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Article *in* Taiwania · July 2019

DOI: 10.6165/tai.2019.64.326

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Taiwania 64(3): 326-338, 2019
DOI: 10.6165/tai.2019.64.326

Four new *Cryptocoryne* (Araceae) from Sumatera, Indonesia: a new variety and three interspecific natural hybrids

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(Manuscript received 8 December 2018; accepted 8 July 2019; online published 26 July 2019)

ABSTRACT: A new diploid variety, *Cryptocoryne cordata* var. *wellyi* from the Riau Province in Sumatera is described. Three interspecific natural hybrids are also described: the diploid *C.* ×*ardyi*, the triploid *C.* ×*jambiensis* and the tetraploid *C.* ×*zukalii* nothovar. *sumateraensis*, of which the tetraploid hybrid involves *C. cordata* var. *diderici* as one parent. The hybrids are sterile but propagate vegetatively, forming large stands. A key to the *Cryptocoryne* taxa of Sumatera is provided.

KEY WORDS: Chromosome number, *Cryptocoryne*, Interspecific hybrids, Pollen fertility, Pollen stainability, Sumatera, Variety.

INTRODUCTION

Cryptocoryne is a widespread amphibious genus throughout most of SE Asia, with 65 recognized species, 19 varieties, 10 named interspecific hybrids including those presented here, and more than 15 unnamed hybrids (Bastmeijer, 2019; Jacobsen *et al.*, 2016; Wongso *et al.*, 2017). The genus is easily recognizable by its unique spathe structure: the basal tube, the rounded kettle, with no trace of a spathe margin fusion, embracing the spadix with female and male flowers, an upper tube (long or short), which is formed by fusion of the spathe margins, and a terminal limb formed at the opening upper end of the tube. The limb which may be flat, ovate elongate, extended into a tail or it may be ± spirally coiled, all of which may have various shapes, sizes and colours. The limb constitutes the main diagnostic characters of the species. When not in flower, the genus is recognized by the aquatic or amphibious leaf rosettes and long leafless, subterranean stolons which produce new rosettes. Without a fully developed spathe, however, it is in many cases difficult or impossible to differentiate among the species.

Cryptocoryne has for many years been very popular as a decorative foliage plant for tropical aquaria. The spathes seldom develop in aquaria due to the continuous submerged state, and the inflorescences have therefore not received much attention. It is the spathe characteristics, however, which are the key taxonomic characters. Leaves can also be used to identify species, but in most cases leaf characters alone are insufficient.

In a number of cases it has proved that unidentified plants, brought into cultivation represented species new to science, i.e. *C. coronata* Bastm. & Wijng., *C. decussilvae* De Wit, *C. hudoroi* Bogner & N. Jacobsen, *C. keei* N. Jacobsen, *C. moehlmannii* De Wit, *C. parva* De Wit, *C. villosa* N. Jacobsen, *C. waseri* Kettner, and *C. wendtii* De Wit (de Wit, 1990; Bastmeijer, 2019).

An important character in *Cryptocoryne* taxonomy has proven to be the chromosome numbers (Jacobsen, 1977; Arends *et al.*, 1982; Wongso *et al.*, 2017). In the present study the chromosome numbers are counted for evaluating the taxonomic identities. Here we establish the taxonomic identity of four *Cryptocoryne* taxa from Sumatera of which three came into cultivation with puzzling data of origin.

MATERIALS AND METHODS

In order to elucidate the identity of unidentified plants of the genus *Cryptocoryne*, it has proven beneficial to include an establishment of their chromosome number, as this in many of cases has proven to be a decisive piece of information as stated in the introduction. Interspecific hybrids have also been proven to occur in a number of cases within the genus *Cryptocoryne* (e.g. Jacobsen *et. al.*, 2017), and when hybridization is between more distantly related species or between species with different chromosome numbers, the hybrids are sterile, most easily detected by the study of pollen stainability/fertility. When observing sterile pollen in a sample from nature, one looks for a cause of this observation, and in the case of *Cryptocoryne*, the occurrence of hybrids provides an explanation to this

Table 1. Chromosome numbers, pollen stainablity and voucher information of ***Cryptocoryne*** from Sumatera.

Taxon	Chromosome number (2*n*)	pollen stainablity*	Collection locality	Collection date	Collection number (Herbarium)
Cryptocoryne cordata Griff. var. *diderici* (De Wit) N. Jacobsen	102	+	Jambi Prov., near Tanjung on the way from Kotabaru to Muaratebo	21 Jun. 2009	*H. Kishi*, *09-01* [*B 1296*], (BO, C, L)
Cryptocoryne cordata Griff. var. *wellyi* Wongso	34	+	Riau Province, Indragiri Hulu Regency, SW of Rengat	1 Sep. 2015	*S. Wongso, SW 1528* [*B 1633*], (BO, C, L)
Cryptocoryne ×*ardyi* Wongso	34	_	Riau Province, Pelalawan Regancy, NW of Rengat	26 Jun. 2015	*S. Wongso*, *SW 1531* [*B 1634*], (BO, C, L)
	34	_	Riau Province, at Sg. "Pelan"	May 2005	*N. Takahashi*, *JPO 0501* [*B 1123*], (C, L)
Cryptocoryne ×*jambiensis* Bastmeijer	51	_	Jambi Province, Batang Hari Regency, Sg. Pijoan	May 2005	*N. Takahashi*, *JPO 0502* [*B 1124*], (BO, C, L).
Cryptocoryne ×*zukalii* Rataj nothovar. *sumateraensis* W. Reichert	68	_	Sumatera sp. 2, exact locality unknown	22 Dec. 2014	*K. Nakamoto*, ex *B. Reichert*, *B 1617,* (BO, C)
	68	_	Riau Prov., Petapahan area, Kampar	18 Sep. 2018	*S. Wongso*, *SW 1849* (C)

*The symbol '+' indicates pollen is stained dark blue with aniline blue; '-' indicates pollen is unstained or stained light blue.

question. With the knowledge of the natural distribution of possible parents and their general morphology and chromosome number, the origin for a given proposed hybrid can be suggested. Another approach is to try to resynthesize the suggested hybrid by artificial hybridization experiments, which has been done in an ongoing study (Jacobsen and Ørgaard, 2019b; Jacobsen *et al.*, 2019), and in relation to the here described *C.* ×*zukalii* nothovar. *sumateraensis*.

For chromosome number counting and pollen stainability/fertility test, varieties of *C. cordata* Griff. s.l. and several suspected *Cryptocoryne* hybrids were sampled (Table 1). Chromosome numbers were determined at somatic metaphase of root-tips. The chromosome preparations were made with a DAPI stain according to the protocol used by Wongso & al. (2017). To ascertain fertility, pollen was stained in a mixture of Cotton Blue (Aniline Blue) 0.5 g, phenol 10 g, glycerol 10 ml, lactic acid 10 ml and distilled water 10 ml. Fertile pollen stained evenly blue, while sterile pollen did not stain or had a slight blue lumpy stain.

