

Rafflesia tuanku-halimii (Rafflesiaceae), A New Species from Peninsular Malaysia

(*Rafflesia tuanku-halimii* (Rafflesiaceae), Satu Spesies Baharu dari Semenanjung Malaysia)

JUMAAT HAJI ADAM*, MOHD AFIQ AIZAT JUHARI, RAHMAH MOHAMED,
NOR AZILAH ABDUL WAHAB, SYAMSURINA ARSHAD, MOHD PAIZ KAMARUZAMAN,
MOHD FIRDAUS MOHD RAIH & KIEW-LIAN WAN

ABSTRACT

Rafflesia tuanku-halimii, a new species from Peninsular Malaysia, is herewith described and illustrated. It is related to *R. azlanii* and *R. sharifah-hapsahiae* by coalesced warts on its lobes. *Rafflesia tuanku-halimii* is different from them in having window covered by almost united rings and these rings almost wholly covering the window.

Keywords: Peninsular Malaysia; *Rafflesia*; taxonomy; tropical

ABSTRAK

Rafflesia tuanku-halimii, spesies baharu dari Semenanjung Malaysia, dihurai dan diilustrasikan. Ia mempunyai persamaan dengan *R. azlanii* dan *R. sharifah-hapsahiae* kerana bintil putihnya bersambung pada permukaan lobus. *Rafflesia tuanku-halimii* berbeza daripada spesies tersebut kerana jendelanya ditutupi oleh lingkaran sangat tebal, tersusun sangat rapat hampir bergabung dan hampir menutupi keseluruhan permukaan jendela.

Kata kunci: *Rafflesia*; Semenanjung Malaysia; taksonomi; tropika

INTRODUCTION

Rafflesia R.B. is a holoparasitic plant of the tropical rainforest. The plant is totally dependent on the host *Tetrastigma* Planch. (Vitaceae) for its nutrition, protection and survival. The vegetative parts of the plants are minute hypha-like structures, embedded in the host tissue, and periodically showed themselves externally as colourful gigantic flowers, with a diameter of up to 107 cm. Several other species, for example, *R. meijeri* Wiriadinata & Sari (Wiriadinata & Sari 2010), *R. pricei* Meijer (Meijer 1984), *R. rochussenii* Teijsmann & Binnendijk (Teijsmann & Binnendijk 1850) and *R. tengku-adlinii* Mat-Salleh & Latiff (Mat-Salleh & Latiff 1989) have smaller flower, less than 30 cm in diameter.

Rafflesia flower blooms regularly particularly so during the rainy season, depending on the presence of large bud (Haji Adam et al. 2013) and similarly for *R. keithii* Meijer, *R. pricei* Meijer and *R. tengku-adlinii* Mat-Salleh & Latiff in Sabah (Nais 2004, 2001). *Rafflesia* has unisexual flowers (Haji Adam et al. 2013; Nais 2004, 2001) but *R. baletei* Barcelona & Cajano and *R. verrucosa* Balete et al. were reported to have bisexual flowers (Balete et al. 2010; Barcelona et al. 2009).

Rafflesia is a small genus, comprising of 32 species. They are found in lowland and hill forest of South-East Asia with the main centre of distribution in the Philippines (10 species) and Borneo (9 species). The genus is represented by five species in Peninsular Malaysia, five in Sumatra, five in Java and one in southern Thailand.

Rafflesia of Peninsular Malaysia are divided into three groups, the *R. kerrii* group, *R. cantleyi* group and *R. sharifah-hapsahiae* group (Haji Adam et al. 2013). The *R. kerrii* group has the lobes covered by minute, discrete and dispersed warts; the *R. cantleyi* group has the lobes covered by rows of large discrete warts; whilst the *R. sharifah-hapsahiae* has the lobes covered by coalesced warts.

RAFFLESIA TUANKU-HALIMII ADAM, AIZAT-JUHARI,
AZILAH & WAN sp. nov

DIAGNOSES

Rafflesia tuanku-halimii showed close resemblance with *R. azlanii* and *R. sharifah-hapsahiae* by coalesced white warts on the perigone lobes. These coalesced white warts distinguish it from *R. cantleyi*. *Rafflesia tuanku-halimii* differs from *R. azlanii* and *R. sharifah-hapsahiae* in having window almost wholly covered by very thick, closely spaced and almost united white rings.

