Phytotaxa 131 (1): 35–40 (2013)
www.mapress.com/phytotaxa/

Correspondence

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

http://dx.doi.org/10.11646/phytotaxa.131.1.6

Mt. Banahaw reveals: The resurrection and neotypification of the name *Rafflesia lagascae* (Rafflesiaceae) and clues to the dispersal of *Rafflesia* seeds

PIETER B. PELSER[1], DANIEL L. NICKRENT[2], JOHN REY C. CALLADO[3] & JULIE F. BARCELONA[1]

[1]*School of Biological Sciences, University of Canterbury, Private Bag 4800, Christchurch 8140, New Zealand;*
email: pieter.pelser@canterbury.ac.nz, julie.barcelona@canterbury.ac.nz.
[2]*Department of Plant Biology, Southern Illinois University Carbondale, 1125 Lincoln Drive, Carbondale, IL 62901-6509, USA.*
[3]*Philippine National Herbarium (PNH), Botany Division, National Museum of the Philippines, P. Burgos St., Manila, Philippines.*

The southeast Asian holoparasite genus *Rafflesia* Brown (1821: 207; Rafflesiaceae) is famous for producing the largest flowers on record (Kuijt 1969). Following a series of discoveries of new *Rafflesia* species and populations, the Philippines recently emerged as one of the centers of its diversity. It is home to no less than ten currently recognized *Rafflesia* species (Barcelona *et al.* 2009, Balete *et al.* 2010). Here, we report two discoveries that resulted from recent fieldwork in the Mts. Banahaw - San Cristobal Protected Landscape in Luzon and show how these new data impact the taxonomy and biology of Philippine *Rafflesia*.

Resurrection and neotypification of the name *Rafflesia lagascae* (Rafflesiaceae)

Rafflesia manillana Teschemacher (1844: 65) was originally described from the island of Samar in the Philippines, but until recently, extant populations by this name were only known from Luzon. In 2007, however, Madulid *et al.* (2008) found a *Rafflesia* population on Samar. This population was located in the municipality of Basey, which is the general area where the type of *R. manillana* was originally collected. This type specimen was a set of three flower buds and is presumed lost (Madulid & Agoo 2008; Barcelona *et al.* 2009). Upon inspection of flowers from the Samar population, Madulid *et al.* (2008) concluded that these plants belong to a different species than the Luzon populations referred to as *R. manillana*. They subsequently described these Luzon populations as *R. panchoana* Madulid, Buot & Agoo (2008: 44), maintaining the name *R. manillana* only for the population of plants from Samar. Barcelona *et al.* (2009) did not follow Madulid *et al.* (2008) in recognizing the Luzon and Samar *Rafflesia* as distinct species. They pointed out that the characters that were used by Madulid *et al.* (2008) to distinguish the two species are quite variable in the Luzon populations and overlap with those reported from Samar. Furthermore, they concluded that examination of more open flowers would be needed to confirm that the characters used by Madulid *et al.* (2008) are consistent across individuals and populations.

In 2011 Barcelona visited the Samar population and was able to study many fresh flowers. This confirmed the overlap in most character states between the Luzon and Samar flowers that Madulid *et al.* (2008) listed as features distinguishing the two species. As discussed by Barcelona *et al.* (2009), many of these characters are correlated with flower size. However, two characters indeed show consistent morphological differences, although these are perhaps not as discrete as is suggested by Madulid *et al.* (2008): the diaphragm color, and the relative size of the diaphragm aperture (Fig. 1). *Rafflesia* flowers from Luzon (Fig. 1A) have bicolored diaphragms of which either the speckles or the background is concolorous with the perigone lobes. In contrast, flowers from Samar (Fig. 1B) have whitish diaphragms, similar to those seen in *R. lobata* Galang & Madulid (2006: 2). Moreover, flowers from Luzon typically have a much wider diaphragm aperture (i.e. considerably wider than the diameter of the disk) than those from Samar. These morphological differences, together with the disjunct distribution of the Luzon and Samar populations, may indicate a current absence of gene flow between them, and that they merit taxonomic recognition as different species under a biological species concept (Mayr 2000).

