Rafflesia balatociana (Rafflesiaceae), a new species from the Cordillera Central, Luzon, the Philippines

Adriane Tobias[1], Chris Thorogood[2], and Pastor Malabrigo[3]

[1]University of the Philippines Los Banos
[2]University of Oxford
[3]University of the Philippines Los Banos College of Forestry and Natural Resources

April 11, 2024

Abstract

The Cordillera Central is a vast mountain range, spanning 22,500 km^2 in the Philippines, containing some of the country's last remaining intact forests. These forests are a reservoir for biodiversity and home to many poorly-known species, including those in the genus *Rafflesia*, renowned for containing the world's largest flowers. Here we describe *Rafflesia balatociana*, a distinctive yet overlooked taxon from the high elevation moss forest, which we name after the Balatoc Indigenous Peoples, one of the subtribes in the Kalinga Province. This species is distinguished from its close relatives by a combination of conspicuous and stable characters including a double-dentate disk rim and strap-shaped lacuna on the annulus interior. We compare *R. balatociana* with co-occurring species in the Cordillera Central, provide a key, and consider our findings in the wider context of the exceptional biodiversity of this region and its conservation requirements. We propose *R. balatociana* should be classified as Critically Endangered, and recommend its habitat be declared as either a Critical Habitat Area (CHA) or a Local Conservation Area (LCA).

Rafflesia balatociana **(Rafflesiaceae), a new species from the Cordillera Central, Luzon, the Philippines**

Abstract. The Cordillera Central is a vast mountain range, spanning 22,500 km^2 in the Philippines, containing some of the country's last remaining intact forests. These forests are a reservoir for biodiversity and home to many poorly-known species, including those in the genus *Rafflesia* , renowned for containing the world's largest flowers. Here we describe *Rafflesia balatociana* , a distinctive yet overlooked taxon from the high elevation moss forest, which we name after the Balatoc Indigenous Peoples, one of the subtribes in the Kalinga Province. This species is distinguished from its close relatives by a combination of conspicuous and stable characters including a double-dentate disk rim and strap-shaped lacuna on the annulus interior. We compare *R. balatociana* with co-occurring species in the Cordillera Central, provide a key, and consider our findings in the wider context of the exceptional biodiversity of this region and its conservation requirements. We propose *R. balatociana* should be classified as Critically Endangered, and recommend its habitat be declared as either a Critical Habitat Area (CHA) or a Local Conservation Area (LCA).

Additional keywords: Flora of the Philippines, Kalinga, parasitic plants, taxonomy

Introduction

Rafflesia R.Br. ex (Thomson 1820) is a genus of parasitic plants that famously includes the world's largest flowers (Nais 2001). There are 42 accepted species of *Rafflesia* in the Malesian Floristic Region (Adam *et al.* 2022; POWO 2023), and in the last two decades, the Philippines has been established to be a center of diversity for the genus (Barcelona *et al.* 2009; Pelser *et al.* 2019; Malabrigo *et al.* 2023). *Rafflesia* occurs on

five major islands of the Philippines: Luzon, Mindanao, Samar, Negros, and Panay. Among these islands, Luzon, which has the largest land area in the country (109,965 km^2), has the highest diversity of species (Barcelona *et al.* 2006, 2008, 2009; Madulid *et al.* 2007, 2008; Malabrigo 2010; Galindon *et al.* 2016; Valenzuela *et al.* 2017). *Rafflesia* are endoparasites that lack leaves, stems and roots, spending most of their life cycle embedded within the tissues of their hosts – vines in the genus *Tetrastigma,* family Vitaceae (Thorogood *et al.* 2021). Parasitic plants, and endoparasites in particular, have long been subject to taxonomic confusion and debate, owing to a dearth of stable morphological characters (the absence of leaves for example). Recent discoveries in the genus *Rafflesia* in the Philippines, such as *R. consueloae* Galindon, Ong & Fernando and *R. camarinensis* F.B.Valenz., Jaucian-Adan, Agoo & Madulid, highlight the need for further exploration in the region. Meanwhile, known species have also been the subject of considerable taxonomic confusion (Malabrigo *et al* . 2023). A firm and objective grasp of taxonomy is needed to inform effective conservation practice, for we cannot adequately conserve what we do not know to exist.