TYPE

Peninsular Malaysia, Pahang, Raub District, N3°52'13.4" & E101°58'58.4", 15th February 2014, 300 m altitude, growing on *Tetrastigma rafflesiae* (Vitaceae), 100 m from river bank in logged lowland dipterocarp forest. Holotype: UKMB. SMP7B1♀.

FEMALE FLOWERS

43-60 cm in diameter. Perigone lobes 5, 10.0-17.5 cm long and 15.0-22.5 cm wide. Warts on perigone consists of 5-8 rows, coalescing vertically and horizontally across perigone lobe, rows closely to very closely-spaced. Warts on each perigone lobe vary at 1-35. Diaphragm 20-28 cm in diameter, covered by 47-87 white or red spots, distributed into 3-5 rings. Aperture 7.5-9.5 cm in diameter. Window covered by three very thick white rings, very closely-spaced and almost united. Window rings 8-27 mm thick with 3-64 white warts. Processes 21-26, distributed into three rings. Disc 9-11 cm in diameter, smooth on the lower surface. Annulus grooves 27-35. Toadstools covering $\frac{3}{4}$ of inner perigone tube, toadstools 4-15 mm long, simple, stout, with white swollen apices. Ramenta 4-13 mm long, simple and branched, branching from lower half and base. Ovules anatropous, surface smooth, micropylar width $137.83 \pm 17.26 \mu\text{m}$, micropylar length $161.87 \pm 36.39 \mu\text{m}$, raphe width $103.67 \pm 11.74 \mu\text{m}$ and raphe length $144.17 \pm 44.97 \mu\text{m}$.

MALE FLOWERS

46-58 cm in diameter. Perigone lobes 5, 11-18 cm long and 14-25 cm wide. Warts on perigone lobe very large in size, 5-9 rows, coalescing across the perigone lobe, rows of warts interconnected and closely to very closely-spaced and almost wholly covering perigone lobes, 7-35 warts on each perigone lobe. Diaphragm 19-23 cm in diameter with 57-100 white or reddish spots and distributed randomly into 3-7 rings. Aperture small in size, 5.5-7.0 cm in diameter. Window covered by 4-5 very thick white rings, closely and very closely-spaced, connected and almost united together, thicker rings covering half to almost whole surface of window. Window rings 11-27 mm thick with 25-67 white warts. Processes 20-25, distributed randomly into three rings, 10-16 in outer ring and 6-10 in middle ring. Disc 10-12 cm in diameter, with numerous hairs on the lower surface. Anthers 24-30. Toadstools covering $\frac{3}{4}$ of inner perigone tube, toadstools 4-11 mm long, stout, with white and swollen apices, simple and branched from lower half to apex. Ramenta on middle section of perigone 6-12 mm long, simple and branched, branching from lower half and apex. Ramenta on lower section of perigone 5-15 mm long, simple and branched, branching from base and lower half. Pollen prolate-spheroidal, surface smooth, equatorial diameter $13.85 \mu\text{m}$, polar axis length $15.65 \mu\text{m}$.

SPECIMENS EXAMINED

Pahang, Raub: SKP5B3♀, Sungai Kenau, N3°57'32.2" & E102°01'22.4", 6/1/2014, 229 m alt.; USYP3B12♀, Sungai Yol, N03°52'26.6" & E101°58'35.3", 299 m alt.; USYP4B10♀, Sungai Yol, 295 m alt.; USYP4B11♀, Sungai Yol, 295 m alt.; SMP4B4♂, Matau, 300 m alt.; USYP2B2♂, Sungai Yol, 19/5/2011, 270 m alt.; USYP2B18♂, Sungai Yol, 27/5/2011, 270 m alt.;

USYP2B49A♂ & USYP2B49B♂, Sungai Yol, 12/12/2012 270 m alt.; USYP3B5♂, Sungai Yol, 299 m alt.; Perak: SBP8B46♀, Gerik District.