RESULTS

The results of the investigation of chromosome numbers of the here described plants are presented in Table 1 and Figure 1. *Cryptocoryne cordata* var. *wellyi* and *C.* ×*ardyi* both have the same chromosome number of $2n = 2x = 34$, representing the diploid level. *Cryptocoryne* ×*jambiensis* has a chromosome number of $2n = 3x = 51$, representing the triploid level. *Cryptocoryne* ×*zukalii* nothovar. *sumateraensis* has a chromosome number of $2n = 4x = 68$, representing the tetraploid level.

The here described *C. cordata* var. *wellyi* has fertile pollen, while the three other samples studied, the diploid *C.* ×*ardyi*, the triploid *C.* ×*jambiensis* and the tetraploid *C.* ×*zukalii* nothovar. *sumateraensis*, the described hybrids, have sterile pollen (Table 1 & Fig. 1).

DISCUSSION

A new variety of *C. cordata* (from Sumatera)

Cryptocoryne cordata Griff. *s.l.* is widespread in the Malesian region from Southern Thailand, Cambodia, Peninsular Malaysia, Sumatera, the Natuna Islands, and Borneo, expressing a relatively broad morphological variation of leaves, spathe and chromosome number (Arends *et al.*, 1982; Bastmeijer, 2019; Bastmeijer *et al.*, 2010; Ipor *et al.*, 2009; Jacobsen, 1977, 1985, 2002; Jacobsen *et al.*, 2012; Othman *et al.*, 2009; de Wit, 1990). Four varieties of *C. cordata* at the diploid, tetraploid, and hexaploid level are mentioned below and are compared with the new variety (Table 2).

Cryptocoryne cordata Griff. var. *cordata*, $2n = 2x = 34$, occurs in the eastern part of Peninsular Malaysia, up to the south-eastern part of Peninsula Thailand (Othman *et al.*, 2009). It is typically found in lowland peat swamp forests with slowly moving water, often influenced by acid water leaching from the forest floor. It is characterized by cordate leaf blades, which in shaded forests are often green, whereas in more open places they are silvery brown-purple marbled, the lower surface can be lightly red-purple. The spathe tube is typically 20 – 40 cm long and the spathe limb bright yellow with a smooth surface, while the inside of the kettle wall is white.

Cryptocoryne cordata Griff. var. *siamensis* (Gagnep.) N. Jacobsen & Sookch., $2n = 6x = 102$ (Bastmeijer *et al.*, 2010), occurs on the west coast of Peninsula Thailand, where it grows in small rivers and streams with limestone influence, and recently it has been reported from SE Thailand and W Cambodia. It is characterized by a more robust texture to the leaves, the lamina slightly cordate to ovate-lanceolate, with the upper surface of the lamina often purple-brown, and the lower surface red to brownish green. The spathe is typically 10 – 15 cm long, with the spathe limb yellow to brown. The inside of the kettle is white or sometimes reddish towards the base.

Cryptocoryne cordata var. *grabowskii* (Engl.) N.

