

**BISEXUAL *RHIZANTHES LOWII* (BECCARI) HARMS  
(RAFFLESiaceae) FROM BORNEO: FIRST DESCRIPTION  
OF FLOWERS, FRUITS AND SEEDS**

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ABSTRACT

*Rhizanthus lowii* bisexuals differ from unisexuals mainly in column morphology. In bisexuals the column carries both the stigmatic fascia and, below it, the annular row of anthers, both being only about half the size of those found in unisexuals (column with either the stigma or the anthers). Sexually dimorphic characters (length of the caudal appendages, depth of the ampulla's crater and width of the stalk) are not intermediate in bisexuals but follow the female model, i.e. they are shorter, shallower and wider, respectively, than in males. When ripe the fruit is a blackish berry, 23–25 cm in circumference, 5 cm long, with tangential and vertical cracks on side walls, radial and circular cracks on the disk-like top. Seeds are minuscule, pitted, 0.70–0.78 mm long and 0.33–0.4 mm wide. An updated key for the identification of the four known species of *Rhizanthus* is presented, along with documentation by photographs and drawings, and biological notes.

Among Rafflesiaceae, bisexuals were known only in *R. zippelii* (Blume) Spach, a Javan species. *R. lowii* is Bornean and the finding of bisexuals in this species is additional evidence of *R. zippelii*'s absence from Borneo; earlier reports of the latter's presence on Borneo are probably due to misidentification based on this peculiar character.

Key words: Borneo, bisexual, frugivores, fruit, Java, Rafflesiaceae, *Rhizanthus lowii*, *Rhizanthus zippelii*, seeds, unisexual.

INTRODUCTION

Rafflesiaceae are believed to have exclusively unisexual flowers except in one species, viz. *Rhizanthus zippelii* (Blume) Spach, which has both unisexual and bisexual flowers (BLUME, 1827; SOLMS-LAUBACH, 1876, 1891; HEINRICHER, 1905; MEIJER & VELDKAMP, 1988; MEIJER, 1997). The family is now generally considered to hold only three genera: *Rafflesia* with 13–22 species, *Rhizanthus* with 4 species, and *Sapria* with 3 species (MEIJER, 1997; BÄNZIGER & HANSEN, 1997, 2000; NAIS, 2001; BARCELONA & FERNANDO, 2002; LATIFF & WONG, 2003; FERNANDO & ONG, 2005; BARCELONA, CAJANO & HADSALL, 2006; LAYS, 2006).

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Received 14 August 2007; accepted 4 October 2007.

Being in the shadow of its giant *Rafflesia* relatives, until recently, *Rhizanthus* has remained poorly known with its more modest flowers of often disconcerting aspect. In a first taxonomic revision of the genus (MEIJER & VELDKAMP, 1988), *R. zippelii*'s distribution was extended from Java to Borneo, Sumatra and Peninsular Malaysia. We assume that Meijer was induced to extend its distribution to Borneo mainly by the presence there of some bisexual forms (then still thought to be exclusive to *R. zippelii*), while its extension to Sumatra was probably based on his finding there of some white specimens (white colour at that time being considered characteristic for *R. zippelii*). Its extension to Malaya was based on a population of *Rhizanthus* discovered by MOLESWORTH ALLEN (1968) which, although originally identified by her as *R. lowii* (Beccari) Harms, was later amended to *R. zippelii* (MEIJER & VELDKAMP, 1988). Unfortunately, in Molesworth Allen's specimens the colour was probably partly from aberrant flowers, partly from immature and old flowers. Because of all the above and other discrepancies, BÄNZIGER (1995, 1996) proposed to merge the two species [this had previously been suggested by HOOKER (1873)] and adopted *R. zippelii*, the older name, for the taxon he studied in South Thailand and West Malaysia. In the landmark treatment of the Rafflesiaceae by MEIJER (1997), the Malay taxon was reverted back to *R. lowii*.

