



Rafflesia mixta (Rafflesiaceae), a new species from Surigao del Norte, Mindanao, Philippines

JULIE F. BARCELONA¹, MUHMIN MICHAEL E. MANTING², ROMEL B. ARBOLONIO³, ROLLY B. CABALLERO³ & PIETER B. PELSER¹

¹School of Biological Sciences, University of Canterbury, Private Bag 4800, Christchurch 8140, New Zealand. E-mail: pieter.pelsler@canterbury.ac.nz, julie.barcelona@canterbury.ac.nz

²Department of Biological Sciences, College of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, 9200 Iligan City, Philippines. E-mail: muhmin.manting@g.msuiit.edu.ph

³Department of Environment and Natural Resources (DENR) Regional Office XIII, Barangay Ambago, Butuan City, Philippines. E-mail: melarbolonio@gmail.com; caballero.rolly@gmail.com

Abstract

Rafflesia mixta Barcelona, Manting, Arbolonio, Caballero & Pelsler is described as a new species from the Caraga Region of north-eastern Mindanao, Philippines. In their general morphology, the flowers of this species most closely resemble those of *R. mira*, but they are different in details of the perigone warts and processes, disk color, and relative size of the diaphragm opening. This discovery brings the total number of Philippine *Rafflesia* species to twelve, of which four are found on the island of Mindanao.

Key words: Caraga Region, Mainit, Mamanwa tribe, parasitic plants, taxonomy

Introduction

Rafflesia Brown (1821: 207; Rafflesiaceae) is a genus of endophytic holoparasites that exclusively infect lianas of the genus *Tetrastigma* Miquel (1863: 72; Vitaceae) and inhabit the tropical rainforests of southern Thailand, Malaysia, the Philippines, and Indonesia. In the Philippines, we currently recognize eleven species (Teschmacher 1844, Blanco 1845, Hieronymus 1885, Barcelona & Fernando 2002, Fernando & Ong 2005, Barcelona *et al.* 2006, 2008, 2009a, 2009b, 2011, Galang & Madulid 2006, Balete *et al.* 2010, David *et al.* 2012, Pelsler *et al.* 2013). Except for one, all of these are endemic to individual Philippine islands. Only *R. speciosa* Barcelona & Fernando (2002: 648) is known from two islands (Negros and Panay). Although *Rafflesia* is found in most of the larger Philippine islands, this genus has, thus far, not been reported from Bohol, Cebu, Masbate, Mindoro, Palawan, and smaller islands. Mindanao is the second largest island in the Philippine archipelago and home to three described *Rafflesia* species (Fig. 1). Of these, *R. schadenbergiana* Göppert ex Hieronymus (1885: 3) stands out by having the largest flowers of any Philippine species. *Rafflesia verrucosa* Balete, Pelsler, Nickrent & Barcelona (2010: 50) is characterized by its relatively small flowers and large warts on its perigone lobes and diaphragm, whereas flowers of *R. mira* Fernando & Ong (2005: 267) display remarkably polymorphic disk processes and a smooth diaphragm lacking ornamentation.

In April 2009, during a resource assessment project that was part of the Ancestral Domain Sustainable Development and Protection Plan (ADSDPP) for the Mamanwa (= Mamanua) tribe's Certificate of Ancestral Domain Title (CADT) application, a team led by Jerwin T. Resola and Catherine Mae Buctuan-Jandug discovered a new population of *Rafflesia* in the mountains east of Mainit in Surigao del Norte Province. In March 2014, photos of a plant from this population were posted by one of the authors of this paper (RBA) on the Co's Digital Flora of the Philippines (CDFP) Facebook Group. This group functions as a medium of correspondence between users and contributors of the CDFP website (www.philippineplants.org, Pelsler *et al.* 2011 onwards). CDFP is a citizen science project in which amateurs, students, and professional botanists edit an online checklist of Philippine vascular plants and illustrate it with in situ photographs that are deposited at the PhytoImages website (Nickrent *et al.* 2006 onwards). During subsequent fieldwork in April, May, and June 2014, flowers and buds of this species were collected and preserved. Morphological studies showed that these flowers are distinct from all presently known *Rafflesia* species in several characters that traditionally have been used for species delimitation in this genus. Assuming that these morphological differences are an indication of reproductive isolation, we name and describe these plants here as a new species under a biological species concept (Mayr 2000). This new addition brings the total number of Philippine *Rafflesia* species to twelve.