ETYMOLOGY

Named after His Majesty the 14th Seri Paduka Baginda Yang Di-Pertuan Agong of Malaysia Almu'tasimu Billahi Muhibbuddin Tuanku Alhaj Sir Abdul Halim Mu'adzam Shah Ibni Almarhum Sultan Badlishah for his very strong support towards conservation of *Rafflesia* in Peninsular Malaysia.

VERNACULAR

Bunga pakma, bunga akar, bunga kubis and bunga tumbuakar.

DISTRIBUTION

It is currently known only to occur in two states in Peninsular Malaysia; Pahang and Perak. In Pahang, it is found in three separate locations in Raub District namely Sungai Kenau, Sungai Yol and Matau. Populations of this species, infecting *Tetrastigma rafflesiae* are found growing along the river bank in after-logged, logged and logged-over lowland dipterocarp forest, at altitude below 400 m. In Perak, this species is recorded in Gerik District and also found growing in logged-over forest, located 10 m from the river bank.

CONSERVATION

Rafflesia tuanku-halimii was found growing in the vicinity of Sungai Matau, Ulu Sungai Yol and Sungai Kenau in Raub, Pahang. The locality of *R. tuanku-halimii* is present at four active sites within Pahang Forest Department logging concession area. There were on-going logging activities when the study was carried out in 2013-2014 but ceased in June 2014. 57 buds were recorded until June 2014. These sites are potentially threatened by future logging activities and illegal intrusion and conversion of land for agriculture. *Rafflesia tuanku-halimii* of Ulu Sungai Yol was recorded from three sites comprising of 80 buds. It was found on a single active site, comprising of 10 buds at Sungai Kenau. These sites are also potentially threatened by future logging and agriculture activities.

RESULTS AND DISCUSSION

Rafflesia tuanku-halimii closely resembles *R. azlanii* in having coalescing white warts on the perigone lobes but differs in many other characters (Table 1). *Rafflesia tuanku-halimii* is easily distinguished from the related species by the perigone lobe pattern, the window pattern, distribution of processes on the disc and marginal ring on the window. *Rafflesia tuanku-halimii* has white warts coalescing both vertically and laterally across the perigone lobes (Figure 1(a)-1(o)) whereas the warts are coalescing

TABLE 1. Summary of characters of *Rafflesia tuanku-halimii* with its close resemblance species

| Characters | <i>R. cantleyi</i> | <i>R. azlanii</i> | <i>R. sharifah-hapsahiae</i> | <i>R. tuanku-halimii</i> |
|-----------------------------------|---|--|--|--|
| Flower diameter (cm) | 30-58 | 38-50 | 43-57 | 43-58 |
| Perigone lobes (cm) | 11-18.5 × 10-24 | 9.5-12 × 13-16 | 11-19.5 × 11-25 | 11-18 × 14-25 |
| Warts (rows) | 5-9 | 4-6 | 7-9 | 5-9 |
| No. warts on 5 perigone lobes | 259-354 | 72 | 70-104 | 30-155 |
| Warts (rows) | Discrete | Coalesced | Coalesced | Coalesced |
| Warts pattern | Well-spaced | Very closely-spaced Almost covering perigone surface | Very closely-spaced Almost covering perigone surface | Very closely-spaced Almost covering perigone surface |
| Diaphragm diameter (cm) | 19-26.5 | 16-18 | 15-23 | 19-28 |
| Diaphragm: circular spots | (25)67-107 | 19-25 | 67-105 | 47-160 |
| Circular spots: ring | 3-6 | 1-2 | 3-5 | 3-7 |
| Aperture (cm) | 4.8-11 | 4.7-8cm | 4.5-9.5 | 5.5-9.5 |
| Window ring: warts | 122-136 | 21 | 46-100 | 3-67 |
| No. of window ring | 5-6 | 3-4 | 5-7 | 3-5 |
| Window ring pattern | Discrete | Discrete & coalesce | Discrete & coalesce | Coalesce |
| Ring thickness (mm) | 5-10 | 11-12 | 3-24 | 11-29 |
| Position of window ring pattern | Well-spaced | Well-spaced | Well-spaced | Very close, almost united & covering window |
| Distinct marginal window ring | Absent | Conspicuous | Absent | Absent |
| Ramenta structure | Simple & branched | Simple & branched | Simple & branched | Simple & branched |
| Ramenta length (mm) | 2-14 | 4-9 | 4-13 | 4-15 |
| Disc diameter (cm) | 9-10.8 | 10 | 9-10.5 | 10-12 |
| No. of processes | 17-24 | 15-17 | 25-31 | 20-26 |
| Distribution of processes (rings) | 3 | 2 | 3 | 3 |
| No. of anthers | 20-25 | 20 | 29-33 | 24-30 |
| <i>Sources</i> | BLP2B3&5, SMP5B1, SKP4B4 Meijer (1997) Latiff & Wong (2003) | Akmal 01 Nais (2004) Latiff & Wong (2003) | CAP1B6, Alia01, CAP1B73, CAP1B14 Adam et al. (2013) | This study |