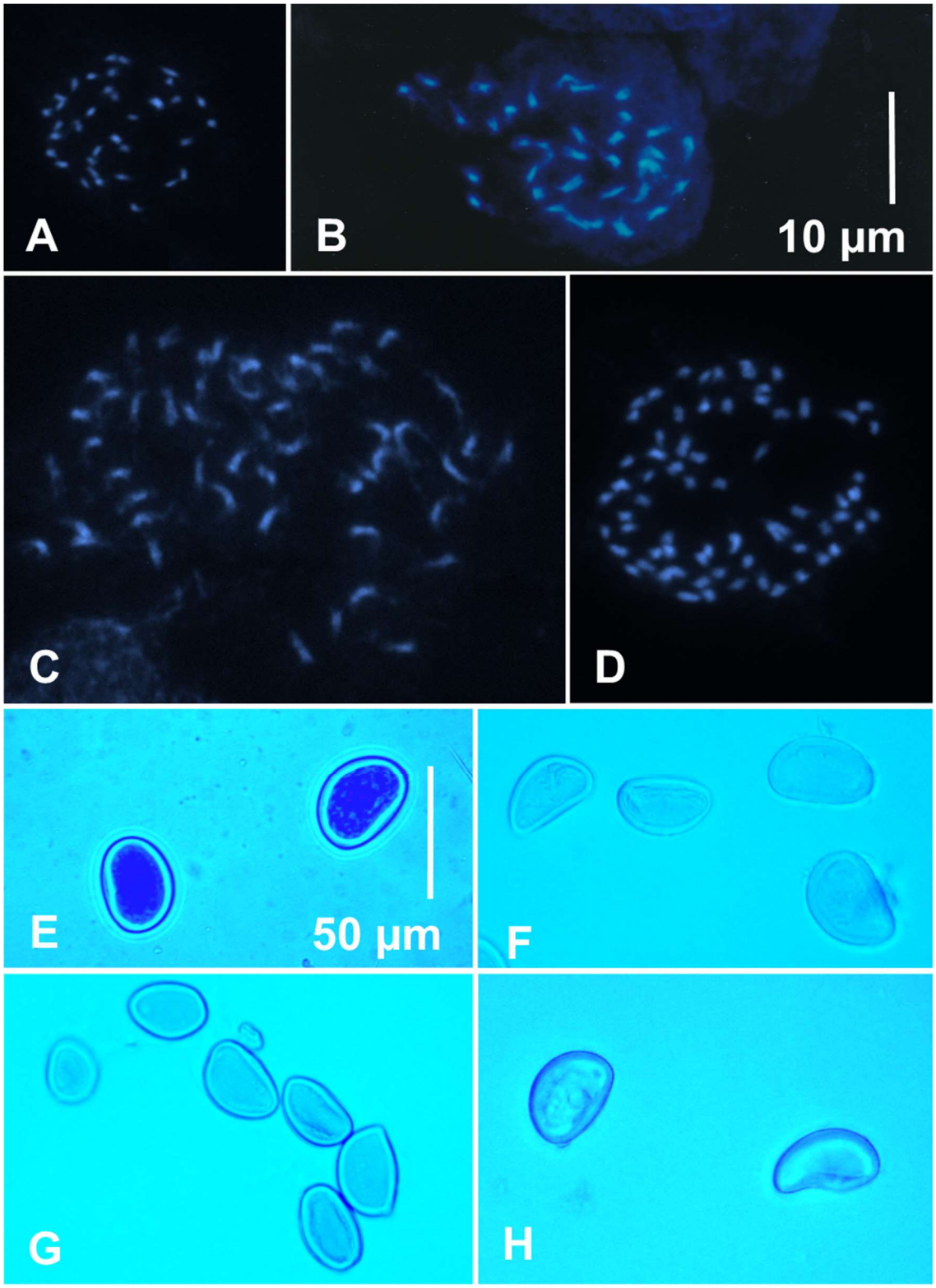

Fig. 1. Mitosis photographs of ***Cryptocoryne*** **A - D**. **A,** ***C. cordata*** var. ***wellyi***, chromosomes showing 2*n* = 34, SW 1528; **B,** ***C.*** **×*ardyi***, chromosomes showing 2*n* = 34, B1123; **C,** ***C.*** **×*jambiensis***, chromosomes showing 2*n* = 51, B 1124; **D,** ***C.*** **×*zukalii*** nothovar. ***sumateraensis***, chromosomes showing 2*n* = 68, B 1617; **Pollen stainability** photographs of ***Cryptocoryne*** **E - H**. **E,** ***C. cordata*** var. ***wellyi***, fertile pollen with an evenly dark blue stain, SW 1528; **F,** ***C.*** **×*ardyi***, sterile pollen with shades of a light blue stain, B1123; **G,** ***C.*** **×*jambiensis***, sterile pollen with shades of a light blue stain, B 1124; **H,** ***C.*** **×*zukalii*** nothovar. ***sumateraensis***, sterile pollen with a slight blue lumpy stain and a deform pollen, B 1617. – Photographs by K. R. Jensen..

Table 2. Listing the key characters for the different ***Cryptocoryne cordata*** varieties

	var. ***cordata***	var. ***wellyi***	var. ***grabowskii***	var. ***siamensis***	var. ***diderici***
Chromosome No.	2n = 34	2n = 34	2n = 68	2n = 102	2n = 102
Distribution	Southern Malay Peninsula: Southernmost Thailand and Peninsular Malaysia	Central Sumatera	Borneo, Natuna Island	Southern Thai Peninsula, E Thailand & W Cambodia	Central and South Sumatera
Leaves	blade cordate, mostly smooth to somewhat bullate, upper surface green to green-brownish with markings to brownish	ovate with slightly cordate base, green to dark green, occasionally with silvery and green markings	blade ovate to cordate, upper surface sometimes purple tinged, smooth to strongly bullate	blade narrowly ovate to ovate, smooth to bullate, upper surface green to dark green to green-brownish with markings to purplish or purple	blade cordate to rounded cordate, mostly smooth, green to olive brown on the upper surface
Leaf blade size	(3-) 5-12 (-15) × 2-10 cm	up to 6 × 10 cm	5-15 × 4-10 cm	5-16 × 3-7 cm	5-9 × 3-5 cm
Leaf length	10 – 60 cm	15 – 25 cm	10 – 40 cm	10 – 40 cm	15 – 35 cm
Spathe length	12 – 35 (- 50) cm	6 - 9 cm	10 – 40 cm	7 – 20 cm	8 – 15 cm
Limb surface	yellow, smooth	greenish, later turning yellow, surface rough	surface yellow to brownish tinged at the margin to all red brown, smooth to rough	yellow, often brownish tinged along the margin to covering larger parts of the distal parts of the limb, more or less smooth	irregularly rough on the brownish to brown
Collar zone	very broad, yellow	greenish, later turning yellow, narrow	broad, yellow, sometimes purple spotted towards the throat	broad, yellow	broad, yellow
Inside kettle wall	white	white	white, but mostly with a purple zone (or spotted) in the upper part (except Natuna Islands)	white but sometimes purple suffused over large portions of the lower part	whitish, or ± small red dots
Stigma shape	ovate to narrowly ovate, sometimes emarginate, occasionally 3-partitite	ellipsoid, sometimes emarginate	ovate to elliptic	rounded, ovate, sometimes emarginate, occasionally 3-partitite	ovate
Spadix appendix	white	white	purple spotted to almost purple	white to purplish spotted	purple spotted to purple
Male flowers	30-60 (-80)	40 - 50	20 - 50	30 – 60 (-80)	25-40

Jacobsen, $2n = 4x = 68$ (Jacobsen, 1985), is found in most of Borneo except in Sabah, and the inside of the kettle is usually marked by a purple zone in the upper part. The known populations of the Natuna Island have the inside of the kettle wall fully white or fully deep purple, respectively. The variety *grabowskii* is characterized by the often robust leaves, smooth to distinctly bullate, green to brownish on the upper surface, and reddish to green on the lower surface and the more or less cordate leaf blades. The spathe is 10 – 20 cm long, the limb is yellow or all shades of brown to almost black brown, with a broad distinct collar zone; the tube throat may be spotted red.

Cryptocoryne cordata var. *diderici* (De Wit) N. Jacobsen, $2n = 6x = 102$, is found in the central and south part of Sumatera, in streams with a muddy bottom largely consisting of mineral soil. The leaf blades are robust cordate-ovate with a brownish upper surface and a reddish lower surface. The spathe is 7 – 12 cm long, the limb yellow with reddish to brownish spots distally. The inside kettle wall is white, often with small purplish-reddish dots.

A recently collected plant from Sumatera of the *C. cordata* type is rather small with bright green, cordate-ovate leaves, a 5 – 10 cm long spathe with a rough yellow limb surface and has a chromosome number of $2n = 34$ and fertile pollen (Fig. 1A & E, Table 1 & 2).The chromosome number of $2n = 34$ within *C. cordata* is only found in var. *cordata* from Peninsula Thailand and Malaysia. Being only 1/3 of the size of var. *cordata* from the peninsula, and with bright green leaves, we consider this Sumateran plant to represent a new variety.

Hybrids in Sumatera *Cryptocoryne*

In recent years it has become evident that hybridization within *Cryptocoryne* is rather common. When two closely related species of *Cryptocoryne* inhabit the same stream or river system, there is a good chance of successful hybridization somewhere in the stream (Jacobsen *et al.*, 2016; Jacobsen and Ørgaard, 2019a). Reitel (2017) reported the occurrence of *C.* ×*timahensis* Bastmeijer (*C. nurii* Furt. var. *nurii* ×*C. schulzei* De Wit) from the island of Singkep, off the north coast of Sumatera. In this study, three hybrids are proposed and discussed below.

