The Cryptocoryne (Araceae) of Borneo

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Fourteen species of *Cryptocoryne* are recognized from Borneo: *C. ciliata* found throughout tropical Asia, *C. longicauda* also found in Johore; *C. zonata, C. grabowskii,* and *C. edithiae* show distinct affinities to the *C. cordata* group from the Malay peninsula; the remaining species, endemic to Borneo, do not show any special, close relationship with species from other areas. The synonomy, distribution, chromosome numbers, and ecology are treated.

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Introduction

The *Cryptocoryne* of Borneo are, morphologically, deviating from most other species of the genus, and they have for a long time been the source for wonder. Beccari's collections from the eighteen sixties are remarkable in more than one way, e.g. in their number of species, but they are also well preserved when one takes into consideration the circumstances under which Beccari travelled and collected (see also Moore 1981).

The first in recent times to investigate the *Cryptocoryne* of Borneo was Henry Ong, Kuching, who, a hundred years after Beccari, had obtained a vast knowledge of the *Cryptocoryne* of Sarawak. Schulze (1971) wrote a series of articles on the localities and habitats in Sarawak, and his very accurate listings and observations can actually serve as a good excursion guide. In 1978 Josef Bogner, Munich, and the author made a trip to Sarawak to study the riverine Araceae. Almost all the collections of *Cryptocoryne* were brought back alive and cultivated at the Botanical Garden in Copenhagen, and these collections are the main basis for the cytological investigations (Arends et al. 1982) and the present revision. The main set of preserved specimens is deposited at C, and duplicates are found at SAR, US, K, WAG, and M. Photographs of the spathes of the species from Borneo are found in Jacobsen (1977), Arends et al. (1982), Jacobsen (1982), and de Wit (1983).

Even with the collections at hand today, some of the species are known only from very few collections and our knowledge of them is, therefore, limited, especially of their distribution. Many more and good collections are badly needed.

Habitats

The habitats of the *Cryptocoryne* of Borneo resemble the habitats of those of the Malay peninsula, but differ markedly from those of e.g. Thailand and Ceylon (cf. Jacobsen 1976, 1979, 1980 a, 1982). Horst (1981, 1982) has carried out water analyses from six *Cryptocoryne* localities in Sarawak, and in comparison to localities in Ceylon and Thailand they were characterized by small amounts of sulphate, the contents of phosphorus and ammonium were almost immeasurable, while the contents of iron was fivefold higher.

There are in a sense three different habitats, viz. the inner tidal zone with what can be characterized as amphibious life forms, the slow to fast running rivers and streams with purely (or almost) aquatic life forms, and the banks of some of the smaller rivers and streams with plants that have a rheophytic way of life. Almost all localities are situated in deep shade.

Of the species typical for the tidal zone, *C. ciliata* is the only one with a tube of the spathe that exceeds a length of a few centimeters. The species with the short

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tubes, viz. *C. ferruginea, C. fusca,* and *C. lingua* are found in the inner part of the freshwater tidal zone, often in deep mud. In cultivation the plants may grow both submerged and emerged, however, not becoming as luxurious in the foliage as plants from the natural habitats. These tidal species are able to flower during the periods of the month when the oscillation in the tidal amplitudes is at a minimum, and the plants growing highest up the riverbed and riverbanks become emerged for several days (Jacobsen 1980 b, Horst 1981). The tidal zone, or the tidal influenced zone, has a much larger extension in the lowland swamp forests than immediately recognizable. The Stapok F. R., a locality for *C. ferruginea,* is situated just above sea-level, and the run-off is strongly influenced by the amplitude of the tide. In the larger streams the freshwater can be pushed back many kilometres upstream by the high tide and, even further up, the water simply stops running during high tide. At the 12.5 mile stone, W of Batu Kitang, also a locality for *C. ferruginea,* the tidal influenced area only extends a few hundred meters beyond the main course of the Sg. Kanan Sarawak.

The locality for *C. grabowskii,* on the road to Matang, is in a lowland swamp forest with a thick layer of leaf-peat (cf. Anderson 1964, Brunig 1974) and black, slow running water (Horst 1981). This *C. grabowskii* locality may also be influenced by the stemming up of water by the tide. Korthaus (1980) has described localities for *C. grabowskii* (as *C. cordata*) and *C. edithiae* (as *C.* sp.) in Kalimantan. *C. edithiae* grows in black, slow running water (lowland forest influenced by the slow run-off) and *C. grabowskii* in clear, more fast running water, but for both species the water conditions were acid with a pH below 5, and a conductivity approaching 0 (20°C).

C. longicauda grows in small rivers, streams, or seasonally flooded forest pools, which may carry running water during the season. The plants are always situated in deep shade, except where the forest has been cut. In the streams they are generally found in thick growths that cover the sides and the bottom completely, while in the forest pools the plants are more scattered. At Kpg. Stutong and Serian, *C. longicauda* was found in smaller or larger patches in small streams from the upper limit of the tidal zone and upwards. Even above the limits of the tidal zone (September), it was evident that the tide had an influence in hindering the run-off from the stream also above the tidal limits, especially, perhaps, in periods with heavy rainfall. In Sg. Engkramut *C. longicauda* grows together with *C. zonata* (see also Schulze 1971). These two species do not grow in exactly the same niches, but occupy adjacent areas in the river: *C. longicauda* perhaps the more sheltered places, and *C. zonata* almost "continuing", from where *C. longicauda* decreases, and out into the banks and the sand bars in the main river. Plants of the two species were only in a few cases found together. Bogner collected *C. zonata* in Brunei at the Badas River and described the locality as "more or less standing water (pools) in a natural forest. The pools were the remains of a small stream, which only carries little water during the drier season".

C. striolata was found to be rather common in Sarawak. It was found in small, rather slow running streams (Pakan (6 miles), Sg. Lalang, Batu Besai, Kpg. Panchor) or in larger rivers (Pakan (4 miles), Sg. Kura, Kpg. Monkus (Horst 1982), Sg. Lanting Gayau), sometimes even in rather fast running rivers (Sg. Entabai). It was always in shaded forests, except where the trees were recently cut. The water was clear, and the bottom was usually stony or sometimes sandy. The plants were usually growing in shallow water (September) and flowering abundantly, but also specimens growing in deeper water were flowering, and the long spathes were often broken or bent because of the flushing water of sudden rains. Near Pakan (6 miles), *C. striolata* was found in a small stream, some plants growing in places with shallow, rapid running water on stony bottom, others in river pools with deep water and a muddy bottom. In this place the plants were 10 to 25 cm tall, and with green to marbled green, purple to marbled purple and purple leaves. At Sg. Entabai, *C. striolata* was found creeping in cracks in the bedrock in the middle of a rapid, a few hundred metres further down the river than *C. auriculata.* This latter species was growing in the stony riverbed up to the high water mark, a typical rheophytic habitat. This was demonstrated eminently during our visit: a few days before our visit, the whole locality, except for a small streamlet, was dry and *C. auriculata* was flowering abundantly in the riverbed. The night before our arrival, heavy rains had started, and when we arrived *C. auriculata* was under 1–2 m of water. When we returned later in the afternoon, the water had fallen more than one meter, and it was possible to find the plants when searching the muddy waters. At Sg. Lalang, *C. auriculata* and *C. striolata* were also growing in the same river, the first emerged on the sandy banks and the second submerged in small pools.

C. bullosa is found in larger, rather quick running rivers (Sg. Sibiak, Pakan), where the plants are rooted deep in the sand and normally completely submerged, only emerged at very low water. The plants are larger and are found in much denser patches in places where the water flows faster, e.g. on sand bars and at rapids.

The distribution maps obtained from the studied herbarium material strongly underestimate the total coverage of the species. Fig. 1 shows a more exact location of the different species in the most extensively collected area in Borneo, western Sarawak. There are differences between the different species in their habitat preferences, but from the experience gained on the field trips in 1978, it can be postulated that there is hardly one river in western Sarawak which does not contain at least one species of *Cryptocoryne,* unless strongly polluted. The same can no doubt be said about most of the other parts of Borneo.

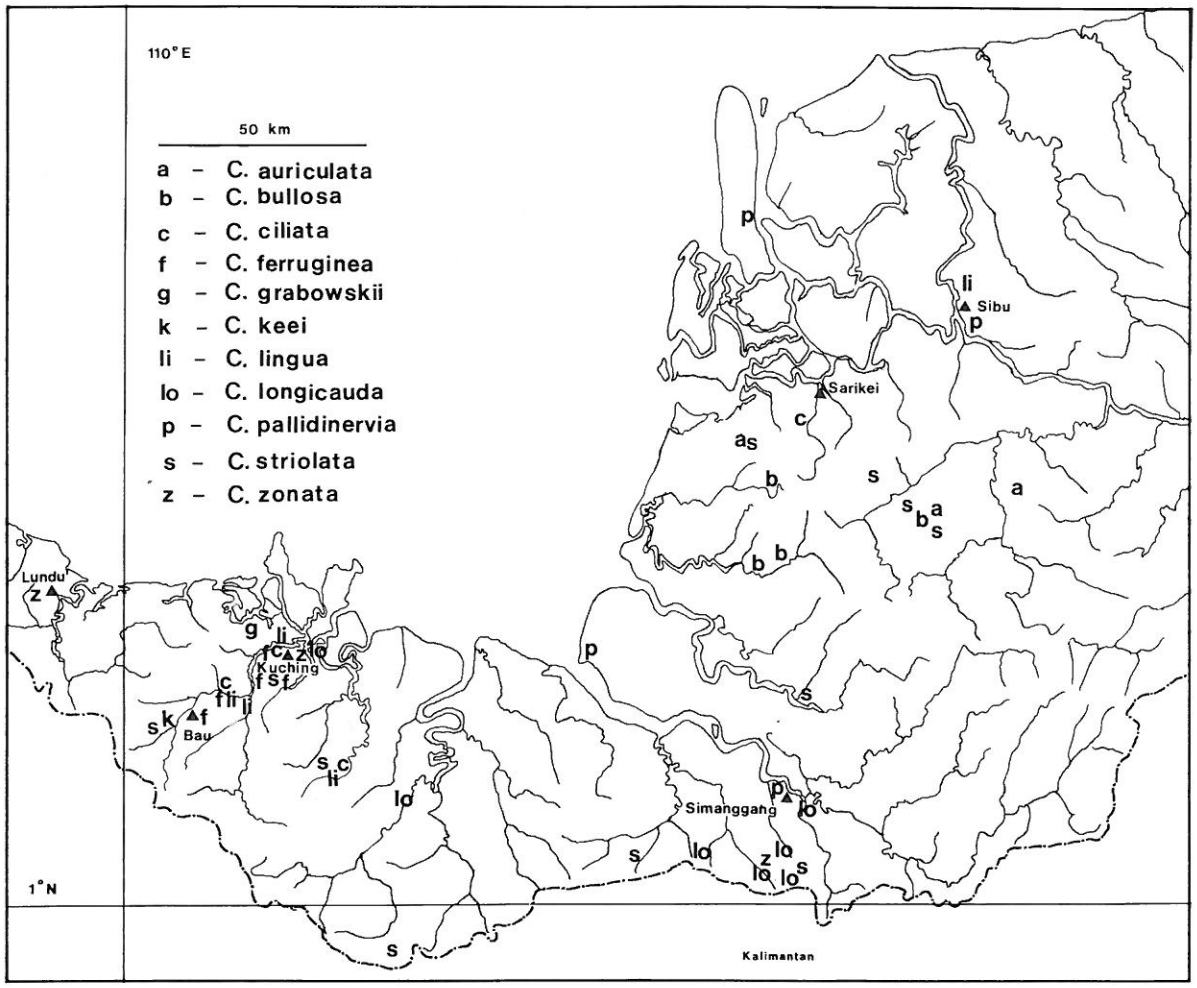

Fig. 1. The known distribution of the *Cryptocoryne* in western Sarawak.

The future of the Cryptocoryne habitats

The rapid exploitation and demolishment of the forests results in a total washout and a subsequent strong erosion in the rivers so the substrate necessary for the *Cryptocoryne* is washed away. The rushing and muddy water prohibits re-establishment of the populations, and the sunlight facilitates dramatic changes in the vegetation towards more light requiring species, further enforced by an abundant supply of washed-in nutrients.