In a second revision which included significant fresh material from the field as well as herbarium specimens (BÄNZIGER & HANSEN, 2000), *R. zippelii* was confined to Java, replaced in Sumatra by the new *R. deceptor* Bänziger et Hansen, and replaced in the Malay Peninsula by the new *R. infanticida* Bänziger et Hansen. The latter was also confirmed as far north as southernmost Thailand and West Sumatra. *R. lowii*, described from Borneo (BECCARI, 1868, 1869, 1875) but extended to Sumatra and the Malay Peninsula (MEIJER & VELDKAMP, 1988; MEIJER, 1997), was also restricted again to Borneo. A fifth taxon from North Sumatra, with ramenta reminiscent of *R. lowii* but with a white basal half as in *R. deceptor* in abrupt contrast to the brownish nectar pads, was excluded from the second taxonomic revision because it was incompletely known; it is likely to be a new species. The second revision closely followed Beccari, who in his original description of *R. lowii* pointed out the differences *vis-à-vis* *R. zippelii*, and HEINRICHER (1905) who underpinned him and made the most detailed study of *R. zippelii* so far.

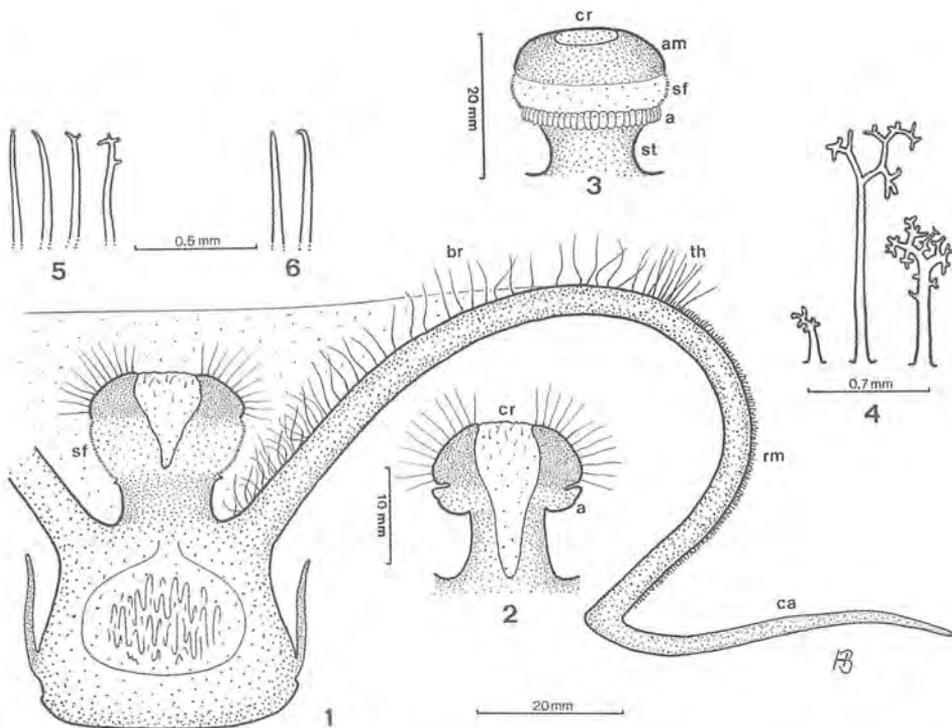
Recent studies on the genus have focused on the ecology and reproduction of *R. infanticida* (then still as *R. zippelii*) and *R. deceptor* (BÄNZIGER, 1995, 1996, 2001). PATIÑO ET AL. (2000) studied thermogenesis in unisexual *R. lowii*. Apparently there is an unpublished study on the more frequent unisexual *R. lowii* by Awg. Samhan bin Nyawa in Brunei (seen by Dr. S. Patiño but not by us; PATIÑO ET AL., 2000). BÄNZIGER (2004) indicated a method, adapted from *Sapria himalayana* Griffith, for manual pollination of *R. infanticida*. There is virtually no biological data on *R. zippelii*, which has not been seen in the wild since 1940 (MEIJER, 1997). Conservation aspects of *Rafflesia*, valid also for *Rhizanthus*, have been covered by ISMAIL ET AL. (1988), LATIFF & MAT-SALLEH (1991), NAIS & WILCOCK (1998).