First new hybrid: ***Cryptocoryne ×ardyi* Wongso**

On 16 May 2005 J.D. Bastmeijer received some commercially exported samples from Japan via Norito Takahashi [*JPO 0501 = B 1123*], said to originate from Sumatera, Riau Province, at Sg. Pelan. The locality Sg. "Pelan" could not be tracked and verified. After a period of time in cultivation, the plants flowered, and the samples proved to be a hitherto unknown *Cryptocoryne*. The chromosome number is $2n = 34$ (Fig. 1B), and the pollen sterile, indicating a hybrid origin (Fig. 1F, Table 1). The colours of the spathe limb of the cultivated samples varied between light greenish yellow and reddish yellow.

Since 2014, the Riau area has been actively surveyed. One day on a routine survey around Rengat - Pekanbaru, A. Fadhly found a new *Cryptocoryne* location NW of Rengat and Sg. Indragiri; these plants resembled the Sg. "Pelan" plants.

In 2015, S. Wongso surveyed the Riau region for *Cryptocoryne* and collected accession *SW1531* which had brown leaves, while the Sg. "Pelan" plants had green leaves (Fig. 3). The population was growing on the muddy banks of a stream several meters wide, in a tertiary vegetation type resulting from the effects of an oil palm plantation.

In 2016 S. Wongso, T. Weiblen, Hendrik, W. Yansen, and A. Fadhly surveyed the Riau region again, revisited the 2015 locality. They also found two new localities close to each other in the same region, SW of Rengat, on the south side of the Sg. Indragiri, and within 50 km of the first locality.

The presently accumulated evidence suggests that the four different accessions of the Sg. "Pelan" type are hybrids presumably between *C. cordata* var. *wellyi* and *C. scurrilis* De Wit. For a hybrid between *Cryptocoryne* species from Sumatera with a chromosome number of $2n = 34$ and a broad *C. cordata* like spathe limb, one needs *C. cordata* var. *wellyi* as one parent, and the short spathe tube, a rugose spathe limb surface with a broad collar opening can be obtained from *C. scurrilis*.

Second new hybrid: *Cryptocoryne ×jambiensis* Bastmeijer

On 16 May 2005 J. D. Bastmeijer received another commercially exported sample from Japan via N. Takahashi [*JPO 0502 = B 1124*], said to come from Sumatera, Riau Province, at Sg. Pijoan (Fig. 4B – G). The accession has flowered several times and its chromosome number is $2n = 3x = 51$ – a triploid (Fig. 1C, Table 1). Suwidji Wongso visited the Pijoan River west of Jambi city in 2012 but could not find the habitat. It seems to have been cleared for human settlement. Later Y. Kobayashi reported similar plants from east of Jambi City. During the 2016 survey, S. Wongso and team visited the location and found it in a small, heavily polluted ditch behind a food factory (Fig. 4A), but later in the year when W. Yansen revisited the habitat, the population could not be found. Another population was found by Narto Tan south of Jambi City in 2017.

The triploid plant is inferred as an interspecific hybrid suggested to be between *C. bangkaensis* Bastm. ($2n = 4x = 68$) and *C. nurii* var. *nurii* ($2n = 2x = 34$), with a chromosome number of $2n = 3x = 51$. To produce a triploid hybrid in Sumatera *Cryptocoryne* species one needs a tetraploid parent, *C. bangkaensis,* and a diploid (several possibilities in Sumatera), but only *C. nurii* var. *nurii* has large, branched protuberances as found in *C. ×jambiensis.*

Third new hybrid: *Cryptocoryne ×zukalii* Rataj nothovar. *sumateraensis* W. Reichert

A third accession, *B 1617*, provided by W. Reichert from K. Nakamoto, Singapore, labelled "*Sumatera sp. 2*" (Reichert, 2015) also proved to be sterile, and it had a chromosome number of $2n = 4x = 68$ (Fig. 1D & H; Table 1). The spathe was slender, a little less than 10 cm long, a narrow limb with a slightly rough surface and a somewhat narrow opening of the tube (Fig. 5). A suggestion to parents for this hybrid would be *C. cordata* var. *diderici* De Wit, $2n = 6x = 102$ (Table 1), and *C. minima* Ridl., $2n = 34$.

An ongoing investigation of artificial hybrids in *Cryptocoryne* produced a successful hybrid between *C. cordata* var. *diderici* and *C. minima*: hybrid number: *CyCy 1311*: *C. cordata* var. *diderici* ($2n = 6x = 102$) × *C. Minima* ($2n = 2x = 34$) (Jacobsen and Ørgaard, 2019b; Jacobsen *et al.*, 2019). The hybrid siblings appeared similar to *B 1617*, being intermediate in size and shape of the spathe, limb and the tube opening, but all having a distinct purple limb.

In early 2018, A. Fadhly collected an unknown *Cryptocoryne* from the Petapahan area, Riau. Suwidji Wongso and a team visited the location later in 2018 and collected *SW 1849* in a small stream inside an oil palm plantation, which was later shown to have a chromosome number of $2n = 4x = 68$ (Table 1). Considering the chromosome number of *B 1617*, *SW 1849* and the artificial hybrid *CyCy 1311*, we would consider all as representing the hybrid combination *C. cordata* var. *diderici* × *C. minima*.

Cryptocoryne ×zukalii Rataj, $2n = 2x = 34$, from Peninsular Malaysia, is accepted as an interspecific hybrid between *C. cordata* var. *cordata* ($2n = 34$) and *C. minima* ($2n = 34$) (Jacobsen *et al.*, 2016 and unpublished). As "Sumatera sp. 2" most likely also is a *C. cordata* × *C. minima* hybrid, the combination *C. ×zukalii* is to be used as the binomial, even though it has a different *C. cordata* variety as parent. The original Peninsular hybrid would then be *C. ×zukalii* Rataj nothovar. *zukalii*, with a chromosome number of $2n = 34$, and the Sumateran counterpart *C. ×zukalii* Rataj nothovar. *sumateraensis* with a chromosome number of $2n = 4x = 68$ (Fig. 1D, Table 1).

The situation is comparable to Peninsular Malaysian *C.* ×*purpurea* Ridl. nothovar. *purpurea* (2*n* = 34) and the Kalimantan *C. purpurea* nothovar. *borneoensis* N. Jacobsen *et al.* (2*n* = 3*x* = 51) as presented by e.g. Jacobsen *et al.* (2016).

TAXONOMIC TREATMENT

Cryptocoryne cordata Griff. var. ***wellyi*** Wongso, ***var. nov.***

Figs. 1A, E & 2

***Type*:** INDONESIA, Sumatera, Riau Province, Indragiri Hulu Regency, SW of Rengat, 01 September 2015, *S. Wongso*, *SW 1528* [*B 1633*], (holotype BO!; isotypes C!, L!).