Suitable habitats for *Cryptocoryne* will thus diminish. Also collecting for commercial aquarium use may more or less exterminate a species from a given area. Especially species with very limited distribution areas are in danger of extermination, e.g. the endemic form of *C. longicauda* from Gunong Pulai in Johore which may be extinct within a few years.

A more positive development for *Cryptocoryne* has been seen in places that have been planted with rubber (*Hevea brasiliensis*). At Kpg. Tekalong near Melugo, the forest was cleared 20–30 yr ago, and in this plantation *C. longicauda* has been able to reclaim streams, rivers, and forest pools. The patches were not so extensive as in undisturbed localities, but they were a prominent part of the herb vegetation. In two other localities where *C. longicauda* was found, viz. Sg. Engkramut and Kpg. Stutong, the forest were also secondary, and the occurrence there is no doubt the result of a recolonization. At Batu Besai, also near Melugo, *C. striolata* was found in a small stream in a 10–15 yr old rubber plantation. It was not dominating as the above mentioned *C. longicauda,* but the habitat was different and the rubber planting much younger. In other localities, e.g. Kpg. Panchor, Kpg. Gileang, and Kpg. Monkus, the forest was either typical secondary or strongly influenced by forest cutting, and here *C. striolata* was also growing in large populations.

The two species from fast running water, viz. *C. bullosa* (Sg. Sibiak) and *C. keei* (near Bau), were also sur-

rounded by more or less secondary forest, apparently being able to keep up with the erosion and depositing of mud and sand (see also Schulze 1971). Apparently these two species are able to adapt, at least to some degree, to the changes in conditions caused by the cutting of the forests, probably as long as it is not accompanied by strong pollution. Thus there seems to be no immediate danger of extinction of the species of *Cryptocoryne* of Borneo.

Morphology and cytology

The *Cryptocoryne* species of Borneo do not represent a homogeneous group like e.g. the *C. albida* group (Jacobsen 1980a) or the *C. beckettii* group (Jacobsen 1976). Based on the morphology and the cytology of the Borneo species, nine groups can be outlined (se also Arends et al. 1982).

2n = 20

C. striolata, C. keei, and *C. hudoroi* show similarities in the morphology, though not obvious at first sight: striate leaves, smooth limb of the spathe, and lack of a collar. The chromosome number, however, is the most prominent common feature.

2n = 22, 33

C. ciliata shows no close similarities to any other Bornean species, but the morphological affinities to *C. vesteegii* Engl. may be close, e.g. the multiciliate embryo.

2n = 30

C. longicauda differs from most other species of Borneo by having the lower part of the limb distinctly, hollowly dilated, the upper part developed into a long tail, and a pronounced collar. The shape of the limb of the spathe could suggest a relation to *C. ferruginea,* but the latter has hairy leaves and a chromosome number of 2n = 34.

2n = 34, 68

The two species *C. ferruginea* and *C. fusca* (2n = 34) are in the principal morphology of the spathe rather similar, the first differing by having a much larger kettle and a caudate limb of the spathe. Both species have the unique hairy leaves.

C. pallidinervia (2n = 34) is characterized by a long tube, a limb of the spathe with a red and rough surface, and a red speckled collar zone. The male and female part of the spadix are only separated from each other by a short distance.

C. bullosa (2n = 34) is characterized by a short tube of the spathe and a rough, red brown surface of the limb, which stops abruptly at the distinct collar or collar zone of a black purple colour. The plant grows submerged and has strongly bullate leaves.

C. auriculata (2n = 34) is characterized by a short tube of the spathe, a smooth surface of the red limb, and a large collar zone of the same colour. The plants are typical rheophytes with rather stiff, smooth leaves.

The three Borneo species with 2n = 68 may be seen as derived from species with 2n = 34, resembling the *C. griffithii – C. purpurea* and the *C. cordata* groups from the Malay peninsula; *C. edithiae* resembles *C. griffithii – C. purpurea* more, while *C. grabowskii* and *C. zonata* do resemble *C. cordata* more.

2n = 36

C. lingua shows no obvious, close similarities to other species, its characteristics being the green spongy leaves, the caudate limb of the spathe, and the lack of a collar.

Flowering

The flowering season of the various species differs, depending on the local rainfall, and on the rainfall in the upland of the rivers in question. A good impression of the rainfall can be obtained from Brunig (1974) and Walter & Lieth (1964) in Fig. 2. The best general season

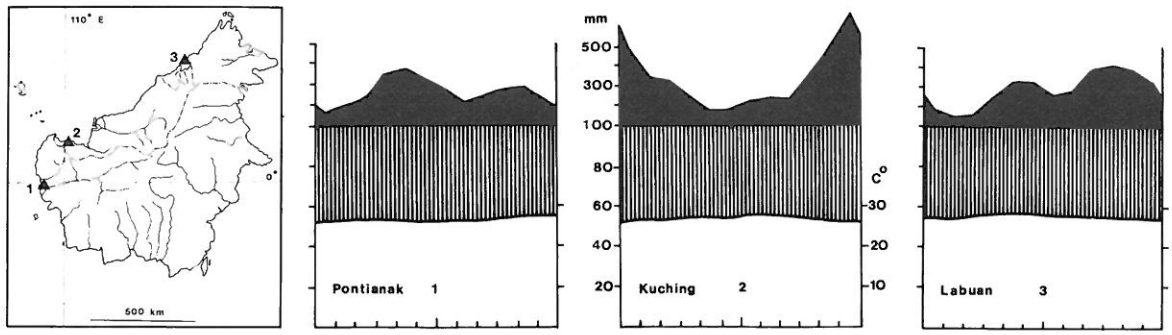

Fig. 2. Three selected climographs from Borneo showing the variation in rainfall and temperature throughout the year. Lower line: Mean monthly temperature. Shaded area: Rainfall below 100 mm monthly. Black area: Rainfall above 100 mm monthly.

in e.g. the Kuching area is in September, while e.g. in the Labuan area it is in February. Some aspects of flowering time in the tidal areas have been discussed in Jacobsen (1980 b).

The pollination of *Cryptocoryne* is performed by small flies, mostly belonging to the families Phoridae, Ceratopogonidae, and Ephydridae. Pollinating insects from several Bornean species of *Cryptocoryne* have been studied and will be presented in a paper dealing with the pollination of the genus as a whole (in prep.).

Key to the species of Cryptocoryne of Borneo

1. Limb of the spathe with long cilia at the margin..... 4. *C. ciliata*
1. Limb of the spathe without cilia at the margin..... 2
2. Leaf-blade more or less covered with hairs on the lower surface and along the margin. Limb of the spathe more than twice as long as the tube..... 3
2. Leaf-blade without hairs. Limb of the spathe shorter than the tube or usually less than twice as long as the tube. 4
3. Limb of the spathe abruptly narrowed to a thin tail, collar pronounced..... 8. *C. ferruginea*
3. Limb of the spathe not abruptly narrowed to a thin tail, collar zone present..... 9. *C. fusca*
4. Tube of the spathe more than twice as long as the limb of the spathe..... 5
4. Tube of the spathe not more than twice as long as the limb..... 10
5. Limb of the spathe with numerous, red protuberances..... 10. *C. pallidinervia*
5. Limb of the spathe more or less smooth, yellow or brown, or with a purple collar zone..... 6
6. Limb 0.5–1 cm broad, with a rather long, more or less twisted point..... 7
6. Limb usually more than 1 cm broad, without a long tail or point..... 8
7. Leaf-blade 3–12 cm long, almost smooth.. 1. *C. striolata*
7. Leaf-blade 10–30 cm long, strongly bullate 3. *C. hudoroi*
8. Limb of the spathe brown with reddish brown spots in the yellow throat..... 13. *C. edithiae*
8. Limb of the spathe yellow, sometimes with a brownish tinge..... 9
9. Collar zone present, lamina of the spathe smooth, the inside of the kettle with a purple zone..... 12. *C. zonata*
9. Collar zone with a bulge on the edge or almost developed into a collar, lamina of the spathe rough to verrucose, inside of the kettle wall without a purple zone..... 11. *C. grabowskii*
10. Limb of the spathe with a long point or tail..... 11
10. Limb of the spathe without a tail..... 13
11. Limb of the spathe rough, with a distinct collar..... 5. *C. longicauda*
11. Limb of the spathe smooth, without a collar..... 12
12. Leaves light green, spongy, veins inconspicuous. Collar zone red, spotted downwards into the throat..... 14. *C. lingua*
12. Leaves green, dark green to more or less purple, veins conspicuous. Collar zone purple to dark purple, sometimes spotted in the throat..... 1. *C. striolata*
13. Leaves smooth, blade green with irregular markings..... 7. *C. auriculata*
13. Leaves strongly bullate, blade dark green without any markings..... 14
14. Limb of the spathe more or less smooth, violet, without a distinctly indicated collar or collar zone..... 2. *C. keei*
14. Limb of the spathe rough, reddish brown, with a distinctly indicated collar and/or collar zone..... 6. *C. bullosa*

1. Cryptocoryne striolata Engler

Bull. Soc. Tosc. Ort. 4: 301 (1879). – *C. striolata* Engler var. *striolata*, de Wit, Aquariumplanten 240 (1983), comb. inval. – Lectotype (selected by Rataj 1975): Beccari 1240, Regiato di Sarawak ad Kuteing (FI, 11623, isotype B).

C. gracilis De Wit, Belmontia 13: 279 (1970). – *C. striolata* Engler var. *gracilis* (De Wit) De Wit, Aquariumplanten 240 (1983), comb. inval. – Holotype: Purseglove 5361, Sg. Mayeng, Tau Range, Sarawak, 4.6.1965 (SING, isotypes L, K, A).

C. "ongii", Tomey, Het Aquarium 48(11): 288 (1978), nom. inval. – *C. striolata* Engler var. *ongii* De Wit, Aquariumplanten 240 (1983), comb. inval. – Specimens from Kpg. Panchor, Sarawak.

Rhizome often short and rugged; plants from deep, slow running water often with long internodes. Runners not frequent. Cataphylls almost always present. Leaves, on the upper side, green to purple brown, often marbled (in shady places mostly green, in sunny places bright red), lower side more or less reddish to brownish; blade ovate to elliptic, 2–12 cm long, 1–4 cm broad with a more or less cordate base; petiole 2–18 cm long (largest specimens in deep water and small compact specimens in shallow, fast running water); surface often more or less smooth, but sometimes a little bullate; margin entire. Raphids sometimes very prominent, but best seen in dried specimens. Spathe 5–20 cm long, sometimes long pedicellate; kettle 0.5–1 cm long, usually white; tube 3–15 cm long, the upper part more or less purple greyish on the outside; limb 2–5 cm long, up to 0.5 cm broad, caudate, before opening twisted into a long, fine tail; collar absent, collar zone prominent, purplish to reddish brown, sometimes more or less finely spotted; colour of the caudate limb ranging from cream to that of the collar zone. Female flowers 4–6, stigmas ovate to rounded emarginate. Olfactory bodies rounded. Male flowers 30–50, smooth. Syncarp ovoid to globular; seeds brownish, short, broad, and more or less spotted, surface more or less rough; endosperm present, embryo cone shaped, with an undifferentiated plumula – (Fig. 3A).

Chromosome number: 2n = 20 (Arends & Laan 1979, and Arends et al. 1982).

Distribution: Endemic to Borneo (Fig. 1 and 6).

Habitat: On stony, sandy or muddy bottom in more or less fast running rivers and streams, sometimes in small sheltered pools in the river (Sg. Lalang), or occasionally in rapids (Sg. Entabai). The most luxurious growths are found in places with a rather swift current. The plants are almost always submerged. Flowering and fruiting specimens are often abundant.

