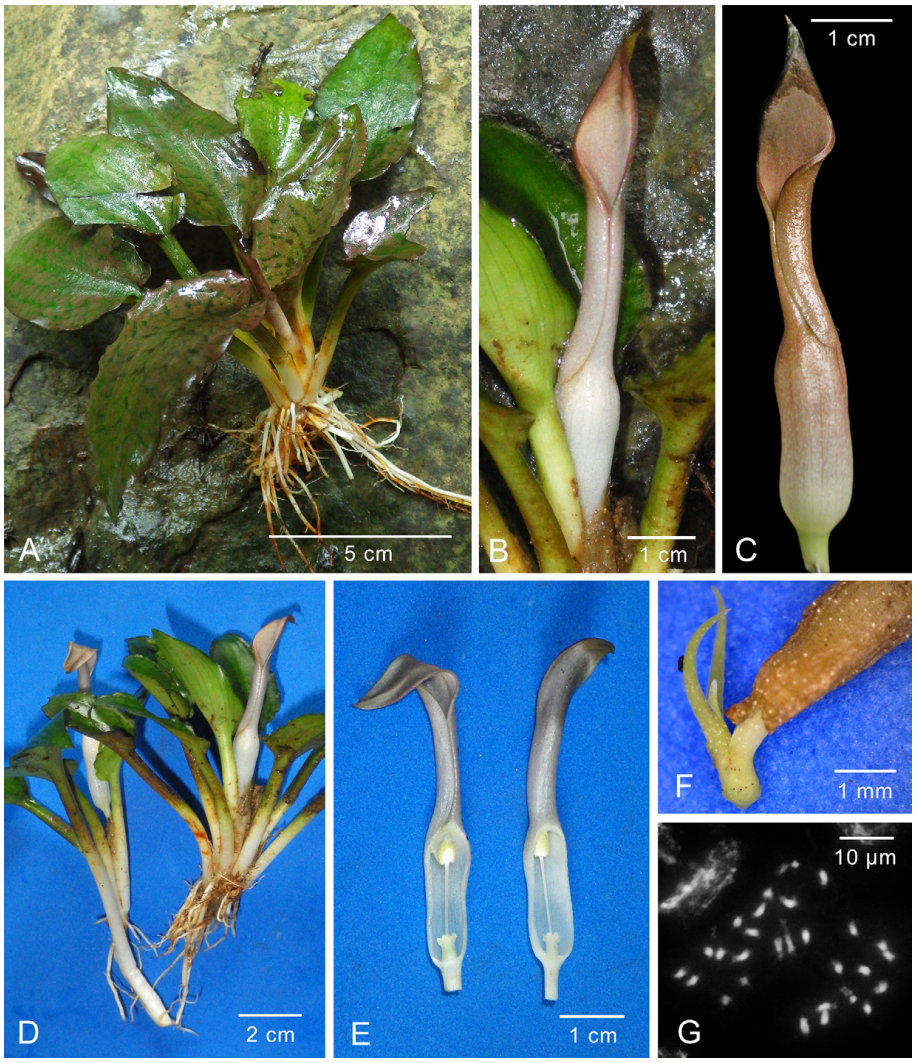



Fig. 12. *Cryptocoryne regina* – A: habit of plant showing marbled leaf blades; B: spathe with upright limb; C: spathe from cultivated specimen; D: habit of plants, with spathes; E: two spathes with kettles cut open; F: seed showing embryo emerging from distal end of seed and two plumulary processes; G: chromosomes showing $2n = 28$ (*SW 1563*). – Photographs: A, B, 20 August 2015 by S. Wongso; C by J. D. Bastmeijer; D–F by S. Wongso; G by K. R. Munk.

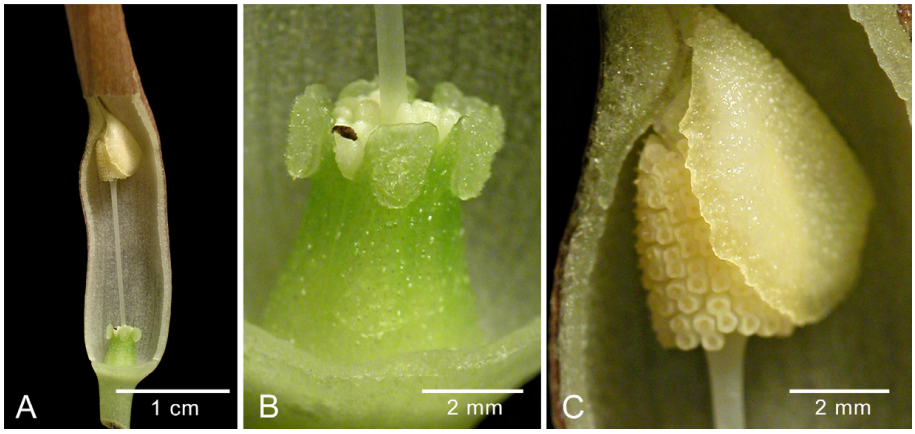



Fig. 13. *Cryptocoryne regina* – A: artificially opened kettle of spathe showing female flowers at base, naked spadix axis, and male flowers at apex; B: female flowers with receptive stigmas; C: male flowers halfway hidden behind flap. – Photographs: J. D. Bastmeijer.

