

Rafflesia zollingeriana Koord.: A REINSTATEMENT

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Abstract. *Rafflesia zollingeriana* Koord. was one of *Rafflesia* that distributed in Java. Although it has been stated as a different species, *R. zollingeriana* is sometimes still regarded as a synonym of *R. patma*. In addition, there are several contradictions in description of *R. zollingeriana*. Therefore, further investigation is needed. This study attempts presents a full the description of the *R. zollingeriana* female flower. In this study, a full description of female flower of *R. zollingeriana* and pictures of important characters such as ramenta, annulus, perigone lobes, disc, processes, bractea are presented. This study is also compared the morphology of *R. zollingeriana* and *R. patma*, to confirm their differences in size, opening of diaphragm, blotches and warts pattern on perigone lobes and diaphragm, annulus, and ramenta.

Keywords: East Java, Indonesia, morphology, *Rafflesia*, ramenta.

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INTRODUCTION

Indonesia has more than 15 species of *Rafflesia* distributed in Sumatra, Kalimantan, and Java. Three of them: *Rafflesia patma* Blume, *Rafflesia rochussenii* Teijsm. & Binn. and *Rafflesia zollingeriana* Koorders, were distributed in Java (Nais, 2001). *Rafflesia patma* was first found by Deschamp from Nusa Kambangan island (van Steenis et al., 1954) and reported distribution in the southern coast of Java such as Leweung Sancang (Suwartini et al., 2008), Pangandaran, Bojonglarang (Ali et al., 2015), Leweung Cipeucang (Triana et al., 2017). *R. rochussenii*

grows at 1246-1488 m asl such as Gunung Gede Pangrango National Park (Saadudin et al., 2012), but also can be found in 563 m asl. such as Mandapajaya, Kuningan (Supartono & Herlina, 2018). *R. zollingeriana* Koord distributed in Meru Betiri National Park, East Java, and surrounding (Lestari et al., 2014a). This species was first described by Koorders from specimens found in Watangan Puger, Jember East Java. Recently, this species is reported rediscovered 5 km from Watangan Nature Reserve (BBKSDA, 2018).

R. rochussenii was different from *R. patma* and *R. zollingeriana* due to the absence of processes on the disk and the flat rim of

the disk (Meijer, 1984). Koorders (1918) stated that *R. zollingeriana* was different from *R. patma* due to its smaller dimensions and the absence of the exterior annulus. But later, Meijer (1997) still considered *R. zollingeriana* as a synonym for *R. patma* though he also stated that *R. zollingeriana* was described by Koorders due to its smaller size and the ramenta that almost absent in the lower part of the flower tube. Meanwhile, Susatya (2011) described that the ramenta of *R. zollingeriana* spread evenly on the inner surface of the tube. He reaffirmed this in his last publication (Susatya et al., 2017). Further investigation is required to observe in-depth and this study attempt to address it. There was no morphology evidence of female flower of *R. zollingeriana*, so this data is an addition and as morphological evidence that *R. zollingeriana* was different from *R. patma*. A full description of female flower with important characters such as ramenta, annulus, perigone lobes, disc, processes, bractea is presented.

MATERIALS AND METHODS

The study was conducted in Meru Betiri National Park, Jember, East Java in March 2016 with no specimen was taken. Morphological characterization was carried out directly in the field. Flower of *R. zollingeriana* was found at 180 m a.s.l. in Timunan Hill, Meru Betiri National Park. This hill is near to Wonoasri Village, Tempurejo, Jember, East Java. The parts observed including the diameter of flower, aperture, perigone lobes, diaphragm, ramenta, the disc, processi and annuli (Sofiyanti et al., 2007; Pranata et al., 2016). Those parts were measured by ruler and electronic digital caliper. The object was documented by two mirrorless cameras and dino-lite 3113 Series using some pieces of paper as a background. The morphological

characters were compared with two flowers from the former study (2011–2012); a spirit specimen of *R. zollingeriana* in herbarium of Tabanan Hortus Botanicus Baliensis (THBB) and one herbarium of Pasuruan Hortus Botanicus Purwodadiensis (PHPB). The characters found compared with specimen of *R. patma* in Bojong Larang Nature Reserve, Cianjur, West Java (collected by Adlan Ali) to confirm their differences.

