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On the *Phyllium* of Peninsular Malaysia and Sumatra, Indonesia, with range expansions for currently known species, description of the previously unknown *Phyllium* (*Pu.*) *abdufatahi* Seow-Choen female, and description of the new species *Phyllium* (*Ph.*) *rubrum* n. sp. from Peninsular Malaysia (Phasmida: Phylliidae)

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Abstract. – The *Phyllium* diversity of Peninsular Malaysia and Sumatra, Indonesia is discussed with records of recent collection and from past literature. The previously unknown female *Phyllium* (*Pulchriphyllium*) *abdufatahi* Seow-Choen, 2017a. is described along with a discussion of the range in which the species can be found and figures of the female. A range expansion into Sumatra and additional regions of Borneo for *Phyllium* (*Pulchriphyllium*) *giganteum* Hausleithner, 1984 is discussed along with figures of corresponding specimens. *Phyllium* (*Phyllium*) *hausleithneri* Brock, 1999 is also newly recorded from Sumatra and a discussion on intraspecific variation with corresponding figures of females and eggs. From Peninsular Malaysia, a new species *Phyllium* (*Ph.*) *rubrum* Cumming, Le Tirant & Teemsma n. sp. is described and illustrated from Perak, Malaysia. *Phyllium* (*Pu.*) *mannani* Seow-Choen, 2017a. and *Phyllium* (*Pu.*) *rimiae* Seow-Choen, 2017a. ranges are expanded to include Peninsular Malaysia, and *Phyllium* (*Pu.*) *bioculatum* Gray, 1832 is expanded to include Sumatra, with discussion on the intraspecific variation of males of all three species included. To conclude, with *Phyllium* (*Ph.*) *rubrum* Cumming, Le Tirant & Teemsma n. sp. described from a female, a key to females of all currently described species of *Phyllium* from Sumatra, Singapore, and West Malaysia is included.

Cumming R. T., Le Tirant S. & Teemsma S. N., 2018. – On the *Phyllium* of Peninsular Malaysia and Sumatra, Indonesia, with range expansions for currently known species, description of the previously unknown *Phyllium* (*Pu.*) *abdufatahi* Seow-Choen female, and description of the new species *Phyllium* (*Ph.*) *rubrum* n. sp. from Peninsular Malaysia (Phasmida: Phylliidae). *Faunitaxys*, 6(2) : 1 – 21.

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Introduction

The large island of Sumatra, Indonesia has historically had limited phylliid material recovered, and erroneously the few collected specimens often were misidentified or described under synonyms (Klante, 1976). To date, no Sumatran specific work has been published focussing on the Phylliidae diversity on the island, with all records generally being of single specimens mentioned in larger works. When this analysis was first begun it was assumed that there would likely be a new species described from the island due to the general trend of many phylliid species being rather island specific with smaller ranges than what has historically been thought. However, after series of specimens had been scoured over - males, females, and eggs included, all materials examined turned out to be previously known species from nearby localities. These records are significant as several species ranges are here expanded to include the island of Sumatra.

Four previously known species were confirmed from the island of Sumatra based on more recent material, and when coupled with historic data, help to clarify the ranges of these known species. The species below discussed and recorded from the

island are *Phyllium* (*Pulchriphyllium*) *abdufatahi* Seow-Choen, 2017a.; *Phyllium* (*Pulchriphyllium*) *giganteum* Hausleithner, 1984; *Phyllium* (*Phyllium*) *hausleithneri* Brock, 1999 and *Phyllium* (*Pu.*) *bioculatum* Gray, 1832. Of these, *Ph.* (*Pu.*) *giganteum* has two additional range expansions recorded from Sabah State, Borneo, Malaysia, and from West Kalimantan Province, Indonesia. *Phyllium* (*Pu.*) *abdufatahi*, besides a range expansion into Sumatra, is also recorded from Peninsular Malaysia, which the previously undescribed female is also identified and described for the first time. *Phyllium* (*Ph.*) *hausleithneri*, from the type locality of Peninsular Malaysia, is also recorded from Sumatra with the same wide variation of morphologies recorded.

A new species of leaf insect is also described from West Malaysia under the name *Phyllium* (*Ph.*) *rubrum* Cumming, Le Tirant & Teemsma n. sp. With many of the discussed species coming from Peninsular Malaysia, the authors saw fit to help fill the current knowledge gaps for this nearby region. With many of the species from West Malaysia also occurring on Sumatra, it would not be surprising if *Phyllium* (*Ph.*) *rubrum* Cumming, Le Tirant & Teemsma n. sp., were also distributed

on the island, although for now it is only confirmed from Peninsular Malaysia.

With this work expanding several of the currently known distributions of several species found throughout Sumatra, Peninsular Malaysia, and Borneo, two species, *Phyllium* (*Pu.*) *mannani* Seow-Choen, 2017a. and *Phyllium* (*Pu.*) *rimiae* Seow-Choen, 2017a. previously only known from Bornean material are here recorded as also occurring in Peninsular Malaysia. Although these two Bornean species are not currently recorded from Sumatra or Singapore it would not be surprising if they eventually were found there as well. Especially due to the fact that *Phyllium* (*Pu.*) *abdufatahi* Seow-Choen, 2017a. and *Phyllium* (*Pu.*) *giganteum* Hausleithner, 1984 are now recorded from Sumatra, Peninsular Malaysia, and Borneo.

To conclude several species noted from Sumatra in past works are discussed but not positively identified due to a lack of material available for observation, and with a new species described from a female a key to known *Phyllium* females of Sumatra, Singapore, and Peninsular Malaysia is included.

Materials and methods

– Measurements of all specimens were made to the nearest 0.1 mm using digital calipers. Morphological examinations were done with a Leica ZOOM 2000 stereomicroscope. Photos for figures 1A-D, 2D, 3A-D, 4A,C-E, 6A,C-F, 7A-E, 8A-I, 9A-D, 10A-E were taken at the San Diego Natural History Museum using a Canon 5D Mark II and a MP-E65mm macro lens and stacked using Zerene photo stacking software, version 1.04, 64-bit.

– Photos in figure 2A-C were taken by Johnson Chee Min of Johor, Malaysia, and figure 6B was taken by Alexandre Banko while visiting the Miyashita collection, Japan.