***Diagnosis*:** *Cryptocoryne cordata* var. *wellyi* is diploid with 2*n* = 34, thereby differing from the tetraploid, var. *grabowskii from Borneo*, and hexaploid var. *siamensis*, from Peninsula Thailand and var. *diderici* from Sumatera. It differs from diploid var. *cordata* from Thai-Malaysian Peninsula by being much smaller in all parts, the leaves are evenly bright green to dark green, not having brownish purplish markings in open, sun exposed sites (like in var. *cordata*), the limb surface is rough, and the collar zone is rather narrow.

Amphibious herb with a thick and stout *rhizome*, and with long, stout subterranean stolons. *Leaves* 5 – 10 in a rosette, 15 – 25 cm long, *lamina* 6 – 10 × 4 – 6 cm, ovate with a slightly cordate base, spreading more or less upright, submerged or emergent, evenly green to dark green, occasionally with silvery and green markings, lighter on the lower surface. *Spathe* 6 – 9 cm long, outside whitish, in deeply submerged specimens the peduncle may be 4 – 8 cm long; *kettle* c.1.5 cm long, cylindrical, inside white, *flap* white; *tube* 3 – 4 cm long; *limb* 2 – 3.5 cm long, 1.2 – 1.5 cm broad, ovate, backwards bent, greenish, later turning yellow, surface rough, especially towards the margins, collar zone narrow. *Spadix* c. 1 cm long, with about 6 white *female flowers* with broadly ellipsoid to emarginate stigmas; *olfactory bodies* yellowish; *male flowers* 40 – 50, yellowish; *appendix* white. *Syncarp* not observed.

***Chromosome number*:** 2*n* = 2*x* = 34.

***Distribution*:** Endemic to Indonesia, Sumatera, and only known from Riau Province, Indragiri Hulu Regency, where it has been seen at three close localities, during the 2015-2016 surveys.

***Ecology*:** Found in drainage canals in oil palm plantations in muddy, mixed mineral soil and plant debris, submerged but also emergent on the stream banks where the plants are deeply rooted with rhizomes and stolons. Altitude range 50 – 100 m. The present habitat is a secondary habitat probably derived from a stream in the previous rainforest similar to that found in the nearby Bukit Tiga Puluh National Park.

***Conservation status*:** As *Cryptocoryne cordata* var. *wellyi* is known only from a few localities, it is difficult to ascertain the conservation status according to IUCN (2017) categories and criteria, except that it is Data Deficient (DD).The habitat of the type collection of *C. cordata* var. *wellyi* is a ditch in an oil palm plantation.

***Eponymy*:** Named after Mr. Welly Yansen, who is a long-time investigator of aquatic plants of Sumatera.

***Cultivation*:** *Cryptocoryne cordata* var. *wellyi* is easily cultivated submerged or halfway emergent in an acidic layer of leaf litter soil.

Cryptocoryne* ×*ardyi Wongso, ***nothosp. nov.***

Figs. 1B, F & 3

***Type*:** INDONESIA, Sumatera, Riau Province, Pelalawan Regancy, NW of Rengat, 26 June 2015, *S. Wongso*, *SW 1531* [*B 1634*], (holotype BO!, isotypes C!, L!).

***Diagnosis*:** *Cryptocoryne* ×*ardyi* is characterized by green to brownish ± bullate leaves, a short spathe with a recurved, broad yellowish limb with small purplish, irregular protuberances, a broad purple tube opening and a collar rim protruding a little; an interspecific hybrid suggested to be between *C. cordata* var. *wellyi* and *C. scurrilis*. 2*n* = 34.

Amphibious herb with long, subterranean stolons. *Leaves* 5 – 8, 12 – 18 cm long, and *lamina* 5 – 8 × 2 – 4 cm, ovate with a slightly cordate base, somewhat bullate, spreading more or less upright, submerged or emergent, brownish on the upper surface, lighter greenish on the lower surface. *Cataphylls* two-keeled, 1.5 – 2 cm long, whitish to greenish. *Spathe* about 5 cm long, outside whitish; *kettle* c.1 cm long, inside white, *flap* light yellowish; *tube* c. 3 cm long; limb 2 – 3.5 (– 4) cm long and 0.7 – 2.5 broad, ovate, backwards bent, greenish to yellow with a rough surface from irregular small purplish protuberances, a broad purple tube opening and a collar rim protruding a little. *Spadix* c. 1 cm long, with about 6 white *female flowers* with broadly ellipsoid to emarginate stigmas; *olfactory bodies* yellow; *male flowers* 35 – 45, yellow, pollen fertility 0%; *appendix* white. *Syncarp* not observed.

***Chromosome number*:** 2*n* = *2x* = 34.

***Distribution*:** Endemic to Indonesia, Sumatera, and only known from the Riau Province, Indragiri Hulu Regency with three known localities.

***Ecology*:** Slow running streams and pools in muddy mixed mineral soil and plant debris, submerged but also emergent with many stolons on the stream banks. Water conductivity 48 µS/cm.

***Conservation status*:** As *Cryptocoryne* ×*ardyi* is known only from three localities, it is difficult to ascertain the conservation status according to IUCN (2017) categories and criteria, except that it is Data Deficient (DD); more observations are needed in order to outline a conservation assessment.

Fig. 2. ***Cryptocoryne cordata*** var**.** ***wellyi*****. A,** flowering submerged specimen at type locality of SW 1528; **B,** habit of plant showing the relatively short spathe and the long peduncle with iron precipitations on the petioles; **C,** spathe limb showing the narrow collar zone and the rough limb surface; **D,** cut open kettle showing female flowers, naked portion of spadix and male flowers above. – Photographs by S. Wongso.