During a recent visit to Sabah in northern Borneo, HB had the opportunity to study *R. lowii*: buds, flowers, fruits and, from left-overs of frugivorous rodents and scandents, the seeds. Observations were also made on its pollination and other reproductive aspects. However, arguably the most exciting result was that the flowers were bisexual, although it appears that this is not the first time bisexuality had been found in *Rhizanthus* on Borneo. MEIJER & VELDKAMP (1988) and MEIJER (1997) must have seen herbarium material of bisexual forms from the island but they allocated it to *R. zippelii*. Similarly, a single bud from Borneo with typical *R. lowii* characters had been allocated to *R. zippelii* because it was bisexual (BARKMAN

ET AL., 2004). Below we describe bisexual *R. lowii* for the first time. We hope that our study will dispel lingering doubts about the absence of *R. zippelii* on Borneo.

### MATERIALS AND METHODS

Observations were carried out by HB on private land in Ulu Moyog, Penampang District, Sabah, East Malaysia, from 17 January until 5 February, 2006. The sites were in steep, dark gullies near streams in evergreen rain forest between about 400 to 1000 m a.s.l. The data presented here are from live specimens studied *in situ* with a powerful hand lens and a small angled dentist's mirror to view recondite parts, and from photographic documentation, as well as from a limited amount of collected material. This was intentionally kept small so as not to impact the species. It mainly included moribund or dead flowers and buds, accidentally knocked off live buds by us or the villagers, cuts of small, not vital but taxonomically important parts of flowers, and remnants of pulp with seeds from fruits eaten by frugivores. They are deposited at the Sandakan Herbarium except two collections on long term loan via HB to the Bangkok Herbarium. No fruit was collected. All illustrations are by HB except the SEM micrographs (Figs. 16–18) made by standard procedures by AK.



Figures 1–6 *Rhizanthus lowii*. (1) Cross-section of female flower; (2) male column; (3) frontal view of bisexual column (hairs omitted); (4) enlargements of variously shaped ramata; (5) distal part of bristles; (6) tuft hairs. a, anthers; am, ampulla; br, bristles; ca, caudal appendage; cr, crater; rm, ramata; sf, stigmatic fascia; st, stalk; th, tuft hairs. Figs. 1, 2 and 4–6 slightly modified after BÄNZIGER & HANSEN (2000).

## RESULTS

### Description of *R. lowii*

#### *Bisexual flowers (Figs. 1–12)*

We observed a total of five flowers (four found freshly opened in the morning thanks to careful monitoring of bud growth, one some two weeks old, black, well beyond anthesis), and about 20 buds in various growth stages. They grew in nine separate clusters from 50 m to a few km apart. All but two of the analyzed specimens (five open flowers and seven buds) matched *R. lowii* as described in BÄNZIGER & HANSEN (2000) except that they were bisexual. All other characters were within the mentioned ranges (some bristles and tuft hairs were slightly longer). The two exceptions were not bisexuals but typical male forms (cf. Fig. 2). No female form (cf. Fig. 1) was found. The hitherto unknown bisexual column (Figs. 3, 9, 10) is described below.

The general shape of the column is essentially the same as that of female unisexual *R. lowii*, i.e. typically clearly longer and with a higher globular head than in males. However, since the bisexual column has to accommodate both the stigmatic fascia and, below it, the annular row of anthers, the sexual parts are much smaller than in unisexuals. The anthers are about half the length and the stigma about half the width of those in unisexuals. The anthers are generally unilocular (only one pore for releasing fluid pollen matrix) instead of having two superimposed loculi as in unisexuals. Three other, minor (less clear and consistent) sexual characters, viz. the depth of the ampulla's crater, the length of the caudal appendages and the width of the stalk, tend to be shallower, shorter and wider, respectively, than in male unisexuals but agree more with the female unisexuals.

#### *Column morphometry*

Column 19–21 mm high; stalk (= collum, style) 4–6 mm high and 9–10 mm wide; globular head 15 mm high; ampulla 6–8 mm high and 20–25 mm in diameter; crater aperture 7–11 mm and depth 11–14 mm; width of stigmatic fascia 4–6 mm; width of annular row of anthers 2–3 mm. Number of anthers (= number of radial lines) 50–65.