– Photo for figure 4B was taken by René Limoges of the Montreal Insectarium using a Nikon D810 DSLR camera with Nikon Micro-Nikkor 200 mm f/4 lens on Manfrotto 454 micrometric positioning sliding plate. Lighting was provided by two Nikon SB-25 flash units with Cameron Digital diffusion photo box. Adobe Photoshop Elements 13 was used as post processing software.

– Photos for figure 1E, 5A-D and 11 were taken by Natural History Museum United Kingdom (NHMUK) personnel, and were used under the license CC0-1.0 (NHMUK, 2017).

– Eggs from *Phyllium* (*Phyllium*) *hausleithneri* Brock, 1999, were provided by Bruno Kneubühler and were from a captive culture originally from Tapah, Perak, Malaysia. Eggs of the Sumatran population were removed from the abdomens of females within the first author's collection. Only eggs with fully developed frills were observed, any eggs that appeared to be underdeveloped were discarded.

– Egg orientation terminology follows that presented by Clark, 1978.

Treatment of species

Phyllium (*Pulchrphyllium*) *abdufatahi* Seow-Choen, 2017a.
(Fig. 1A-E, 2A-D, 3A-D, 4A-E)

Type locality. – MALAYSIA, Borneo, Sabah State.

Range expansion. – MALAYSIA: Perak and Penang States. – INDONESIA: Sumatra, West Sumatra Province.

Material examined [5 ♂ & 5 ♀]

MALAYSIA:

– 1 ♀: Perak, Cameron Highlands, Tapah Hills: January, 2017 [Coll RC 17-249]

– 1 ♀: Cameron Highlands, Tapah Hills: April, 2013 [Coll RC 16-039]

– 1 ♀: Perak, Tapah Hills: February, 2012 [Coll RC 16-040]

– 1 ♂: Perak, Tapah Hills: May, 2016 [Coll RC 16-222]

– 1 ♂: Perak, Cameron Highlands: January, 2010 [Coll RC 16-155]

– 1 ♂: Perak, Tapah Hills: June, 2014 [Coll RC 16-006]

– 1 ♂ & 1 ♀: Perak, Tapah, March, 2014: from the collection of Stephane Le Tirant

– 1 ♀: Malaya. Penang, Sungei Pinang Hills, 30.vii.1958, H.T. Pagden on *Nephelium zappaceum*. C.I.E.Coll. 16407, Started to lay eggs on 20.vii.58, ceased 24.Xii.58, died 27.xii.58, laid 141 eggs [Catalogue# NHMUK012497235].

INDONESIA:

– 1 ♂: Sumatra, West Sumatra Province, Sijunjung Regency, Tanjung Gadang District, Batang Dikat, Telkom Tower “Bukit Rasam Tapanggang”: 10th-12th May, 2002 [From the collection of Jerri Larsson, United States, California].

Discussion. – This species has for many years been erroneously referred to as *Phyllium bioculatum* Gray, 1832, *Phyllium pulchrifolium* Audinet-Serville, 1838, and has even from time to time been in culture within the phasmid breeding community and called *Phyllium bioculatum* “morph” or *Phyllium bioculatum* “Tapah”. It was not until recently that the species was described from a single male specimen from Sabah, Borneo under the name *Phyllium* (*Pulchrphyllium*) *abdufatahi* Seow-Choen, 2017a. Seow-Choen did not however recognize the species as the same one he illustrated and called *Phyllium pulchrifolium* Audinet-Serville, 1838 in his book “An Illustrated Guide to the Stick and Leaf Insects of Peninsular Malaysia and Singapore” (Seow-Choen, 2000). In the 2000 book, Seow-Choen illustrated both sexes and the eggs of the species but in the 2017 description of *Ph. (Pu.) abdufatahi* Seow-Choen left the female undescribed. With additional material examined, the female *Phyllium* (*Pu.*) *abdufatahi* is below described and the species is recognized as having a wider distribution than originally recorded with specimens from both Peninsular (Perak and Penang) and Bornean Malaysia (Sabah), and the Indonesian island of Sumatra. Despite its expansive range, *Phyllium* (*Pu.*) *abdufatahi* Seow-Choen, 2017a. appears to be less frequently encountered than congeners from the same localities.

Description of previously unknown female

Coloration. – Variable and as observed from dried specimens, the preservation technique is likely an influence. Overall coloration green, with several different shades of green recorded. Occasionally a colored form is found with reddish-brown markings throughout the body, onto the legs, and even notable on the vertex of the head (fig. 2C). On the more commonly colored solid green individuals the antennae are of a tan color with notable paler spots throughout (fig. 3A-C).

Morphology

Head. – *Capsule* slightly longer than wide, with a rather smooth vertex with only fine granulation occasionally along the posterior margin near the posteromedial tubercle which is broad, but not prominent. Frontal convexity broad and stout, not exceeding the length of the first antennomere, and sparsely covered in short, thin, transparent setae. – *Antennae* with nine *segments*, occasionally it appears as though there are ten segments due to antennomere VIII having a rather prominent groove around the center, but this groove is superficial and does not fully split the antennomere (fig. 3A-C). – *Antennomeres I-VIII* sparsely marked with small transparent setae, leaving the apical