laterally across the perigone lobes in *R. azlanii* (Figure 2(a)-2(c)). This perigone pattern in *R. azlanii* was clearly illustrated for our sample bearing collection number Akmal 01 (Figure 2(b)), Nais (2004) (Figure 2(c)) and Latiff and Wong (2003) (Figure 2(a)). The windows of *R. tuanku-halimii* have white rings which are very thick, reaching up to 28 mm, very closely-spaced, almost united, almost covering the window and without distinct marginal white rings (Figure 1(c) & 1(k)). Conversely, *R. azlanii* has moderately thick rings, 11-12 mm, well-spaced and presence of distinct marginal white rings (Figure 2(a)). *Rafflesia tuanku-halimii* has a higher number of processes than *R. azlanii* (Table 1) and these processes are distributed into three concentric rings but only into two concentric rings in related species. These characters conform to the finding of the previous authors (Haji Adam et al. 2013; Latiff & Wong 2003; Nais 2004). This study also indicated that *R. tuanku-halimii* has a larger flower diameter, more

rows of white warts on perigone lobes, more number and rings circular spots on the diaphragm, more anthers and longer ramenta. The huge floral morphological differences between them strongly showed that *R. tuanku-halimii* is not conspecific to *R. azlanii*.

Rafflesia tuanku-halimii also closely resembles *R. sharifah-hapsahiae* by warts coalescing vertically and laterally across the perigone lobes (Figure 2(d)-2(g)), without marginal window white ring and processes on the disc distributed into three concentric rings. Conversely, it is different from this species in having the windows covered by almost united thick white rings, and these thick rings cover from half to whole surface of the window (Figure 1(a)-1(o)). On the other hand, the window of *R. sharifah-hapsahiae* is covered by well-spaced white rings (Figure 2(e)). This study showed that both the species have overlapping range in most flower characters that is flower diameter, size of perigone lobes, number and distribution