The new species we describe was brought to the attention of the first author in 2019 by staff of the Department of Environment and Natural Resources. The plant was photographed in 2013 by members of the Balatoc, Kalinga Tribal Inc. (BKTI) during a resources inventory. Careful examination reveals that this taxon is morphologically distinct from closely related and co-occurring species in the region, and requires recognition at the specific rank. The plant we name *Rafflesia balatociana* is the 9$^{\text{th}}$ species of *Rafflesia* to be described from Luzon Island and the 16$^{\text{th}}$ species in the Philippines.

Materials and methods

Field Survey and Documentation

Extensive field surveys were carried out between 2021 and 2022 in the Banao Protected Landscape in Kalinga Province, and adjacent areas, with the aim of documenting localities for *Rafflesia banaoana*Malabrigo. During these surveys, local guides also pointed out populations of an unknown *Rafflesia* species, first seen in 2013. From June to December 2022, the phenology of *Rafflesia balatociana* sp. nov. was monitored, and material was sectioned and examined. The coordinates of the location were recorded and stored using GaiaGPS. Associated vegetation and forest formation type were also documented.

Morphological Characterization and Conservation Assessment

Fresh samples of the putative new species, along with co-occurring*R. banaoana* , *R. consueloae* , and *R.* cf.*aurantia* , were collected and preserved in a 70% ethyl alcohol solution. As with most taxonomic studies on *Rafflesia,* limited material was available due to the rarity of the plant and poor accessibility; however specimens were observed at several stages of development (from bud to anthesis), both male and female. Specimens were deposited in CAHUP, LBC, and PNH (abbreviations according to Thiers 2019). Dissected flowers were examined and the floral parts measured using the ruler tool in Adobe Photoshop CC, calibrated using image pixels. Material was compared with that of closely related species (**Table 1)** . We follow the morphological species concept (Davis and Heywood 1963; Knapp and Vorontsova 2016), which emphasizes the importance of observable physical traits in identifying and categorizing species.

The provisional conservation status of the species was assessed following the criteria and categories of the IUCN (IUCN Standards and Peititions Committee 2022). The extent of occurrence (EOO) and area of occupancy (AOO) of the species were estimated with the Geospatial Conservation Assessment Tool (Bachman *et al.* 2011).

Taxonomic Treatment

Rafflesia balatociana sp. nov. (**Figs.1–2, 4a**).

Type: PHILIPPINES. Luzon Island, Kalinga Province, Pasil Municipality, Barangay Balatoc, Mt. Amferchuwan, 1780 m elev., male flower, 01 October 2022, *Tobias 2022-2* (spirit collection; holotype LBC!).

Diagnosis

Rafflesia balatociana is distinguished from closely related species by a combination of characters: bilobed outermost bract (entire in *R. aurantia, R. banaoana* and *R. consueloae*), diaphragm discolorous from perigone lobes (concolorous in *R. aurantia* and*R. banaoana*), a weakly dome-shaped disk (shallowly depressed centrally in *R. aurantia* , conspicuously dome-shaped in *R. banaoana*), a dark red, leathery and distally 'pockmarked' (indented) upper disk surface (creamy-white to pale pink, covered with brown acicular hairs throughout in *R. consuelaoe* , ivory to brownish yellow in *R. banaoana*), a doubly-dentate disk rim with bristles (vs. crispate in *R. consueloae* and *R. aurantia* , with minute brown hairs in *R. banaoana*), a long strap-shaped lacuna on the annulus interior (contracted and blunt in *R. aurantia* and*R. consueloae* , long and basally-expanded in *R. banaoana*), and an annulus exterior without a basal ridge (basal ridge prominent in*R. banaoana*).