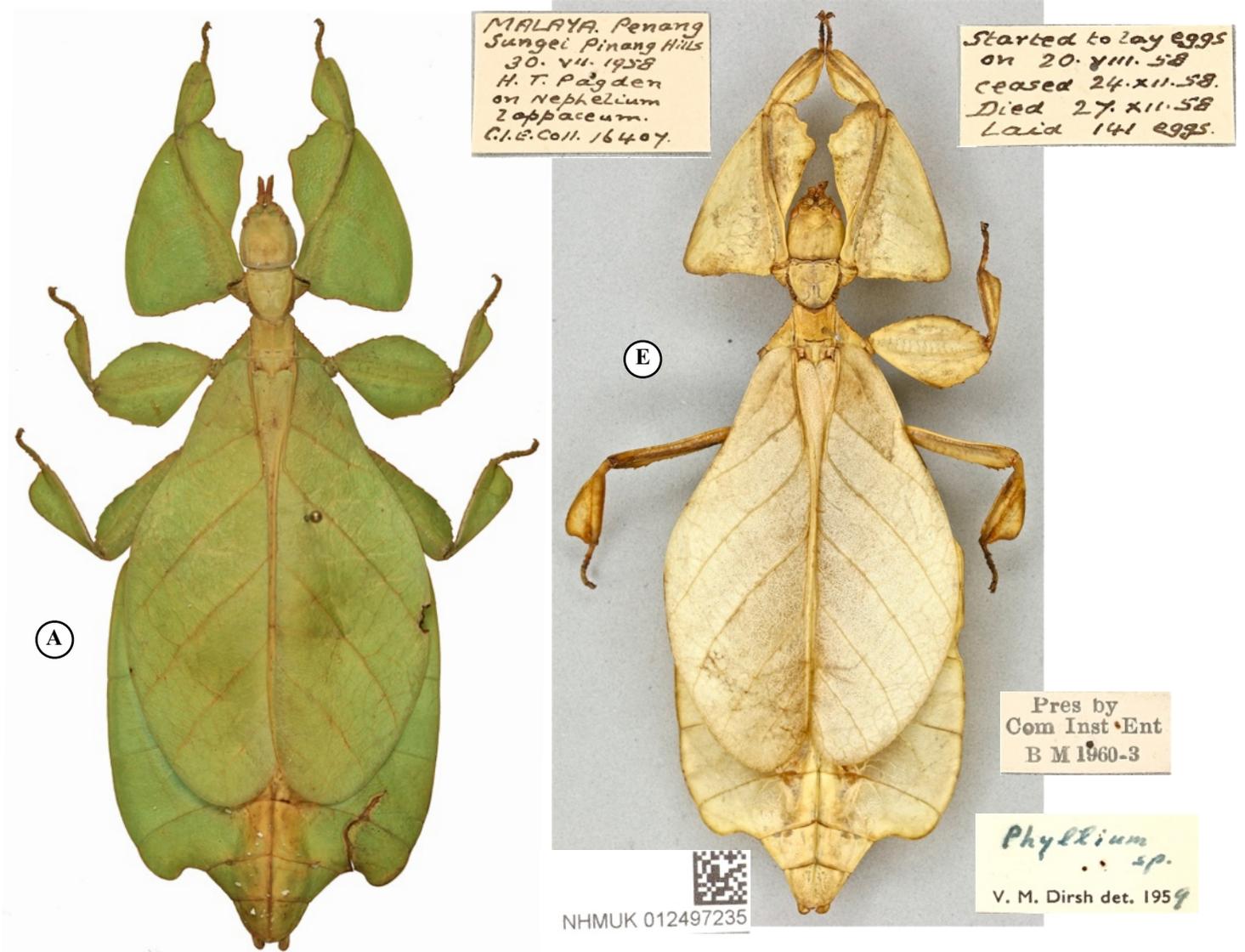


Fig. 1. - *Phyllium* (*Pulchriphyllium*) *abdufatahi* Seow-Choen, 2017; females. - **A**: Dorsal full body [Coll RC 16-039]. - **B**: left profemora [Coll RC 16-039]. - **C**: left profemora [Coll RC 17-249]. - **D**: left profemora [Coll RC 16-040]. - **E**: Dorsal full body (Natural History Museum United Kingdom collection).

antennomere as the only segment covered in dense, stout, brown setae. – *Apical antennomere* narrower than VIII in which it sits, giving it a dwarfed appearance (fig. 3A-C). – *Compound eyes* not exceptionally large and rather tight against the head capsule, not widely protruding (fig. 2D). – *Ocelli* absent. Antennal fields wider than the first antennomere but not exceptionally large.

Thorax. – *Pronotum* with anterior margin only slightly concave and lateral margins that are slightly convex converging to a narrow, slightly rounded posterior margin that is only about half the width of the anterior rim (fig. 2D). The pronotum is rather smooth, with a surface that only has fine granulation and a shallow pit in the center. The pronotum anterior and lateral rims have only a slight rim, posterior lacks a rim. – *Pro-, meso-, and metasternum* smooth, with only the slightest amount of fine granulation. – *Mesopraescutum* only slightly wider than long, giving it a rectangular appearance, with lateral margins only slightly converging to the posterior. – *Lateral rims* with 11-14 irregularly shaped small granules, with no prominent tubercles present, which gives the rims a rather smooth, straight appearance. – *Mesopraescutum anterior rim* smooth, lacking a tubercle and only has a weak rim. – *Mesopraescutum crest* with 10-14 fine granules which are made less prominent due to the smooth surface of the mesopraescutum that rises up to meet it, making the crest little more than a slight ridge (fig. 2D). – *Mesopleurae* strongly diverging; lateral margin with four to five minor tubercles, with one to two small nodes between each minor tubercle. This small granulation gives the lateral margins a rather smooth appearance (fig. 2D). Face of the mesopleurae smooth, with only small granulation near the lateral margins, and two faint divots, one on the anterior and one closer to the center. – *Tegmina* long, extending to the anterior margin of abdominal segment VIII.

Alae. – Rudimentary (fig. 2B).

Abdomen. – *Abdominal segments II* through the anterior half of IV diverging, posterior half of IV through most of VII parallel to subparallel. – *Segment VIII* has a single lobe which can be moderate to strong and curves back towards segment IX. – *Segments IX-X* with converging sides with the anal abdominal segment ending in a broad rounded apex. – *Anal abdominal segment* at its widest is wider than long giving it a broad appearance. – *Subgenital plate* starting at the anterior margin of segment VIII and only extending to the posterior of segment IX. The subgenital plate is rather stout with a fine pointed tip. – *Gonapophyses* are exceptionally slender and short, only just slightly protruding from under the subgenital plate leaving most of the ventral aspect of the anal abdominal segment exposed (fig. 3D). – *Cerci* short and rounded, only slightly protruding from under the anal abdominal segment. Cerci flat not cupped, with a lumpy surface with posterior most rims that has a row of thin clear setae.