Notes: The identity of *C. striolata* has been rather uncertain, as no one, since the discovery of the species by Beccari more than 100 years ago, had been able to present a specimen and document that it actually was *C.*

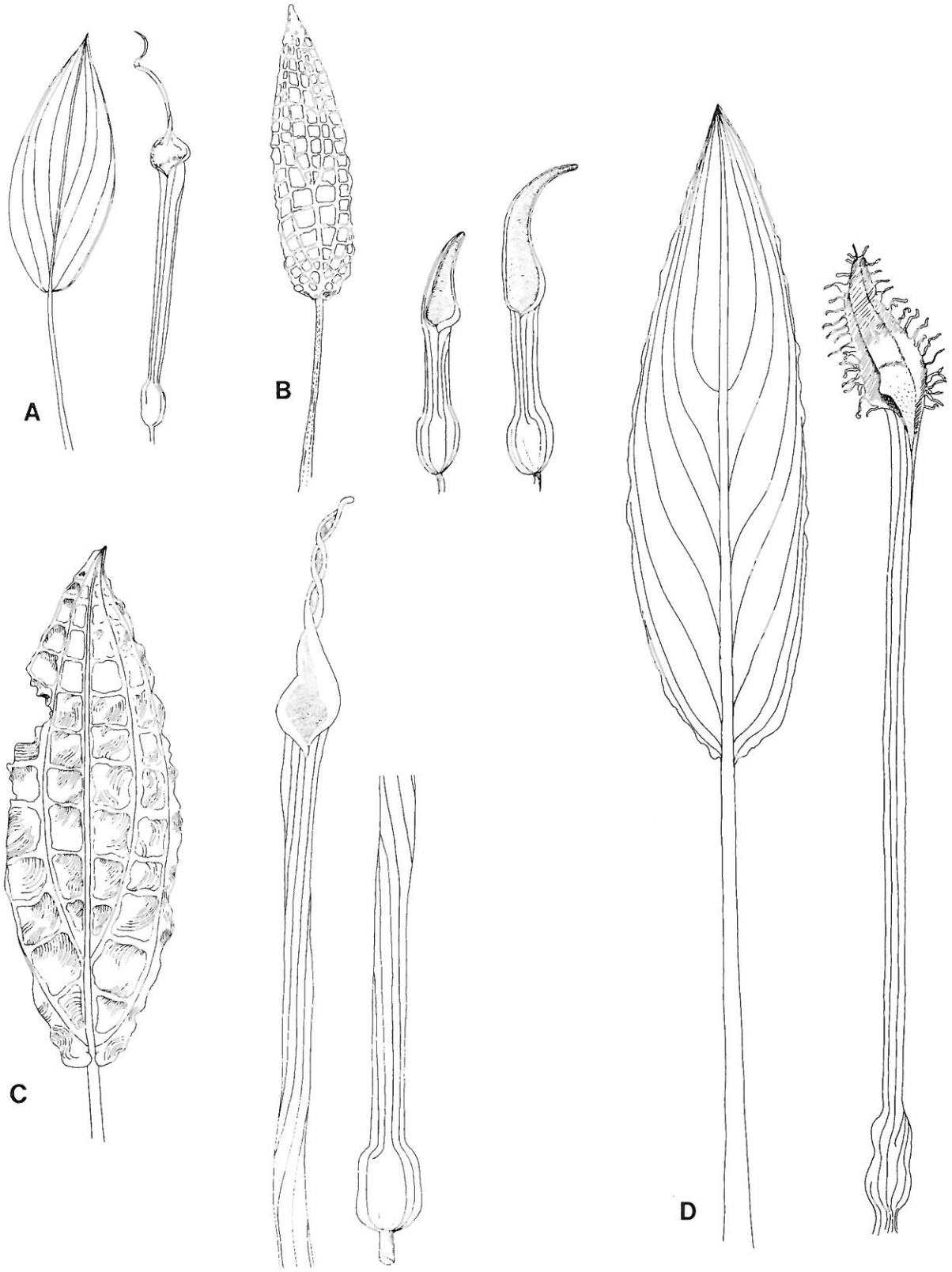

Fig. 3. Leaf and spathe of: A. *Cryptocoryne striolata* (NJ 78–52). – B. *C. keei* (Ong s.n.). – C. *C. hudoroi* (Hudoro s.n.). – D. *C. ciliata* (NJ 2845) – (All × 2/3).

striolata although the species is rather common in Borneo. The main reason for this was that the type was one large, almost flowering specimen, and the exact shape and colour of the limb of the spathe was thus unknown. Moreover, the characteristic striation of the leaves is not always present, and it is seen most prominently in dried specimens.

De Wit (1983) suggests that it may be possible to recognize three varieties within *C. striolata,* when more material is studied.

The material found in Sarawak was, however, rather homogeneous, and the variation in shape and colour of the limb of the spathe and the variation in size, shape, and colour of the leaves as found in their natural habitats can only be characterized as limited.

De Wit (1983) mentions several fruitsettings in a single cultivated specimen, apparently without crosspollination. This has not been verified by cultivation experiments in Copenhagen. In some specimens the male and female parts of the spadix are almost adnate, a possible explanation of the fruitsettings observed in Wageningen.

Characteristics: C. striolata is characterized by the ovate, more or less striate leaves, the numerous cataphylls, and by the caudate limb which lacks a collar but has a pronounced dark purple collar zone (see also *C. hudoroi*).

Specimens studied: Kalimantan: Alston 13315, Permantang, S of Kwala Kwajan, 26.1.1954 (BM); Chaper s.n., Lebroeang, Sept. (?) 1890 (P); Kostermans 13991, Mt. Ilas Mapulu, Berouw, 22.9.1957 (SING, K, L, A); Teysmann 11339, Tandren (FI). – Sarawak: Argent & Siduk 773, Gunong Mulu National Park, N of Gua Angin, 17.11.1977 (E, M); Haviland 1593, Saribas, Kalong, July 1892 (K, SING (2079 ?)); NJ 78–1, cult. H. Ong ex Panchor, 2.9.78 (C); NJ 78–3, 6 miles from junction N of Pakan, towards Entabai, 3.9.78 (C); NJ 78–4, 4 miles from Pakan towards Sarikei, 3.9.78 (C); NJ 78–5, Sg. Entabai, c. 10 miles E of Pakan, 3.9.78 (C); NJ 78–8, Kpg. Gluleong, Sg. Lalang, 4.9.78 (C); NJ 78–12, Sg. Kura, 70 miles from Kuching towards Simmanggang, 8.9.78 (C); NJ 78–18, Batu Besai (Dor), 9.9.78 (C); NJ 78–49, Sg. Kambang, tributary to Sg. Panchor, Kpg. Panchor, ca. 30 miles SE of Kuching, 22.9.78 (C); NJ 78–52, Sg. Lanting Gayau, tributary to Sg. Monkus, near Kpg. Monkus, 23.9.78 (C). – Cult.: NJ 3085.

2. Cryptocoryne keei Jacobsen

Nordic J. Bot. 2 (5): 454 (1982). – Holotype: Henry Ong Kee Chuan s.n., Bau, Sarawak (C, isotype WAG).

Rhizome in submerse specimens slender with long internodes; stolons stout. Leaves 10–40 cm long, 1–4 cm broad, strongly bullate, dark green, lower surface more brownish, often striate because of small bundles of raphides; veins conspicuous, sometimes purplish on the lower surface; base more or less cordate; margin finely undulate. Cataphylls often present in non flowering specimens. Spathe about 5 cm long; tube ca. 1 cm long; limb ca. 2 cm long, narrowly ovate, more or less funnel-shaped, violet, surface more or less smooth; collar lacking. Spadix ca. 1 cm long; female flowers ca. 6, stigmas narrowly ovate; olfactory bodies irregularly lobed, more or less united; male flowers ca. 40. Syncarp ovoid, seeds plump, brownish, ridged, with conspicuous raphid bundles; endosperm present, embryo cone-shaped with an undifferentiated plumula. – (Fig. 3B).

Chromosome number: 2n = 20 (Arends et al. 1982).

Distribution: Endemic to Borneo (Fig. 1 and 6).

Habitat: On sandy to stony bottom in fast running rivers.

Notes: The drawing is a reconstruction of the holotype, which, however, is not complete as the tip of the spathe is missing.

Just before the end of our stay in Sarawak in 1978, H. Ong received notice that a *Cryptocoryne* with lanceolate, strongly bullate leaves, apparently *C. bullosa,* was found near Bau, not too far from Kuching. However, heavy rains did not permit us to collect this plant. Later, H. Ong obtained plants from the Bau area. The chromosome number found in these plants was 2n = 20, which suggested that it was not *C. bullosa* (2n = 34), and a preserved specimen with an inflorescence proved that it was an undescribed species.

C. keei is named as an appreciation to Henry Ong Kee Chuan who has shared his experience and keen interest in aquatic plants with so many people.

C. keei is much easier to cultivate than *C. bullosa* and it grows well both emerged and submerged in a mixture of clay and peat, best under acid conditions.

Characteristics: C. keei is characterized by the bullate leaves, the short spathe with a funnel-shaped, violet limb of the spathe which is more or less smooth, and the lack of a collar (see also under *C. hudoroi*).

Specimens studied: Sarawak: NJ 78–73, Bau, 1978, leg. H. Ong (C).

3. Cryptocoryne hudoroi Bogner & Jacobsen sp. nov.

Folia ut in *C. bullosa* et *C. keei*, saepe tamen majora. Spatha 10–30 cm longa; limbus 3–6 cm longus, longe acuminatus, plus minus in helicem tortus, lacteus vel dilute violaceus, scabridus; faux violacea vel violaceo maculata.

Holotypus: F. Hudoro s.n., Apr. 1982, prope Banjarmasin, Kalimantan (C, isotypus K, M, WAG).

Rhizome mostly slender, internodes 0.1–2 cm long. Stolons slender. Leaves 15–45 cm long; blade narrowly ovate, with a more or less cordate base, 10–30 cm long, 2–5 cm broad, surface between the veins strongly bullate, veins conspicuous; petiole 5–20 cm long. Cataphylls large, up to 8 cm long. Spathe 10–30 cm long; kettle 0.5–1 cm long; tube 5–20 cm long, the upper part

whitish to more or less purplish brown on the outside; limb 3–6 cm long, narrowly ovate, more or less spirally twisted, pale yellowish to slightly purplish, surface slightly rough, collar lacking, collar zone broad, conspicuous, violet to more or less purple spotted. Female flowers 4–6, stigmas broadly ovate appearing emarginate. Olfactory bodies irregularly rounded. Male flowers 20–40, smooth. Syncarp unknown. – (Fig. 3 C).

Chromosome number: 2n = 20 (Arends et al. 1982, see under *C. keei*), Hanrieder s.n.

Distribution: Endemic to Borneo (Fig. 6).

Habitat: Probably fast running rivers on sand or gravel bottom.

Notes: In August 1978, Father Stroh collected *C. bullosa* like plants near Plaihari SE of Banjarmasin (NJ 3123), and in 1980 E. Korthaus also collected such plants SE of Banjarmasin (NJ 3143). Both these Kalimantan collections are in cultivation and have the chromosome number of 2n = 20, but neither of them have flowered yet. In August 1981 F. Hudoro presented photographs of flowering specimens, and in April 1982 he sent several flowering specimens to J. Bogner. These specimens showed that all the mentioned collections from an area SE of Banjarmasin belong to the undescribed species *C. hudoroi* (cf. also Arends et al. 1982).

The chromosome number (2n = 20) and the morphology of the spathe shows that *C. hudoroi* is related to *C. striolata* and *C. keei.*

C. hudoroi is easy to cultivate even though it is difficult to flower.

Characteristics: C. hudoroi is characterized by the bullate leaves, the long spathe with a long more or less spirally twisted, cream coloured to slightly violet limb of the spathe which is nearly smooth, and the large conspicuous more or less purple to purple spotted collar zone.

C. bullosa and *C. keei* resemble *C. hudoroi* in the vegetative parts, but differ in their shorter spathes, the first having a reddish brown, short limb and a conspicuous, darker collar, and the second having a purple funnel-shaped limb of the the spathe which lacks a collar. *C. hudoroi* resembles *C. striolata* in the spathe.

Specimens studied: Kalimantan: NJ 3123, c. 40 km SE of Banjarmasin towards Plaihari, near Tanjung Pecah, leg. Stroh s.n. (C, M); NJ 3143, SE of Banjarmasin, leg. E. Korthaus s.n. (C); Hanrieder s.n., Sg. Kahayan, near Palankaraya (C, M).

4. Cryptocoryne ciliata (Roxburgh) Schott

Melet. Bot. I: 16 (1832). – *Ambrosina ciliata* Roxb., Coromandel Pl. VII: 90 (1819). – Lectotype (selected by Rataj 1975): Roxburgh s.n., Ind. Orient. (G).