Endophytic holoparasite (devoid of a vegetative body).**Mature bud** 10–15 cm diameter. **Cupule** c. 2.5–3 cm high, 5–6 cm wide. **Bracts** dark brown to black, in a set of 5 imbricate whorls, 5 bracts per layer, outermost smallest, c. 2–3 cm long by 4.5 cm wide, innermost bilobed about 2 cm deep, largest, c. 9–10 cm by 8–9 cm. **Flowers** 25–35 cm diameter when fully expanded, 5–6 cm high. **Perigone tube** slanted, 5–7 cm long.**Perigone lobes** 5, 8–10 cm by 10 cm, 3-6 mm thick, ochre when young, reddish-brown when mature, apically recurved, broadly orbicular, basally valvate, with margins darker in color, entire, covered with conspicuous, highly embossed, small, round, elongated, sharply-edged warts, white in color, denser near the base. **Diaphragm** 16–18 cm diameter, 3–6 cm wide from aperture rim to base of perigone lobe, 5–9 mm thick, background discolorous, darker from the perigone, outer surface with highly embossed sharply-edged and fence-like warts, 1-2 mm high. **Diaphragm Aperture** 9-10 cm diameter, margin entire, white becoming concolorous with the diaphragm. **Windows** absent.**Ramenta** reddish brown, simple filiform, 2–5 mm, longer on the lower perigone tube, simple and filiform, sometimes bi-lobed, shorter on the lower surface of the diaphragm; ramenta confluent at the base, multi–lobed above. **Disk** 7-8 cm diameter, 1–1.5 cm thick, pale pink when young, dark red when mature, centrally dome–shaped, rim extended horizontally, margin darker in color, doubly-toothed with bristles, the upper surface smooth, shiny and leathery, 'pockmarked' at the distal portion, centrally with conspicuous processes about 0.5–1 cm, the undersurface white in the middle portion near the neck of the column, brownish yellow to reddish brown in the outer zone, with minute white hairs. **Processes** 10–15, concolorous with disk, apex with a few bristles, those of the female flower generally shorter, 5–6 cm, polymorphic, conical on the outer zone, lobed and flattened on the inner zone; those of the male flower longer, conical, pointed apically.**Male flower** generally larger (to 35 cm), without vestigial ovary, *anthers* 17–18, 3–5 mm diameter, globose, attached to a brown sub-structure about 5–8 mm wide, immersed in anther sulci 7–8 mm long and 5–8 mm wide; *neck of the column* 7–8 mm height, 4-4.5 cm diameter; *lamella* 18–20, 0.3–1 cm long from the neck margin,*lacuna* (or grooves between the lamella on annulus interior) 1.2–1.8 cm long and 0.3–1 cm wide, glabrous; *interior annulus structure* similar in size from the disk, 7–8 cm diameter, surface with small bristles, about 3 mm, reddish–brown becoming darker towards the margin, curving upward, with minute hairs; *exterior annulus structure* 1–2 cm from the edge of the interior annulus structure, concolorous with the disk's upper surface, glabrous, devoid of ramenta.**Female flower** smaller (c. 25 cm), with vestigial white anthers in narrow grooves along the disk's undersurface; *neck of the column* 7–8 mm height, 3–3.2 cm diameter, margin lobed;*interior annulus structure* of similar size to the disk, 7 cm in diameter, reddish-brown in color, surface glabrous but hispidulous along the margin, grooves strap-shaped, 1.7 cm long, 0.4–0.5 cm wide; *exterior annulus structure* similar to the male flower, *ovary* 5 cm wide, 1.2 cm height, lunate–triangular, acutely angled. **Fruit** and **seeds**not observed.

Distribution and habitat

Rafflesia balatociana is known currently only from the south-western Kalinga Province, in the tropical upper montane forests of the Cordillera Central, Luzon Island (**Figs. 4A-D**). It occurs in mossy forests at an elevation of ca.1750–1800 m near Mt. Alimungao. The host *Tetrastigma* species (refer to **Fig. 4L**), could not be identified with certainty (taxonomic limits in the genus are unresolved), and due to restrictions in accessibility, specimens could not be collected or deposited.

Etymology

Rafflesia balatociana is named in honor of the Balatoc Indigenous Cultural Community.

Phenology

Buds emerge from June to August and take several months to mature. Based on our field observations over the course of three years, and those of the Indigenous Community over the last decade, the anticipated flowering period spans from September to December, with a peak in October.

Provisional conservation status

Over the course of three years of field surveys, the species was found only in seven sites within a locality of approximately 11 ha. There were fewer than 50 individuals documented. In 2020, 20 blooming and senesced flowers were recorded. With the aid of GeoCAT, the extent of occurrence (EOO) and area of occupancy (AOO) were estimated to be 8 km^2. We propose the species be assessed as Critically Endangered [CR B1ac(ii,iv)+2ac(ii,iv); C2a(i)b; D] following the IUCN Criteria and Categories.