RESULTS AND DISCUSSION

Description

Rafflesia zollingeriana Koord., 1918, Bot. Overz. Rafflesiac. Need. Ind., 67, 1-128. –Type INDONESIA; Java, Puger, Koorders, 40312β (holo, BO!)

Flower buds prior to bloom up to 23 cm in diameter (Figure 1). **Mature female flower** size 27 × 25 cm. **Perigone lobes** 5.9 – 10 × 9 – 12 cm with rounded apex. Warts have some irregular sizes. Perigone dominated by orange coloured background than white cream warts. **Diaphragm** 15 × 17 cm in diameter, with irregular white cream warts more dominant than orange areas. **Opening of diaphragm** 8 × 9 cm in diameter. **Flower tube** 15 cm high. **Ramenta** below the surface of the diaphragm were groups of deeply or shallowly lobed tuberculate with 1.7 – 2.3 mm long. **Disc** 8.5 × 9 cm in diameter, rim disc 1.7 cm high with some smooth spines at the upper and lower rim, orange, surface of the disc white cream. **Processes** orange, spiky flat cone, arranged in three rings: 20 processes in the outer ring, 15 in the middle rings, and 10 in the central rings. Processes range from 0.5 × 1.5 cm high, with some smooth spine at the top. **Annulus** covered with dense hairy; annulus exterior well developed, 8.2 × 9.5 cm in diameter, thick 5 mm; annulus interior 7.5 × 9 cm in diameter, so thin, weakly developed, 1 mm

thick. **Central column** 1.5 cm high, smooth groove running down to annulus interior with irregular size. **Female flower** with ovary in column, 6 × 10 cm in diameter, 5.2 cm from the cupula (flower base). There are a lot of white tiny ovules in the chamber. **Anthers** are unknown.

Spesimens Examined

Indonesia: East Java, Meru Betiri National Park, 23 Desember 2016, DL 337 (THBB); Sukamade, Meru Betiri National Park, East Java, 27 June 1991, P1991060283 (PHBP).

Phenology

R. zollingeriana in this study blooms in March. In the previous study, Lestari et al. (2014b) found this species blooms during the

rainy or drain seasons: January, March, April, June, July, August, October, and November.

Distribution

Meru Betiri National Park, Jember, Banyuwangi, East Java.

Habitat

R. zollingeriana growth on the hillside, on slightly acidic soil, lowland forest, slightly shaded area on 180 m asl.

Conservation Status.

The conservation status of *R. zollingeriana*, based on Lestari et al. (2014b) is vulnerable. Possible, that this status will be changed if there are the other information closed in this species

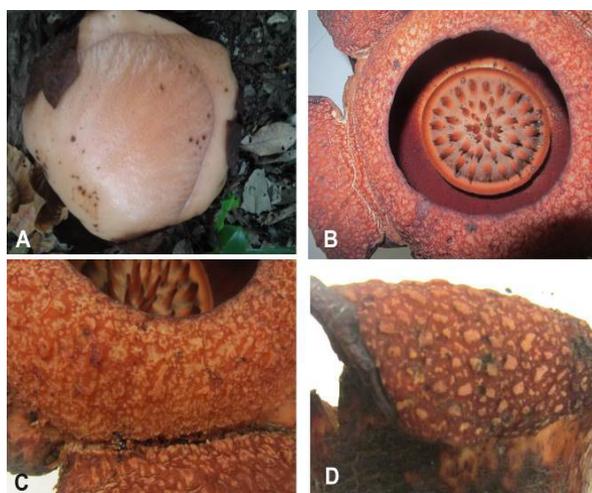


Figure 1. A. *Rafflesia zollingeriana* bud, a day before blooms. B. The opening diaphragm, C. Diaphragm that dominated by white cream warts, D. Warts of perigone dominated by orange background. (Photos: Dewi Lestari)