Accepted by Benjamin vanEe: 28 Aug. 2013; published: 13 Sept. 2013

Barcelona *et al.* (2009) argued that if the Luzon populations previously known as *R. manillana* indeed represent a species distinct from the *R. manillana* populations on Samar, an earlier name, *R. lagascae* Blanco (1845: 595), is available for the Luzon taxon, as opposed to the name *R. panchoana*. *Rafflesia lagascae* is one of two *Rafflesia* species that Blanco (1845) described from Mt. Banahaw; the second being *R. philippensis* Blanco (1845: 565). Most likely because Blanco did not preserve the specimens that he studied, and because *Rafflesia* was no longer reported from Mt. Banahaw in the remainder of the 19th and 20th centuries, both names were considered synonyms of *R. manillana* by later authors (e.g., Solms-Laubach 1891, 1901, Brown 1912, Merrill 1923, Meijer 1997, Nais 2001).

In 2007, two separate teams of researchers, Barcelona *et al.* (2007) and Madulid *et al.* (2007) reported *Rafflesia* plants on Mt. Banahaw that were morphologically distinct from those known as *R. manillana* elsewhere in Luzon. The name *R. philippensis* was subsequently resurrected for these plants (Barcelona *et al.* 2009; Fig. 2A). Here, we report the finding of a second species of *Rafflesia* at the foot of Mt. Bananaw. This species is conspecific with the Luzon populations previously known as *R. manillana*. This discovery confirms that Blanco was correct in recognizing two distinct *Rafflesia* species in the area. In addition, it provides further support for the conclusion that his *R. lagascae* is the earlier and valid name for *R. panchoana*. Because the type specimen of *R. lagascae* collected by Azaola and presented to Blanco was not preserved, we designate *Barcelona 3819 with Pelser* (CHR) as the neotype for this species:

Rafflesia lagascae Blanco (1845: 595; Fig. 1A)

***Type*:**—PHILIPPINES. Luzon: Monte de Majaijai (Mt. Banahaw), 22 April 1840 (fide Solms-Laubach 1891), *Azaola s.n.* (not preserved). *Neotype (designated here):*—PHILIPPINES. Luzon: *Quezon Prov., Dolores Municipality, Barangay Kinabuhayan, Bangkong Kahoy Valley, Mts. Banahaw – San Cristobal Protected Landscape, 14°2'56" N, 121°26'35"E, ca. 700 m, 3 April 2013, Barcelona 3819 with Pelser (CHR).*

= *Rafflesia panchoana* Madulid, Buot & Agoo (2008: 44). ***Type*:**—PHILIPPINES. Luzon: Laguna Prov., Mt. Makiling, 1914, *W.H. Brown s.n. (Species Blancoanae 535)* (holotype: US904212).

Clues to the dispersal of *Rafflesia* seeds

In addition to rediscovering Mt. Banahaw's second *Rafflesia* species, our fieldwork has contributed data that may help resolve a long-standing secret about the life cycle of *Rafflesia*: the mode of seed dispersal. *Rafflesia* fruits produce thousands of tiny seeds (ca. 0.5–0.75 x 0.3 mm) in leathery, dome-shaped, indehiscent berries (Fig. 2B–D). These appear to rely on the destruction or decay of the fruit wall for the seeds to be dispersed (Kuijt 1969). A wide variety of animals have been considered as potential dispersers of *Rafflesia* seeds ranging from ants and termites to elephants, mice, pigs, and termite predators (Teijsmann 1856, Justesen 1922, Kuijt 1969, Nais 2001). To our knowledge, direct observations of seed dispersal have thus far only been reported by Emmons *et al.* 1991, who observed a treeshrew (*Tupaia tana*) and squirrel (*Callosciurus notatus*) feeding on *Rafflesia* fruits.