Additional specimens examined

PHILIPPINES. Luzon Island: Kalinga Province, Pasil Municipality, Barangay Balatoc, Mt. Amferchuwan, 1780 m, female flower, *Tobias 2022-3* (CAHUP!); female flower buds, *Tobias 2022-3* (PNH!) and *Tobias 2022-5* (LBC!).

Discussion

Taxonomy

The Philippines is the centre of diversity for the genus *Rafflesia* with 16 species recognized, including the species we describe here: *Rafflesia balatociana.* Nine of these occur on Luzon Island. The taxonomy of the *Rafflesia* of Luzon has been confused and in a state of flux, despite nearly a century and a half of documented botanical exploration in the region. For example *R. banahawensis* Madulid, Villariba–Tolentino & Agoo (Madulid *et al.* 2008) [as *R. philippensis* in Barcelona *et al.*2009b; Blanco 1845] in the Banahaw–San Cristobal Protected Landscape (Barcelona *et al.* 2008b; Madulid *et al.* 2006; Pelser*et al.* 2013) and *R. panchoana* Madulid, Buot & Agoo in the Mount Makiling Forest Reserve (Madulid *et al.* 2007, 2012) [as*R. manillana* in Fernando & Ong 2005a; as *R. lagascae* in Barcelona *et al.* 2009c, 2011; Pelser *et al.* 2013] were both overlooked until recently, and synonymised under *R. manillana* , a distinct species from Basey, Samar Island (Madulid & Agoo 2007). More recently, *R. banaoana* Malabrigo, was first described in 2010 (Malabrigo 2010), synonymized with *R. leonardi* Barcelona & Pelser (Barcelona *et al.* 2011), and then recently reinstated (Tobias *et al.* 2023). Traditionally, *Rafflesia*spp. in the Philippines have been described with emphasis on various diagnostic characters including habit, flower color and size, wart ornamentations on the perigone lobes, color and surface of diaphragm, diaphragm aperture, types of ramenta and number of anthers. Recently, we emphasized the importance of stable yet hitherto neglected features such as the stigmatic fascia surface, disk shape, process structure, annulus interior and exterior distinction, and ovary shape (Tobias *et al* . 2023). Meijer (1997), in his monograph of the genus, also highlighted the significance of annulus structure in classifying *Rafflesia,*as well as their ramenta. Since then, authors across Southeast Asia have placed varying emphasis on different characters, leading to inconsistent descriptions that are challenging to compare objectively. Some of these – specially size- and colour-related, are continuously variable, so must be considered alongside more stable characters, such as the shape of the processes and their apical indumentum, disk undersurface, rim extension and margin of the disk, structure of the anther attachment to the sulci, structure of the lamella and grooves on the annulus interior and shape of the ovary. Accordingly, *R. balatociana* should be distinguished by its combination of stable characters, especially the double-dentate disk rim and the strap-shaped lacuna on the annulus interior.

Key to the Rafflesia *species of the Cordillera Central*

1. Flower large, typically 35-50 cm across, reddish–orange with paler warts; disk weakly domed .....

R. banaoana

1. Flower small, typically 10-35 cm across, reddish–orange with paler warts or uniformly orange; disk flat to weakly depressed. 2

2. Flowers uniformly orange including warts, with a concolorous diaphragm. . . . . .

R. aurantia

2. Flowers orange to brownish-pink with paler warts. . . . . .

3. Flowers [?] 12 cm across; upper disk ring crispate; lacuna on annulus interior contracted and blunt. . . . . ***R. consuelaoe***

3. Flowers [?] 25 cm across; upper disk ring doubly-dentate with bristles; annulus interior strap-shaped. . . . . R. balatociana