Legs. – *Profemora exterior lobes* very broad, at least twice the width of the interior lobe, and with an acute exterior angle. – *Posterior edge of the exterior profemora lobe* with three to four fine serrate teeth, lateral edge is smooth and arcing to the anterior end of the profemora. – *Interior lobe of the profemora* with an obtuse angle and marked with three blunted teeth that are broad and relatively evenly spaced (fig. 1B-D). – *Interior lobe of mesofemora* smoothly arcs from end to end and has nine to ten small serrate teeth evenly distributed. – *Exterior lobe of the mesofemora* arcs end to end but has a slight angle to it with three to four teeth only on the distal half of the arc. Mesofemora interior and exterior lobes are of approximately the same width. – *Exterior lobe of metafemora* thin and lacking dentition, relatively straight. – *Metafemora interior lobe* thin near the base and widening near the end into a rounded lobe that has six to seven serrate teeth pointing distally, and more prominent on the distal end. – *Protibiae exterior lobe* narrow, at its widest, near the anterior, is about the same width as the shaft of the protibiae itself. – *Protibiae interior lobe* several times wider than exterior lobe, and shaped as an isosceles triangle reaching the entire length of the protibiae. – *Mesotibiae exterior lobe* a rounded scalene triangle reaching end to end, with the wider side, which is about the width of the shaft of the mesotibiae, located on the distal end. – *Metatibiae exterior lobe* reaching end to end, in a large rounded scalene triangle, with the widest side, which is at least twice the width of the shaft of the metatibiae, on the distal end.

Measurements of females within the first author's collection [mm]

- length of body (including cerci and head, excluding antennae): 79.1-87.1
- length/greatest width of head: 6.8/5.9-7.6/6.9
- pronotum: 5.3-5.8
- mesonotum: 4.8-5.5
- length of tegmina: 46.5-52.6
- greatest width of abdomen: 33.6-39.7
- profemora: 19.3-19.8
- mesofemora: 13.4-14.1
- metafemora: 14.5-15.4
- protibiae: 8.7-9.2
- mesotibiae: 8.0-8.9
- metatibiae: 11.6-13.6
- antennae: 4.3-4.5.

Variation within sexes

Males. – Only two features were noted as variable within the males observed, the size of the eyespot on abdominal segment V and the size of the lobe of the abdominal segment VIII. The eyespots in *Ph. (Pu.) abdufatahi* were noted as being relatively variable ranging in size from 2.5-3.6 mm. The smaller eye spot variations of *Ph. (Pu.) abdufatahi* make them appear similar to *Ph. (Pu.) pulchrifolium* (with eye spots that range in size from 1.1-2.4 mm wide), however several features allow quick separation between the two species. *Phyllium (Pu.) pulchrifolium* can be separated from *Ph. (Pu.) abdufatahi* by the lower margin of the exterior lobe of the profemora which is always with a slightly arcing margin, not straight like *Ph. (Pu.) abdufatahi*. Additionally, the exterior lobe of the protibiae is always wider than the shaft of the protibiae in *Ph. (Pu.) pulchrifolium* and very thin (no more than the width of the protibiae shaft itself) in *Ph. (Pu.) abdufatahi*.

The lobes of abdominal segment VIII were also shown to be rather variable, ranging from small, only slightly protruding back, (fig. 4D) to a larger lobe, reaching slightly further back than the apex of the abdomen (fig. 4C). As with other variable species, this species also has a wide range of intermediate lobe sizes (fig. 4A, B, E). No stable feature could be detected from males throughout the range when compared to the holotype *Ph. (Pu.) abdufatahi* and it is therefore determined that all three locations, Peninsular Malaysia, Borneo, and Sumatra, belong to the same moderately variable species.

Females. – Only females from Peninsular Malaysia could be assessed as no known females have been recorded from Borneo or Sumatra to date. Females observed appear to have a more stable morphology than their male counterparts. This is a less common trend of the phylliids as generally the females come in a variety of forms (lobed, unlobed, intermediate) with males having a typically more stable morphology.

The only morphological difference that could be noted was a variation in the profemora. Females with more prominent features have an exterior lobe of the profemora that can be elongated, coupled with teeth of the interior lobe that are generally more pronounced (fig. 1B-C). On the opposite end of the spectrum, females with less pronounced features generally tended to have narrower exterior lobes of the profemora and less pronounced teeth of the interior lobe (fig. 1D).

***Phyllium (Pulchriphyllium) giganteum* Hausleithner, 1984** (Fig. 5A-D, 6A-F)

Type locality. – “Malaysia, Cameron Highlands” (Hausleithner, 1984), presumed to be Perak State.



Fig. 2. - *Phyllium (Pulchriphyllium) abdufatahi* Seow-Choen, 2017; females. - **A:** Dorsal full body [Coll RC 17-249]. - **B:** With tegmina raised, showing underdeveloped alae [Coll RC 17-249]. - **C:** Showing front end of live female [Coll RC 17-249]. - **D:** Head through thorax, dorsal view [Coll RC 16-040]. Figures 2A-C taken by Johnson Chee Min of Johor, Malaysia of specimen 17-249 right after collecting, while still alive.

Known range. – MALAYSIA: (Peninsular) Perak, Pahang, and Selangor States; (Bornean) Sarawak State. – INDONESIA: Sumatra, Bengkulu Province.

Range expansion. – MALAYSIA: (Borneo) Sabah State. – INDONESIA: (Sumatra) “Southern Sumatra”, and (Borneo) West Kalimantan Province.

Material examined [16 ♀, 8 ♂]

MALAYSIA [16 ♀, 4 ♂]:

- 1 ♂: Perak, Tapah Hills, August, 2014 [Coll RC 16-047]
- 4 ♀: Perak, Tapah Hills, January, 2012 [Coll RC 16-041, 045, 043, 044]
- 1 ♀: Perak, Tapah Hills, April, 2011 [Coll RC 16-042]
- 1 ♀: Tapah Hills Reserve, March, 1987 [Coll RC 16-046]
- 10 ♀: Perak, Tapah Hills, April, 1990, November, 1992, July, 2016 (Collection Stéphane Le Tirant)
- 1 ♂: Borneo, Sabah, Pensiangan, [91-23] January 9th, 1991, leg. Cornelio, from the collection of Jerri Larsson, California, United States
- 1 ♂: Borneo, Sarawak, Bintulu env., April, 2012 [Coll RC 16-048]
- 1 ♂: Borneo, Sarawak, 1909, J.E.A. Lewis [Catalogue# NHMUK012500164].

INDONESIA [4 ♂]:

- 1 ♂: “Southern Sumatra”, from the Miyashita collection
- 1 ♂: Sumatra, Benkoelen Dist. 1912-1919, C.J. Brooks, 1920-43. [Catalogue# NHMUK012500165]
- 2 ♂: West Kalimantan Province, Mount Bawang, elevation 245 meters, January, 2016 [Coll RC 16-220, 16-219].