In November 2011, we encountered a fruit of *R. philippensis* in an advanced state of decay. After removing some of the decaying fruit wall, we noticed the presence of numerous ants (*Technomyrmex* sp. and *Pheidologeton* sp.) among the disintegrating tissue. Several of these ants were carrying *Rafflesia* seeds away from the fruit (Fig. 2E–H). This discovery fits in well with Kuijt's (1969) hypothesis that the chalazal swelling of *Rafflesia* seeds (giving them the shape of a two-seeded peanut; Fig. 2D) might be an elaiosome. Elaiosomes are characteristic oily appendages on seeds of myrmecochorous plants, such as arils, crests, etc. that offer food bodies to ants (Jackson 1960). It certainly seems plausible that ants, attracted to a nutritious elaiosome, would transport these seeds to their nests. There, they might germinate and infect the roots of a nearby vine of *Tetrastigma* (Miquel 1863: 72) Planchon (1887: 423; Vitaceae; the only known host genus of *Rafflesia*). Infection most likely takes place in the underground parts of *Tetrastigma* (Justesen 1922), because although it is not uncommon to see *Rafflesia* buds and flowers emerging from the climbing parts of a *Tetrastigma* vine, all *Rafflesia* species flower primarily at ground level. This finds some support from Teijsmann's (1856) experiments in which he successfully infected *Tetrastigma* by inserting *Rafflesia* seeds into slits that he cut in its roots. Although it is entirely unknown how *Rafflesia* infects *Tetrastigma* in natural conditions, it is possible that this involves a mycorrhizal partner, as is observed in other holoparasitic plants with miniscule seeds, such as *Conopholis americana* (Linnaeus 1767: 88) Wallroth (1825: 78) (Baird & Riopel 1986). Even though we were not able to locate and excavate the ant nest and confirm the presence of *Tetrastigma* roots and/or *Rafflesia* seedlings, our discovery revitalizes the ant-dispersal hypothesis. Detailed field studies are needed to explore this further.