Ecology

Rafflesia spp. occur at a range of elevations and are variably widespread across the Philippines from near sea level to high elevation. Most *Rafflesia* species in the Philippines are geographically isolated – often restricted to disjunct and inaccessible mountain forests – with limited opportunity for gene flow among populations (Pelser *et al* . 2019). Indeed, populations within species can be markedly genetically differentiated, such as *R. panchoana*on Mount Labo compared with other populations on Luzon (Pelser *et al.* 2017). Meanwhile the recently delineated *R. banaoana* and*R. leonardi* occur at a different elevations, in habitats with distinct plant assemblages (Tobias *et al* . 2023). Unusually,*R. balatociana* co-occurs in the same broader area as three other taxa: *R. banaoana* , *R. consueloae* , and *R.* cf.*aurantia* in the Cordillera Central. This presents an opportunity for gene flow among sympatric species – something hitherto unreported in *Rafflesia.* The species in closest proximity is *R. banaoana,* which also occurs in high elevation moss forest in the southwest of Kalinga Province. While *R. balatociana* blooms predominantly in September to December, with a peak in October; *R. banaoana* blooms between March to June, with an apparent peak in May. Therefore, these species appear to co-occur in sympatry. Specimens of the two species flowering in synchrony outside these periods is possible. However, fruit-set is rare in *Rafflesia* species, which are all unisexual (with synchronous blooming of male and female flowers uncommon), and flower erratically, often in small numbers. Indeed, we have never observed fruits in *R. balatociana* or *R. banaoana* during several years' field work and observation throughout the calendar year. *Rafflesia consueloae* seems to flower in synchrony with *R. banaoana;* data on the phenology of *R. aurantia* are absent. However, *R. consueloae* typically occurs at lower elevation (300-500 m) (Galindon *et al* . 2016), and *R. aurantia* occurs mainly in disturbed lowland dipterocarp forest, and lower mountain slopes (Barcelona *et al* . 2009a); neither has been observed in close proximity to *R. balatociana* .

Pelser *et al.* (2016) report the occurrence of distinct*Rafflesia* taxa reportedly collected 5-10 m from one another, and the presence of *R. lobata* and *R. speciosa* in sympatry in Panay. The authors noted that these sympatric species often diverge significantly in flower size (as is the case for *R. balatociana*and *R. banaoana*), which could lead to pollinator incompatibility. In Malaysian Borneo, *R. keithii* and *R. pricei* co-occur in close proximity with no evidence of gene flow, as pointed out by Meijer (1984); meanwhile in Indonesia the authors have observed *R. arnoldii, R. kemumu* and *R. bengkuluensis* in the same district (albeit separately), again without any apparent intermediates; however the genetic relatedness of these taxa has not been investigated and they are morphologically similar. Hybridisation has not been reported in the genus *Rafflesia;* hybrids might be expected to be exceedingly rare, given the scarcity of most putative parent species, brief and erratic blooming, and the allopatric and sympatric barriers between them, as discussed above. A detailed molecular study is needed ascertain whether hybridisation has been, or is, an evolutionary driver in the genus unequivocally. In the case of *R. balatociana,* we consider hybridization with co-occurring

species unlikely because of the lack of intermediate morphological features (stressed above, and see key), as well as ecology and phenology.

Little is known about the host specificity of *Rafflesia* . Data available from the Philippines indicate that the plants may be less host–specific than considered previously, and that host–parasite co–speciation may not have been a major driver of diversification in the genus (Pelser *et al.* 2016). The genus *Tetrastigma* is itself taxonomically complicated, which has further hindered our understanding of the host specificity of *Rafflesia* . In the Cordillera Central, our observations suggest that *R. banaoana*grows on *Tetrastigma* cf. *sepulchrei* Merr. and *T. loheri* Gagnep; the *Tetrastigma* hosts of *R. consueloae* , and *R. aurantia* are unreported. We were unable to collect vouchers of the host of *R. balatociana* because there were no leaves within reaching distance; a common problem in the host identification with *Rafflesia.*

Ethnobotany

Indigenous Peoples - who represent only 5% of the globe's human population – have been described as the stewards of 80% of the Earth's biodiversity (Ogar *et al.* 2020). Indigenous Peoples have played a significant role in the discovery and documentation of *Rafflesia*in the Philippines. For example, *R. leonardi* was first seen by Mr. Sumper Arresta, a member of the Agay Indigenous Community in Cagayan Province. In addition, *R. banaoana* , which co-occurs with *R. balatociana* in Kalinga province, was found in 2009 with the help of the Banao Indigenous Cultural Community and published a year later (Malabrigo 2010). This tribe believes the flowers to possess and evil spirit that will bring misfortune to anyone who disturbs them. Indeed author PLM, was hard put to convince the local people to accompany him and collect specimens (Malabrigo 2010; Malabrigo *et al* . 2023).