Known range discussion. – Besides the type locality of Perak State, Malaysia, two other Peninsular Malaysia states are listed as having *Ph. (Pu.) giganteum* records- Pahang: Kuala Tahan and Selangor: Kuala Lumpur (Brock, 1994). The species is also known to occur in Sarawak State on the Island of Borneo from a record within the NHMUK (formerly the British Museum, fig. 5A-B) and from a male within the first author’s collection (Coll RC 16-048, fig. 6C). Although Brock, 1994 was not certain of the Sumatran male he discussed on page 56 being *Ph. (Pu.) giganteum*, examination of the specimen clearly confirms the identity as *Ph. (Pu.) giganteum* (fig. 5C-D). It is worth pointing out that the data on the historic label states “Benkoelen Dist.” which is the historic name for Bengkulu Province (Harfield, 1995).

Range expansion discussion. – Two additional localities from the island of Borneo are here added. Two males within the first author’s collection [Coll RC 16-220, 16-219], both from the Indonesian territory on the island, West Kalimantan Province. Also a male from the collection of Jerri Larsson, California, United States, from Borneo, Sabah State, Pensiangan Town, adds the state of Sabah to the known distribution (fig. 6A). Regarding Indonesia, besides the additional records from the island of Borneo, Sumatra is again noted as having *Ph. (Pu.) giganteum*, after the first record of Sumatra (Brock, 1994) appears to have been overlooked by subsequent authors. A male from the inexact locality of “Southern Sumatra”, Indonesia (fig. 6B) from the Miyashita collection, helps to confirm the expansion of the range of *Ph. (Pu.) giganteum* onto the island of Sumatra.

Variation within sexes

Females. – Widely variable in color and abdomen width. Overall color of female specimens can range from a pale lime green, to rich forest green, and in some individuals brown patches are notable on legs or the tip of the abdomen, occasionally covering most of the body. Abdomen width and overall specimen size for all females examined had a wide range, with overall length 106.7-117.0 mm and abdomen width

51.4-61.8 mm. It is also worth noting that the widest individuals measured were not always also the largest, for example the widest female measured was 110.6 mm long, a very average length individual.

Males. – Male morphology, similar to female, was relatively stable with only slight ranges of features exhibited. Due to the wide range of female abdomen widths observed, it was no surprise that the most variable feature of the males was also the width of the abdomen. Specimens from all regions of the range exhibited a spectrum of narrow (fig. 5A) to broad (fig. 6A) abdomens with intermediate shapes observed (fig. 5C).

***Phyllium (Phyllium) hausleithneri* Brock, 1999**

(Fig. 7A-E, 8A-I)

Type locality. – MALAYSIA, Perak.

Range expansion. – INDONESIA: Sumatra, Bengkulu Province.

Material examined [18 ♀, 12 ♂, 62 eggs]:

MALAYSIA [6 ♀, 3 ♂, 35 eggs]

- 2 ♀: Perak, Cameron Highlands, Tapah Hills: May, 2017 [Coll RC 17-253, 17-254]
- 1 ♀: Pahang, Cameron Highlands District: June, 2010 [Coll RC 16-085]
- 1 ♂: Perak, Tapah: June, 2014 [Coll RC 16-087]
- 2 ♀: Cameron Highlands: May, 2011 [Coll RC 16-084, 16-169]
- 1 ♀, 2 ♂: Perak, Tapah Hills: April, 2012 [Coll RC 16-086, 16-088, 16-170]
- 10 Eggs: Origin Perak (from captive culture supplied by Bruno Kneubühler) [Coll RC 18-002--011]
- 25 Eggs: Origin Perak (from captive culture supplied by Bruno Kneubühler).

INDONESIA [12 ♀, 9 ♂, 27 eggs]:

- 5 ♂: Sumatra Island, Bengkulu Province: January-March, 2017 [Coll RC 17-064--068]
- 9 ♀: Sumatra Island, Bengkulu Province: January-March, 2017 [Coll RC 17-083--090, 17-107]
- 3 ♀: Sumatra Island: February, 2017 [Coll RC 17-216--218]
- 4 ♂: Sumatra Island: April, 2017 [Coll RC 17-211, 17-212, 17-213, 17-214]
- 4 Eggs: Removed from the abdomen of female 17-107 [17-377--380]
- 5 Eggs: Removed from the abdomen of female 17-089
- 10 Eggs: Removed from the abdomen of female 17-086
- 3 Eggs: Removed from the abdomen of female 17-087
- 5 Eggs: Removed from the abdomen of female 17-085.

Discussion. – It was originally thought that the Sumatran records of this species represented an undescribed species, native to the island of Sumatra. This thought was fueled by the remarkable color difference in the eggs as well as a first impression that the center pattern of short pinnae on the lateral views of the eggs were consistently different. Due to this first impression of the marked difference between eggs, an extensive search was begun to pinpoint morphological differences between adults.

The first impression was that the Sumatran population was smaller than their Perak counterparts, this was dismissed when actual measurements were taken to find a recordable difference, and it was found that both populations had larger and smaller individuals and a consistent range of sizes in between. Perak females ranged in size from 74.6-82.8 mm and the Sumatran population ranged in size from 70.3-79.3 mm, and males ranging in size from 55.8-57.8 mm for the Perak population and 51.4-56.1 mm for the Sumatran population. Although on average the Sumatran population had measurements that were slightly smaller than the Perak population,