part (*C. griffithii* is strongly recurved) with a relatively narrow opening with a thin collar rim; the surface of the limb has many small, rounded protuberances (*C. griffithii* has a rather thick collar and larger, prominent, rounded protuberances). Its chromosome number of $2n = 22$ has previously been reported for *C. ciliata*.

*Description* — Amphibious herbs, 6–10(–15) cm tall. *Rhizome* thick, stout, notched, with long, subterranean stolons. *Leaves* up to 20–30 together in a rosette, spreading horizontally on water and mud surface, 10–15 cm long; *blade* dark green to lighter brownish (reddish), lighter green abaxially, ovate to narrowly ovate, 2.5–3.5 × 6–8 cm, smooth. *Cataphylls* whitish to greenish distally, c. 3 cm long, 2-keeled. *Peduncle* 1–3 cm long. *Spathe* 4–6 cm long, outside purplish or green leopard-spotted in distal part, whitish in proximal part; *kettle* ovate-cylindric, 1.5–2 cm long, white inside, *flap* light yellow; *tube* c. 2 cm long, white inside; *limb* upright or backward bent, 2–3 cm long, adaxial surface with many small, rounded protuberances, purple-red (to yellowish), with a relatively narrow, often vertically situated opening with a thin collar rim, throat dark purple continuing a few mm into tube. *Spadix* to 2 cm long, with usually 5 or 6 whitish to greenish *female flowers* with short, broadly ellipsoid to emarginate stigmas; *olfactory bodies* yellow, rounded; *male flowers* 20–30, yellowish. *Syncarp* ovoid, pointed, with persistent stigmas. *Seeds* rough with ridges; embryo germinating with 3 plumu-

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lary processes, protruding radicle first from distal end of seed.

*Chromosome number* — 2*n* = 22, reported here for *SW 1509* and an additional collection *SW 1628*.

*Distribution* — Known from the Müller mountains, C Kalimantan, S part of Gunung Mas Regency, NW of Kuala Kurun, and from W Kalimantan, in the N Müller mountains, Kapuas Hulu Regency, SW of Temuyuk (*SW 1628*).

*Ecology* — Submerged to emergent plants in small and slow-flowing streams in a clay-sand substrate (together with *Cryptocoryne striolata* and *Barclaya rotundifolia* M. Hotta). Water parameters at the type locality: pH 6.2, conductivity 30 µS/cm, temperature 26 °C. At Kapuas Hulu Regency (*SW 1628*), the plants were submerged to emergent near or just above the lower water level and rooted in between the fine tree roots at the banks of smaller rivers. Altitude range 75–225 m.

*Eponymy* — Named after Abdul Sahal, who discovered the type population with his trained eye for plants.

*Remarks* — *Cryptocoryne sahalii* resembles *C. griffithii* (Othman & al. 2009): the



Fig. 14. *Cryptocoryne sahalii*, habitat at type locality with leaf rosettes just submerged. – Photograph: 4 April 2015 by S. Wongso.

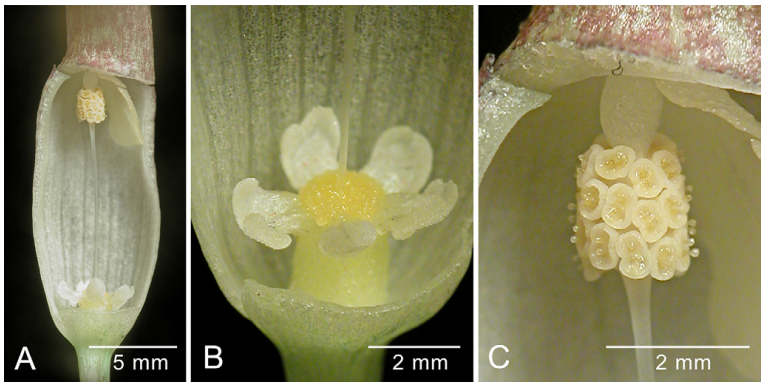



Fig. 15. *Cryptocoryne sahalii* – A: artificially opened kettle of spathe showing female flowers at base, naked spadix axis, and male flowers at apex; B: female flowers with outward bent stigmas; C: male flowers showing droplets of pollen on apex of horn. – Photographs: J. D. Bastmeijer.