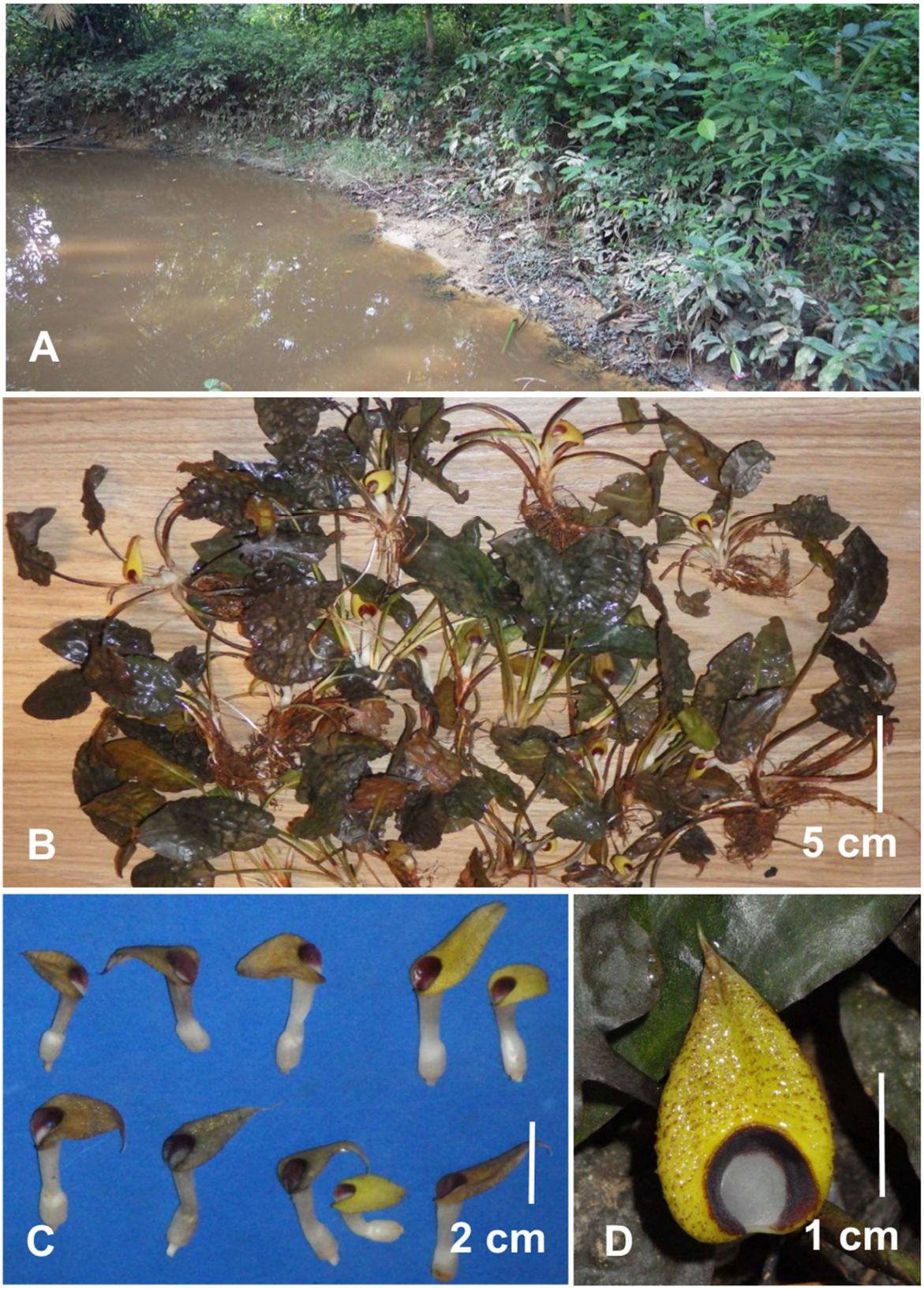

Fig. 3. *Cryptocoryne ×ardyi*. A, habitat at type locality of SW 1531, with an emergent stand along the bank of the eroded stream; **B,** type collection with many flowering specimens; **C,** spathes from type collection; **D,** spathe showing the characteristic yellow, rough limb surface with small purplish protuberances and a broad purple tube opening. – Photographs by S. Wongso.

***Eponymy*:** Named after Mr. Ardy Fadhly, who discovered the type population.

***Notes*:** The cultivated samples of *B 1123* from Sg. "Pelan" has smooth to somewhat green leaves. The colour of the limb of the spathe is either greenish yellow with distant purple protuberances, or darker yellow with dense, distinctly coloured brown-purple protuberances making the spathe limb appear brown-purple, much darker than those of *SW 1531*.

Variation in of colour of the spathe limb, as in accessions of *C.×ardyi*, have been observed in other *Cryptocoryne* hybrids, e.g. in *C.* ×*purpurea* Ridl. nothovar. *purpurea*, in which eight different spathe limb colour types are reported found (Jacobsen *et al.*, 2016).

***Cultivation*:** *Cryptocoryne* ×*ardyi* is easily cultivated submerged or halfway emergent in an acid layer of leaf litter soil.

Cryptocoryne* ×*jambiensis Bastmeijer, ***nothosp. nov.*** **Figs. 1C, G & 4**

***Type*:** INDONESIA, Sumatera, Jambi Province, Batang Hari Regency, Sg. Pijoan, May 2005, *N. Takahashi*, *B 1124* [*JPO 0502*], (holotype BO!, isotypes C!, L!).

***Diagnosis*:** *Cryptocoryne* ×*jambiensis* is characterized by brownish ± bullate leaves, a spathe with a backwards recurved-twisted, purple limb with irregular, almost branched purplish protuberances, a narrow purple tube opening and a distinct collar; an interspecific hybrid suggested to be between *C. bangkaensis* Bastm. ($2n = 4x = 68$) and *C. nurii* var. *nurii* ($2n = 2x = 34$), with a chromosome number of $2n = 3x = 51$.

Amphibious herb with long, subterranean stolons. *Leaves* 5 – 8, 12 – 16 cm long, *lamina* 4 – 8 × 2 – 4 cm, ovate with a slightly cordate base, somewhat bullate, spreading more or less upright, brownish on the upper surface, lighter on the lower surface. *Spathe* about 7 cm long, outside whitish; *kettle* c. 1.5 cm long, inside white in the lower half, upper part with a purple zone continuing into the lower part of the tube, *flap* whitish; *tube* c. 3 cm long; limb 3 – 5 cm long and c. 1.5 cm broad, narrowly ovate, backwards twisted, purple with a rough surface of irregular, almost branched protuberances, a narrow purple tube opening and a distinct collar. *Spadix* c. 1.5 cm long, with about 5 white *female flowers*, finely purplish sprinkled towards the ovate to emarginate stigmas; *olfactory bodies* irregularly rounded, yellow; *male flowers* 40 – 50, yellow, pollen fertility 0%; *appendix* purple spotted. *Syncarp* not known.

***Chromosome number*:** $2n = 3x = 51$.

***Distribution*:** Endemic to Indonesia, Sumatera, and previously only known from one locality, supposedly in Jambi Province. In January 2017 N. Tan collected an unidentified *Cryptocoryne* from Tangkit Sungai Gelam, near Jambi, which flowered in December 2017, with a spathe very similar to Sg. "Pijoan".

***Ecology*:** Slow running ditch in mixed mud and plant debris, growing submerged and producing many stolons. Water pH 6.0 and conductivity 50µS/cm.

***Conservation status*:** As *Cryptocoryne* ×*jambiensis* is known only from one small area, it is difficult to ascertain the conservation status according to IUCN (2017) categories and criteria, except that it is Data Deficient (DD): more observations are needed in order to outline a conservation assessment.

***Etymology*:** Named after province of Jambi, the region from where the plants come from.

***Cultivation*:** *Cryptocoryne* ×*jambiensis* is easily cultivated submerged or halfway emergent in an acid layer of leaf litter soil.