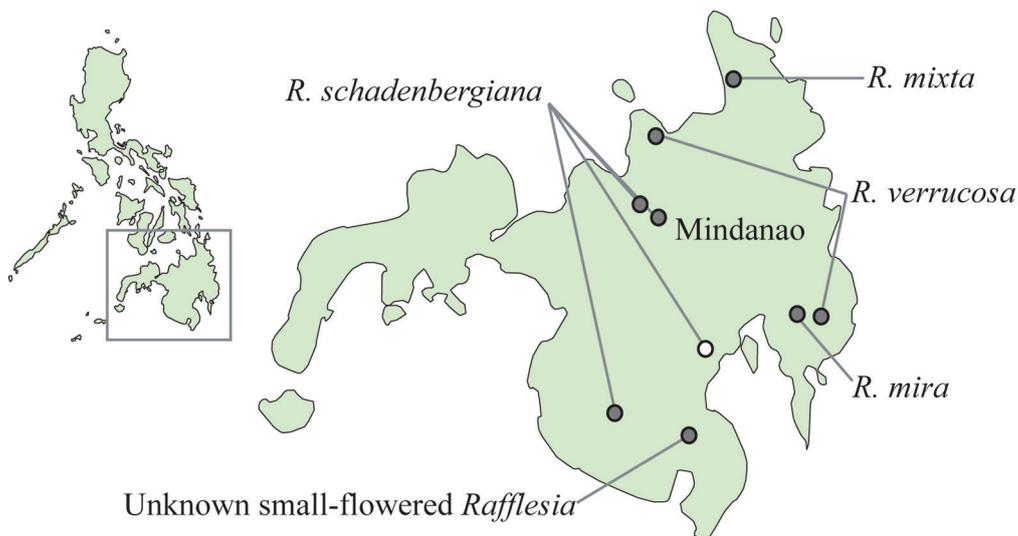


FIGURE 1. Distribution map of *Rafflesia* in Mindanao, Philippines. White circle: type locality of *R. schadenbergiana*, presumably locally extinct. An unknown small-sized *Rafflesia* species was collected from Mt. Matutum in the 1980s (Central Mindanao University Herbarium!; Barcelona *et al.* 2009b).

Taxonomy

Rafflesia mixta Barcelona, Manting, Arbolonio, Caballero & Pelsner, *sp. nov.* – Figs. 2 & 3.

Type:—PHILIPPINES. Mindanao: Caraga Region, Surigao del Norte Province, Mainit Municipality, Barangay Cantugas, loco dicto Sarawag, lowland evergreen forest interior, on steep slopes with loose soil, 9°34'38.9" N, 125°27'7.3" E, c. 622 m, 7 June 2014, Arbolonio & Caballero 5 (female flower; holotype: PNH; female flower; isotype: Mindanao State University - Iligan Institute of Technology).

Rafflesia mixta differs from *R. mira* in having flowers with substantially sparser and smaller warts on the perigone lobes, a more or less uniformly reddish orange or maroon instead of yellowish-orange disk with longer and dimorphic instead of polymorphic processes, and a relatively smaller diaphragm aperture through which the disk is only partially visible.