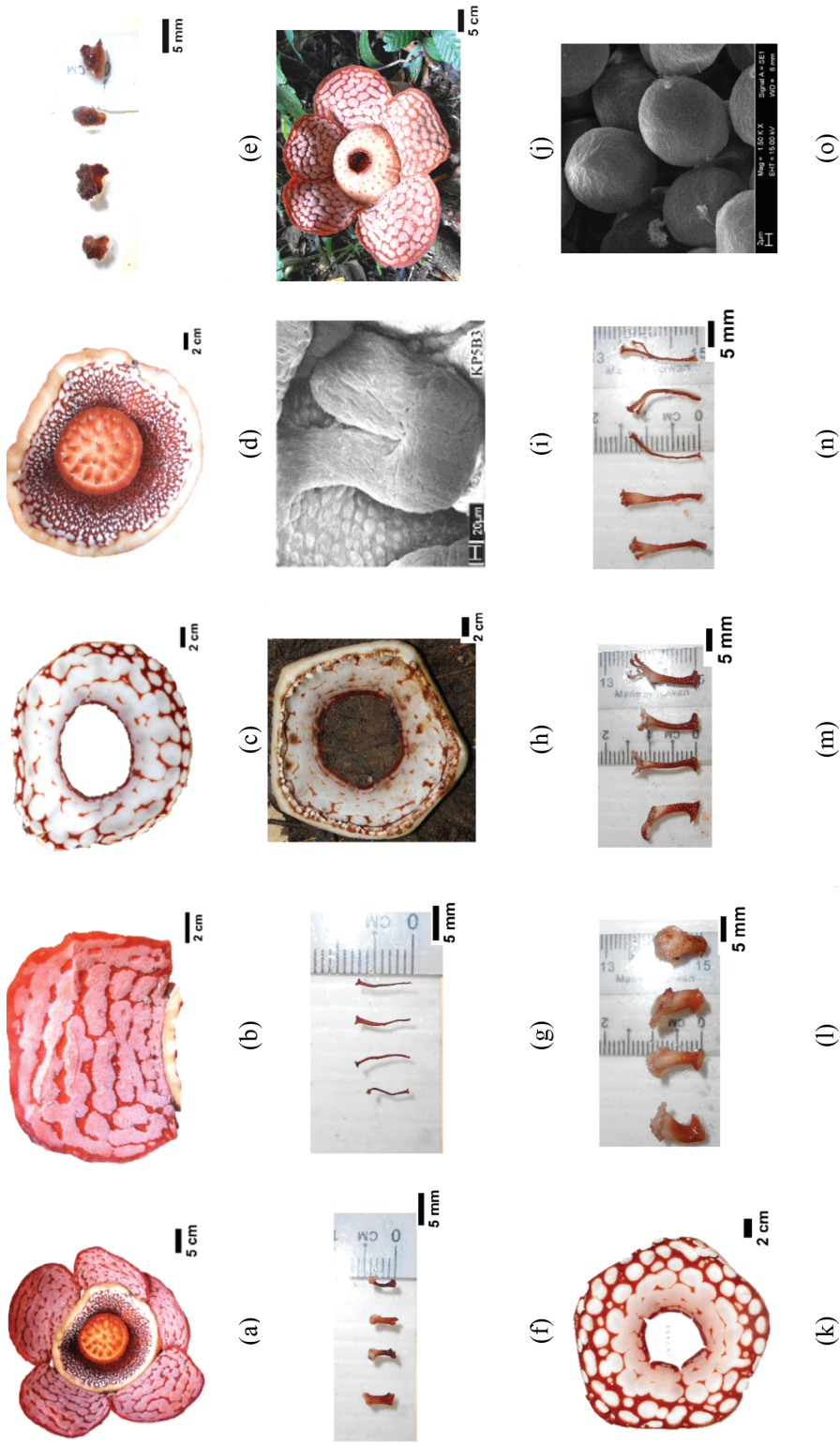


FIGURE 1. *Rafflesia tuanku-halimii* (a)-(o). (a)-(g) (SMP7B1♀; holotype): (a) flower, (b) warts on perigone lobe, (c) window pattern, (d) inner perigone tube, (e) toadstools on upper section of perigone tube, (f)-(g) Ramenta; (h)-(i) (SKP5B3♀): (h) window, (i) flower, (j)-(o) (SMP4B4♂): (j) toadstools, (m)-(n) ramenta and (o) SEM pollens