According to Koorders (1918) that *R. zollingeriana* develops with only inner annulus ± 4 mm wide ring, gradually sloping on both sides, in place of the outer annulus, but we found two annuli, interior, and exterior. Figures 4A and 4B showed that the exterior annulus is well developed into 5 mm, while the interior annulus is weakly developed. Based

on specimen of *R. zollingeriana* in THBB, it was seen so thin, shallowly wrinkled, almost fused with exterior annulus (Figure 5). Perhaps this very thin interior annulus made Susatya (2011) conclude that *R. zollingeriana* was only had one annulus.

For the character of ramenta, Koorders (1918) described that *R. zollingeriana* due

to its smaller size and the ramenta that are almost absent in the lower part of the flower tube. This study found that ramenta of *R. zollingeriana* spread evenly in the inner surface of diaphragm and inner of the tube, into 1– 2 cm before exterior annulus (Figure 2C and 2F). It supported Susatya (2011) statement that ramenta spread evenly on the inner surface of the tube.

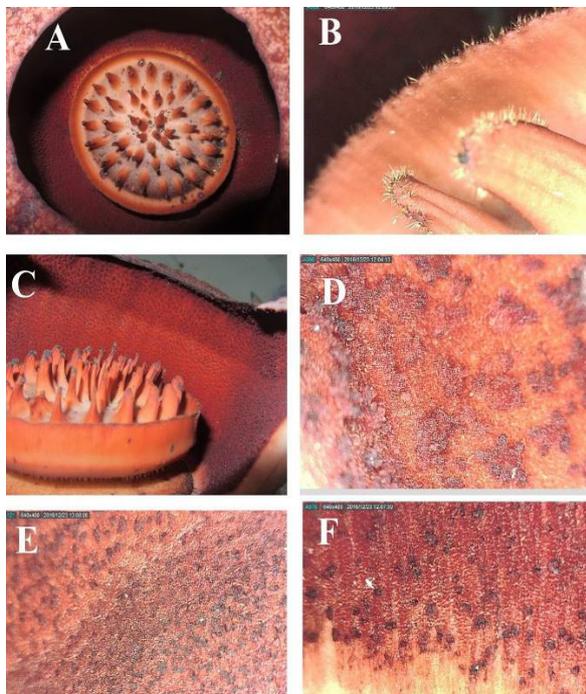


Figure 2. *R. zollingeriana*. A. Processes. B. Smooth spine on the top of processes and disc rim (upper and lower); C. The pattern of ramenta in the lower surface of diaphragm, in the middle of the tube and lower of the tube; D. Ramenta in the lower surface of diaphragm consist of groups of deeply or shallowly lobe tuberculate; E. Dense single tuberculate in the middle of the tube; F. Sparsely single tuberculate ramenta in lower tube. Ramenta in this section is shorter than ramenta in the middle of the tube. There is an empty zone without ramenta (about 0.8-1 cm) between the last ramenta and annuli. This zone is indicated by white cream colour. (Photos: Dewi Lestari)

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Figure 3. Ramenta of *R. zollingeriana*. A. Ramenta in the lower surface of diaphragm were groups of deeply or shallowly lobe tuberculate (arrow); B. Dense single tuberculate ramenta in the middle of the tube; C. Shorter tuberculate ramenta before annuli. (Photos 4A: Dewi Lestari; Photo 4B, 4C: Aninda RUW)