Mature flower buds to 19–22 cm diam. Flowers 40–55 cm diam. when fully open, 8.5–15 cm high, male and female flowers similar in size, 1.25–2.25 kg fresh weight. Cupule to 11.5 cm diam.; bracts imbricate, orbicular, largest c. 13 cm long, 14.5 cm wide. Perigone tube 10–15 cm high. Perigone lobes 5, broadly orbicular, 9.0–19 cm long, 12–23 cm wide, reddish brown, margins entire to irregularly sinuate; warts powdery white becoming concolorous with background with age, relatively sparse compared to other Philippine *Rafflesia* species, largest ones concentrated at the base of perigone lobes, mostly wider than long, to 0.6 by 1.5 cm wide, variously shaped, and becoming smaller and rounder towards the margin of perigone lobes, interspersed by smaller warts of less than 1 mm diam. Diaphragm 15–25.5 cm diam., c. 3 mm thick, 5–7.2 cm wide from aperture rim to base of perigone lobe, velvety and ferruginous throughout, devoid of warts or other forms of ornamentation (Fig. 3A), windows absent; aperture 6.5–14.25 cm diam. in its widest dimension, rim white surrounded by a thinner dark red band, aperture to disk diameter ratio less than 1 (0.72–0.95). Disk 9–11.5 cm diam., to 2 cm thick towards center, nearly flat but with a prominently raised margin; margin c. 1.5–2.5 cm tall, shallowly incised or crenulate; disk only partially visible through the aperture, reddish orange to maroon, darker near the margin, similar in color underneath. Processes 22–29, more or less regularly disposed, largest c. 3.5 cm long and 2 cm wide at base, apex glabrous, tinged white in buds and fresh flowers, dimorphic between a central and peripheral/outer zone; processes of the central zone 6–9, conical; processes of the outer zone 16–20, somewhat radially flattened at base and more clearly so at apex, to 2 cm wide at base, to 1.5 cm wide at apex (Fig. 3A, C & D). Column short, less than 1 cm long, c. 5 cm broad. Corona c. 2 cm wide, smooth, slightly paler in color than the disk above, glabrous except in anther sulci of male flowers where sparse, white, filiform hairs are present similar to those on the annulus interior. Annulus exterior less than 1 cm broad, 9–10 cm diam., smooth, yellowish and sparsely hairy towards the interior, becoming golden to reddish orange and glabrous towards the exterior. Ramenta polymorphic, maroon, concolorous with perigone tube, those on the floor of perigone tube filiform, to 2 cm long, dense, becoming stouter and branched or cleaved apically towards the diaphragm aperture (Fig. 2C & E). Male flower without vestigial ovary; anthers 19 or 20, semi-globular, c. 5 mm diam., deeply immersed in anther sulci that are c. 1 cm long and c. 8 mm wide (Fig. 3E). Female flower without vestigial anthers, disk becoming dome-shaped as it develops into fruit in senescent flowers, ovary c. 4 cm high, c. 8.5 cm wide, slightly lunate in longitudinal section (Fig. 3B). Mature fruits not seen. Host plant is *Tetrastigma* sp. (Arbolonio *et al.* 3, CHR, Mindanao State University - Iligan Institute of Technology, PNH).