C. elata Griff., Notul. Pl. As. III: 134 (1851), Ic. Pl. As., t. 170, 171 (1851), *C. alata* Griff., ort. mut. – Lectotype (selected here): Griffith 6013, Malacca (K).

C. drymorriza Zipp., in sched., in Schott, Ann. Mus. Lugd. Bat. 1: 122 (1863). pro. syn.

C. ciliata (Roxb.) Schott var. *latifolia* Rataj, Rev. Gen. Cryptocoryne Fisch., ČSAV, č. 3: 38 (1975). – Holotype: Rataj (PR 335239), 15.4.1973, cult. in Bot. Inst. Šumperk (PR).

Rhizome stout, 5–10 cm long, 1–3 cm thick. Runners epiterranean, in diploid forms up to 50 cm long, rooting at the nodes, and quite firmly attached to the parent plant; in triploid forms they are 5–15 cm long, erect, non-rooting, branching at the internodes, and quite fragile, breaking off at the nodes and rooting later. Cataphylls, large surrounding the younger leaf, only present in flowering specimens. Leaves green, somewhat spongy; blade linear to ovate, 15–50 cm long, 2–20 cm broad, with truncate to cordate base; petiole 10–50 cm long; surface smooth; margin entire. Spathe 15–50 cm long; kettle 1–2 cm long, white inside, more or less constricted in the middle, the inner surface rough; tube 4–40 cm long, whitish, with the fused margins somewhat bulging, somewhat elliptic in cross section; limb narrowly ovate to ovate, 3–10 cm long, 2–3 cm broad, surface rough, purple reddish, more or less abruptly changing into yellow towards the collar and throat; collar more or less conspicuous, yellow, sprinkled with small red spots; margin of the limb with numerous 0.5–1 cm long, sometimes branched, red purple cilia. Female flowers 4–8, stigmas more or less narrowly ovate, sometimes emarginate. Olfactory bodies small, rounded or more or less irregular, white. Male flowers 20–50, sometimes mammillose. Syncarp globular; seeds smooth, with a thin, whitish testa, embryos with numerous cilia-like prophylls which are folded within the testa; endosperm lacking in mature seeds. – (Fig. 3 D).

Chromosome number: 2n = 22, 33 (Jacobsen 1977, Sarkar et al. 1976, 1979, Arends et al. 1982). The exact distribution of diploids and triploids is not known; only that triploids have been found in Bangkok, Singapore, and in Sarawak at Kuching and Kpg. Stutong. The triploids are sterile, and their only mode of reproduction is by their fragile runners.

Rataj (1975) distinguished var. *latifolia,* with shorter runners and broader leaves, versus the form with long runners and narrower leaves. However, plants from India have narrow leaves (reported as diploid by Sarkar et al. 1979) and plants from Borneo and New Guinea, both with narrow and very broad leaves, have long runners and are fertile; thus the correlation between broad leaves being triploid and the narrow leaves being diploid is not absolute. Rataj (1975) did not explicitly state the correlation between the broad leaves and the triploids but between the broad leaves and the short runners, and these latter are from triploid plants.

The variation and distribution in the leaf-shape and the distribution of the cytotypes is at present quite insuf-

ficiently known, wherefore the recognition of var. *latifolia* is not accepted.

Distribution: From India to Indo-China, Indonesia, and New Guinea (Fig. 1 and 6).

Habitat: On mudflats in smaller or larger rivers, ditches, and canals, in tidal areas, brackish as well as freshwater (see e.g. Jacobsen 1980 b). It is one of the outposts along the rivers, often associated with mangrove trees, e.g. *Bruguiera, Rhizophora,* and *Nypa.* The plants are often growing in open sun and are mostly covered with a distinct layer of silt (see e.g. Jacobsen 1979, 1982 and Schulze 1967, 1971).

Notes: C. ciliata was intended as the type species for the new genus *Myrioblastus* Wall. in sched. (C. Muell., Bot. Zeit. 6: 158 (1846), *Melioblastis,* ort. mut.), Griffith, Proc. Linn. Soc. 1: 264 (1846), nom. nud. However, as Griffith himself mentions, the name *Cryptocoryne* had priority.

Griffith (1851 a & b) gave a detailed anatomical description of the flower structure of *C. ciliata.* The superfluous publication of *C. elata* is due to the posthumous publication of Griffith's (1851 b) Notulae & Icones by J. M'Clelland, who was not aware of the fact that Griffith had already earlier (1846 op. cit., and 1851 a) accepted the name *C. ciliata.*

The seeds of *C. ciliata* are, like those of *C. versteegii* Engl. (2n = 34, New Guinea), different from the rest of the genus by having numerous, folded, cilia-like appendages (prophylls) on the embryo, and by lack of endosperm. The seeds have a thin, white testa which breaks soon after the dehiscence of the seed, releasing the fully developed embryo that unfolds its cilia, forming an immediately growing seedling resembling the hair of the Greek Gorgon Medusa.

In the opening mechanism of the syncarp, *C. ciliata* also differs from other species of *Cryptocoryne,* as each of the female flowers opens and soon breaks off, ensuring a quick release of the seeds. Van Bruggen (1962) has observed the release of seeds in a submerged specimen in an aquarium where they immediately floated to the surface.

In nature, most of the fruits probably open at low tide when the sun heats them up, thereby ensuring, at least to start with, that the seeds will float upstream with the tide. If the testa is not broken, some seeds are transported downstream again but they will germinate where they settle, even in deep water, and if they can survive the silt (they grow well submerged) their long runners can move the plants to shallower water suitable for flowering.

The chromosome number of 2n = 22 and a base number of x = 11 suggests a closer relationship to *C. spiralis* (Roxb.) Wydl. from India, which has been reported with 2n = 33, 66, 88, and ca. 132 (e.g. Arends et al. 1982). Morphologically the two species do not show close affinities.

If assumed that the primitive state of the seeds in *Cryptocoryne* are with a cone-shaped embryo that protrudes into the endosperm and an undifferentiated plumula, then the multiciliate embryo, found in *C. ciliata,* is a derived state.

In *C. ciliata* and *C. versteegii* the early stages of the embryo are the same as in other species of *Cryptocoryne,* where the plumula is in an inverted position, characteristic for Araceae. In later developmental stages of the *C. ciliata* embryo the plumula develops the plumulary processes turning the embryo around so that the radicle comes into a sideways to downwards position. In the other species of *Cryptocoryne* there is not such an enormous development of the plumula, which stays inverted with the radicle pointing upwards. In *C. ciliata* the cotyledon is broken off with the testa and the radicle, and an accessory radicle is formed (Griffith 1851 a).

In *C. longicauda,* which also has several plumulary processes at the maturity of the seed, the embryo is still inverted and has an upright radicle (de Wit 1971, 1983). In many species of *Cryptocoryne* the embryo does not develop any prophylls before the radicle has emerged from the testa and formed the first root hairs.

If the chromosome numbers of 2n = 22 is to be taken as evidence of a common ancestry for *C. spiralis* and *C. ciliata,* and the multiciliate embryo is also considered evidence of common ancestry between *C. ciliata* and *C. versteegii,* one must postulate that a multiciliate embryo of *C. spiralis* has again been reduced to the present simple form, as the characters, taken under one, are contradictory. A multiciliate embryo is also found in *Aponogeton appendiculatus* Van Bruggen, a tidal species from southern India (van Bruggen 1968), and can perhaps be seen as an adaptation to the tidal habitat. Only few tidal species of *Cryptocoryne* have multiciliate embryos, and the multiciliate embryo in *Aponogeton* could support the view, that the character "multiciliate embryo" is a state which is easily formed in the tidal habitats.

It is therefore not certain that the multiciliate embryo in *Cryptocoryne* has evolved just once, and the relatively different morphological characters found in the mentioned species may favour such an assumption.

Regarding the above mentioned contradictory morphological and cytological data of *C. ciliata, C. versteegii* and *C. spiralis,* respectively, I would interpret the chromosome number of x = 11 in *C. ciliata* and in *C. spiralis,* as having evolved independently of each other.

Characteristics: C. ciliata is characterized by the epiterranean runners, short or long, and the large, green, spongy leaves. The limb of the spathe has a collar, a rough surface, and a ciliate margin. The seeds have multiciliate embryos.

Specimens studied: The localization of the 102 collections of *C. ciliata,* from which material was studied, are found on Figs 1 and 6. (A specified list can be obtained from the author). The following specimens represent probable and verified triploids (2n = 33), in plants with short runners: Thailand: Kerr 6992, Bangkok, 6.5.1923, (BKF, K, P); Marcan 1962, T. Dan Kok, 31.1.1926 (BM, BK). – Malay peninsula: Ridley s.n., Singapore, 1896 (SING); Sinclair 7521, Sg. Sebew, Singapore (E). – Sarawak: Gaudet 263, Papar, 21.3.1967 (KLU); NJ 78–46, Kpg. Stutong (C). – Cult.: Anonymous 1671/6 (C); NJ 2895 (C); NJ 2994 (C).

5. Cryptocoryne longicauda Engler

Bull. Soc. Tosc. Ort. 4: 302 (1879). – Lectotype (selected here): Beccari s.n., Batang-Lupar, 1867, drawing at FI, 11628. A drawing of the spathe was published in Beccari, Malesia I, tab. 27, fig. 6 (1881). – Non *C. longicauda* quoad de Wit (1953 & 1958) which is *C. fusca* De Wit.

C. caudata N. E. Brown, J. Linn. Soc. 18: 242 (1880). – Lectotype (selected here): Burbidge s.n., Lawas River, Northwest Borneo, 1877–78 (K, isotypes K and BM).

C. johorensis Engler, Pflanzenreich IV, 23, F: 244 (1920). – Lectotype (selected by Rataj 1975): Ridley 3721, between Gunong Pulai and Johore, 10.12.1893 (SING, isotypes BM, K).

Rhizome rather slender; plants from deep water with long internodes. Runners long and slender. Cataphylls only present in flowering specimens. Leaves green, occasionally evenly purple; blade ovate, with a cordate base, 3–15 cm long, 3–10 cm broad, surface smooth to rough to strongly bullate, margin entire to finely undulate; petiole 5–30 cm long (largest specimens in deep, slow running water; smaller specimens more or less emerged in forest pools). Spathe 20–50 cm long, sometimes long pedicellate; kettle 1–2 cm long, white; tube 8–20 cm long, the upper part more or less purple on the outside; limb 15–30 cm long, caudate; collar present, dark red to black purple, sometimes yellowish; limb dark red to black purple, rugose, the tail sometimes whitish. Female flowers 5–7, stigmas ovate to elliptic, the upper part more or less emarginate. Male flowers 30–50, smooth. Olfactory bodies whitish, rounded. Syncarp ovoid, seeds brownish, more or less smooth; endosperm present, embryo in the fully developed seed with several plumulary processes. – (Fig. 4A).

Chromosome number: 2n = 30 (Arends & Laan 1979, and Arends et al. 1982).

Distribution: Borneo, Johore, and perhaps Indonesia (Fig. 1 and 6). This is the only species which has been found on the Malay peninsula as well as in the archipelago. Mr. Thung Kim Tek, Djakarta, has cultivated *C. longicauda,* and Holm (1980) cites Mr. Thung for having found it outside the Malay peninsula, and Schulze (1971) mentions Djakarta exporters to have found it on Sumatra but no localities are given.

Habitat: Forming large stands in more or less slow running rivers, or in lowland forest pools, mostly in deep mud. In small forest streams, the plants can form luxurious growths that cover the whole bottom and sides while, in forest pools, the specimens are smaller and more scattered. *C. longicauda* can also grow into the freshwater tidal zone (Stutong and Serian), but not into the zone where e.g. *C. ferruginea* grows.

Notes: As the synonomy indicates, the identity and the circumscription of this species has for many years been rather uncertain. However, from the recent collections made by J. Bogner at Gunong Pulai and by the author from Borneo, it is quite clear that *C. longicauda, C. caudata,* and *C. johorensis* are conspecific. The only difference that has been found between them is that the plants from Gunong Pulai have somewhat smaller, more stiff leaves, and are easier to cultivate than those from Borneo.