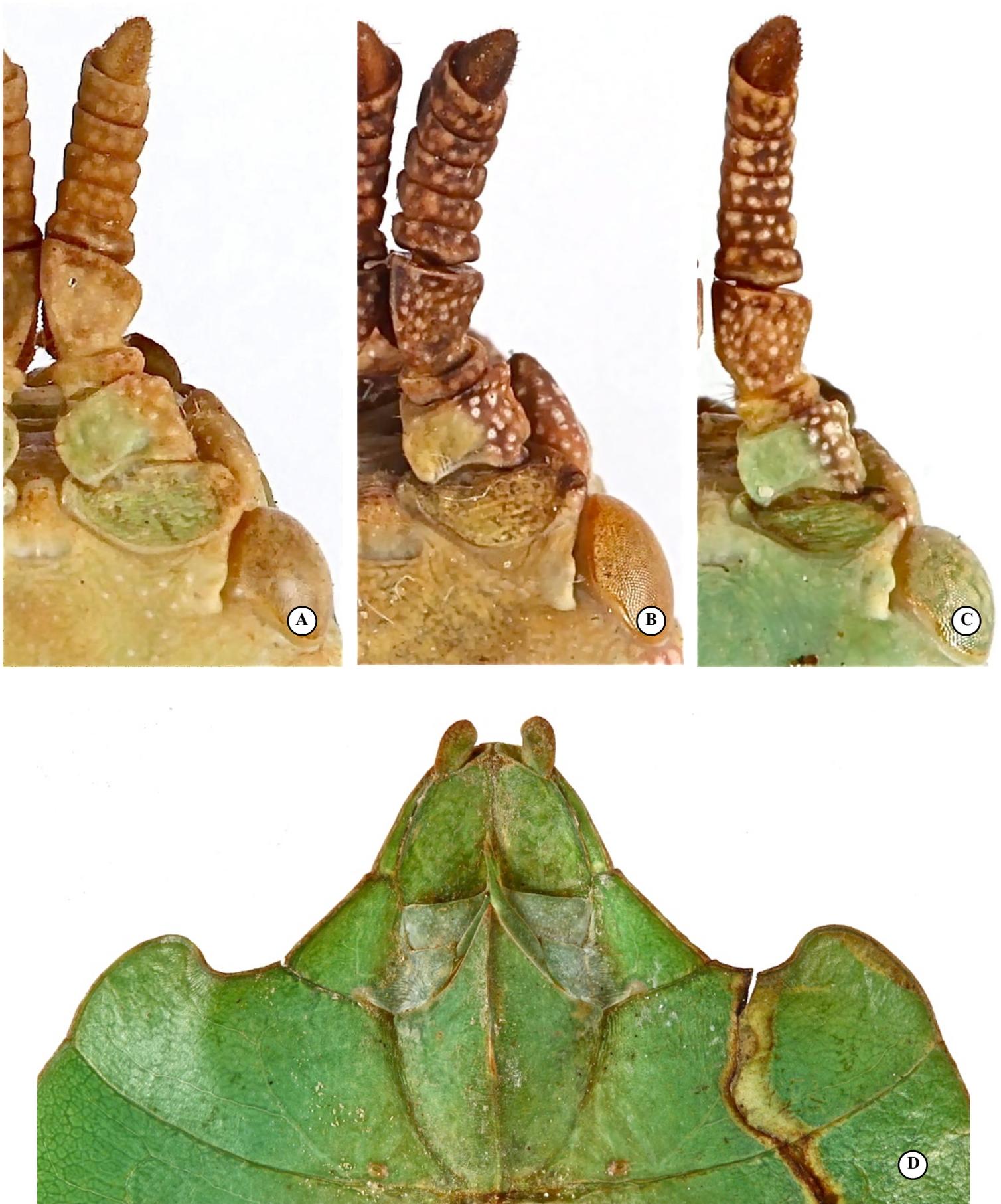


Fig. 3. - *Phyllium (Pulchriphyllium) abdufatahi* Seow-Choen, 2017; females. - **A:** Antennae [Coll RC 16-039]. - **B:** Antennae [Coll RC 17-249]. - **C:** Antennae [Coll RC 16-040]. - **D:** Genitalia, ventral view [Coll RC 16-039].

extremes within each population overlapped significantly. With this notable overlap in size range and a consistent spectrum of sizes in each population, this immediate observation was dismissed.

To adequately differentiate the two populations based on adults, finer details were then observed. At every point during the search both populations had individuals that would exhibit extremes of several features along with the corresponding intermediates showing mixed forms. Some of the features observed that were thought to be significant, were later found not to be after a wider sample of specimens was observed. These features included: the granulation on the vertex of the head, ratio of width of interior lobe of profemora versus the exterior lobe, female genitalia (shape and length of subgenital plate and length of gonapophyses), length of tegmina, and greatest width of abdomen versus length of abdomen. Each time a possible unique feature was systematically eliminated, more and more doubt was placed on their uniqueness.

The last feature to be looked at in fine detail was the female antennae. Immediately it became clear that all females from the Sumatran population had nine segmented antennae, a feature that surprised us as Hennemann *et al.*, 2009 states *Ph. (Ph.) hausleithneri* has a ten segmented antennae. The original description of *Ph. (Ph.) hausleithneri* however states the type material as having a nine segmented antennae. After all Sumatran specimens antennae were examined, the antennae of the Perak population from the first author's collections were examined. All females examined clearly had nine antennae segments (except for a single aberrant female within the first author's collection, with antennomeres VIII and IX fused giving it an eight segmented antennae with a remarkably long terminal segment). This observation was then sent to Frank Hennemann and Hennemann reviewed all of his *Ph. (Ph.) hausleithneri* females, and found that the illustration that was used in the 2009 work must have been based on a single aberrant female in his collection with a ten segmented antennae, as all other specimens in his collection exhibited the common nine segmented antennae (pers. comm. Jan. 28th, 2018).

The final feature reviewed on the female specimens was the number of teeth on the pars stridens of antennomere III, a feature that has proven useful in species differentiation when larger features seemed to be difficult to keep separated in morphological keys. Größer in 2008 lists *Ph. (Ph.) hausleithneri* as having a pars stridens with 44-46 teeth, and the following year Hennemann *et al.*, 2009 then listed it as having 44-48 teeth, a moderately wide range for a species. The number of teeth observed on the Sumatran populations pars stridens was again eye opening to the wide range of morphologies of this species with a range of 37-44 teeth. With this wide range observed from the Sumatran population, it is likely that the Perak population also has a wider range than has previously been observed. It is likely to be revised after a larger sample size is surveyed.

It was thought that possibly the number of teeth of the pars stridens could be linked to the form of the female (lobed, smooth, or intermediate), but when compared with abdomen morphology no clear pattern was present. As illustrated by two females with extremely different abdominal morphologies (lobed and smooth abdomens) had the same number of teeth on the pars stridens. Other more moderate/intermediate forms showed a greater variability with as few as 37 teeth observed and as many as 44 teeth (the lower threshold previously recorded on the Perak population).

Eventually eggs were again looked at, under a wider spectrum. This broader look at the eggs of both the Perak and Sumatran populations revealed that eggs of the Perak population were not

solely marked with intricate short pinnae designs on the lateral views. Instead eggs of the Perak population were widely variable, with eggs that had simple straight markings to ones that were very complex (fig. 8F-I). Figure 8F-I shows a range of designs, with the most simple on the left, ranging to a more complex design on the right which was originally thought to be the average egg for the Perak population. This thought that the complexly marked eggs were the most prevalent was what originally led us to assume this population was a separate species.