#### *Fruit (Figs. 13–15)*

Fruits of Rafflesiaceae have drawn little interest compared to their flowers, although they are of fundamental importance for conservation. The mature fruit and seeds of *Sapria himalayana* were described only recently (BÄNZIGER, 2004), nearly 160 years after the flower's discovery. In *Rhizanthus*, HEINRICHER (1905) described and figured a nearly mature fruit of *R. zippelii* and BÄNZIGER (1995) an unripe one of *R. infanticida*.

A total of six fruits of *R. lowii* were seen. Two were probably only half way through their development to judging from their still relatively small size and absence of cracks, while one other was nearer maturity. Two mature fruits were checked for two weeks. At the end of this period one of them was found broken open, only the lower parts of the side walls remaining, with the pulp and seeds nearly completely eaten. Another fruit was found nearly completely consumed. The frugivore involved in one case was probably a tree shrew: tooth marks in the pulp consisted of four parallel lines, corresponding to the lower incisors; several species of tree



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Figures 7–8 Bisexual *R. lowii*. (7) Freshly opened flower. Note the very long ramenta pads (pale brown), typical of *R. lowii*. (8) Detail of flower. Note the white stigmatic fascia and, only partly visible below the stigma, the anthers. The bristles at tepal vertex (center left) are sparsely set, typical for *R. lowii*. The fly is female *Hemipyrellia ligurriens*, the main pollinator (size: 10 mm long). Colour photographs by H. Bänziger.



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Figures 9–11 Bisexual *R. lowii*. (9) Flower cut *in situ* because considered moribund since it stopped to open fully. Note the column: stalk, ring of anthers, stigmatic fascia, and red ampulla. The very long pads of ramenta are typical. (10) Cross section of a large bud found dead. Note the ampulla discolored to dark brown, the stigma and anthers yellowish to brownish. (11) Ramenta pads magnified. Note the relatively long, strongly branched ramenta (best seen along the edges and tip).



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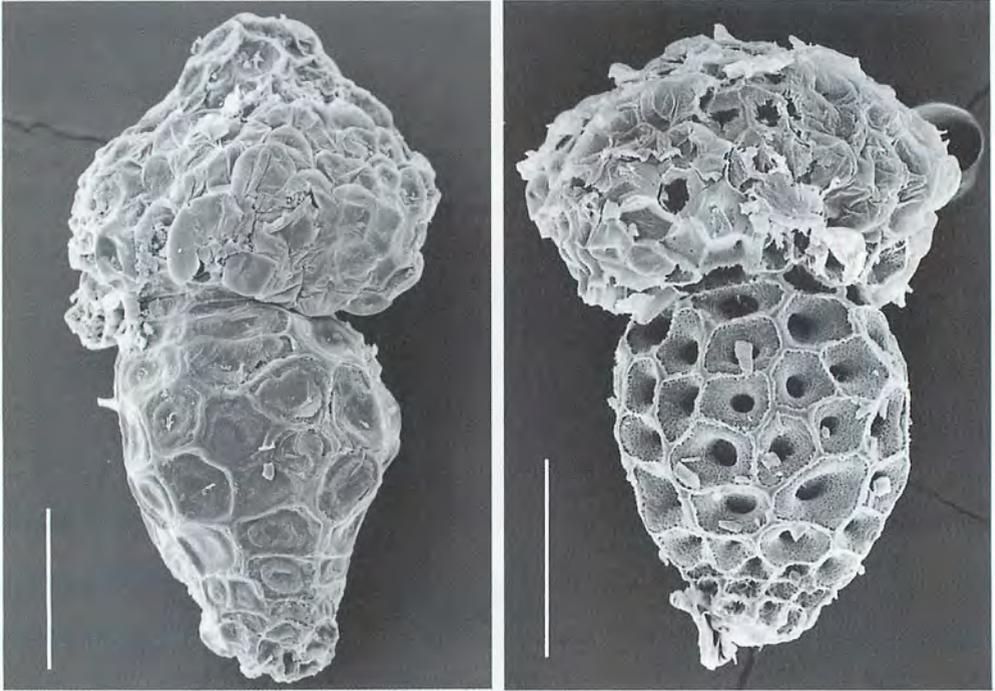