Cryptocoryne* ×*zukalii Rataj nothovar**. *sumateraensis*** W. Reichert, ***nothovar. nov.*** **Figs. 1D, H & 5**

***Type*:** INDONESIA, Sumatera, exact locality unknown, 22 December 2014, *K. Nakamoto*, *Sumatera sp. 2*, ex W. *Reichert*, *B 1617* (holotype BO!, isotype C!).

***Diagnosis*:** *Cryptocoryne* ×*zukalii* nothovar. *sumateraensis* is characterized by its green leaves, a spathe with a rather narrow, backwards bent, brownish limb with a somewhat rough surface, a not narrowed, yellowish-brownish tube opening with a distinct collar zone; an interspecific hybrid suggested to be between *C. cordata* var. *diderici* ($2n = 6x = 102$) and *C. minima* ($2n = 2x = 34$).

Amphibious herb with long, thin subterranean stolons. *Leaves* 5 – 8, 10 – 15 cm long, *lamina* 3 – 7 × 1.5 – 4 cm, ovate with a slightly cordate base, smooth, with somewhat undulate margins, green on the upper surface, lighter on the lower surface. *Spathe* 6 – 8 cm long, outside whitish, upper part dark greenish-brownish; *kettle* 0.8 – 1 cm long, inside white, *flap* whitish; *tube* 3 – 3.5 cm long; *limb* 3 – 4 cm long and c. 1 cm broad, narrowly ovate, backwards bent, brown with a somewhat rough surface, a broad, yellowish, finely but densely red spotted tube opening and a distinct collar zone. *Spadix* c. 1 cm long, with 6 – 7 white-greenish *female flowers* with broadly ovate ± emarginate stigmas; *olfactory bodies* irregularly rounded, yellow; *male flowers* 35 – 45, yellow, pollen fertility 0%; *appendix* purple spotted. *Syncarp* not observed.

***Chromosome number*:** $2n = 4x = 68$.

***Distribution*:** Endemic to Indonesia, Sumatera where the exact location for type collection is unknown.

***Additional collections*:** A. Fadhly collected an unidentified *Cryptocoryne* from the Petapahan area, Riau in the spring 2018 which was recently confirmed as *Cryptocoryne* ×*zukalii* nothovar. *sumateraensis*. During the 2018 survey, S. Wongso and team visited the location and collected specimens in a small stream inside an oil palm plantation: Riau Prov., Petapahan area, Kampar, 18 September 2018, *S. Wongso*, *SW 1849* (C!).

***Ecology*:** The Petapahan population was found thriving in drainage canals in an oil palm plantation in muddy, mixed mineral soil and sand, submerged but also emergent on the stream banks.

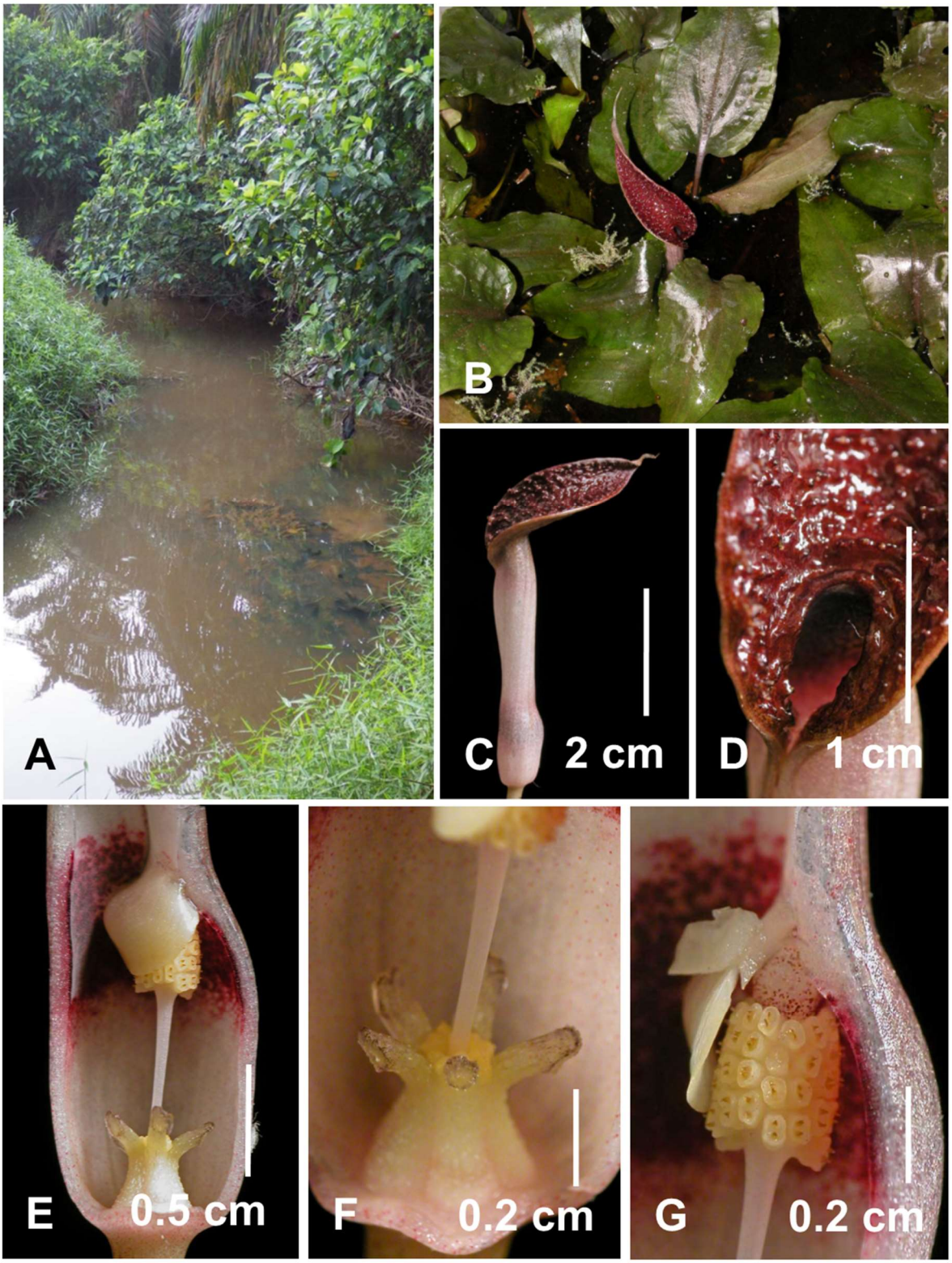

Fig.4. ***Cryptocoryne ×jambiensis*****. A,** habitat east of Jambi City in a small, heavily polluted ditch; **B,** submerged cultivated specimens with the twisted spathe limb above water; **C,** whole spathe seen from the side; **D,** closeup of spathe limb with protuberances, narrow collar and black purple tube opening; **E,** cut open kettle showing female flowers, naked portion of spadix and male flowers above and below the flap and the upper part of kettle wall with a purple zone; **F,** female flowers with outward bent stigmas and yellow olfactory bodies; **G,** male flowers with flap partly cut away showing the purple spotted appendix. B – I, cultivated specimens of the type collection, B 1124. – Photographs: A by S. Wongso, B by N. Jacobsen, C – G by J. D. Bastmeijer.