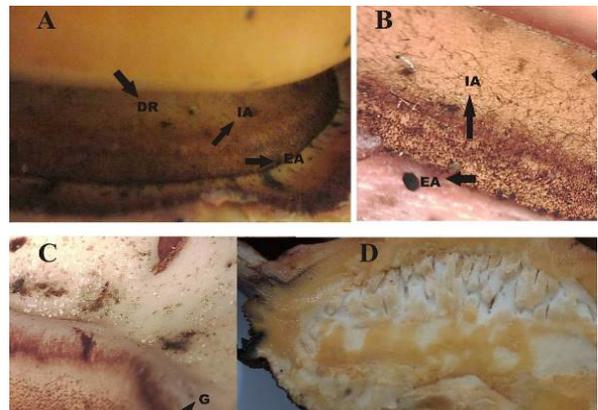


Figure 4. A. Disc, disc rim, and annulus in the base of the tube; B. Cilia fills area beyond the disc, especially in the annulus. Exterior annulus (EA) well developed, with 0.5 cm thick, interior annulus weakly developed, only 0.1 cm thick; C. Shallow groove (G) beneath the disc was without hairy ridges; D. Ovary in the column with a lot of white tiny ovules. (Photos: Dewi Lestari)

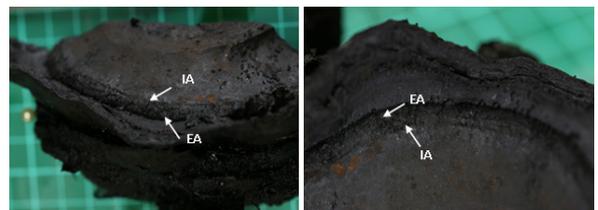


Figure 5. The interior annulus was so thin, fused to the exterior annulus. A. Annulus from a side view; B. Annulus from the above view. (Photos of spirit specimen THBB: Aninda RU Wibowo).

Differences of *Rafflesia zollingeriana* and *Rafflesia patma*

Some characters like flower size, the diameter of the opening diaphragm, number of processes, the pattern of white blotches on the perigone lobes and diaphragm, structure and length of ramenta, and their position, number of annulus and column used to be compared.

The size of *R. zollingeriana* was 27 cm (Figure 6A) and *R. patma* size (Figure 6B) in Bojong Larang Nature Reserve was about 43 cm. The other two flowers of *R. zollingeriana* that have been seen in Meru Betiri National Park were also about 30 – 32 cm. Diameter of *R. patma* in Bogor Botanic Garden is also 40 cm (Mursidawati et al., 2020) and Hidayati et al. (2000) said that the diameter of *R. patma* fully flowers are 40 – 52 cm. These confirmed that *R. zollingeriana* is smaller than *R. patma*.

Figure 6 showed that white cream

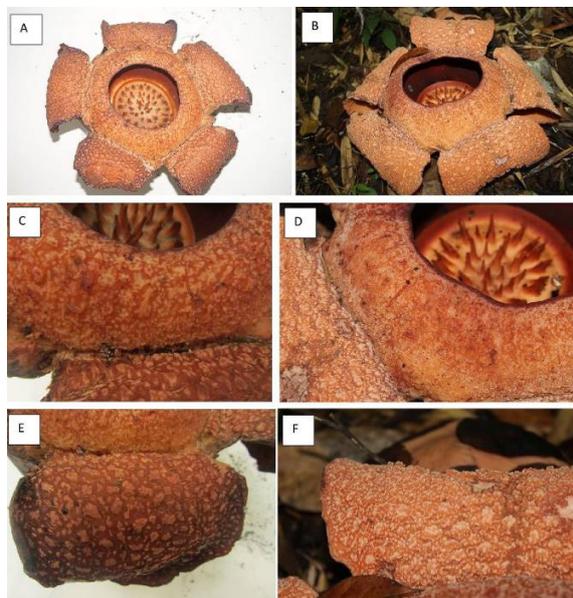


Figure 6. A. Blooming flower; C. Warts on diaphragm; E. Warts on perigone lobes (A, C & E *R. zollingeriana* in Meru Betiri National Park); B. Blooming Flowers; D. Warts on diaphragm; F. Warts on perigone lobes (B, D, & F *R. patma* in Bojong Larang Nature Reserve). (Photos of *R. zollingeriana*: Dewi Lestari; Photos of *R. patma*: M Adlan Ali)