The type specimen of *C. longicauda* in FI is represented only by a drawing of a leaf and of a spathe. It is scanty, but quite sufficient as type material, and *C. longicauda* is in no way a nomen nudum as Rataj (1975) suggests.

The type of *C. caudata* is a plant with strongly bullate leaves, and the characters mentioned by de Wit (1971, 1983) are quite within the variations found in *C. longicauda,* even within one locality in Sarawak, e.g. at Sg. Dor.

Whether the multiciliate embryo of *C. longicauda* is a response to its occurrence in the freshwater tidal zone, as it may be in *C. ciliata* and *C. versteegii,* is not known. In the last mentioned two species the radicle appears inferior, while it is superior in *C. longicauda* (see notes under *C. ciliata*).

Characteristics: C. longicauda is characterized by the ovate leaves with a cordate base, the more or less bullate surface, and the finely undulate margin giving it a denticulate appearance. The spathe has a long tube, a dark red to black purple, ovate, rugose limb with a distinct collar, and a long caudicle. The embryo has several plumulary processes and a superior radicle.

Specimens studied: Johore: Bogner 1511 (= NJ 3109 = Bast 390), Ulu Pulai, Kpg. Gelang Patah, Sept. 1979 (C); Ridley 12141, Stream on the way to Gunong Pulai, Dec. 1905 (K, SING, BM). – Sarawak: Argent 952, NW of Sg. Melinau, G. Mulu N. P., 9.4.1978 (E); Brooke 10905, Simanggang, Oct. 1955 (L, SAR); Hansen 77, Sg. Melinau, G. Mulu N.P., 19.1.1978 (C); NJ 78–13, Sg. Dor, Melugo, 8.9.1978 (C); NJ 78–17, Kpg. Tekalong, Melugo, 9.9.1978 (C); NJ 78–21, Sg. Engkramut, 10.9.1978 (C); NJ 78–22, Gua Sukat, 10.9.1978 (C); NJ 78–47, Kpg. Stutong, Kuching, 19.9.1978 (C); NJ 78–48, Sg. Lubok Medin, E of Serian, 20.9.1978 (C); Lor, 1953 (W); Ong, S. C. 37, Tekalong Dor (WAG). – Cult.: Bastmeijer (WAG); Blass 511, 18.5.1971 (WAG); NJ 3079, ex Sadilek (C); de Wit s.n., cult. ex Djakarta, leg. Thung Kim Tek, 3.1.1957 (WAG).

6. Cryptocoryne bullosa Engler

Bull. Soc. Tosc. Ort. 4: 302 (1879). – Lectotype (selected here): Beccari 3487, Torrente Entabai, 1867 (FI, 11629; isotype FI, 11629 A).

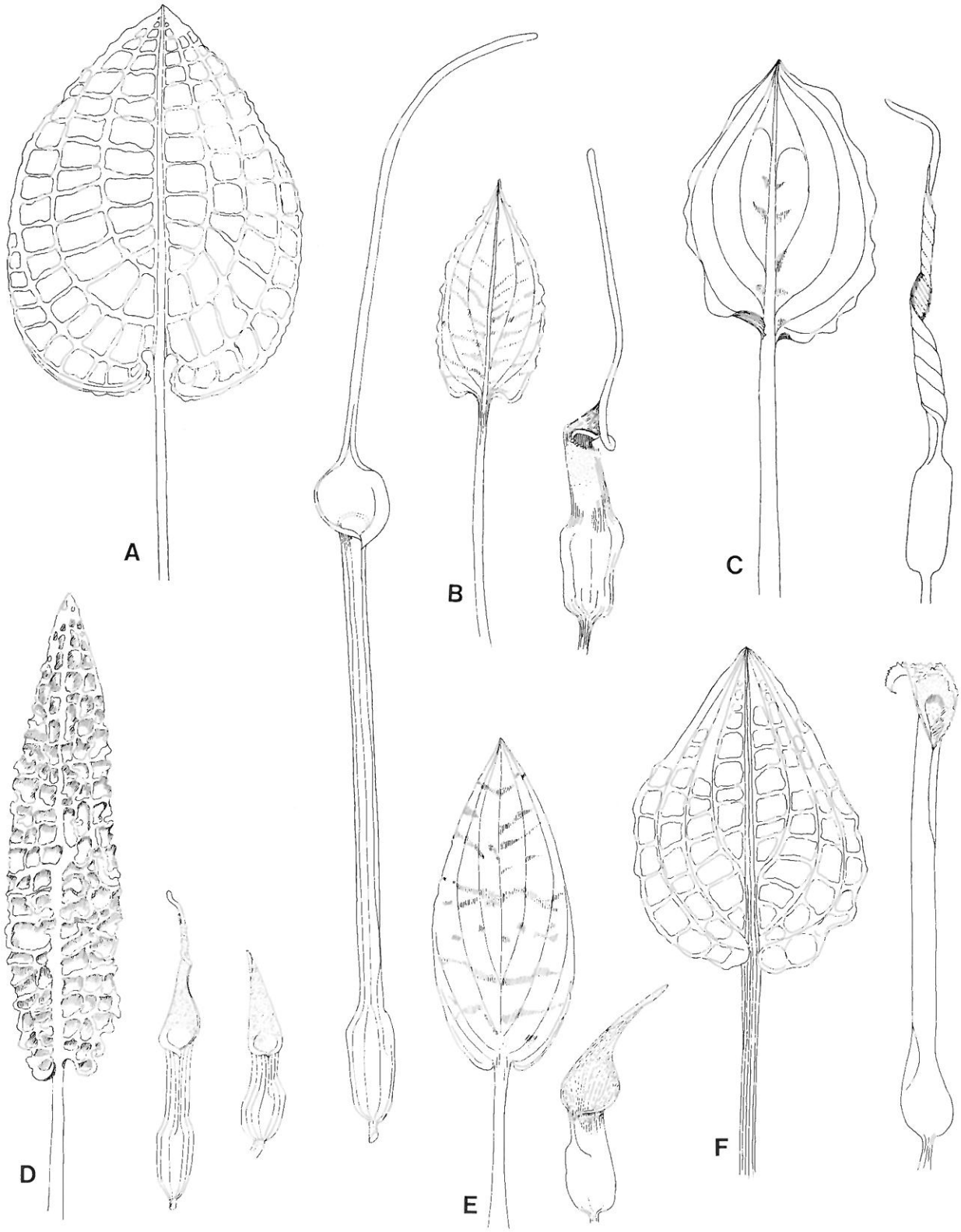

Fig. 4. Leaf and spathe of: A. *Cryptocoryne longicauda* (NJ 78–21). – B. *C. ferruginea* (NJ 2954). – C. *C. fusca* (Bast 294). – D. *C. bullosa* (leaf NJ 78–7, spathe 1. Ong s.n., r. Schulze 591). – E. *C. auriculata* (NJ 78–6). – F. *C. pallidinervia* (Bast 104) – (All × 2/3).

Rhizome mostly slender, internodes 0.2–1.0 cm long. Runners long, up to 0.3 cm thick, often only 1–5 from each rhizome. Cataphylls only present when flowering. Leaves green to dark olive brown; blade narrowly ovate, with a more or less cordate base, 5–25 cm long, 1–3 cm broad, petiole 5–15 cm long (largest specimens in deep, not so fast running water, and small, compact specimens in rushing currents), surface between the veins strongly bullate (depressions on the upper surface), resulting in the margins and the base appearing irregularly dentate; veins conspicuous. Spathe 5–8 cm long, mostly long pedicellate; kettle about 1 cm long; tube 1–2 cm long, the upper part more or less purplish brown on the outside; limb long ovate, 1–2 cm long, rugose reddish brown; collar or collar zone present, black purple. Female flowers 4–8, stigmas rounded. Olfactory bodies rounded. Male flowers 30–50, smooth. Syncarp ovoid; seeds brownish, short, surface somewhat ridged to almost smooth; endosperm present, embryo cone-shaped, with an undifferentiated plumula. – (Fig. 4D).

Chromosome number: 2n = 34 (Arends et al. 1982).

Distribution: Endemic to Borneo (Fig. 1 and 6).

Habitat: On sandy to stony bottom in fast running rivers. The most luxurious growths are found on sandy to gravelly bansk in the river, where there is shallow, fast running water. The plants are deeply rooted in the sand and are connected by their long, stout runners. In and near the rapids, the runners and the roots form a thick, interwoven mat which keeps the plants securely anchored. Over the sand-banks, all leaves are turned according to the direction of the current and are more or less adpressed to the bottom. The upper leaf-surface is always situated upward, apparently kept in position by the bullate depressions in the leaf.

Notes: This species has only been found in Sarawak (2. & 3. division) in the river systems of Sg. Krian, Sg. Sibiak, and Sg. Kanowit (cf. Schulze 1971, van der Vlugt 1970). Reports of other localities are erroneous, as these finds represent *C. striolata, C. keei, C. decus-silvae* De Wit, and *C. affinis* N. E. Brown, the last two from the Malay peninsula (van der Vlugt 1969, de Wit 1971, 1983, and Rataj 1975).

Characteristics: C. bullosa is characterized by the narrowly ovate to narrowly elliptic, strongly bullate leaves. The spathe is short, and the rugose limb is reddish brown with a pronounced collar (see also under *C. hudoroi*).

Specimens studied: Sarawak: Bogner 1357, Sg. Sibiak, 4.9.1978 (M, WAG); Horeman s.n., K 6049.407, Kuching (cult.) 2.10.1970 (K); NJ 78–7, Sg. Sibiak, 4.9.1978 (C); NJ 78–24, Sg. Entabai near Pakan, 11.9.1978 (C); Ong, WAG 12373, Pakan, 20.1.1970 (WAG); Schulze 607, Sartok, 20.9.1970 (WAG); Schulze 591, Sg. Kabo, E. Sartok, 22.9.1970 (WAG).

7. Cryptocoryne auriculata Engler

Bull. Soc. Tosc. Ort. 4: 302 (1879). – Lectotype (selected by Rataj 1975): Beccari 3845, Torrente Kemmukei (Kanovit), 1867 (FI, 11630).

Rhizome short and rugged. Runners long. Cataphylls only present in flowering specimens. Leaves green, smooth, rather stiff, upper side silvery green with irregular, slanting, dark green markings; margin often reddish; the lower surface green with red tinges in emerged specimens, sometimes dark red in submerged specimens; blade stiff, narrowly ovate, with a cordate base, 3–10 cm long, 1–3 cm broad; petiole 2–5 cm long. Spathe 5–8 cm long, shortly pedicellate; kettle more than 1 cm long, white; tube 1–2 cm long, the upper part more or less red purple on the outside; limb 3–5 cm long, dark red to black purple, narrowly ovate, forward bended-twisted; collar absent, collar zone prominent, of the same colour as the limb. Spadix more than 1 cm long. Female flowers 5–7, stigmas ovate to elliptic. Olfactory bodies rounded. Male flowers 30–50, smooth. Syncarp ovoid; seeds greenish, more or less ridged, endosperm present, embryo cone-shaped, plumula with two or more plumulary processes. – (Fig. 4E).

Chromosome number: 2n = 34 (Arends et al. 1982).

Distribution: Endemic to Borneo (Fig. 1 and 6).

Habitat: On stony to sandy ground in more or less shaded habitats, in smaller or larger rivers with rather fast running water. It grows up on the riverbank, below the high water mark, occasionally below the low water mark. The short, stiff leaves enable it to withstand the strong currents of the frequently occurring spates, and the short spathe shows that it is emerged during flowering.

Notes: C. pygmaea Merr., from the Philippine Islands, has wrongly been referred to this species by e.g. Engler (1920) and de Wit (1971), while Sadilek (1972) expresses some uncertainty. Rataj (1975) retained *C. pygmaea* (neotype Ebalo 717), but wrongly referred two other collections from the Philippine Islands, viz. Merrill 9272 and Ramos & Edano 37040, to *C. auriculata.* Live material of C. pygmaea, obtained from the Philippine Islands (NJ 2962, see Jacobsen 1979, 1982, Arends et al. 1982, and de Wit 1983), and a closer study of the above cited specimens proved that the Philippine material did not belong to *C. auriculata.* The principal differences are that *C. pygmaea* has a collar of the spathe that is very conspicuous towards the front of the opening of the tube, a limb of the spathe which is rugose, an opening of the spathe which is almost obliquely twisted, and leaves which are olive brown marbled and slender. There is some variation in the shape of the spathe but the author interprets this as a variation within the species.