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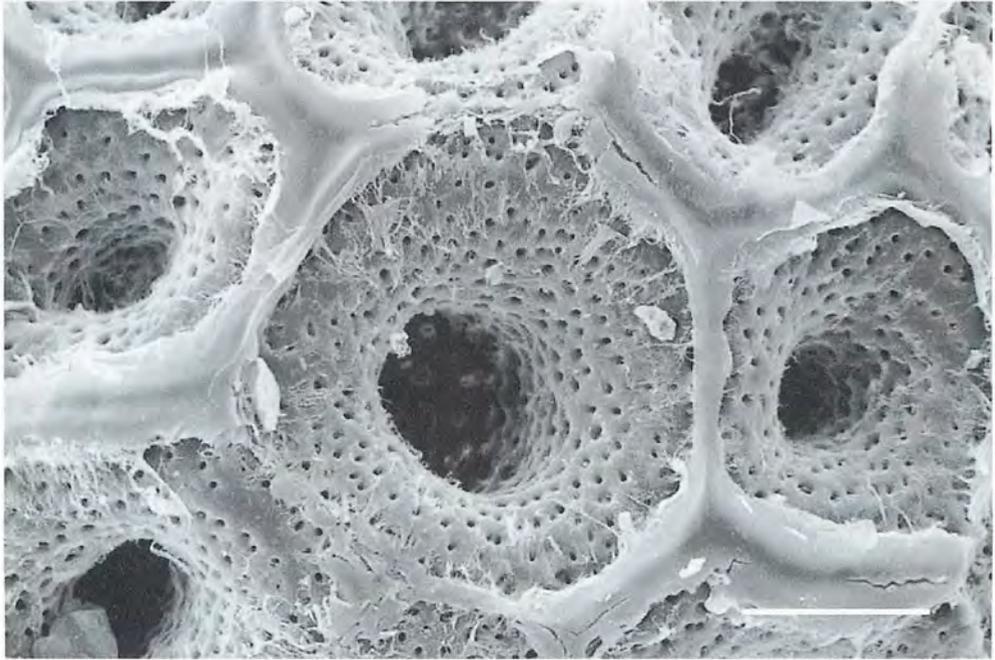
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Figures 12–15 Bisexual *R. lowii*. (12) Two buds; the one in the foreground is 5.4 cm in diameter and is about to open, as visible from the splitting tepal tips. (13) Mature fruit (diameter 7.3 cm). Note the circular and radial cracks on top of the fruit, and the tangential and vertical cracks on the side walls. (14) Fruit. Note the cracks on the side walls. (15) Remains of fruit shown in (14), ten days later, nearly completely eaten by a presumed giant rat (*Leopoldamys* or *Sundamys*). Note the double parallel lines caused by the rat's incisor teeth; the dark granulation are the seeds.



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Figures 16–18 Seeds of bisexual *R. lowii*. Whole seed before (16) and after (17) removal of the periclinial wall. Bar = 0.2 mm. (18) Detail of pit of seed. Bar = 0.03 mm. SEM micrographs by A. Kocyan.

shrews occur in Borneo. EMMONS, NAIS & BIUN (1991) have documented photographically the tree shrew *Tupaia tana* and the squirrel *Callosciurus notatus* eating the fruit of *Rafflesia keithii* Meijer. From the remains of the second fruit of *R. lowii*, a rodent was involved since the tooth-marks consisted of two parallel lines. They were 6.5 mm wide, hence far too large for any other squirrel except giant squirrels (*Ratufa* spp.) which, however, live in the high canopy. Tooth-marks which HB saw of *Callosciurus*-sized squirrels are in the region of 3–4 mm width only. HB suspects giant rats, either *Leopoldamys* or *Sundamys*, were the consumers. Jungle rats have previously been suspected and recently been proved to consume fruits of *S. himalayana* in North Thailand (BÄNZIGER, 2004 and in prep.).