When the eggs from the Sumatra population were reassessed and the sample size was greatly increased, these eggs also showed a variation in the lateral sort pinnae markings, albeit with a range slightly less variable than that observed in the Perak population. The most commonly encountered egg pinnae design was one with a single marking down the center with relatively straight to wavy sides, a marking very similar to part of the spectrum that the Perak eggs, with their greater variety also showed frequently.

The only consistent feature observed between the two populations from egg morphology, was the color of the eggs, with the Perak population consistently darker than the Sumatran population. There is a possibility that because the Sumatran eggs that were observed in this study were removed from the abdomens of various females, they could be considered not fully developed due to this premature removal, and therefore their color could not have been fully developed. Thanks to discussion with Bruno Kneubühler, who has received freshly laid and therefore fully developed eggs from a Sumatran population female, all of his eggs also exhibited this paler color when compared with the Perak population.

Another possibility that has not been widely studied as of yet is the variation of egg color not only within populations but also within a single females egg color variability. *Phyllium (Phyllium) westwoodii* Wood-Mason, 1875 has been recorded as having a predictable egg color (white or brown) based on if the females eggs were the product of thelytoky or if they were fertilized (Arai and Yago, 2015). To date this is the only species to have had a systematic study done on egg color coupled with egg production (unfortunately done without replicates however) and it would be interesting to see the results of a similar study if done with *Ph. (Ph.) hausleithneri*. This possibility leaves the authors with the belief that these two *Ph. (Ph.) hausleithneri* populations lack any morphological features that would consistently separate them to the grounds of naming them as separate species.

It is likely that future genetic work will help to clarify the relationship between these Perak and Sumatran populations, but for now, due to a lack of morphological differences observed between series of males, females, and eggs, these two populations are considered the same species.

Variation within sexes

Females. – Females of both populations expressed a wide range of forms with many of their features quite variable. Overall body length varied with a range of 8-9 mm difference between the smallest and largest individuals of both populations. Greatest abdominal width showed moderate variation within both populations, however this appears to be more closely linked to overall individual size as larger individuals also frequently had wider abdomens when compared to their smaller counterparts. The length of tegmina was only slightly variable within both populations, either at the anterior edge of abdominal segment VIII or at most reaching half way into VIII. Considerable variation was observed in the shape of the abdominal segments, ranging from smooth continuously converging sides to subparallel sides ending in abdominal segments VII and VIII widely lobed (fig. 7A-D). The size of the teeth of the profemora interior lobe was more or less

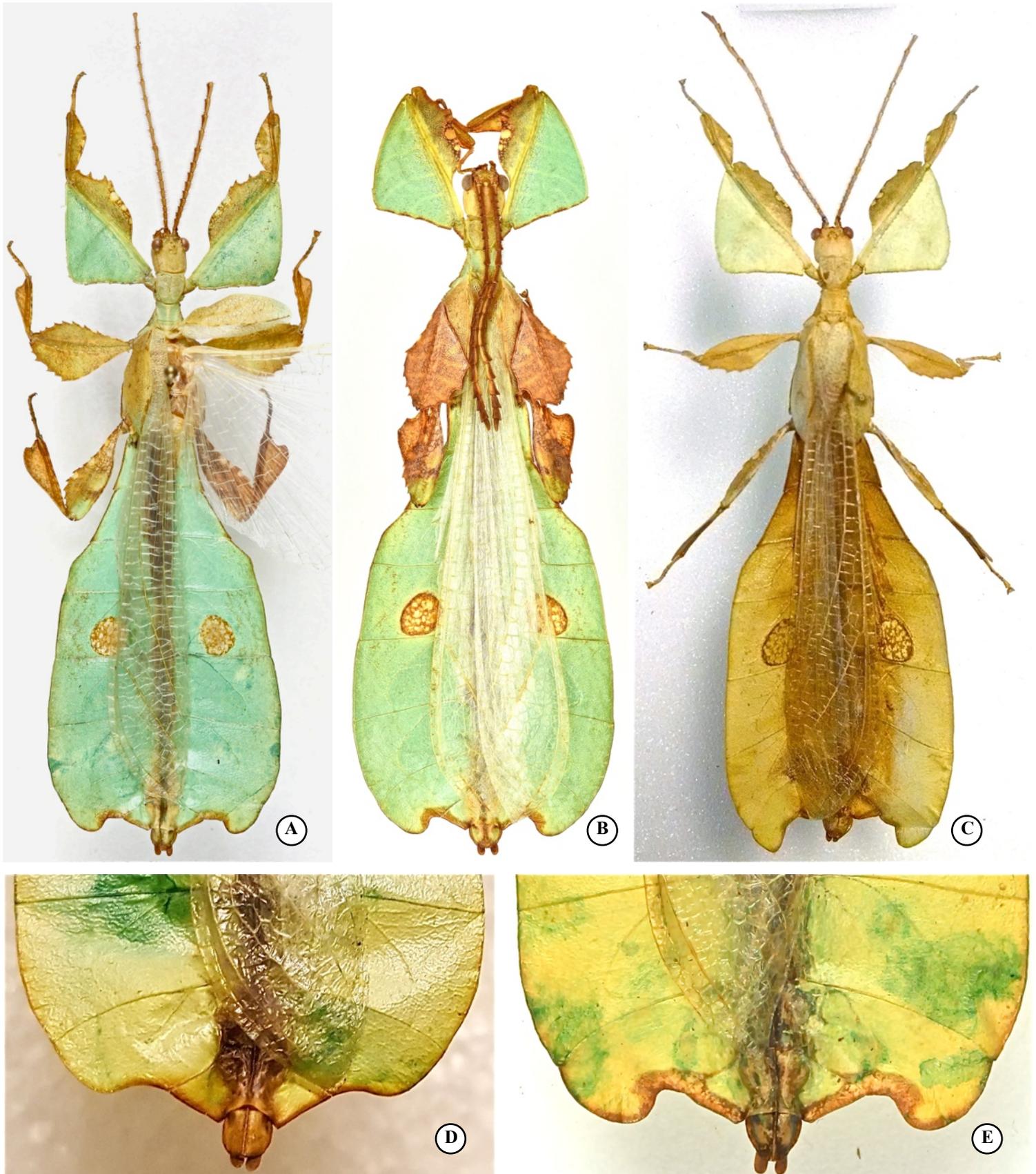


Fig. 4. - *Phyllium (Pulchriphyllium) abdufatahi* Seow-Choen, 2017; males, dorsal views. - **A:** Peninsular Malaysia [Coll RC 16-155]. - **B:** Peninsular Malaysia, coll. Stephane Le Tirant, photo credit René Limoges. - **C:** Sumatran record from the collection of Jerri Larsson. - **D:** Peninsular Malaysia, reduced lobes, posterior closeup [Coll RC 16-222]. - **E:** Peninsular Malaysia, moderate lobes, posterior closeup [Coll RC 16-006].

linked to the general abdominal shape. Individuals with more pronounced abdominal lobes had larger teeth of the profemora and those with smaller lobes had smaller finer pointed teeth.