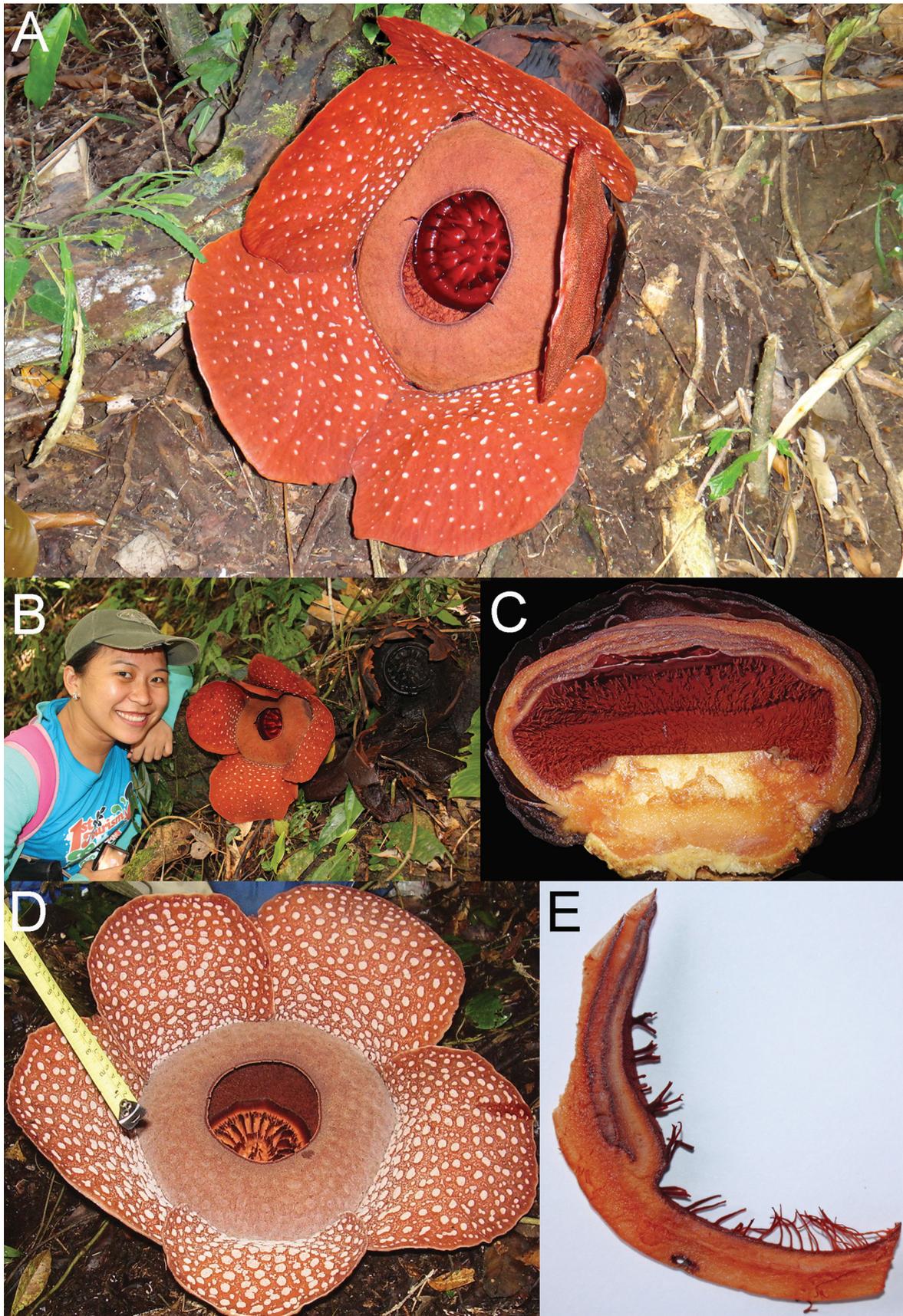


FIGURE 2. *Rafflesia mixta*. A. Open flower. B. Open flower with Ms. Mary Love P. Sanchez for scale. C. Longitudinal section through an immature male bud showing ramenta distribution. D. *Rafflesia mira*, open flower. E. *Rafflesia mixta*, thin section of a male bud showing details of ramenta (lower right: perigone tube, upper left: diaphragm). A. *Arbolonio & Caballero 5* (isotype, collected 4 days after this photograph was taken). B. *Barcelona 4044* with *Manting*, *Arbolonio & Caballero*. C & E. *Barcelona 4043* with *Manting*, *Arbolonio & Caballero*. D. Photo courtesy of Department of Tourism, Region 11.