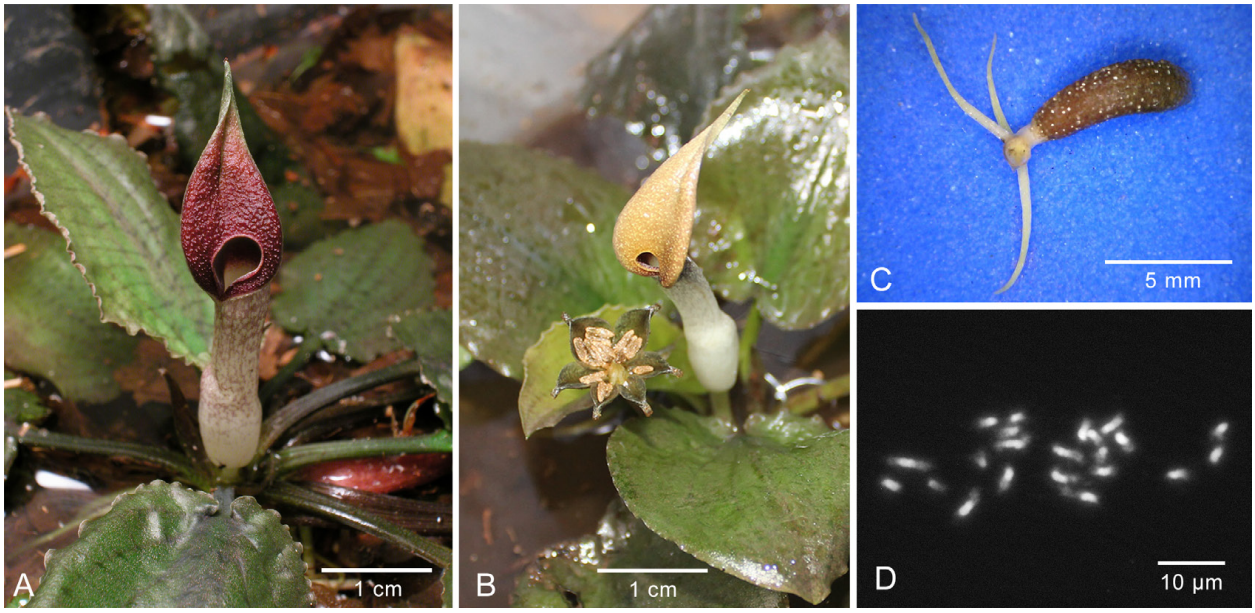



Fig. 16. *Cryptocoryne sahalii* – A: flowering cultivated plant with purple spathe limb; B: flowering cultivated plant with yellow spathe limb and opened syncarp with seeds; C: germinating seed showing three plumulary processes that have emerged through distal end of the seed; primary root has not yet begun developing; D: chromosomes showing 2*n* = 22 (*SW 1509*). – Photographs: A by J. D. Bastmeijer; B by H. Budianto; C by S. Wongso; D by K. R. Munk.

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Fig. 17. *Cryptocoryne yujii* var. *hendrikii*, close-up of habitat at type locality, showing flowering plants with leaf rosettes just submerged. – Photograph: 1 April 2016 by S. Wongso.

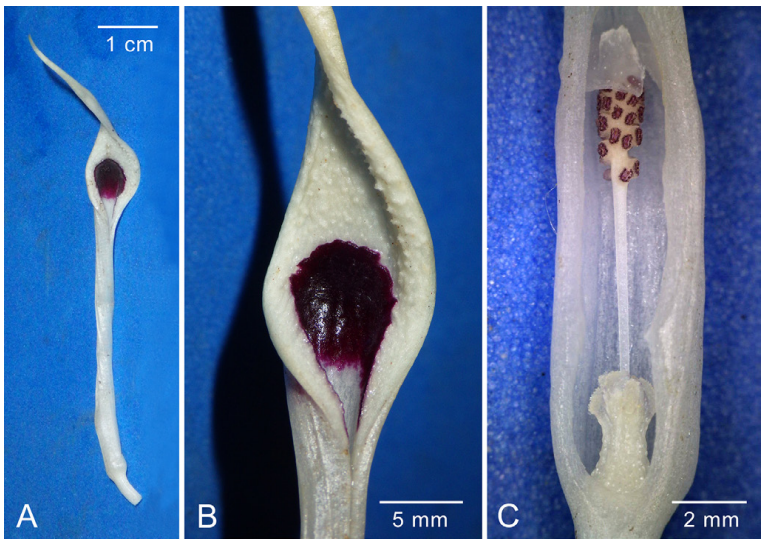



Fig. 18. *Cryptocoryne yujii* var. *hendrikii* – A: whole spathe; B: spathe limb with black-purple zone in throat; C: opened kettle showing characteristic purple-rimmed male flowers. – Photographs: S. Wongso.