A specimen of *Cryptocoryne* collected by J. & M. S. Clements 4310, at Mt. Bana, Vietnam, 8.5.1928 (P), resembles *C. auriculata* in the habitus, but the specimens are sterile. However, judging from the shape of the leaves, it is neither *C. auriculata* nor *C. pygmaea* but probably a new species.

Characteristics: C. auriculata is characterized by the rather stiff, silvery green leaves. The spathe is short, with a forward bended-twisted, dark red to black purple limb which has a conspicuous collar zone.

Specimens studied: Sarawak: NJ 78–6, Sg. Entabai, 3.9.1978 (C); NJ 78–9, Sg. Selalang, 4.9.1978 (C). Cult.: NJ 3074, no doubt originally from Sg. Entabai (C).

8. Cryptocoryne ferruginea Engler

Bull. Soc. Tosc. Ort. 4: 302 (1879). – Lectotype (selected here): Beccari 3983, Kutieng, 1865 (FI, 11629, isotype B).

C. pontederiifolia Schott var. *sarawacensis* Rataj, Rev. Gen. Cryptocoryne Fischer, ČSAV, č. 3: 62 (1975). – *C. sarawacensis* (Rataj) Jacobsen, Bot. Notiser 130: 77 (1977). – Holotype: Rataj, cult. in Bot. Inst. Šumperk, 18.9.1974 (PR, 335235).

Rhizome short and rugged, sometimes slender with long internodes, especially in submerged specimens. Runners long, slender. Cataphylls only present in flowering specimens. Leaves green, on the upper surface often with slanting, silvery green markings, the lower surface often paler, sometimes with a purplish tinge, more or less covered with minute hairs also along the margin; blade narrowly ovate to ovate, 3–12 cm long, 1.5–3 cm broad, with a truncate to cordate base; petiole 5–15 cm long, longest in continuously submerged specimens. Spathe 10–15 cm long, the upper part purplish on the outside, lower part more whitish, inside dark purple; more or less pedicellate; kettle large, inflated, the upper part somewhat constricted, 1–2 cm long, up to 1 cm broad; tube 1–2 cm long; limb 8–11 cm long, surface strongly rugose above the prominent collar, more or less obliquely twisted, caudate; the colour of the whole inside of the spathe purple, the collar black purple. Female flowers 4–7, stigmas ovate to elliptic. Olfactory bodies irregularly rounded, purplish. Male flowers 20–50, smooth. Syncarp ovoid; seeds brownish, smooth, 2–3 mm long; endosperm present, embryo cone-shaped, with an undifferentiated plumula. – (Fig. 4B).

Chromosome number: 2n = 34 (Jacobsen 1977, and Arends et al. 1982).

Distribution: Endemic to Borneo (Fig. 1 and 6).

Habitat: In slow running rivers and streams in the inner part of the tidal zone in deep shade (see e.g. Jacobsen 1980 b, and Schulze 1971), sometimes together with *C. lingua* and *Barclaya motleyi;* according to Nicolson's collection from the Bau area, it apparently also grows in streams above the tidal zone. The plants are situated in deep mud, the larger specimens in deeper water. The plants collected at Stapok were found in a lowland swamp forest where the freshwater run-off was stopped during high tide. The flowering probably takes place just after full or new moon, when there is minimum oscillation in the monthly tidal movements.

Notes: The identity of *C. ferruginea* has been problematic for many years, mainly because the spathe of the type specimen was immature, but also because of the lack of material, as the species was not recollected until the 1960'ies. Specimens from Borneo, collected by H. Ong and imported to Europe by van der Vlugt and Schulze, were referred to *C. pontederiifolia* Schott (de Wit 1971, Schulze 1971), a species from Sumatra, the spathe of which was not known at that time. Later the Borneo collections were recognized as *C. pontederiifolia* ssp. *sarawacensis* and later as *C. sarawacensis* (a view still maintained by de Wit 1983).

Jacobsen (1977) recovered a spathe on the type specimen of *C. pontederiifolia,* proving that it is in no way related to the above mentioned Borneo material. However, the collections made in Sarawak in 1978 (see also Jacobsen 1980 b) showed that *C. sarawacensis* was identical with *C. ferruginea.* The collections made in the 1960'ies did not clearly exhibit the characteristic minute hairs on the lower surface of the leaves found in the type specimen of *C. ferruginea.* The collections from Sarawak, 1978, proved that the minute hairs are not always present. Transitions have been observed between a complete cover of hairs and a complete absence of hairs, even in the same plant. Why and when the hairs develop is not known, perhaps it is connected with the tidal habitat.

Rataj (1975) lumped *C. tortilis* and *C. fusca* into *C. ferruginea* and placed it in subgenus *Saturina,* section *Gomeziae.* However, Rataj himself does not believe in this disposition, as he, on the basis of live material, recognizes *C. pontederiifolia* ssp. *sarawacensis* in subgenus *Submersina,* section *Thwaitesiae.*

After establishing the true identity of *C. ferruginea,* there remains no basis for the lumping of *C. fusca* (incl. *C. tortilis*) into *C. ferruginea,* as these two species are clearly distinguished by the morphology of their spathes (see also note under *C. fusca*).

Characteristics: C. ferruginea is characterized by the ovate leaves which are more or less hairy on the lower surface. The spathe has a large, inflated kettle, purple on the inside, a short tube, a purple, caudate limb which has a rough surface, and a prominent black purple collar.

Specimens studied: Sarawak: NJ 78–35, 36, 37, W of Batu Kitang, 17.9.1978 (C); NJ 78–44, Stapok F. R., 19.9.1978 (C); Nicolson 1286, vicinity of Bau, 6.8.1961 (US); Nicolson 1338, Stapok Forest Reserve, 9.8.1961 (SAR, US); Tomey leg., de Wit 12274, = Ong SC-14, (10.12.1967) (WAG); Tomey s.n., 3

mile Rock Rd., Kuching, 12.8.1974 (C); van der Vlugt, Ong SC-25, 1967 (WAG); de Wit 12642, 4.1.1971 (WAG). Cult.: NJ 2947 (C); NJ 2954 (C); NJ 78–2, ex H. Ong (C); NJ 78–43, ex H. Ong (C).

9. Cryptocoryne fusca De Wit

Belmontia 13: 279 (1970). – Holotype: Cult., de Wit s.n., December 1962 (WAG).

C. tortilis De Wit, Belmontia 13: 279 (1970) nom. inval.; Aquarienpflanzen 192 (1971), nom. inval.; Artedi 26: 113 (1975), nom inval.; Aquariumplanten 243 (1983). – Holotype: de Wit leg., 22.10.1965 (WAG).

C. longicauda sensu de Wit, non Engl., e.g. de Wit (1953, 1958).

Rhizome slender, often with long internodes. Runners long, slender. Cataphylls only present in flowering specimens. Leaves dull green, more or less bullate, sometimes purple tinged; blade ovate, 4–5 cm long, 3–10 cm broad, with a cordate base, lower surface and margin more or less covered with minute hairs; margin more or less finely undulate; petiole 5–15 cm long. Spathe 10–15 cm long; kettle 1–2 cm long, inside red purple; tube 2–5 cm long, inside red purple; limb 7–10 cm long, more or less twisted, brownish red to pink-livercoloured on the outside, and sparsely covered with minute hairs (!), inside covered with prominent, dark red purple protuberances; collar zone conspicuous. Female flowers 4–7, stigmas elliptic. Olfactory bodies rounded. Male flowers 20–50. Syncarp globose; seeds more or less vermiform, green and brown, smooth to somewhat rugose; endosperm present, embryo cone-shaped, with an undifferentiated plumula. – (Fig. 4C).

Chromosome number: 2n = 34 (Legro 1971, and Arends et al. 1982).

Distribution: Endemic to Borneo (Fig. 6).

Habitat: On muddy bottom in slow running streams and rivers in the forest near sea level. Tomey has collected *C. fusca* in Kalimantan but no notes exist on the exact habitat.

Notes: Problems regarding the identity and nomenclature of *C. fusca* have lasted thirty years, because of scarcity of material and an unfortunate combination of circumstances.

De Wit (1953) proposed a neotypification and a new description of *C. longicauda,* assuming that a flowering, cultivated specimen (Veldhuizen s.n., 15.9.1951 (L) from Bogor Bot. Gard., originating from Borneo) represented *C. longicauda.* The type of *C. longicauda* is, however, represented by a drawing in FI. Later on material distinctly different from the above mentioned Veldhuizen (s.n.) specimen, was collected in Borneo (H. Ong (SC 37, WAG) and Schulze 1971), and quite in accordance with Beccari's drawing. Instead of describing the Veldhuizen (s.n.) specimen as a new species, it was given a new name, *C. tortilis* (de Wit 1970), with reference to de Wit (1953), but neither a latin description was given nor a type specimen was cited. De Wit (1975) gave a latin diagnose, but a direct indication of a type specimen was not included before 1983 when he (de Wit 1983) indicated the type specimen to be de Wit leg., 22.10.1965 (WAG).

De Wit (1970) described a new species, *C. fusca,* also based on a cultivated specimen from Borneo, as being characterized by the "spathe outside straw-brown, fuscous. Stigma almost orbicular", while *C. tortilis* was characterized by "spathe outside pink, with a greyish hue. Stigma elliptic, with a sunken centre bordered by a rim" (de Wit 1971).

Rataj (1975), on basis of herbarium material and descriptions, lumped *C. fusca* together with *C. tortilis* into *C. ferruginea* (see also note under *C. ferruginea*).

De Wit (1983) maintained *C. fusca* and *C. tortilis* as separate species, presenting further distinguishing characters (de Wit 1983: 190): length of tube, length of spathe, number of male flowers, and the pubescence of the leaves. He also presents two colour photographs of *C. fusca* (No. 38) and *C. tortilis* (No. 39) which appear quite distinct.

The plant pictured in Arends et al. (1982, Fig. 3 A, Bast 294) is somewhat intermediate between the above mentioned photographs (Nos. 38 and 39). Another specimen, Bast 330, is also somewhat intermediate, but more brownish on the outside of the spathe than Bast 294.

However, having studied the below mentioned specimens I find no basis for separating *C. fusca* and *C. tortilis,* as I find none of the mentioned characters significantly different, and because the above mentioned photograph (No. 38) represents an immature spathe.

The first validly published name for this species is therefore *C. fusca.*

Characteristics: C. fusca is characterized by the large, ovate leaves with a cordate base, and the lower surface of the blade which is covered with minute hairs. The spathe has a short tube, a long limb which is brownish red to pink-livercoloured on the outside, dark red purple on the inside; the surface is covered with prominent, dark red purple protuberances and hairs, and the collar zone is conspicuous.

Specimens studied: Kalimantan: Tomey s.n., Mindor River, 7.7.1978 (WAG 78–446 = Bast 294 (WAG, C)); Tomey s.n., Domlo Kapuas (WAG 79–156 = Bast 331, and WAG 79–157 = Bast 330 (WAG, C)). – Borneo: Hallier 64 (L); Hallier 2551 (L). – Cult.: ex Kebun Raya, Bogor, No. I and II, 17.11.1953 (L); Nicolson 951, Boger Botanic Garden, 17.4.1961 (US); Veldhuizen s.n., cult. ex Borneo, 15.9.1951 (L); WAG s.n., 19.8.1954, 3.9.1954, July 1962 (WAG); de Wit 12432, 14.9.1965 (WAG); Zewald s.n., Oct. 1958 (WAG).

10. Cryptocoryne pallidinervia Engler

Bull. Soc. Tosc. Ort. 4: 301 (1879). – Lectotype (selected here): Beccari 3857, Samangang, 1867 (FI, 11626, isotype FI, 11627, and B).

C. venemae De Wit, Belmontia 13: 279 (1970). – *C. pallidinervia* Engl. ssp. *venemae* (De Wit) De Wit, Aquariumplanten 219 (1983). – Holotype: Haviland 1879, October 1892, Rejang Sibu, Kalong, (K).