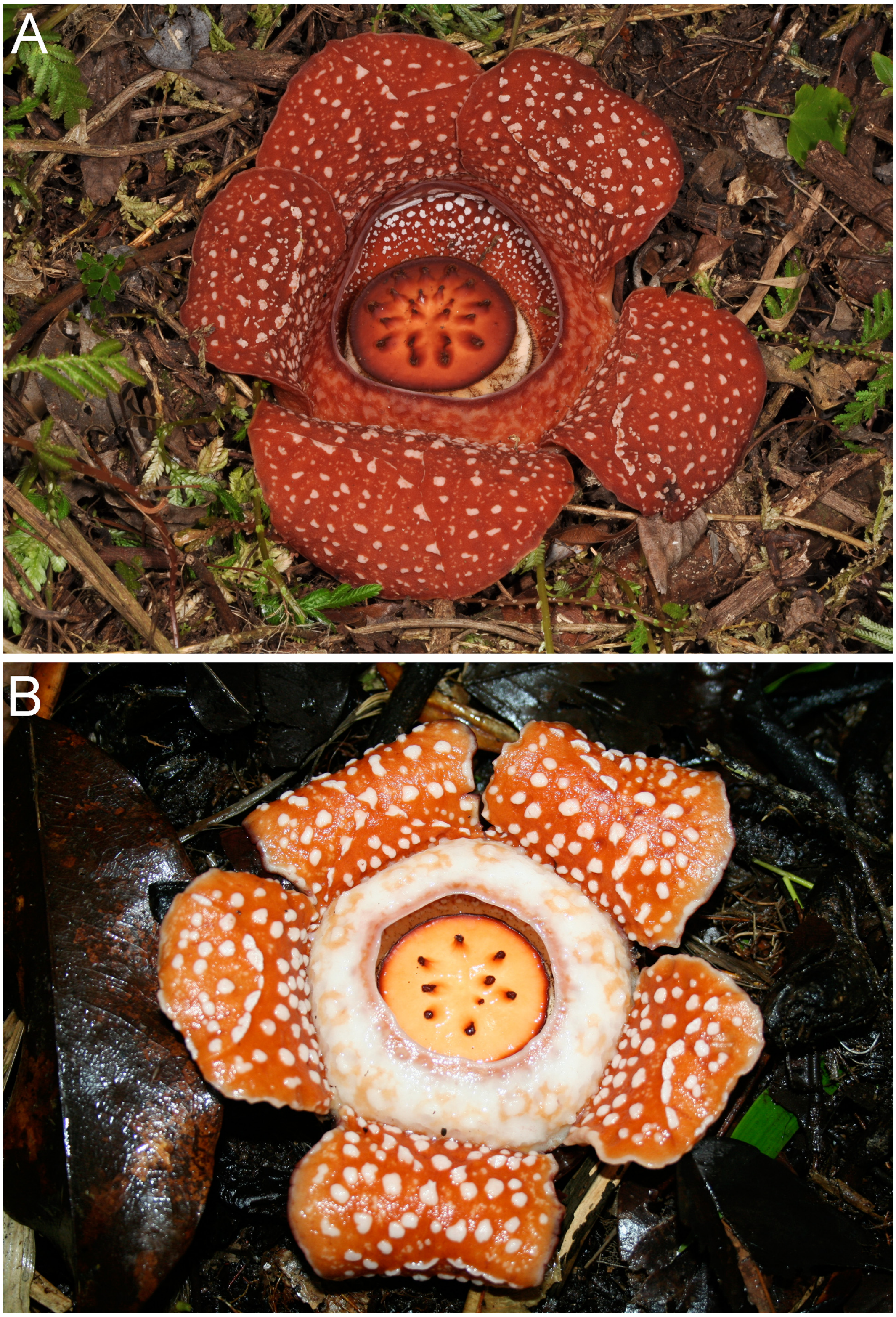

FIGURE 1. A. *Rafflesia lagasacae*, Mt. Banahaw, Luzon, Philippines; *Barcelona 3819 with Pelser* (neotype, CHR). B. *Rafflesia manillana*, Samar Island Natural Park (SINP), Sitio Bagong Silang, Brgy. Guirang, Basey, Samar, Philippines. Photographs taken by Pelser & Barcelona.