The mature fruit is a blackish berry comparable to that of *S. himalayana*. However, in *R. lowii* it is not barrel-shaped but has side walls slightly converging towards the disk-like top. It is also slightly smaller: 23–25 cm in circumference at the bottom and 3–5 cm in length (from bract attachment to tepal attachment; 7 cm if measured from root attachment to tepal attachment). Remnants of the bases of bracts, tepals and the stalk of the column remained. As in *S. himalayana*, at a later development stage there are brownish cracks all over, circular and radial on top, vertical and tangential on the side walls. They increase in depth and width and at full maturity the fruit splits open along them exposing the white pulp and myriad of tiny seeds. The wall thickness is about 7 mm.

#### *Seeds (Figs. 15–18)*

As already noted by BOUMAN & MEIJER (1994), the seeds of *Rafflesia* and *Rhizanthus* are structurally essentially the same. The seeds of *Sapria* are also similar (BÄNZIGER, 2004). Minor differences include the size of the seed (about a third longer in *Rafflesia kerrii* compared to *S. himalayana*) and the number of pits in the exotegmen (slightly fewer but larger in *Ra. kerrii*). Seeds of *R. lowii* are intermediate between *Rafflesia* and *Sapria* in length and pit size. In *R. lowii* the seeds are 0.70–0.78 mm long (micropylar portion 0.36–0.44 mm, raphe portion 0.29–0.36 mm) and 0.33–0.40 mm wide. The ultrastructure of the pits consisting of small perforations (Fig. 18) is found also in *Sapria himalayana* and *Rafflesia kerrii*.

It has been demonstrated in experiments with rats (*Rattus norvegicus*) feeding on fruit of *S. himalayana*, that seeds recovered from their dung had the periclinal wall removed after gut passage (BÄNZIGER, 2004). It is well-known that in the seeds of many plants the periclinal membrane must be removed (cf. Fig. 17) before germination can start but whether this is also the case for Rafflesiaceae is not yet known.

Because of taxonomic changes since 2000, the seeds described by BOUMAN & MEIJER (1994) as being of *R. lowii* and *R. zippelii* actually pertain to an incompletely known taxon from North Sumatra and to *R. deceptor*, respectively (cf. Table 2 in BÄNZIGER, 2004).

#### *Additional notes on biology*

Hosts infected were *Tetrastigma pedunculare* (Wall. ex Laws.) Planchon (Vitaceae) at low elevations but *T. papillosum* (Blume) Planchon at high elevations; the two host species meet at around 600 m. The pollination will be treated in detail elsewhere but it is clear that blow flies (Calliphoridae), especially *Hemipyrellia ligurriens* (Wiedemann) (Fig. 8), are involved. The pollination system is sapromyophily, but not of the pernicious type found in *R. infanticida*. It is akin to that observed in *R. deceptor* where pollinators are not misled into laying eggs (BÄNZIGER, 2001).

## New Key to the Four Recognized Species

- 1a. A tangle of fine, strongly sinuous, intertwined, densely set furry hairs (600–1400 hairs/cm<sup>2</sup> at tepal vertex) covers most of the tepal; distally a short (3–14 mm) pad of ramenta may or may not be present. Radial lines 36–51. Tepal length 50–100 mm
- 2a. Ramenta absent. Basal 1/2–2/3 of tepal, and caudal appendage, ivory colour, distal 1/3–1/2 pale fleshy, ampulla dark brown. Unisexual or bisexual. W Java..... *R. zippelii*
- 2b. Non- to multi-branched ramenta cover distal 1/20–1/5 of tepal. Tepal pale yellowish basally, more centrally and distally a tendency to pale brownish with grayish-pink tone, overshadowed by cinnamon hairs; tuft hairs and pad with ramenta dark brown; caudal appendages and ampulla pinkish brown. Unisexual only. S Thailand, W Malaysia and Sumatra ..... *R. infantida*
- 1b. Relatively stiff, not so sinuous, sparsely set bristles (20–70 bristles/cm<sup>2</sup> at tepal vertex), cover much of the tepal; distally a short to very long (7–90 mm) pad of ramenta. Radial lines 46–70. Tepal length 75–135 mm
- 3a. A pad of non- to moderately-branched ramenta covers distal 1/15–1/5 of tepal which is 75–100 mm long. Radial lines 46–54. Tepal white throughout except near the apex where there is a dark brown area with tuft hairs and ramenta. Unisexual only. Sumatra..... *R. deceptor*
- 3b. A pad of strongly multi-branched ramenta covers distal 1/3–2/3 of tepal which is 90–135 mm long. Radial lines 50–70. Tepal pale yellowish basally, but centrally and distally gradually darker to brownish, with or without reddish brown areas, whitish to yellowish speckles or marbling; area of ramenta cinnamon to brown. Unisexual or bisexual. Borneo..... *R. lowii*