Fig. 5. ***Cryptocoryne* ×*zukalii* nothovar. *sumateraensis***, cultivated type specimen B 1617. **A,** emergent specimen showing the horizontally bent brownish spathe limb and yellowish tube opening; **B,** spathe limb seen from above; **C,** cut open kettle showing female flowers, naked portion of spadix and male flowers above and halfway behind flap the purple spotted appendix. Photographs by W. Reichert.

***Conservation status*:** As *Cryptocoryne* ×*zukalii* nothovar. *sumateraensis* is known only from one locality, it is difficult to ascertain the conservation status according to IUCN (2017) categories and criteria, except that it is Data Deficient (DD): more observations are needed in order to outline a conservation assessment.

***Etymology*:** Named after the island of Sumatera.

***Notes*:** The above description of *C.* ×*zukalii* nothovar. *sumateraensis* is based on the cultivated type specimen. The new collection from Sumatera, *SW 1849*, has slightly larger, more purplish leaf blades than the type specimen, and the spathe limb is evenly purple red coloured.

Cryptocoryne minima was in Sumatera previously only recorded from North Sumatera near the border to Aceh Province. However, a recent collection from the Rokan Hulu area, Riau proved to be *C. minima*, hereby extending the *C. minima* distribution in Sumatera.

***Cultivation*:** *Cryptocoryne* ×*zukalii* nothovar. *sumateraensis* is easily cultivated submerged or halfway emergent in an acid layer of leaf litter soil.

Key to *Cryptocoryne* species and hybrids of Sumatera and adjacent islands excluding the Anambas and Natuna Islands.

With the new taxa of *Cryptocoryne* described here and previously, a key is provided. The characters and measurements are from wild growing accessions. For brevity, the term "limb" refers to the limb of the spathe.

1a. Limb with long cilia at margin . ***C. ciliata*** (Roxb.) Schott var. ***ciliata***
1b. Limb without cilia at margin ……..……. 2
2a. Leaf blade ± covered with hairs on abaxial surface and/or along margins ……..…… 3
2b. Leaf blade glabrous ……..……... 4
3a. Spathe tube short, < half of limb length ……. ***C. fusca*** De Wit
3b. Spathe tube long, > 2 × limb length ……. ***C. wongsoi*** I. B. Ipor
4a. Tube of spathe > 2 × as long as limb ……..…… 5
4b. Tube of spathe ≤ 2 × as long as limb ……..…….. 11
5a. Limb surface covered by short black purple hairs .. ***C. villosa*** N. Jacobsen
5b. Limb surface not covered by short black purple hairs ……..... 6
6a. Limb surface with ± distinct protuberances …… 7
6b. Limb surface without distinct protuberances, but± rough …… 9
7a. Collar with a narrow opening, and with distinct protuberances or conspicuous denticulations along the margins …….. 8
7b. Collar with a broad, black-purple, funnel-shaped opening, and smaller protuberances not specifically along the margins …… …… ***C. schulzei*** De Wit
8a. Limb surface densely covered with many branched protuberances ….. …… ***C. nurii*** Furt. var. ***nurii***
8b. Limb with distinct protuberances or conspicuous denticulations along the margins …….. ***C. bangkaensis*** Bastm.
9a. Limb narrow, brownish to purplish, surface ± smooth, collar zone narrow, brown spotted to evenly purplish …….. …….. ***C.*** ×***zukalii*** Rataj nothovar. ***sumateraensis*** W. Reichert
9b. Limb broad, yellow to brown, surface rough, collar zone broad, yellow ……..……..……. 10
10a. Leaves green; limb surface yellow, rough ……..……. ……..…… ***C. cordata*** Griff. **var.** ***wellyi*** Wongso
10b. Leaves purple ± with markings; limb surface ± brownish tinged, ±smooth to a little rough ……..…… …….. ***C. cordata*** Griff. **var.** ***diderici*** (De Wit) N. Jacobsen
11a. Limb with a tail about as long as the tube …….. ***C. longicauda*** Engl.
11b. Limb without a long tail …….. 12
12a. Limb surface with ± distinct protuberances …….. 13
12b. Limb surface without ± distinct protuberances …… 19
13a. Limb surface with uniformly rounded protuberances ……..…….. …… ***C. griffithii*** Schott
13b. Limb surface with irregular protuberances …….. 14
14a. Limb surface with ± branched protuberances …… 15
14b. Limb surface without ± branched protuberances ……..……. 18
15a. Collar thick, asymmetrical collar opening, protuberances irregular, only slightly branched ……..……..… ***C. scurrilis*** De Wit
15b. Collar thin, regular in opening, protuberances branched ……..... 16
16a. Limb distinctly twisted ……..…… ***C.*** ×***jambiensis*** Bastm.
16b. Limb flat, ± recurved ……..…….. 17
17a. Limb surface densely covered with many branched protuberances ……..…… ***C. nurii*** Furt. **var.** ***nurii***
17b. Limb surface with fewer branched protuberances …… ……..…….. ***C.*** ×***timahensis*** Bastm.
18a. Limb narrow, < 1 cm broad ……. ***C. minima*** Ridl.
18b. Limb broad, > 1 cm broad ……..……..…….. ***C.*** ×***ardyi*** Wongso
19a. Limb distinctly recurved and narrowed, with a broad, vertical, funnel-shaped purple collar zone ……..…… ***C. schulzei*** De Wit
19b. Limb not distinctly recurved, yellow or purple, upright or forward obliquely twisted without a vertical funnel-shaped purple collar zone ……..…… 20
20a. Limb ± purplish, upright to forward obliquely twisted ……... …….. ***C. moehlmannii*** De Wit
20b. Limb ± yellow to reddish, upright to somewhat twisted ……. …….. ***C. pontederiifolia*** Schott

ACKNOWLEDGEMENTS

We thank four anonymous reviewers for constructive comments on an earlier version of the manuscript. Hendra Budianto for discussion and comments. Jacob Weiner kindly reviewed the English text in an earlier version.

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