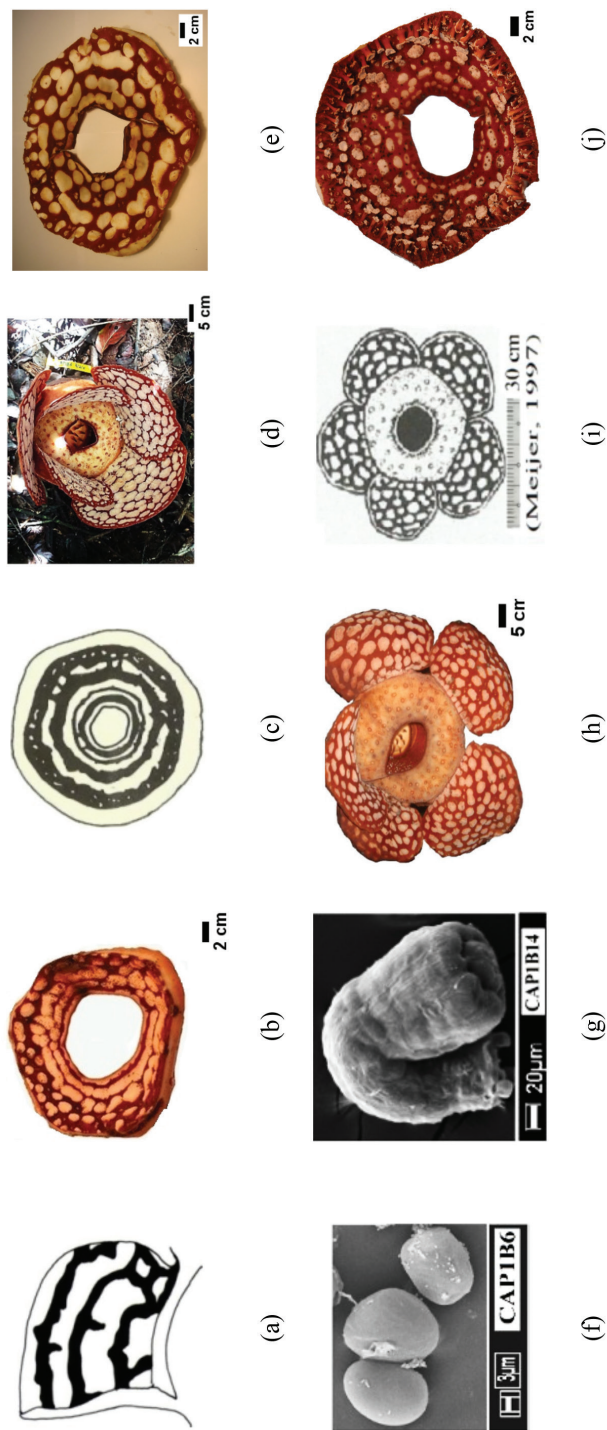


FIGURE 2. *R. azlanii* (a)-(c): (a) warts on Perigone lobes (M. Wong 5), (b) window (Akmal 01) and (c) window (Nais 2004); *R. sharifah-hapsahiae* (d)-(g) (CAPIB6♂): (d) flower, (e) window, (f) SEM pollen and (g) SEM ovule; *R. cantleyi* (h)-(j): (h) male flower (BLP2B3), (i) flower (Meijer 1997) and (j) window (SMP6B)

of white or red spots on diaphragm, diaphragm diameter, aperture diameter, number of processes and number of anthers (Table 1). The diagnostic character of the window pattern strongly supports this species is not conspecific to *R. sharifah-hapsahiae*.

Rafflesia tuanku-halimii is distinguishable from *R. cantleyi* by differences in the pattern of the perigone lobes and the windows. In *R. cantleyi*, the perigone lobes and the white warts are discrete and well-spaced (Figure 2(h)) and their windows are also covered by rings of well-spaced discrete white warts (Figure 2(h)-2(j)). *Rafflesia tuanku-halimii* also differs in many other characters from *R. cantleyi*, for example the density of white warts on the perigone lobes and window, well-spaced white rings on the window and thickness of window rings (Table 1).

Palynology study by scanning electron microscope (SEM) of *R. tuanku-halimii*, *R. sharifah-hapsahiae*

and *R. cantleyi* showed that their pollens are monads, prolate-spheroidal in shape with smooth surfaces (Table 2). The differences of flower morphology between them showed that *R. tuanku halimii* is a different species from *R. cantleyi*. Similar finding was also recorded for pollen characters of *R. cantleyi* by Sofiyanti and Choong (2012). However, this study showed that *R. tuanku halimii* has smaller pollen than *R. sharifah-hapsahiae* but bigger than *R. cantleyi* and *R. azlanii*. The ovules of *R. tuanku-halimii*, *R. azlanii* and *R. sharifah-hapsahiae* are very similar in shape and structure but different in size. The ovules of these three species are anatropous, having reversed J-shape, with micropylar end pointed downwards (Figures 1(i) & 2(g)). This study showed that *R. tuanku-halimii* has the longest micropylar length and funiculus length, followed by *R. azlanii* and *R. sharifah-hapsahiae* (Table 3).