*Emendation*

In BÄNZIGER & HANSEN (2000), in the description of *R. lowii*, *R. infantida* and *R. deceptor*, under section ‘Colour’ on pp. 126, 128 and 131, respectively, the term ‘column’ should be replaced by ‘collum’, i.e. the stalk (in females the style, see Fig. 2 there) which supports the globular head. Further, in the section ‘Description’ on the same pages, ‘style’ should be replaced by ‘collum’ because the term style applies only to females. Finally, in *R. deceptor* the collum is reddish rather than pale yellowish.

## ACKNOWLEDGMENTS

Sincerest thanks are due to Dr. W. Brockelman, Bangkok, for improving the manuscript; to Ms. S. Panthi, Chiang Mai University, for help with computer matters; and to two anonymous peer reviewers.

## REFERENCES

- BÄNZIGER, H. 1995. Ecological, morphological and taxonomic studies on Thailand's fifth species of Rafflesiaceae: *Rhizanthus zippelii* (Blume) Spach (Rafflesiaceae). *Nat. Hist. Bull. Siam Soc.* 43: 337–365.
- BÄNZIGER, H. 1996. Pollination of a flowering oddity: *Rhizanthus zippelii* (Blume) Spach (Rafflesiaceae). *Nat. Hist. Bull. Siam Soc.* 44: 113–142.
- BÄNZIGER, H. 2001. Studies on the superlative deceiver: *Rhizanthus Dumortier* (Rafflesiaceae). *Bull. Brit. Ecol. Soc.* 32: 36–39.
- BÄNZIGER, H. 2004. Studies on hitherto unknown fruits and seeds of some Rafflesiaceae, and a method to manually pollinate their flowers for research and conservation. *Linzer biol. Beitr.* 36: 1175–1198.
- BÄNZIGER, H., AND B. HANSEN. 1997. Unmasking the real identity of *Sapria poilanei* Gagnep. emend., and description of *Sapria ram* sp. n. (Rafflesiaceae). *Nat. Hist. Bull. Siam Soc.* 45: 149–170.
- BÄNZIGER, H., AND B. HANSEN. 2000. A new taxonomic revision of a deceptive flower, *Rhizanthus Dumortier* (Rafflesiaceae). *Nat. Hist. Bull. Siam Soc.* 48: 117–143.
- BARCELONA, J. F., AND E. S. FERNANDO. 2002. A new species of *Rafflesia* (Rafflesiaceae) from Panay Island, Philippines. *Kew Bull.* 57: 647–651.
- BARCELONA, J. F., M. A. O. CAJANO, AND A. S. HADSALL. 2006. *Rafflesia baletei*, another new *Rafflesia* (Rafflesiaceae) from the Philippines. *Kew Bull.* 61: 231–237.
- BARKMAN, T. J., S.-K. LIM, K. MAT SALLEH, AND J. NAIS. 2004. Mitochondrial DNA sequences reveal the photosynthetic relatives of *Rafflesia*, the world's largest flower. *Proc. Nat. Acad. Sci. U.S.A.* 101: 787–792.
- BECCARI, O. 1868. Descrizione di tre nuove specie di piante Bornensi. *Atti Soc. Ital. Sci. Nat.* 11: 197–198.
- BECCARI, O. 1869. Illustrazione di nuove specie di piante Bornensi. Rafflesiaceae. *Nuovo Giorn. Bot. Ital.* 1: 84–91 (+ Table V).