rosette has 20–30 leaves in *C. sahalii* (vs up to c. 10 in *C. griffithii*); yellowish spathes have been observed twice in *C. sahalii* (vs never in *C. griffithii*); the spathe limb is ± upright and slightly recurved in the distal part in *C. sahalii* (vs strongly recurved in *C. griffithii*); the outside of the unopened spathe limb is purplish sometimes green leopard-spotted in *C. sahalii* (vs uniformly green to purplish in *C. griffithii*); the surface of the spathe limb is dark purple in *C. sahalii* (vs often reddish in *C. griffithii*); the spathe limb has small, more distantly distributed protuberances or larger, irregular protuberances in *C. sahalii* (vs uniformly rounded protuberances rather closely distributed and not irregular in *C. griffithii*); the collar opening is ± vertical in *C. sahalii* (vs ± horizontal in *C. griffithii*); the collar rim is rather thinner in *C. sahalii* than in *C. griffithii*; the chromosome number is $2n = 22$ in *C. sahalii* (vs $2n = 34$ in *C. griffithii*).

The second known accession from the N Müller mountains, Kapuas Hulu Regency, SW of Temuyuk, *SW 1628*, differs from the type gathering by having the spathe limb with more distinct protuberances and the unopened limb of the spathe is not leopard-spotted on the outside.

The chromosome number $2n = 22$ has previously been reported for *Cryptocoryne ciliata*, but most likely does not reflect any closer relationship with *C. sahalii*.

***Cryptocoryne yujii*** var. ***hendrikii*** Wongso, **var. nov.** – Fig. 17–19.
Holotype: Indonesia, W Kalimantan, Schwaner mountains, Sekadau Regency, SW of Sekadau, 1 Apr 2016, *S. Wongso SW 1601* (BO; isotypes: C, L).

*Diagnosis* — *Cryptocoryne yujii* var. *hendrikii* often has more than 25 spreading leaves to 15 cm long, with a green to purplish green, cordate blade; the spathe is white, c. 8 cm long; the limb has a rough surface and is upright with a long tail and a black-purple collar, thereby resembling *C. yujii* var. *yujii* from Sarawak; it differs, however, in the many-leaved rosette of > 10 and often > 25 leaves (vs 5–8 in *C. yujii* var. *yujii*) with the blade to 4 × 8 cm (vs to 7 × 10 cm in *C. yujii* var. *yujii*).

*Description* — Amphibious herbs c. 10 cm tall. *Rhizome* thick, stout, notched, with rather short, stout, subterranean stolons. *Leaves* often more than 25 together in a rosette, 10–15 cm long; *blade* green to purplish green when sun-exposed, cordate, 2–4 × 6–8 cm, smooth. *Cataphylls* whitish, brownish distally, c. 2 cm long, 2-keeled, usually situated below soil surface. *Peduncle* 1–2 cm long. *Spathe* 7–10 cm long, white outside; *kettle* c. 1 cm long, cylindric, white inside, *flap* white; *tube* c. 3 cm long, white inside; *limb* to 4 cm long, distal part a little twisted, white with a rough surface and a blackish purple collar continuing a few mm into tube. *Spadix* c. 1 cm long, with usually 5 whitish *female flowers* with broadly ellipsoid stigmas; *olfactory bodies* light yellow, rounded; *male flowers* 25–40, yellowish with a distinct brownish colour along thecae margins. *Syncarp* whitish brownish, ovoid, pointed, stigmas persistent. *Seeds* yellowish brownish, somewhat rough, germinating with 2 plumulary process, protruding radicle first from distal end of seed.

*Chromosome number* — $2n = 34$, reported here for *SW 1601*.

*Distribution* — Probably endemic to W Kalimantan, Schwaner mountains, where it is known from three localities.