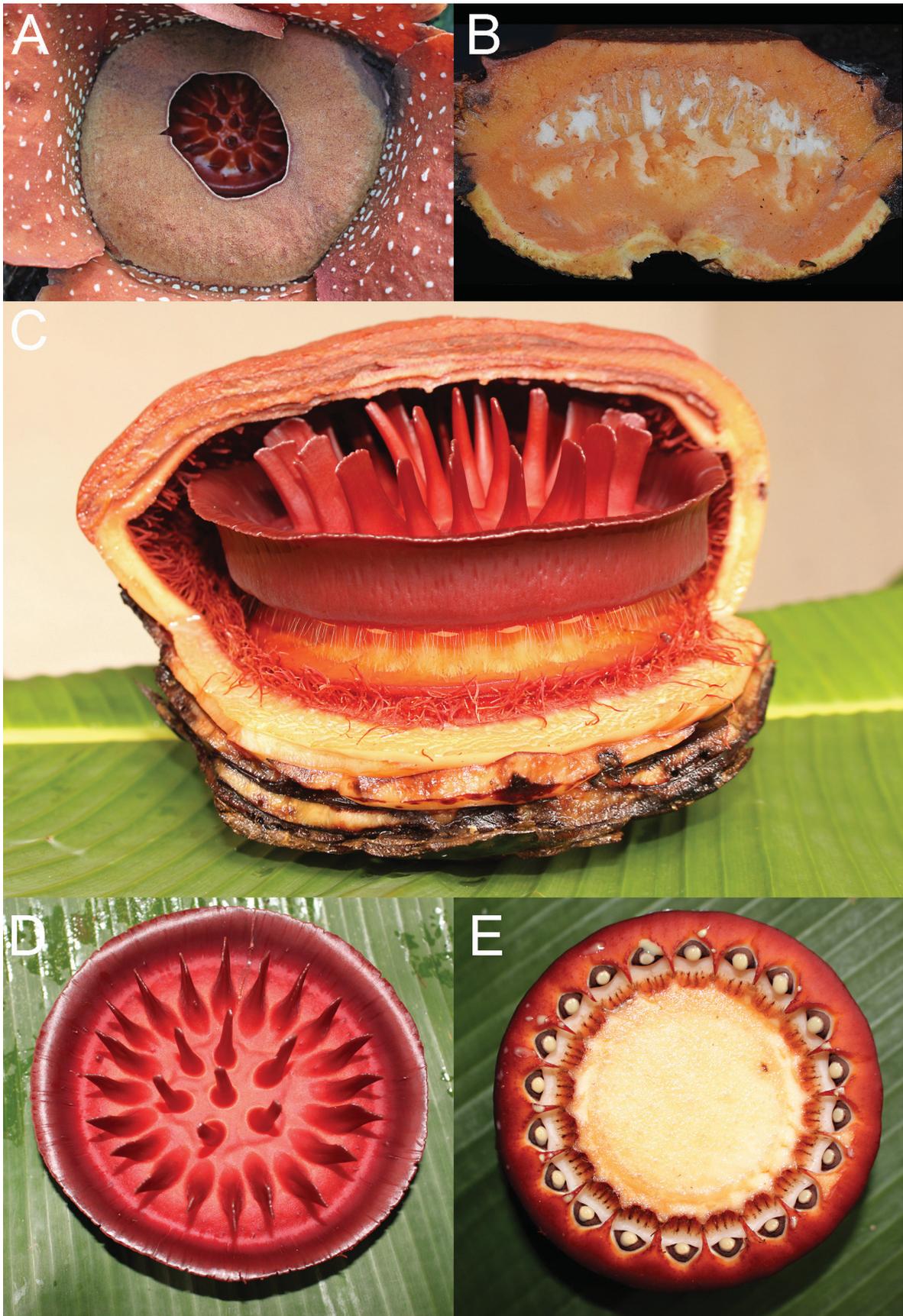


FIGURE 3. *Rafflesia mixta*. A. Open male flower showing partially visible disk processes through the diaphragm aperture. B. Longitudinal section through a female flower showing ovary. C. Bud with perigone lobes removed to show the short column, blade-like processes, and rameta. D. Disk with regularly distributed processes in two zones. E. Anthers underneath the disk. A. *Barcelona 4044* with Manting, Arbolonio & Caballero. B. Arbolonio & Caballero 5. C–E. *Barcelona 4043* with Manting, Arbolonio & Caballero.

Additional specimens examined (paratypes):— The following specimens were collected from the same site as the holotype and isotype, the first two probably infected the same host and may represent the same plant as the holotype: 9°34'38.9" N, 125°27'7.3" E, c. 622 m, 5 April 2014, *Barcelona with Manting, Arbolonio & Caballero*. 4042 (immature male bud; CAHUP), 4043 (mature male bud; CHR); 9°34'39.7" N, 125°27'6.6" E, c. 615 m, 5 April 2014, *Barcelona 4044 with Manting, Arbolonio & Caballero* (male flower; PNH), *Barcelona 4045 with Manting, Arbolonio & Caballero* (immature male bud; Central Mindanao University Herbarium).