blotches dominated in the perigone and diaphragm of *R. patma*, so its colour is lighter than *R. zollingeriana*. White cream blotches and warts in *R. patma* spread evenly and irregular pattern, white cream in perigone of *R. zollingeriana* spread in a regular pattern (Figure 1D). The pattern of warts on perigone is also differentiated *R. hasseltii* from *R. cantleyi* (Munirah et al., 2020).

Processes of *R. zollingeriana* is about 31 – 33, processes *R. patma* is 30 – 46. The shape of both of them is similar. Processes in the middle of the disc are conical apex, processes at the edge are flattened apex (Figure 7). Processes colour are orange and the decaying processes is started by the darkening of the apex. The both of this species have three rings of processes, either in regular or irregular pattern (Figure 8).

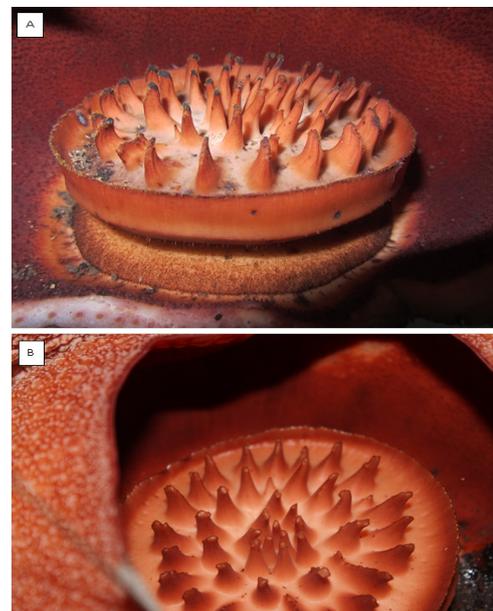


Figure 7. A. Processes of *R. zollingeriana* in Meru Betiri National park that start darkening its apex at 5th day blooming; B. Processes of *R. patma* in Bojong Larang Nature Reserve at 2nd day blooming. (Photo of *R. zollingeriana*: Dewi Lestari; Photo of *R. patma*: M Adlan Ali)

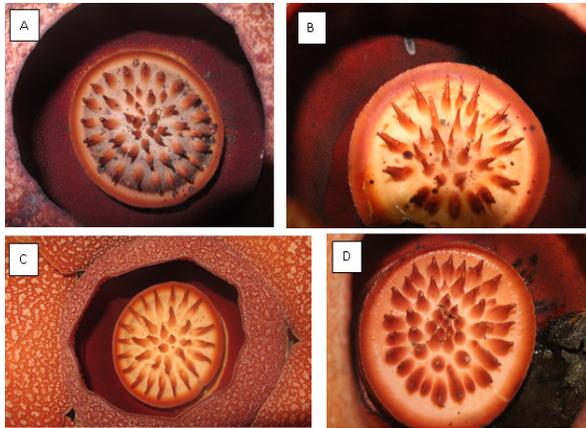


Figure 8 Processes (A, C) *R. zollingeriana*, *R. patma* (B, D) consist of three layers, either in regular or irregular pattern. (Photos of *R. zollingeriana*: Dewi Lestari; Photos of *R. patma*: M. Adlan Ali).