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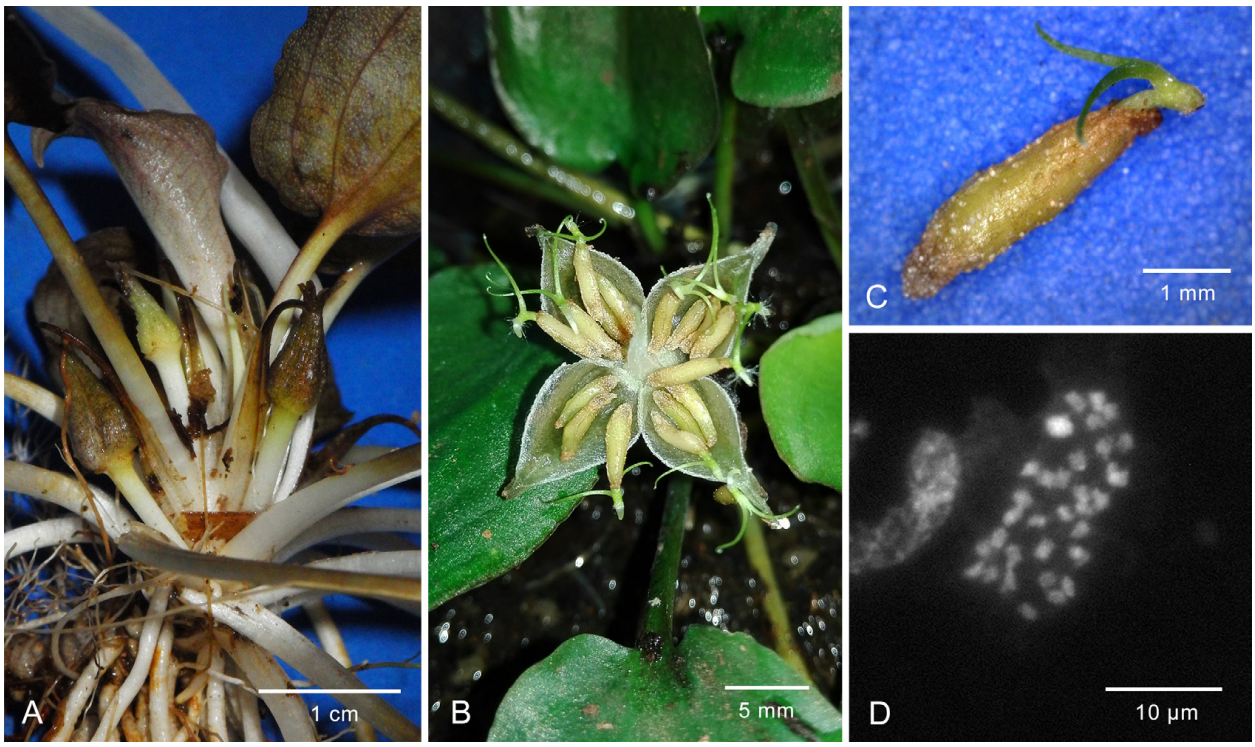



Fig. 19. *Cryptocoryne yujii* var. *hendrikii* – A: basal part of plant seen from side showing several syncarps and cataphylls; B: mature open syncarp with germinating seeds showing two plumulary processes and early growth of primary root; C: germinating seed showing two plumulary processes; D: chromosomes showing $2n = 34$. – Photographs: A–C by S. Wongso; D by K. R. Munk.

*Ecology* — Small, muddy streams and creeks with slow-running water seeping over the surface of the clayey-sandy soil, with the leaves spreading over the surface. Water parameters: pH 6.4, conductivity 30 µS/cm, temperature 26 °C. Altitude range 50–100 m.

*Eponymy* — Named after Hendrik, who has assisted in discovering several new *Cryptocoryne* species during field trips in Kalimantan.

*Remarks* — *Cryptocoryne yujii* var. *hendrikii* and var. *yujii* differ in leaf number and size and spathe length: leaves > 10, often > 25 together, 2–4 × 6–7 cm and spathe 7–10 cm long in var. *hendrikii* vs. leaves 5–8 together, 3–7 × 6–10 cm and spathe 15–20 cm long in var. *yujii,* which is strictly correlated to habitat. *Cryptocoryne yujii* var. *hendrikii* may be considered an ecotype adapted to small, shallow streams and seeping mudflats, whereas var. *yujii* is an ecotype adapted to larger streams or rivers with deeper water. The use of varietal rank is in accordance with the varieties of *C. crispatula* Engl. s.l. as used in the *Flora of Thailand* (Jacobsen & al. 2012).

The chromosome number $2n = 34$ is found in a number of *Cryptocoryne* species in the Malesian region (see, e.g., Arends & al. 1982; Bastmeijer 2017), including *C. yujii* var. *yujii*.

## Conservation status

As most of the presently described new *Cryptocoryne* are known only from one or a few localities, it is difficult to ascertain their conservation status according to the IUCN (2016), except that they are mostly Data Deficient (DD). In relation to the more than 250 *Cryptocoryne* localities known from Kalimantan, the records mainly concern *C. cordata* var. *grabowskii*, *C. fusca* and *C. striolata*; those described here represent just a few, which as far as is known are local endemics to the Schwaner mountains and Müller mountains. More observations are needed in order to outline a conservation assessment.