We name *R. balatociana* in honor of the Balatoc Indigenous Cultural Community. This unique community has a rich history and a unique socio-political structure. The people of Balatoc practice "*bodong"* , a sacred bond between indigenous communities and a covenant to protect life, natural resources, and property. In recognition of their ancestral rights, the National Commission on Indigenous Peoples (NCIP) has formally granted to the Balatoc people their priority rights over their ancestral domains through a resolution. This acknowledgment solidifies their authority in managing and preserving the important botanical landscape of Cordillera Mountains. The customs and traditions of Balatoc go hand-in-hand with the preservation of their forests. The people of Balatoc still practice the *"lapat* " and "*imong* ", a system that prohibits the cutting of trees.

Conservation

Recently we estimated that of the 42 species of *Rafflesia* known to science, most are now severely threatened with extinction, yet just one is listed by IUCN. We estimated 60% of *Rafflesia* species face a severe risk of extinction (CR), and at least 67% of known habitats fall outside protected areas, exacerbating their vulnerability (Malabrigo *et al* . 2023). *Rafflesia balatociana* is no exception. In a campaign of fieldwork carried out by the authors in the Cordillera Mountains, and in consultation with Indigenous Peoples, we were only able to identify seven sites for *R. balatociana* in an area of c. 11 ha., comprising fewer than 50 individuals. Although there was no evidence of logging or biological resource extraction within the locality, the municipality of Pasil has lost around 13.7 ha of primary forests (GFW 2023). Accessibility to the locality is difficult, requiring an arduous trek; hence, disturbance due to anthropogenic activities is unlikely.

Taken together, we propose the species be assessed as Critically Endangered [CR B1ac(ii,iv)+2ac(ii,iv); C2a(i)b; D] following the IUCN Criteria and Categories. The species' occurrence falls outside the Banao Protected Landscape. We recommend the local area should be declared as either a Critical Habitat Area (CHA) or a Local Conservation Area (LCA). Beyond *in situ* conservation (the single best measure of protection), a multi-pronged approach to *Rafflesia*conservation has been suggested, incorporating: (i) action devolved to local communities and awareness campaigns linked to social media networks, with ecotourism where appropriate, (ii) strengthened taxonomy to inform priority-setting, and (iv) judicious and sustainable *ex situ* propagation (Malabrigo *et al* . 2023).

References

Adam JH, Aizat-Juhari MA, Ariff NN-FN, Khamis S, Yasin MHM, Wan K-L (2022) Rafflesia tunku-azizahiae (Rafflesiaceae), a New Species from Pahang, Malaysia. *Sains Malaysiana* **51** , 3843–3855.

Bachman S, Moat J, Hill AW, De La Torre J, Scott B (2011) Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. ZooKeys 150: 117–126.

Barcelona JF, Cajano MAO, Hadsall AS (2006) Rafflesia baletei, another new Rafflesia (Rafflesiaceae) from the Philippines. *Kew Bulletin* . doi:10.2307/20443266.

Barcelona JF, Co LL, Balete DS, Bartolome NA (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* (Rafflesiaceae). *Blumea: Journal of Plant Taxonomy and Plant Geography* 54: 77–93. https://doi.org/10.3767/000651909X474122

Barcelona J, Fernando E, Nickrent D, Balete D, Pelser P (2011) An amended description of Rafflesia leonardi and a revised key to Philippine Rafflesia (Rafflesiaceae). *Phytotaxa* **24** , 11–18. doi:10.11646/phytotaxa.24.1.2.

Barcelona JF, Pelser PB, Cabutaje EM, Bartolome NA (2008) Another new species of Rafflesia (Rafflesiaceae) from Luzon, Philippines: R. Leonardi. *Blumea: Journal of Plant Taxonomy and Plant Geography* . doi:10.3767/000651908X608197.

Davis PH, Heywood VH (1963) Principles of Angiosperm Taxonomy. *The Journal of Ecology* **52** , 796. doi:10.2307/2257863.

Galindon JMM, Ong PS, Fernando ES (2016) Rafflesia consueloae (Rafflesiaceae), the smallest among giants; a new species from Luzon Island, Philippines. *PhytoKeys* . doi:10.3897/phytokeys.61.7295.

GFW (2023) Pasil, Kalinga, Philippines Interactive Forest Map | GFW. https://www.globalforestwatch.org/map/country/PHL/.