Ramenta is an important character in distinguishing species. *Rafflesia patma* and *R. zollingeriana* were categorized by Susatya et al. (2017) into a complex due to their ramenta characteristics. Both of them have simple tubercle ramenta, but different positions. The tuberculate ramenta of *R. patma* were only found at the inner surface of diaphragm (Figure 9D), but tubercle ramenta covered the inner diaphragm and the inner

tube of *R. zollingeriana*, up to 1 cm before exterior annulus (Picture 2C and 2F). Instead of ramenta, the inner tube of *R. patma* was covered by tiny protuberances (Figure 9C) or something that Mursidawati et al. (2020) called ramenta-like structures. Characters found to support Susatya (2011) who described that ramenta of *R. zollingeriana* spread evenly on the inner surface of the tube. Another evidence of ramenta in the lower tube of is also shown by *in spirit* specimen in PHBP (Figure 9B). Bendiksby et al. (2010), supported that both is a different clade. Morphology and molecular data support each other.

Meijer (1997) described that the annulus interior of *R. patma* was about 4–6 mm broad, well defined, and sharply elevated, about 8–9.5 cm in diameter. Annulus exterior 3–10 mm wide average and c. 1 mm thick, rather weakly developed, wrinkled like a rolled-up blanket which is curved into a circle. Meanwhile, this study found that the annulus exterior of *R. zollingeriana* was well developed, 8.2 × 9.5 cm in diameter with thick 5 mm, the annulus interior is weakly developed, 7.5 × 9 cm in diameter, so thin, only 1 mm thick (Figure 4).

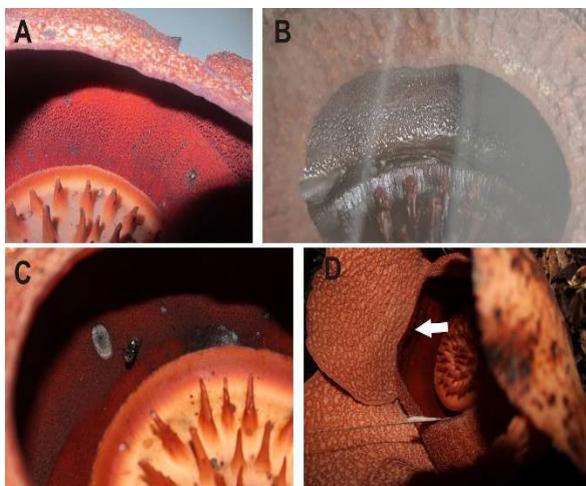


Figure 9. A. Ramenta in inner diaphragm and inner tube of *R. zollingeriana*; B. Ramenta also spread evenly in lower of the tube of *R. zollingeriana*, spirit collection of PHBP; C. There is no ramenta on the lower tube of *R. patma*, but the tube was filled with protrusion; D. Tuberculate ramenta (arrow) were only in inner diaphragm of *R. patma* (Photo of *R. zollingeriana*: Dewi Lestari; Photos of *R. patma*: M. Adlan Ali)

Table 1. Morphological comparison between *Rafflesia zollingeriana* and *Rafflesia patma* (Meijer 1997)

Characteristics	<i>R. zollingeriana</i>	<i>R. patma</i>
Flower size	20–30 cm	30–60 cm
Diameter of the opening diaphragm	8–9 cm	5–9 cm
Diameter of disc	8–9 cm	(7)9–13,5 cm
Number of disc processes	31–33	30–46
White cream blotches on the perigone lobes and diaphragm	creamy white warts in perigone lobes arranged in a regular shape, creamy white warts in diaphragm arranged in an irregular shape	the irregular shape of creamy white warts dominated the lobes and diaphragm
Colour on diaphragm and perigone lobes	orange colour dominated the perigone lobes	brighter than <i>R. zollingeriana</i>
Structure and length of ramenta and position of their occurrence	simple tuberculate ramenta scattered in the tube, from lower of the diaphragm into 1 cm before annulus	tuberculate ramenta only in the lower of diaphragm
Number of annulus	2, interior annulus less developed than exterior annulus	2, exterior annulus less developed than interior annulus

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Dewi Lestari (DL) is major author of this manuscript and Ridha Mahyuni (RM) is co-author. DL design the study, collecting the data, analyzing the data and write the manuscript with support from RM. RM also contributed in data analyzing of *R. zollingeriana* specimens.

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