*Cryptocoryne bastmeijeri* is currently known from two localities. The habitat is rather inaccessible, which might help to preserve it.

*Cryptocoryne erwinii* is known only from the type locality. The habitat is rather inaccessible, which might help to preserve it.

*Cryptocoryne isae* is, in addition to the type locality, known only from one other locality, which is potentially threatened. The habitat of the type locality is rather inaccessible.

*Cryptocoryne regina* seems rather widespread and not immediately in danger, as it is found at more than ten known localities within an area of 40 × 30 km. In order to sustain this, monitoring is needed to outline a conservation assessment.

*Cryptocoryne sahalii* is known from the type locality NW of Kuala Kurun, C Kalimantan, and an additional three localities SW of Temuyuk, W Kalimantan; more observations are needed in order to outline a conservation assessment.

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*Cryptocoryne yujii* var. *hendrikii* is known only from two localities additional to the type locality, but within a restricted area. The habitat is rather inaccessible, which might help to preserve it.

**Key to the *Cryptocoryne* taxa of Borneo**

With the new taxa of *Cryptocoryne* described here and previously, a new key is provided. The characters and measurements are from wild-growing accessions. Deviant specimens are not included in the key. For brevity, the term "limb" refers here to the limb of the spathe.

1. Limb with long cilia at margin . . . . . ***C. ciliata***
– Limb without cilia at margin . . . . . **2**
2. Leaf blade ± covered with hairs on abaxial surface and/or along margin . . . . . **3**
– Leaf blade glabrous . . . . . **5**
3. Leaf blade lanceolate, ± bullate; spathe 5–7 cm long, very narrow, kettle white inside . . . . . ***C. uenoi***
– Leaf blade ovate to shortly lanceolate, not significantly bullate; spathe 7–10(–12) cm long, broad, kettle ± purplish inside, often inflated . . . . . **4**
4. Limb abruptly narrowed into a tail, collar pronounced . . . . . ***C. ferruginea*** var. ***ferruginea***
– Limb gradually tapering into a tail, collar zone present . . . . . ***C. fusca***
5. Tube of spathe > 2× as long as limb . . . . . **6**
– Tube of spathe ≤ 2× as long as limb . . . . . **15**
6. Limb with reddish or purplish protuberances . . . . . **7**
– Limb ± smooth, yellow, brown or purple . . . . . **9**
7. Limb c. 1 cm wide, with black-purple, coarse protuberances on a white base, collar purple . . . . . ***C. zaidiana***
– Limb c. 0.5 cm wide, with fine protuberances, collar not purple . . . . . **8**
8. Limb ± recurved, with red protuberances, especially on margin, collar yellow with red spots; leaf blade ovate, occasionally slightly bullate . . . . . ***C. pallidinervia***
– Limb ± spirally recurved, with yellow to purple protuberances over whole surface, collar zone present; leaf blade lanceolate, bullate . . . . . ***C. keei***
9. Limb 0.5–1 cm wide, with a rather long, ± twisted apex . . . . . **10**
– Limb usually more than 1 cm wide, without a long tail or apex . . . . . **11**
10. Leaf blade 3–12 cm long, usually flat . . ***C. striolata***
– Leaf blade 10–30 cm long, noticeably bullate . . . . . ***C. hudoroi***
11. Limb yellow to brownish, collar zone yellow . . . **12**
– Limb brownish to purple, collar zone purple or purple spotted . . . . . **13**
12. Limb 1–2 cm wide, tube 5–10(–15) cm long; leaf-margin plain . . . . . ***C. cordata*** var. ***grabowskii***
– Limb c. 0.5 cm wide, tube 4–6 cm long; leaf with a distinct, membranous, ciliate margin . . . . . ***C. aura***
13. Limb brownish purple, collar zone yellow-purple spotted . . . . . ***C. ×purpurea*** nothovar. ***borneoensis*** . . . . . (incl. *C. edithiae*)
– Limb purple, collar zone plain purple . . . . . **14**
14. Limb almost smooth, shiny purple, collar zone almost as wide as limb . . . . . ***C. ×batangkayanensis***
– Limb rough or with protuberances, dull purple, collar zone c. ½ as wide as limb . . . . . ***C. ×purpurea*** nothovar. ***borneoensis***
15. Limb white to silvery, occasionally pinkish, collar white or purple . . . . . **16**
– Limb purple or brownish to yellowish . . . . . **19**
16. Limb (collar zone) white, with a long, thin, purple tail . . . . . ***C. erwinii***
– Limb wholly white, silvery or pinkish, short or long, collar white or purple . . . . . **17**
17. Limb > 3 cm long, upright, white, surface with protuberances, collar purple . . . . . **18**
– Limb ≤ 3 cm long, if longer not upright, collar whitish . . . . . ***C. regina***
18. Leaves 5–8 together, blade 3–7 × 6–10 cm; spathe 15–20 cm long . . . . . ***C. yujii*** var. ***yujii***
– Leaves > 10, often > 25 together, blade 2–4 × 6–7 cm; spathe 7–10 cm long . . . . . ***C. yujii*** var. ***hendrikii***
19. Limb taper-pointed or with a long tail . . . . . **20**
– Limb neither taper-pointed nor with a tail . . . . . **26**
20. Leaves light green, blade vertically oriented, spongy, veins inconspicuous; distal part of limb red-purple, collar zone yellow, spotted red . . . . . ***C. lingua***
– Leaves various shades of purplish, blade ± horizontally oriented . . . . . **21**
21. Limb at base usually open circular in view, with a distinct collar, tail 10–15 cm long . . . . ***C. longicauda***
– Limb at base not open circular in view, with or without a distinct collar, tail ≤10 cm long . . . . . **22**
22. Limb purple or yellowish, with ± rough protuberances . . . . . **23**
– Limb purple to dark purple, ± smooth . . . . . **25**
23. Limb with a long, filiform tail, kettle inflated . . . . . ***C. ferruginea*** var. ***sekadauensis***
– Limb with a long, but not filiform tail, kettle not inflated . . . . . **24**
24. Limb yellow(ish), throat purplish spotted . . . ***C. keei***
– Limb purple, throat purple . . . . . ***C. uenoi***
25. Limb ± upright backward coiled, throat open . . . . . ***C. striolata***
– Limb forward obliquely twisted, throat hidden . . . . . ***C. ideii***
26. Leaf blade conspicuously bullate . . . . . ***C. bullosa***
– Leaf blade not conspicuously bullate . . . . . **27**
27. Limb upright or recurved, collar narrow, conspicuous . . . . . **28**
– Limb ± forward obliquely twisted, if ± upright then collar zone broad . . . . . **29**
28. Limb strongly recurved, with many distinctly regular, round protuberances, collar thick in view, ± horizontal in circular opening . . . . . ***C. griffithii***