Diagnostic characters:—*Rafflesia mixta* is one of five Philippine *Rafflesia* species with flowers that grow larger than 35 cm in diameter: *R. leonardi* Barcelona & Pelsner (2008: 224), *R. mira*, *R. schadenbergiana*, and *R. speciosa*. Of these, the range of flower sizes of *R. speciosa* from Negros and Panay ((31–)45–56 cm diam.; Barcelona *et al.* 2009) is perhaps most similar to that of *R. mixta* (40–55 cm). *Rafflesia speciosa* also resembles *R. mixta* in the presence of perigone warts that are generally less prominent than in the other three large-flowered species, although they are more sparsely distributed in *R. mixta*. Both taxa can be easily distinguished by, amongst others, features associated with their processes. These are monomorphic and cone-shaped in *R. speciosa* and dimorphic in *R. mixta* (cone shaped processes in the central zone of the disk and apically flattened processes in the outer zone). The processes of *R. speciosa* are usually crowned with golden tufts of trichomes that are absent in *R. mixta*. Furthermore, the disk of *R. speciosa* is always paler in color than the diaphragm, whereas this is the opposite in *R. mixta*. The diaphragm of *R. speciosa* is ornamented with whitish warts whereas it is uniformly colored and lacks ornamentation in *R. mixta*.

The range of flower size of *R. mixta* also overlaps with that of *R. leonardi* from northern Luzon (25.5–50 cm diam.; Barcelona *et al.* 2011), but *R. leonardi* flowers have a diaphragm aperture that is much wider than the diameter of the disk (1.2–1.5 ratio), whereas it is narrower than the disk in *R. mixta* flowers (0.72–0.95 ratio). Furthermore, *R. leonardi*, when at all present, has fewer processes (up to 16 vs. 22–29) and these are considerably shorter in length (up to 1.2 vs. up to 3.5 cm; Barcelona *et al.* 2011).

Rafflesia schadenbergiana of central and southern Mindanao has larger flowers (52–80 cm diam.; Barcelona *et al.* 2011) than *R. mixta*. Its conical processes are very similar in size and shape as those of *R. mixta*, but the outer whorl of processes is less flattened at the apex. The warts on the perigone lobes and diaphragm of *R. schadenbergiana* are variously shaped, often coalescent, and prominently raised.

Overall, *R. mixta* is most easily confused with *R. mira* and, in fact, to an untrained eye, the resemblance between these species is quite striking. Both have a similar range of floral dimensions, a uniformly rust-colored diaphragm devoid of warts and other ornamentations, a very faint scent, and polymorphic rameta. However, *R. mixta* markedly differs from *R. mira* in its sparser and smaller variously-shaped warts on the perigone lobes, longer (up to 3.5 vs. up to 2.3 cm long), and dimorphic disk processes in two zones (polymorphic and in four zones in *R. mira*), and a nearly uniformly-colored, reddish orange to maroon disk that is only partially visible through the diaphragm opening (entirely visible and yellowish-orange with a dark-red margin in *R. mira*).

Etymology:— Named for its flower morphology, which shows a combination of features characteristics of three other Philippine *Rafflesia*: the shape and size of the conical processes of *R. schadenbergiana*, the floral size and sparsely distributed perigone warts of *R. speciosa* and the overall resemblance, floral size, faint scent, and diaphragm and rameta morphology of *R. mira*.

Distribution and habitat:—Only known from the type locality in the mountains east of Barangay Cantugas, loco dicto Sarawag, Mainit Municipality, Surigao del Norte Province, in the Caraga Region (Region XIII) of Mindanao. The area flanks the northeast side of Lake Mainit and is an important watershed of Mainit Municipality. The habitat is a relatively intact lowland evergreen forest on very steep slopes with loose soil. This site is some 250 km away from populations of *Rafflesia mira* of Compostela Valley (Fig. 1) to which it is most similar in general morphology. Whereas *R. mira* plants inhabit the elevational range of 900–1300 m, *R. mixta* is found at much lower elevation (584–622 m).