- BECCARI, O. 1875. Osservazioni sopra alcune Rafflesiacee. *Nuovo Giorn. Bot. Ital.* 7: 70–75.
- BLUME, C. L. 1827. Over een nieuw Plantengeslacht, de *Brugmansia*, uit de natuurlijke familie der Rhizanthaeae. In: H. C. van Hall, *Bijdr. Natuurk. Wetensch.* 2: 419–422.
- BOUMAN, F., AND W. MEIJER. 1994. Comparative structure of ovules and seeds in Rafflesiaceae. *Pl. Syst. Evol.* 193: 187–212.
- EMMONS, L. H., J. NAIS, AND A. BIUN. 1991. The fruit and consumers of *Rafflesia keithii* (Rafflesiaceae). *Biotropica* 23: 197–199.
- FERNANDO, E. S., AND P. S. ONG. 2005. The genus *Rafflesia* R. Br. (Rafflesiaceae) in the Philippines. *Asia Life Sciences* 14: 263–270.
- HEINRICHER, E. 1905. Beiträge zur Kenntnis der Rafflesiaceae. I. *Denkschr. Königlichen Akad. Wissenschaften, Wien, mathem.-naturwiss. Klasse* 78: 57–81 (+ 3 Tables).
- HOOKE, 1873. (Not seen). Reference in Heinricher, 1905.
- ISMAIL, G., K. MAT-SALLEH, A. LAMRI, AND T. D. Z. ADLIN. 1988. *Rafflesia* of Sabah: A case for conservation. *Sabah Journal* 8: 437–456.
- LATIFF, A., AND K. MAT-SALLEH. 1991. *Rafflesia*. In: R. Kiew (ed.), *The state of nature conservation in Malaysia*, pp 89–94. Malayan Nature Society and the International Development and Research Centre of Canada. Kuala Lumpur.
- LATIFF, A., AND M. WONG. 2003. A new species of *Rafflesia* from Peninsular Malaysia. *Folia Malaysiana* 4: 135–146.
- LAYS, P. 2006. Rediscovery of a floral jewel in the Philippine Archipelago: *Rafflesia schadenbergiana* Göppert, 1885 (Rafflesiaceae). *Lejeunia* 182: 1–16.
- MEIJER, W. 1997. Rafflesiaceae. *Flora Malesiana* I, Vol. 13: 1–42.
- MEIJER, W., AND J. F. VELDKAMP. 1988. A revision of *Rhizanthus* (Rafflesiaceae). *Blumea* 33: 329–342.
- MOLESWORTH ALLEN, B. 1968. Interesting jungle plants. *Malayan Nature Journal* 21: 29–33.
- NAIS, J. 2001. *Rafflesia of the World*. Sabah Parks and Natural History Publications (Borneo) Sdn. Bhd., Kota Kinabalu, Sabah, Malaysia.
- NAIS, J. AND C.C. WILCOCK. 1998. The *Rafflesia* conservation incentive scheme in Sabah, Malaysian Borneo. *Sabah Parks Nature Journal*, 1: 9–17.
- PATIÑO, S., J. GRACE AND H. BÄNZIGER. 2000. Endothermy by flowers of *Rhizanthus lowii* (Rafflesiaceae). *Oecologia* 124: 149–155.

SOLMS-LAUBACH, H. GRAFEN ZU. 1876. Die Entwicklung der Blüthe bei *Brugmansia Zippelii* Bl. und *Aristolochia Clematidis* L. *Bot. Zeitung* 34: 449-461, 465-470, 481-489, 497-503 (+ Table 8).

SOLMS-LAUBACH, H. GRAFEN ZU. 1891. Ueber die Spezies in der Gattung *Rafflesia*, Insonderheit über die auf den Philippinen sich findenden Arten. *Ann. Jard. Bot. Buitenzorg* 9: 184-246 (Tables 26-28).