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– Limb upright, not recurved to any extent, protuberances rather small and ± distinct, collar thin, vertical, funnel-shaped . . . . . ***C. sahalii***
29. Limb brown, spotted . . . . . ***C. noritoi***
– Limb light to dark purple . . . . . **30**
30. Throat whitish silvery to pinkish . . . . . ***C. regina***
– Throat dark purple . . . . . **31**
31. Limb 1–1.5 cm long; leaves 5–15 cm long, blade not spongy, ± horizontally oriented . . . . ***C. bastmeijeri***
– Limb to 3 or 3–5 cm long; leaves 5–20 or 20–25 (–30) cm long, ± spongy, vertically or horizontally oriented . . . . . **32**
32. Limb to 3 cm long; leaves 20–25 (–30) cm long, ± vertically oriented, green . . . . . ***C. isae***
– Limb 3–5 cm long; leaves 5–20 cm long, ± horizontally oriented, green or with silvery purplish markings . . . . . ***C. auriculata***

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## References

Arends J. C., Bastmeijer J. D. & Jacobsen N. 1982: Chromosome numbers and taxonomy in *Cryptocoryne* (*Araceae*) II. – Nordic J. Bot. **2:** 453–463.

Bastmeijer J. D. 2017: The crypts pages. – Published at http://crypts.home.xs4all.nl/Cryptocoryne/index.html [accessed 1 Feb 2017].

Brown N. E. 1880: On some new *Aroideae*; with observations on other known forms. – Part I. – J. Linn. Soc., Bot. **18:** 242–263.

Cusimano N., Sousa A. & Renner S. S. 2012: Maximum likelihood inference implies a high, not a low, ancestral haploid chromosome number in the *Araceae*, with a critique of the bias introduced by "*x*" – Ann. Bot. **109:** 681–692.

Dao Z.-L., Chen S.-T., Ji Y.-H. & Li H. 2007: *Typhonium baoshanense* Z. L. Dao & H. Li, a new species of *Araceae* from western Yunnan, China. – Acta Phytotax. Sin. **45:** 234–238.

Devos K. M. 2010: Grass genome organization and evolution. – Curr. Opin. Pl. Biol. **13:** 139–145.

Dransfield J., Uhl N. W., Asmussen C. B., Baker W. J., Harley M. M. & Lewis C. E. 2008: Genera palmarum: the evolution and classification of palms, ed. 2. – Kew: Royal Botanic Gardens.

Engler A. 1879: *Araceae* specialmente Borneensi e Papuane raccolte da O. Beccari. – Bull. Reale Soc. Tosc. Ortic. **4:** 265–271, 295–302.