IUCN Standards and Peititions Committee (2022) Guidelines for Using the IUCN Red List Categories and Criteria, version 15.1. Prepared by the Standards and Petitions Committee. https://nc.iucnredlist.org/redlist/content/attachment_files/RedListGuidelines.pdf.

Knapp S, Vorontsova MS (2016) A revision of the 'African Non-Spiny' clade of Solanum L. (Solanum sections Afrosolanum Bitter, Benderianum Bitter, Lemurisolanum Bitter, Lyciosolanum Bitter, Macronesiotes Bitter, and Quadrangulare Bitter: Solanaceae). *PhytoKeys* **66** , 1–142. doi:10.3897/phytokeys.66.8457.

Madulid DA, Buot, Jr. IE, Agoo EMG (2007) Rafflesia panchoana (Rafflesiaceae), a new species from Luzon Island, Philippines.*Acta Manilana* **55** , 43–47.

Madulid DA, Villariba-Tolentino C, Agoo EMG (2008) Rafflesia banahawensis (Rafflesiaceae), a new species from Luzon, Philippines.*The Philippine Scientist* . doi:10.3860/psci.v43i0.370.

Malabrigo PL (2010) Rafflesia banaoana (Rafflesiaceae): another new species from Luzon, Philippines. *Asia Life Sciences-The Asian International Journal of Life Sciences* **Suppl. 4** ,.

Malabrigo PL, Tobias AB, Witono JR, Mursidawati S, Susatya A, Siti-Munirah MY, Wicaksono A, Raihandhany R, Edwards S, Thorogood CJ. (2023). Most of the world's largest flowers (Rafflesia) are now on the brink of extinction. Plants, People, Planet. https://nph.onlinelibrary.wiley.com/doi/full/10.1002/ppp3.10431.

Meijer W. (1984). New species of *Rafflesia* (Rafflesiaceae). Blumea 30: 209-215.

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

Nais J (2001) 'Rafflesia of the World.' (Sabah parks).

Ogar, E., Pecl, G., & Mustonen, T. (2020). Science must embrace traditional and indigenous knowledge to solve our biodiversity crisis. One Earth, 3(2), 162–165.

Pelser, P.B., Nickrent, D.L. & Barcelona, J.F. (2016) Untangling a vine and its parasite: host specificity of Philippine *Rafflesia*(Rafflesiaceae). Taxon 65: 739–758.

Pelser, P.B., Nickrent, D.L., van Ee, B.W. & Barcelona, J.F. (2019) A phylogenetic and biogeographic study of *Rafflesia* (Rafflesiaceae) in the Philippines: limited dispersal and high island endemism. Molecular Phylogenetics and Evolution: 1–13.

POWO (2023) Rafflesia R.Br. ex Gray | Plants of the World Online | Kew Science. *Plants of the World Online* . http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:77089854-1.

Thiers B (2019) Index Herbariorum: a global directory of public herbaria and associated staff. New York: New York Botanical Garden's Virtual Herbarium.

Thomson T (1820) Proceedings of the Linnaean Society, June 6 and 30.**16** , 225.

Thorogood, C.J., Teixeira-Costa, L., Ceccantini, G., Davis, C. & Hiscock, S.J. (2021) Endoparasitic plants and fungi show evolutionary convergence across phylogenetic divisions. New Phytologist 232: 1159–1167. https://doi.org/10.1111/NPH.17556

Tobias AB, Thorogood CJ, Malabrigo PL (2023) The reinstatement of Rafflesia banaoana (Rafflesiaceae), and implications for assessing species diversity and conservation requirements of the world's largest flowers. Phytotaxa 612(2):201-216. https://www.biotaxa.org/Phytotaxa/article/view/phytotaxa.612.2.5

Valenzuela FB, Jaucian-Adan GG, Agoo EMG, Madulid DA (2017) Rafflesia camarinensis (Rafflesiaceae), a new species from Mt. Asog, Camarines Sur, Luzon Island, Philippines. *Philippine Journal of Systematic Biology* . doi:10.26757/pjsb.201610001.

Hosted file

`2023_Rafflesia balatociana_Figures and Tables.docx` available at https://authorea.com/users/385193/articles/816886-rafflesia-balatociana-rafflesiaceae-a-new-species-from-the-cordillera-central-luzon-the-philippines