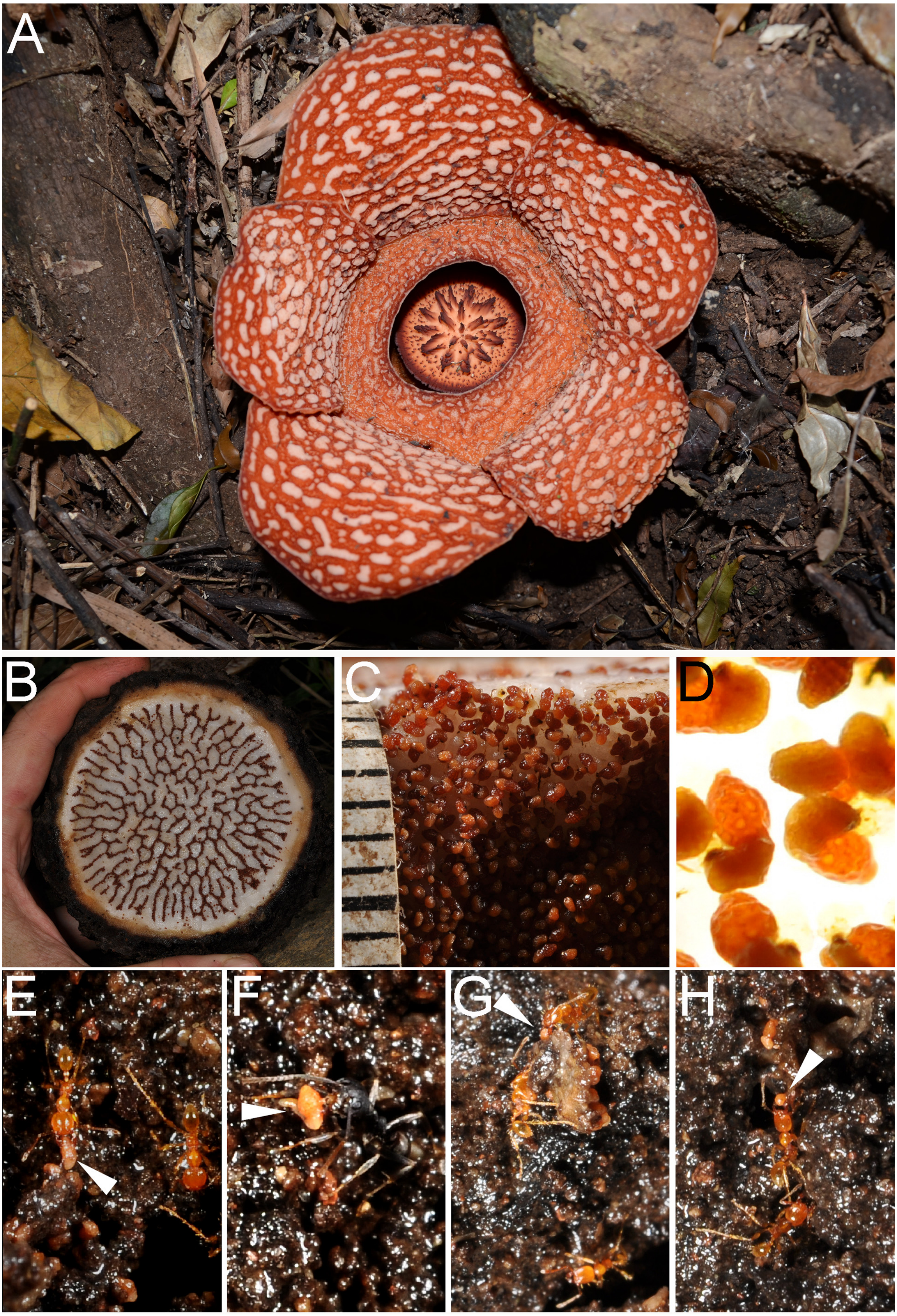

FIGURE 2. A–H. *Rafflesia philippensis*, Mt. Banahaw, Luzon, Philippines. A. Flower, *Barcelona 3809 with Pelser* (CANU). B–D. Nearly mature fruit. B. Cross section of fruit. C. Seeds, 1 mm scale. D. Seeds. E–H. Ants *(Technomyrmex* sp. (F) and *Pheidologeton* sp. (E, G, H)) carrying seeds (indicated with white arrows) from a decaying fruit. Photographs taken by Pelser & Barcelona.

Acknowledgements

We are grateful to the people of Barangay Kinabuhayan, Dolores, Quezon, especially Kagawad Jerry R. Mendua, Ananias (Dingdong) M. Cahilo Sr., Richard (Bebot) Manao, Brgy. Captain Romeo R. Diala, ex-Barangay Captain and Mrs. Angeles Coronado, the Protected Area Management Board (PAMB), Mts. Banahaw – San Cristobal Protected Landscape and Protected Area Superintendent (PASu) Salud Pangan. For field assistance in Samar Island National Park (SINP), we thank Guirang ex- Barangay Captain Ignacio Gimbaolibot, Wilfredo G. Depalco, Judah Aliposa, and staff of DENR Region 8, namely, Eires M. Mate, Felix D. Bernal, Paquito P. Dabuet, and Allan C. Reyna. Matt Walters prepared the ant and seed photos for publication. Perry Archival C. Buenavente provided taxonomic identifications for the ants. This project was supported by the National Geographic Society and the Marsden Fund Council from Government funding, administered by the Royal Society of New Zealand.

References

Baird, W.V. & Riopel, J.L. (1986) The developmental anatomy of *Conopholis americana* (Orobanchaceae) seedling and tubercles. *Canadian Journal of Botany* 64: 710–717.
http://dx.doi.org/10.1139/b86-090

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.