Engler A. 1883: Aracee della Malesia e della Papuasia raccolte da O. Beccari determinate ed illustrate dal Dott.r A. Engler (1882). – Pp. 259–304, tab. xvi–xxviii in: Beccari O., Malesia **1.** – Genova: Tipografia del R. Istituto Sordo-Muti.

Engler A. 1898: Beiträge zur Kenntnis der *Araceae* VII. – Bot. Jahrb. Syst. **25:** 1–28.

Ipor I. B., Tawan C. S., Abai J., Saupi N. & Meekiong K. 2009: Notes on occurrence and distribution of *Cryptocoryne* species in Sarawak. – Fol. Malaysiana **10:** 115–138.

IUCN 2016: Guidelines for using the IUCN Red List categories and criteria. Version 11. Prepared by the Standards and Petitions Subcommittee of the IUCN Species Survival Commission. – Published at http://cmsdocs.s3.amazonaws.com/RedListGuidelines.pdf [accessed 1 Feb 2017].

Jacobsen N. 1977: Chromosome numbers and taxonomy in *Cryptocoryne* (*Araceae*). – Bot. Notiser **130:** 71–87.

Jacobsen N. 1985: The *Cryptocoryne* (*Araceae*) of Borneo. – Nordic J. Bot. **5:** 31–50.

Jacobsen N. 1987a: *Cryptocoryne*. – Pp. 85–99 in: Dassanayake M. D. & Fosberg F. R. (ed.), A revised handbook to the flora of Ceylon **VI.** – New Delhi: Amerind Publishing Co.

Jacobsen N. 1987b: Portraits of threatened plants: *Cryptocoryne elliptica* Hook. f. *Araceae*. – Malayan Naturalist **40(3 & 4):** 34–35.

Jacobsen N., Idei T. & Sookchaloem D. 2012: *Cryptocoryne.* – Pp. 218–232, pl. xlv–lviii in: Boyce P. C., Soockchaloem D., Hetterscheid W. L. A., Gusman G., Jacobsen N., Idei T. & Du N. V., Flora of Thailand **11(2).** *Acoraceae* & *Araceae*. – Bangkok: The Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation.

Kasselmann C. 2003: Bogners Wasserkelch – neue ökologische Erkentnisse. – Aquarien- Terrar. Z. **56:** 26–31.

Moore G., Devos K. M., Wang Z. & Gale M. D. 1995: Grasses, line up and form a circle. – Curr. Biol. **5:** 737–739.

Ørgaard M., Jacobsen N. & Heslop-Harrison J. S. 1995: The hybrid origin of two cultivars of *Crocus* (*Iridaceae*) analysed by molecular cytogenetics including genomic southern and in situ hybridization. – Ann. Bot. **76:** 253–262.

Othman A. S., Jacobsen N. & Mansor M. 2009: *Cryptocoryne* of peninsular Malaysia. – Pulau Pinang: Penerbit University Sains Malaysia.

Petersen G. 1989: Cytology and systematics of *Araceae*. – Nordic J. Bot. **9:** 119–166.

Rataj K. 1975: Revision of the genus *Cryptocoryne* Fischer. – Stud. Ceskoslov. Akad. Ved. **3.**

Ridley H. N. 1905: The aroids of Borneo. – J. Straits Branch Roy. Asiat. Soc. **44:** 169–188.

Schulze J. 1971: Cryptocorynen aus Sarawak I–IV. – Aquarien- Terrar. Z. **24:** 230–233, 267–270, 303–306, 336–339.

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Sousa A., Cusimano N. & Renner S. S. 2014: Combining FISH and model-based predictions to understand chromosome evolution in *Typhonium* (*Araceae*). – Ann. Bot. **113:** 669–680.

Wit H. C. D. de 1971: Aquarienpflanzen. – Stuttgart: Ulmer.

Wit H. C. D. de 1990: Aquarienpflanzen, ed. 2. – Stuttgart: Ulmer.

Wang Z., Li H. & Bian F. 2002: *Typhonium jinpingense*, a new species from Yunnan, China, with the lowest diploid chromosome number in *Araceae*. – Novon **12:** 286–289.

Wong S. Y. & Boyce P. C. 2014: Studies on *Schismatoglottideae* (*Araceae*) of Borneo XXX – new species and combinations for *Bucephalandra*. – Willdenowia **44:** 149–199.

Wongso S., Ipor I. B., Tawan C. S., Budianto H., Bastmeijer J. D. & Jacobsen N. 2016: *Cryptocoryne aura* (*Araceae*), a new species from W Kalimantan, Indonesia. – Willdenowia **46:** 275–282.

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