Rhizome rather slender. Runners slender. Cataphylls only present in flowering specimens. Leaves green, ovate with a cordate base; blade 3–7 cm long, 2–4 cm broad, surface smooth to strongly bullate, margin sometimes finely undulate, appearing denticulate; petiole 5–10 cm long. Spathe 6–10 cm long; kettle ca. 1 cm long, black purple inside; tube 3–8 cm long, brownish, white outside; limb ca. 1 cm long, ovate, more or less recurved, surface with red protuberances; collar zone present, yellowish with small red spots that become smaller towards the throat. Female flowers 4–7, stigmas ovate to somewhat emarginate. Olfactory bodies yellowish, rounded. Male flowers 30–50, smooth, situated on a short sterile spadix immediately above the olfactory bodies. Syncarp unknown. – (Fig. 4F).

Chromosome number: 2n = 34 (Arends & Laan 1979).

Distribution: Endemic to Borneo (Fig. 1 and 6).

Habitat: A plant of lowland forests where it grows in slow running rivers and streams, and in seasonally inundated forest pools. Herbarium label information indicates that it grows under acid conditions.

Notes: The only collection existing in cultivation is the one made by Driessen in Kalimantan. The opportunity to study living flowering specimens made it quite clear that it is not possible to distinguish between *C. venemae* and *C. pallidinervia* at the species level, nor at the subspecies level as suggested by de Wit (1983).

Characteristics: C. pallidinervia is characterized by the cordate, more or less bullate leaves. The spathe has a long tube, the limb is red with protuberances, and the collar zone is yellowish with red spots. The spadix has the male and female flowers situated adjacent to each other.

Specimens studied: Sarawak: Anderson 12212, Triso P. F., 1,5 miles from Triso, 8.10.1955 (SAR, WAG); Anderson 8022, Sg. Kelepu, Bulan Bruit, 8.5. 1957 (K, SAR, SING); Brooke 9287, Kelepu, July 1954 (L, BM); Haviland 2375, Rejang Sibu, Oct. 1892 (SING). – Kalimantan: Driessen s.n., Sg. Punggur Besar, Rasau Jaya to Sg. Durian, Pole 9, 5.12.1975 (WAG, C).

11. Cryptocoryne grabowskii Engler

Bot. Jahrb. 25: 28 (1898). – Lectotype (selected here): Grabowski, Florif. m. Nov. 1881, in districtu Dussen Timor, ad flomen Siong (B).

C. grandis Ridley, J. As. Soc. Straits Settl. 44: 170 (1905) – *C. cordata* Griff. ssp. *grandis* (Ridl.) Sadilek, DATZ 32: 57 (1979). – Lectotype (selected here): Haviland 2319, Jungle stream path to Matang, 23.9.1892 (SING).

Rhizome usually slender and with long internodes, as the plants usually grow in deep water. Runners long, rather slender. Cataphylls only present in flowering specimens. Leaves usually green; blade ovate, upper surface somtimes purple tinged, lower surface pale green or more or less purple tinged to purple, 5–15 cm long, 4–10 cm broad, more or less smooth, margin entire, and with a more or less cordate base; petiole 5–25 cm long. Spathe 15–40 cm long; kettle 1–2 cm long, white; tube 10–35 cm long, whitish; limb ovate, 3–5 cm long, > 1.0 cm broad, outer surface brownish green, inner surface yellow, sometimes brownish tinged, rough to verrucose; collar zone yellow, with a bulge on the edge towards the limb, sometimes perhaps better characterized as an indistinct collar. Female flowers 5–6, stigmas elliptic. Olfactory bodies rounded, white. Male flowers 20–50, smooth. Syncarp unknown. – (Fig. 5A).

Chromosome number: 2n = 68 (Arends et al. 1982).

Distribution: Endemic to Borneo (Fig. 1 and 6).

Habitat: In slow running streams and rivers in the lowland forest. The locality at Matang is a lowland peat forest where the run-off is no doubt influenced by the tide. The water is black and the plants are situated deep in the plant debris.

Notes: In the *C. cordata* group, to which *C. grabowskii* belongs, the distinguishing characters are rather difficult to ascertain, as it is a question of the form and the colour of the spathe. In dried specimens these characters are difficult to see, and in most cases well preserved material is necessary to make a correct determination.

The type specimen of *C. grabowskii* consists of one leaf and one spathe with the spadix missing, and Engler's description of *C. grabowskii* is not very informative. About the spathe, he writes in "Das Pflanzenreich" (Engler 1920), and not in the protologue, "purpuream transiens", which is not very precise. At a comparison with the type of *C. grandis* (and the recent collections from Matang) no differences can be observed between the two. Colour slides taken by Hanrieder (Plaihari), and by Korthaus (1980) from Kalimantan of some *Cryptocoryne* with yellow spathes, also support the present interpretation.

C. grabowskii is related to *C. zonata* and the Malayan *C. cordata* s.l. (regarding *C. cordata* see Arends et al. 1982). There are indications that these three species could be regarded as e.g. morphological, geographical subspecies (see also Furtado 1935 and Sadilek 1979). However, I believe the problem is more intricate than just to regard them as three subspecies. Much more ma-

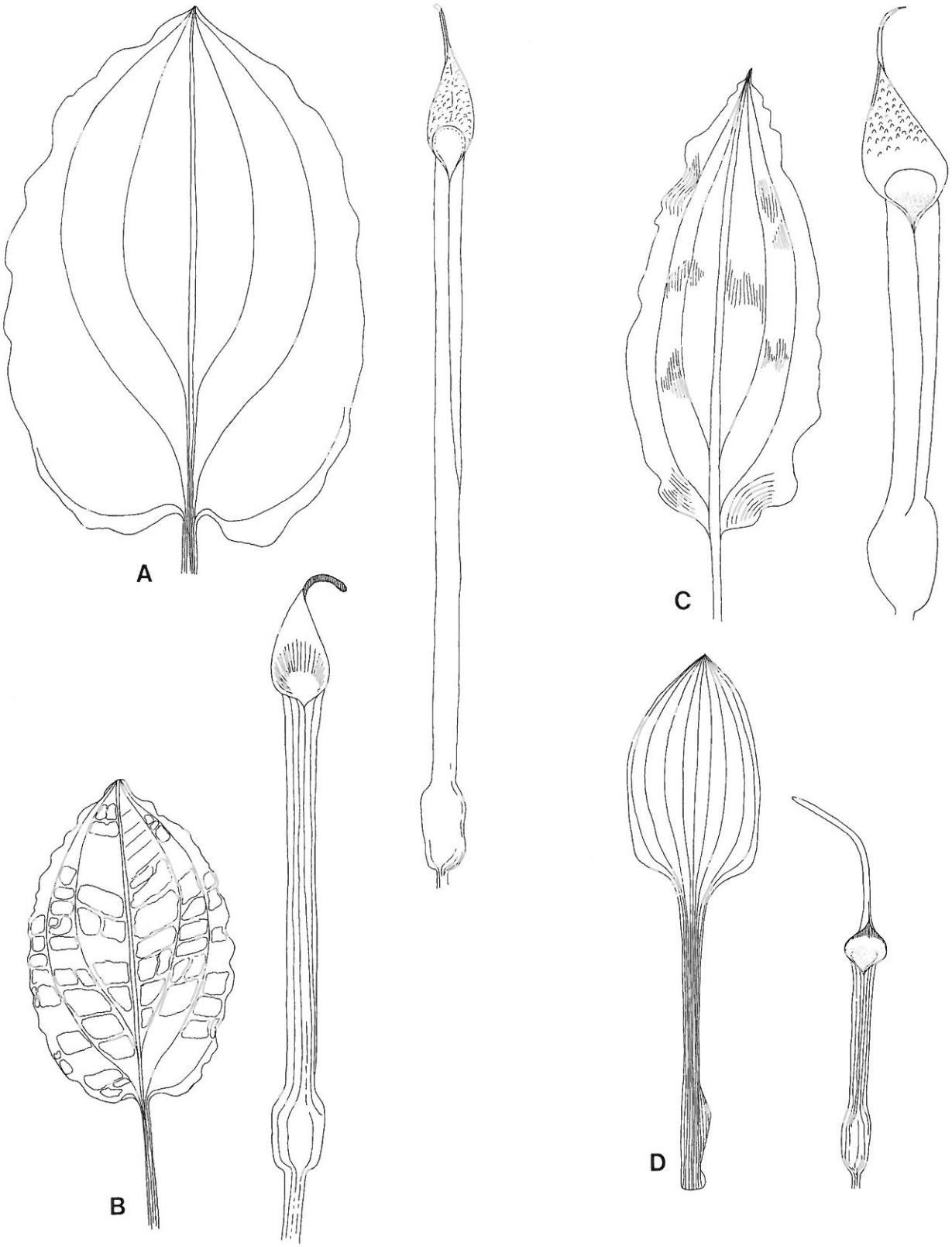

Fig. 5. Leaf and spathe of: A. *Cryptocoryne grabowskii* (Bogner 1483). – B. *C. zonata* (NJ 78–20). – C. *C. edithiae* (Möhlmann No. 52). – D. *C. lingua* (NJ 2955) – (All × 2/3).

terial, of documented origin, is needed for cultivations experiments and cytological investigation before the problem can be solved. Until then I suggest to retain them as three species.

The above mentioned notes imply that *C. grabowskii* is found in Borneo, while *C. cordata* s.l. is found in the Malay Peninsula. De Wit's (1971, 1983) drawings of *C. cordata* and *C. grabowskii* have been switched around: de Wit (1983) Fig. 50, 1–5 is *C. grabowskii,* drawn after the Korthals specimen cited below. Earlier reports of *C. grabowskii* in cultivation are undocumented and are no doubt referable to *C. cordata.*

In a recent paper Sadilek (1982) (see also Sadilek 1979) discusses some of the problems regarding the species belonging to the *C. cordata* group, viz. *C. grabowskii, C. grandis, C. zonata,* and *C. edithiae.* These problems have been dealt with above, but can, in relation to Sadilek's (1982) paper, be concentrated in two points: 1. The taxonomic circumscription of the species from Borneo. 2. The identification of the type specimens as to which species they belong. With these two points in mind, the present taxonomic conclusion is reached: 1. *C. grabowskii* (syn. *C. grandis*) has a rough yellow limb of the spathe with a raised collar zone. 2. *C. zonata* has a smooth, yellow limb of the spathe (sometimes brownish tinged) and a broad, flat collar zone. 3. *C. edithiae* has a rough, brownish limb of the spathe with a raised collar zone, and the throat is brownish spotted.

Material present in K, P, and U, without collector, is from Java according to the label and resembles *C. grabowskii – C. cordata,* but more material is needed to sustain that.

Characteristics: C. grabowskii is characterized by the large green leaves with a cordate base and by a more or less pale green or purple tinged lower surface. The spathe has a kettle that is white inside, a long tube, a yellowish rough to verrucose limb which may have a brownish to reddish tinge, and a clearly raised, bulged collar zone.

Specimens studied: Sarawak: Anonymous, native collector 826, ex Bureau of Science, Manila (GH, US, K, P); Haviland 1822, Path to Matang, 23.9.1892 (K); NJ 78–26, Road to Matang, 11.9.1978 (C); Bogner 1483, Matang, 21.8.1979 (C, M). – Kalimantan: Hanrieder s.n., Strasse nach Plaihari, km 70 (photo C); Korthaus (1980), photo in Das Aquarium, as *C. cordata;* Motley 664, Bangarmassing, 1857–58 (K). – Borneo: Korthals s.n. (L).

12. Cryptocoryne zonata De Wit

Belmontia 13: 279 (1970). – Holotype: A. J. Key, s.n., 17–28.12.1961, Sg. Lumut, Brunei (WAG).

? *C. striolata* Engl. var. *cordifolia* Ridley, J. Str. Br. Roy. As. Soc. 49: 47 (1908). – Lectotype (selected here): Ridley s.n., Siul Hill, "purple", Sept. 1909 (SING).

C. "lastii" Bouwmeester, Het Aquarium 34: 32–34 (1963), nom.inval.; Oosterbaan, ibid. 35: 26–27 (1964), nom.inval.; Bouwmeester & Hoogendoorn, ibid. 37: 52–57 (1966), nom. inval.