KEY TO RELATED SPECIES OF *RAFFLESIA* IN PENINSULAR MALAYSIA

- 1 Window with distinct, thick, marginal white ring on *R. azlanii*
- 1 Window without distinct, thick, marginal white ring on 2
- 2 Rings on window well-spaced and not united *R. sharifah-hapsahiae*
- 2 Rings on widow very closely space to almost united *R. tuanku-halimii*

TABLE 2. Summary of pollen characters of *Rafflesia tuanku-halimii* and its closely related species

| Species | E (µm) [min] | P (µm) [min] | P/E [min] | Shape | Surface |
|--|------------------------|------------------------|---------------------|--------------------|---------|
| <i>R. tuanku-halimii</i> (SMP4B4) | 13.30-13.50 [13.40] | 15.00-15.70 [15.30] | 1.13-1.17 [1.15] | Prolate-spheroidal | Smooth |
| <i>R. azlanii</i> (AZLP-1) (Sofiyanti et al. 2007) | 11.67 | 12.34 | 1.03 | Prolate-spheroidal | Smooth |
| <i>R. sharifah-hapsahiae</i> (CAP1B6) | 11.50-13.85 [12.68] | 15.00-17.8 [16.45] | 1.29-1.31 [1.30] | Prolate-spheroidal | Smooth |
| <i>R. cantleyi</i> (BLP2B5) | 9.00-11.00 [10.00] | 10.00-14.00 [14.40] | 1.11-1.30 [1.24] | Prolate-spheroidal | Smooth |
| <i>R. cantleyi</i> (CANP-5) (Sofiyanti & Choong 2012) | 10.97 | 12.20 | 1.12 | Prolate-spheroidal | Smooth |

P - Polar axis length; E - Equatorial diameter; NA - Not Available

TABLE 3. Summary of ovules characters of *Rafflesia tuanku-halimii* and its closely related species

| Species | MPW (µm) | | ML (µm) | | RL (µm) | | FL (µm) | |
|---|--------------|---------|--------------|---------|--------------|---------|--------------|---------|
| | Mean ±SE | Range | Mean ±SE | Range | Mean ±SE | Range | Mean ±SE | Range |
| <i>R. tuanku-halimii</i> (SKP5B3) | 161.87±36.39 | 100-200 | 161.87±36.39 | 100-200 | 144.17±44.97 | 96-220 | 182.67±13.89 | 160-183 |
| <i>R. azlanii</i> (Akmal 01) | 133.00±23.10 | 116-165 | 133.00±23.10 | 116-165 | 91.00±9.24 | 88-99 | 149.00±16.50 | 132-165 |
| <i>R. sharifah-hapsahiae</i> (CAP1B14) | 113.43±11.22 | 93-130 | 113.43±11.22 | 93-130 | 115.11±10.25 | 100-133 | 85.00±8.86 | 70-111 |

MPW - Micropylar width; ML - Micropylar length; RL - Raphe length; FL - Funiculus length

CONCLUSION

Rafflesia tuanku-halimii has very close resemblance with *R. sharifah-hapsahiae* and *R. azlanii* by white warts coalescing across the perigone lobe. These coalescing white warts distinguished them from *R. cantleyi*, *R. kerrii* and *R. su-meiae*. *Rafflesia tuanku-halimii* differs from the two closely related species in having very thick, almost united and much closed-spaced white rings and almost wholly covering the window.

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- Jumaat Haji Adam*, Nor Azilah Abdul Wahab & Syamsurina Arshad
School of Environmental and Natural Resource Sciences
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
43600 Bangi, Selangor Darul Ehsan
Malaysia
- Mohd Afiq Aizat Juhari
Fraser's Hill Research Centre
Universiti Kebangsaan Malaysia
43600 Bangi, Selangor Darul Ehsan
Malaysia
- Rahmah Mohamed
INTI International University
Persiaran Perdana BBN, Putra Nilai
71800 Nilai, Negeri Sembilan Darul Khusus
Malaysia
- Mohd. Paiz Kamaruzaman
Jabatan Perhutanan Negeri Pahang
Tingkat 5, Kompleks Tun Razak, Bandar Indera Mahkota
25990 Kuantan, Pahang Darul Makmur
Malaysia
- Mohd Firdaus Mohd Raih & Kiew-Lian Wan
School of Biosciences and Biotechnology
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
43600 Bangi, Selangor Darul Ehsan
Malaysia

*Corresponding author; email: adamj@ukm.edu.my

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