Barcelona, J.F., Pelser, P.B. & Cajano, M.O. (2007) *Rafflesia banahaw* (Rafflesiaceae), a new species from Luzon, Philippines. *Blumea* 52: 345–350.
http://dx.doi.org/10.3767/000651907x609089

Barcelona, J.F., Pelser, P.B., Balete, D.S. & Co, L.L. (2009) Taxonomy, ecology, and conservation status of Philippine *Rafflesia*. *Blumea* 54: 77–93.
http://dx.doi.org/10.3767/000651909x474122

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

Brown, W.H. (1912) The relation of *Rafflesia manillana* to its host. *The Philippine Journal of Science. C. Botany* 7: 209–226.

Emmons, L.H., Nias, J. & Briun, A. (1991) The fruit and consumers of *Rafflesia keithii* (Rafflesiaceae). *Biotropica* 23: 197–199.
http://dx.doi.org/10.2307/2388307

Galang, R. & Madulid, D.A. (2006) A second species of *Rafflesia* (Rafflesiaceae) from Panay Island, Philippines. *Folia Malaysiana* 7: 1–8.
http://dx.doi.org/10.2307/4110994

Jackson, B.D. (1960) *A glossary of botanic terms with their derivations and accent*. Gerald Duckworth & Co. Ltd., London, 481 pp.

Justesen, P.T. (1922) Morphological and biological notes on *Rafflesia* flowers observed in the highlands of mid-Sumatra. *Annales du Jardin Botanique de Buitenzorg* 32: 64–87.

Kuijt, J. (1969) *The biology of parasitic flowering plants*. University of California Press, Berkeley and Los Angeles, 246 pp.

Linnaeus, C. 1767. *Mantissa plantarum* 1. Laurentius Salvius, Stockholm. 142 pp.

Madulid, D.A., Villariba-Tolentino, C. & Agoo, E.M.G. (2007 [2006]). *Rafflesia banahawensis* (Rafflesiaceae), a new species from Luzon, Philippines. *Philippine Scientist* 43: 43–51.
http://dx.doi.org/10.3860/psci.v43i0.370

Madulid, D.A. & Agoo, E.M.G. (2008 [2007]) On the identity of *Rafflesia manillana* Teschem. (Rafflesiaceae). *Philippine Scientist* 44: 57–70.
http://dx.doi.org/10.3860/psci.v44i0.379

Madulid, D.A., Buot, I.E. & Agoo, E.M.G. (2008 [2007]) *Rafflesia panchoana* (Rafflesiaceae), a new species from Luzon island, Philippines. *Acta Manilana* 55: 43–47.
http://dx.doi.org/10.3860/acta.v55i0.1485

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.

Meijer, W. (1997) Rafflesiaceae. *Flora Malesiana, Series 1* 13: 1–42.

Merrill E.D. (1923) *An enumeration of Philippine flowering plants* Vol. 2. Bureau of Printing, Manila, 530 pp.

Miquel, F.A.W. (1863) Ampelideae novae. *Annales Museum Botanicum Lugduno-Batavi* 1: 72–101.

Nais, J. (2001) *Rafflesia of the world.* Sabah Parks, Kota Kinabalu, 260 pp.

Planchon, J.E. (1887) Ampelideae, in: De Candolle, A.L.P.P. & De Candolle, A.C. (eds.) *Monographiae phanerogamarum* 5. Paris, pp. 305–637.

Solms-Laubach, H. (1891) Ueber die Species in der Gattung *Rafflesia* insonderheit ueber die auf dem Philippinen sich findenden Arten. *Annales du Jardin Botanique de Buitenzorg* 9: 184–246.

Solms-Laubach, H. (1901) Rafflesiaceae. *Das Pflanzenreich* 4: 1–18.

Teijsmann, J.E. (1856) Nadere bijdrage tot de kennis van de voortteling van *Rafflesia arnoldii* R.Br. in 's Lands Plantentuin te Buitenzorg. *Natuurkundig Tijdschrift voor Nederlands Indië* 12: 277–281.

Teschemacher, J.E. (1844) On a new species of *Rafflesia*, from Manilla. *Boston Journal of Natural History* 4: 63–66.

Wallroth, C.F.W. (1825) *Orobanches generis diaskene*. Fredericus Wilmans, Frankfurt, 80 pp.