Conservation:—*Rafflesia mixta* is only known to infect three *Tetrastigma* host plants within a 30 m radius at the type locality, which is c. 100 m uphill from a recent *kaingin* (slash & burn farm) of more than half a hectare and an abandoned small-scale mine. Hence, this species is Critically Endangered (CR B1ab(iii,iv); D; IUCN 2001; Fernando *et al.* 2008). Rampant mining activities in the Caraga Region pose a major threat to the watershed area in which *R. mixta* is found. In our opinion, it is in the best interest of the people of Mainit, and especially the Mamanwa tribe, that this area be legally protected. In this way, future management of this biodiversity-rich forest can be decided upon by all its stakeholders. Currently, efforts are being initiated by the DENR and the local governments of Mainit Municipality and Barangay Cantugas as well as the Mamanwa tribe to declare the forest of Cantugas a Critical Habitat and Community Watershed.

Acknowledgements

We would like to thank Mayor Ramon Mondano and staff of the Municipality of Mainit, barangay officials of Cantugas led by Brgy. Captain Perfecto S. Galvez Jr., Datu Cain P. Hukman, chieftain of the Mamanwa tribe, and guides Teddy Y. Hukman, Benjie H. Macopahon, and Targim M. Tiambong. Sergio S. Padilla, Ciriaco D. Sabandal, and Randy B. Ruaya provided company in the field. Thanks to Avelita T. Pagaran, Ponciana G. Margin and Maria Remediosa P. Sanchez and the people of Barangay Cantugas for their hospitality and providing accommodation during the fieldwork. Foresters Jerwin T. Resula, DENR, CENRO-Surigao City and Catherine Mae Buctuan-Jandug, former PAFID (Philippine Association for Intercultural Development) researcher and now with DENR, Caraga Region kindly provided the first photos *R. mixta*. Distribution data for *R. verrucosa* was in part provided by Mr. Roel Dahonog and Edgar B. Cañete, DENR-Region 10, Cagayan de Oro City. Director Mundita S. Lim, Josefina de Leon, and Cecile G. Francisco of the Biodiversity Management Bureau (BMB), Dr. Antonio Manila (DENR-NCR), and Nonito M. Tamayo, OIC-Regional Executive Director of DENR, Caraga Region helped facilitate the issuance of collecting, transport, and export permits. Fieldwork was supported by the Marsden Fund Council from Government funding, administered by the Royal Society of New Zealand.