Rhizome usually slender, often with long internodes. Runners long, rather slender. Cataphylls only present in flowering specimens. Leaves green to dark green; blade ovate, upper surface sometimes purple tinged, lower surface purple tinged to deep, dull purple, 5–10 cm long, 3–8 cm broad, smooth to strongly bullate, margin entire, sometimes finely undulate, base more or less cordate; petiole 5–15 cm long. Spathe 10–15 cm long; kettle 1–1.5 cm long, outside white, inside with a conspicuous purple zone in the upper half; tube 7–10 cm long, greenish white, sometimes slightly purple tinged; limb ovate, 2–4 cm long, outer surface brownish green, inner surface yellow, sometimes brownish tinged along the margin, smooth; collar zone yellow, flat. Female flowers 5–7, stigmas ovate. Olfactory bodies rounded, white. Male flowers 20–50, smooth. Syncarp broadly ovoid, seeds fusiform, brownish. – (Fig. 5B).

Chromosome number: 2n = 68 (Arends et al. 1982).

Distribution: Endemic to Borneo (Fig. 1 and 6).

Habitat: In slow running forest streams and small rivers in deep mud or on sand banks, sometimes in small forest pools in dead arms of the stream. At Sg. Engkramut growing in the same river as *C. longicauda.*

Notes: The leaves of *C. striolata* var. *cordifolia* are broader and more obtuse than in the collections of *C. zonata* from the same locality, and the spathe was stated to be purple. It is not certain, but most probable, that this collection belongs to *C. zonata* and that the "purple spathe" is just a strong colouring of the reddish brown tinge sometimes found in *C. zonata* (see Arends et al. 1982).

The collections by van Niel (3395, Lumut River) have strongly bullate leaves, a feature which also develops under certain conditions in cultivated specimens (see also Bouwmeester & Hoogendorn op. cit.).

Characteristics: C. zonata is characterized by the ovate leaves with a more or less cordate base, the smooth to strongly bullate surface, and the more or less purple tinged upper and lower surfaces. The spathe has a kettle with a distinct purple zone inside, a long tube, and a yellow, smooth, sometimes reddish brown tinged limb with a conspicuous collar zone.

Specimens studied: Sarawak: Beccari 170, Siul, Kutieng, Julio 1865 (FI); Bogenberger 7 & 9, Gunong Subio, Niah Caves, 1981 (C); Brook 8486, Karanji, Lundu, 11.5.1954 (BM, G, L, SAR, US); Burtt & Woods No. B. 2039, Penghalan Lobang to Niah Caves, 7.6.1962 (E, SAR); Hewitt No. 9, Siol, Sept. 1905 (SING); NJ 78–20, Sg. Engkramut, 10.9.1978 (C); Ridley s.n., Siul, Kuching, Sept. 1905 (SING); Ridley 12471, Siul, Kuching, Sept. 1905 (K). – Brunei: Bogner 1503, Badas area, Andulau, 2.9.1979 (C, M); van Niel 3395, Lumut River, Seria Distr., 1963 (L); van Niel 4603, Badas River, Belait Distr., 1.3.1969 (L). – Kalimantan: Endert 1920, W. Koetai, Tg. Isaei forest, 3.7.1925 (L).

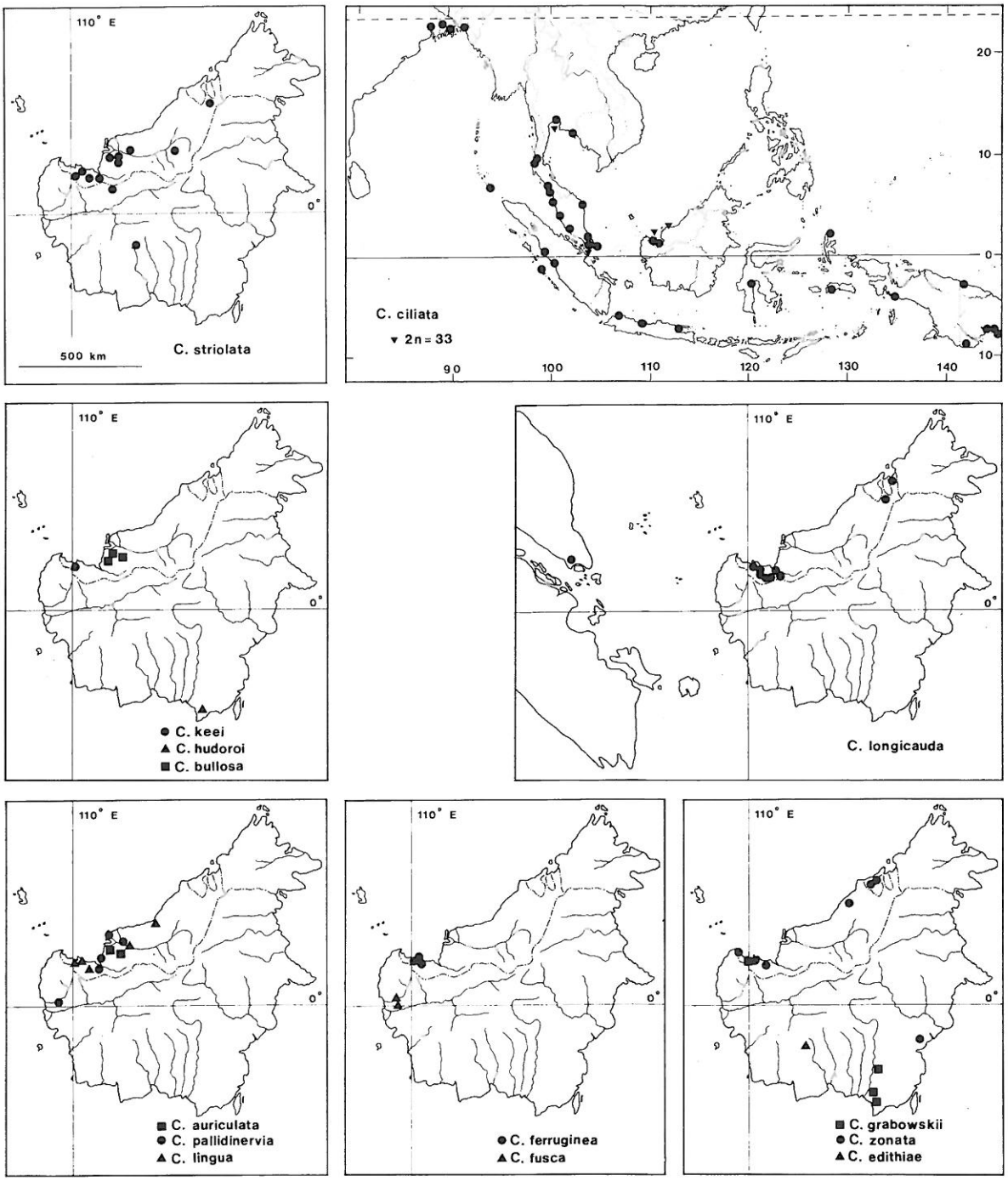

Fig. 6. Distribution of the *Cryptocoryne* of Borneo.

13. Cryptocoryne edithiae De Wit

Aquariumplanten 185 (1983). – Holotype: Möhlmann No. 52, rainforest, 12 boat-hours N of Sanpit, Kalimantan, leg. Korthaus, March 1978 (WAG, isotype C).

Rhizome stout, plants from deep water with long internodes. Runners long, slender. Cataphylls only present in flowering specimens. Leaves dark green to more or less purple, lower surface more purplish; blade ovate, 4–10 cm long, 3–7 cm broad, with a more or less cordate

base, margin entire; petiole 10–15 cm long. Spathe at least 12 cm long; kettle 1 cm long, whitish; tube ca. 9 cm long, brownish; limb ca. 2 cm long, ovate, brownish, rough, collar present, but not very prominent, yellow, sprinkled with fine reddish brown spots that become less dense downwards through the throat. Female flowers 5–7, stigmas elliptic. Olfactory bodies rounded. Male flowers 20–50, smooth. Syncarp unknown. – (Fig. 5C).

Chromosome number: 2n = 68 (Arends et al. 1982).

Distribution: Endemic to Borneo (Fig. 6).

Habitat: In muddy to sandy places in slow running streams and rivers in the lowland forest.

Notes: This species has been described on the basis of the cultivated plants, and the dimensions given in the above description are only to be regarded as minimum figures.

Characteristics: C. edithiae is characterized by the ovate leaves with a more or less cordate base and by the dark green, more or less purple upper and lower surfaces. The spathe has a long tube, a brownish, rough to verrucose limb, and a not very prominent collar, with sprinkled, reddish brown spots in the yellow throat.

Specimens studied: Type collection cultivated (C, and M). Photo in Möhlmann (1978), Korthaus (1980), and Bogner (1984).

14. Cryptocoryne lingua Engler

Bull. Soc. Tosc. Ort. 4: 301 (1879). – Lectotype (selected here): Beccari 3998, Bintulu, 1867 (FI, 11632).

C. spathulata Engler, Bull. Soc. Tosc. Ort. 4: 301 (1879). – Lectotype (selected here): Beccari, Rejang, Sept. 1867 (FI, 11631).

Rhizome up to 1 cm thick, often whitish. Runners long, mostly several from each plant, whitish. Cataphylls present in flowering specimens only. Leaves green, of a somewhat spongy texture, surface smooth, margin entire; blade ovate to oblong with a more or less truncate base, 2–4 cm long, 1–2 cm broad, petiole whitish at the base, 4–10 cm long. Spathe 10–15 cm long; kettle ca. 1 cm long, white; tube 3–8 cm long; limb caudate, on the outside brownish; collar absent, collar zone yellowish, with red spots that become denser upwards where they fuse, giving the upper part of the limb a deep red colour. Female flowers 4–6, stigmas ovate. Olfactory bodies rounded. Male flowers 20–50, smooth. Syncarp globular; seeds 0.5–1 cm long, brownish; endosperm present, embryo cone-shaped, with an undifferentiated plumula. – (Fig. 5D).

Chromosome number: 2n = 36 (Legro 1967, Jacobsen 1977, and Arends et al. 1982).

Distribution: Endemic to Borneo (Fig. 2 and 6).

Habitat: Open or shaded mud-flats in the inner part of the mangrove, often just below the maximum level of the fresh water tidal zone. The plants are deeply rooted, often with only the leaf-blades above the mud. Leaves often coated with a layer of silt (see e.g. Schulze 1967, 1971, Jacobsen 1980 b, and Horst 1981, 1982).

Notes: The somewhat cordate leaf-base found in the plants from Betong led Engler to describe *C. spathulata.* In the type specimen of *C. lingua* the spathe is immature, while in the type specimen of *C. spathulata* it is open. However, the only difference between the two is found in the shape of the leaf-blade.

C. lingua is said to have been introduced to Singapore by aquarium dealers. Schulze (1971) reports *C. lingua* from Sg. Krian.

Characteristics: C. lingua is characterized by the ovate to oblong, green, spongy leaves and the caudate limb of the spathe which lacks a collar but has a redspotted throat with a gradual transition of colour towards the upper, red part of the limb.

Specimens studied: Sarawak: Gauded, M 265, Kuching, 10.3.1967 (KLU); Haviland 3129, Kalong, Rejang Sibu, April 1894 (K, SING); NJ 78–38, W of Batu Kitang, 17.9.1978 (C); NJ 78–40, Batu Kitang, 17.9.1978 (C); NJ 78–50, Kpg. Panchor, 20.9.1978 (C). – Cult.: NJ 78–33, ex H. Ong; NJ 2856 (C); NJ 2928 (C); NJ 2945 (C); Zewald 12459 (WAG); Zewald 12631, 8.3.1971 (WAG); Zewald 12658, 25.3.1971 (WAG).

Unsolved problems

A main point of interest, where our knowledge is almost lacking, is the occurrence of species of *Cryptocoryne* in the archipelago between the Malay peninsula, Sumatra, Java, and Borneo. Several reports, i.e. Schulze (1971) and de Wit (1961, 1983), state that *Cryptocoryne* have been found on the Natuna Islands, and the Terampa Islands. I do not doubt their occurrence there, but I do not know of any documented material that can throw any light on what species it might be. Such material is badly needed.

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