References

- Balete, D.S., Pelser, P.B., Nickrent, D.L. & Barcelona, J.F. (2010) *Rafflesia verrucosa* (Rafflesiaceae), a new species of small-flowered *Rafflesia* from eastern Mindanao, Philippines. *Phytotaxa* 10: 49–57.
<http://dx.doi.org/10.11646/phytotaxa.10.1.8>
- Barcelona, J.F. & Fernando, E.S. (2002) A new species of *Rafflesia* (Rafflesiaceae) from Panay Island, Philippines. *Kew Bulletin* 57: 647–651.
<http://dx.doi.org/10.2307/4110994>
- Barcelona, J.F., Cajano, M.O. & Hadsall, A.S. (2006) *Rafflesia baletei*, another new *Rafflesia* (Rafflesiaceae) from the Philippines. *Kew Bulletin* 61: 231–237.
- Barcelona, J.F., Pelser, P.B., Cabutaje, E.M. & Bartolome, N.A. (2008) Another new species of *Rafflesia* (Rafflesiaceae) from Luzon, Philippines: *R. leonardi*. *Blumea* 53: 223–228.
<http://dx.doi.org/10.3767/000651908x608197>
- Barcelona, J.F., Co, L.L., Balete, D.S. & Bartolome, N.A. (2009a) *Rafflesia aurantia* (Rafflesiaceae): a new species from northern Luzon, Philippines. *Gardens' Bulletin Singapore* 61:17–27.
- Barcelona, J.F., Pelser, P.B., Balete, D.S. & Co, L.L. (2009b) Taxonomy, ecology, and conservation status of Philippine *Rafflesia*. *Blumea* 54: 77–93. <http://dx.doi.org/10.3767/000651909x474122>
- Barcelona, J.F., Fernando, E.S., Nickrent, D.L., Balete, D.S. & Pelser, P.B. (2011) Redefinition of *Rafflesia leonardi* and an updated key to Philippine *Rafflesia* (Rafflesiaceae). *Phytotaxa* 24: 11–18.
- Barcelona, J.F., Nickrent, D.S., LaFrankie, J.V., Callado, J.R.C. & Pelser, P.B. (2013) Co's Digital Flora of the Philippines: Plant identification and conservation through cybertaxonomy. *Philippine Journal of Science* 142: 57–67.
- Blanco F.M. (1845) *Flora de Filipinas*, ed. 2. M. Sanchez, Manila, 619 pp.
- Brown, R. (1821) An account of a new genus of plants, named *Rafflesia*. *Transactions of the Linnean Society of London* 13: 201–234.
<http://dx.doi.org/10.1111/j.1095-8339.1821.tb00062.x>
- David, M., de Jesus, A.C. & Barcelona, J.F. (2012 '2011') *Rafflesia of the Philippines: a story of adventure, appetite, and affinity*. Energy Development Corporation (EDC), Manila. 180 pp.
- Fernando, E.S. & Ong, P.S. (2005) The genus *Rafflesia* R.Br. (Rafflesiaceae) in the Philippines. *Asia Life Sciences* 14: 263–270.
- Fernando, E.S., Co, L.L., Lagunsad, D.A., Gruezo, W.S.M., Barcelona, J.F., Madulid, D.A., Lapiz, A.B., Texon, G.I., Manila, A.C. & Zamora, P.M. (2008) Threatened plants of the Philippines. *Asia Life Sciences Supplement* 3: 1–52.
- Galang, R. & Madulid, D.A. (2006) A second new species of *Rafflesia* (Rafflesiaceae) from Panay Island, Philippines. *Folia Malaysiana* 7: 1–8. <http://dx.doi.org/10.2307/4110994>
- Hieronymus, G. (1885 '1884') Über *Rafflesia schadenbergiana* (Göppert). *Ein Beitrag zur Kenntnis der Cytinaceen*. Breslau. Reprinted in *Bulletin du Congrès international de botanique et d'horticulture de St. Pétersbourg* (1884, published 1885) 35–36 and as: Über eine neue, von Dr. A. Schadenberg und O. Koch auf Süd-Mindanao entdeckte Art der Gattung *Rafflesia*. *Gartenflora* 34 (1885) 3–7, t. 1177.

- IUCN (2001) *IUCN Red List Categories: Version 3.1*. IUCN Species Survival Commission, IUCN, Gland, Switzerland and Cambridge, U.K., ii + 30 pp.
- Madulid, D.A., Tandang, D.N. & Agoon, E.M.G. (2006 '2005') *Rafflesia magnifica* (Rafflesiaceae), a new species from Mindanao, Philippines. *Acta Manillana* 53: 1–6.
- Mayr, E. (2000) The biological species concept, in: Wheeler, Q.D. & Meier, E. (eds.) *Species concepts and phylogenetic theory: a debate*. Columbia University Press, New York, pp. 17–29.
- Miquel, F.A.W. (1863) Ampelideae novae. *Annales Museum Botanicum Lugduno-Batavi* 1: 72–101.
- Nickrent, D.L., Costea, M., Barcelona, J.F., Pelsner, P.B. & Nixon, K. (2006 onwards) PhytoImages. Available from: <http://www.phytoimages.siu.edu>.
- Pelsner, P.B., Barcelona, J.F. & Nickrent, D.L. (eds.) (2011 onwards) Co's Digital Flora of the Philippines. Available from: <http://www.philippineplants.org>.
- Pelsner, P.B., D.L. Nickrent, J.R.C. Callado & Barcelona, J.F. (2013) Mt. Banahaw reveals: The resurrection and neotypification of the name *Rafflesia lagascae* (Rafflesiaceae) and clues to the dispersal of *Rafflesia* seeds. *Phytotaxa* 131: 35–40.
<http://dx.doi.org/10.11646/phytotaxa.131.1.6>
- Teschemacher, J.E. (1844) On a new species of *Rafflesia*, from Manilla. *Boston Journal of Natural History* 4: 63–66.