Both populations had the characteristic purple colored coxae and thorax with the same placement and size range of nodes with minimal variation. The variation in the number of teeth of the pars stridens is already discussed above, and with a larger sample size the variation is expected to be even greater as our small sample size gave no indication of the average number to expect.

Males. – Unlike females, males of both populations showed very little variety in morphological features. All features of the antennae, thorax, legs (including teeth and lobes of legs), and tegmina were stable features between both populations. The only detectable variations within both populations were the length of alae and the maximum width of abdomen. Alae of both populations ranged from the shortest, reaching the anterior of abdominal segment IX, to the longest just passed the posterior of segment IX, with intermediate lengths from both populations present. Variation of the greatest width of the abdomen was also notable, although not as extreme as the abdominal variation expressed within the females. With females expressing a wide range of abdominal characteristics it is no surprise that males showed a slight variation as well.

Eggs. – Eggs had a steady size range and the arrangement/ length of the marginal pinnae was consistent. Color was variable, and from what was assessed it appears as though the color is steady between the Perak (dark brown) and Sumatra (cream) populations. Length of the micropylar plate was slightly variable within both populations showing both longer (fig. 8D) and shorter (fig. 8E) variations. Inner design of the short pinnae on the lateral surfaces were more variable in the Perak population (fig. 8F-I), however the Sumatran also showed some variation, just not as widely as the Perak population.

***Phyllium (Phyllium) rubrum* Cumming, Le Tirant & Teemsma n. sp.**

(Fig. 9A-D, 10D-E)

ZooBank : <http://zoobank.org/ED5306F6-B1F1-4D46-AC80-04088F92D764>

Holotype, ♀: MALAYSIA, Perak, Tapah Hills, April, 2017 [Coll. RC 17-204]: Deposited in the Montreal Insectarium type collection.

Paratypes:

– 1 ♀: “Malaysia, Tapah Hills”; bred by staff of the Long Island Butterfly Exhibit staff, January-March, 2017 [Coll. RC 17-005]: retained within the collection of the first author.

– 10 Eggs: “Malaysia, Tapah Hills” (from captive culture supplied by Bruno Kneubühler) [Coll. RC 17-339, 17-342, 17-374, 18-012-018]: retained within the collection of the first author.

Discussion and differentiation. – This species has occasionally been in culture throughout Europe for a number of years and has been referred to as *Phyllium* “red coxae” or *Phyllium* “Tapah Hills, red coxae” because of the characteristic red color of the meso- and metacoxae. This species however seems to be much less encountered than sympatric species in the same type locality, with *Ph. (Ph.) hausleithneri* Brock, 1999 frequently offered for sale and *Ph. (Ph.) rubrum* n. sp. rarely offered. The lack of exterior lobes and the rudimentary alae place this new species within the siccifolium species-group within the (*Phyllium*) subgenus as per Hennemann et al., 2009.

It was originally planned to wait until a male specimen could be obtained to describe the species, however, due to the lack of an official name within the phasmid breeding community, a description of at least the female was warranted to help clear up

current confusion and it is unlikely that a male will be obtained in the near future due to the species apparent rarity.

The female appears most closely related to *Ph. (Ph.) hausleithneri* Brock, 1999, *Ph. (Ph.) jacobsoni* Rehn and Rehn, 1933, and *Ph. (Ph.) palawanense* Größer, 2001, as observed by the abdominal shape and structure of the profemoral lobes and teeth. From all these species it can be distinguished by its larger size (~90.0 mm) and the orange-red color of the meso- and metacoxae. From *Ph. (Ph.) palawanense* it can more specifically be distinguished by the singular line of nodes running along the sagittal plane of the mesopraescutum (mesopraescutum irregularly granulose in *Ph. (Ph.) palawanense*). From *Ph. (Ph.) hausleithneri* and *Ph. (Ph.) jacobsoni* it can further be distinguished by the lateral margins of the mesopraescutum which have nodes of steadily increasing size from the anterior to the posterior (in *Ph. (Ph.) hausleithneri* and *Ph. (Ph.) jacobsoni* these nodes are of a uniform maximum height with the largest on the anterior of a similar size as those on the posterior).

Males, although not available for this description, from photos of captive bred stock also have meso- and metacoxae that are clearly marked with an orange-red color. This clearly colored coxae separates them from other similar species, *Ph. (Ph.) hausleithneri* Brock, 1999, *Ph. (Ph.) jacobsoni* Rehn and Rehn, 1933, *Ph. (Ph.) bradleri* Seow-Choen, 2017a., and *Ph. (Ph.) chenqiae* Seow-Choen, 2017a. Although Seow-Choen did not describe the color of the coxae of the two Bornean species that appear closely related, 6 male *Ph. (Ph.) chenqiae* Seow-Choen, 2017a. and 23 *Ph. (Ph.) bradleri* Seow-Choen, 2017a. from within the first and second authors collections were examined and all lacked colored coxae. This lack of colored coxae makes *Ph. (Ph.) chenqiae* and *Ph. (Ph.) bradleri* appear more closely related to *Ph. (Ph.) jacobsoni*, a congeneric which Seow-Choen failed to differentiate both species from.

Eggs, morphologically are less similar to *Ph. (Ph.) hausleithneri* and are instead more similar in their pinnae pattern on the lateral view to those of *Ph. (Ph.) philippicum* Hennemann, et al., 2009. Instead of a pinnae pattern on the lateral view with straight marginal rows and a center row that varied in pattern from straight sided to intricate, *Ph. (Ph.) rubrum* n. sp., has these three rows uniformly marked by circular bare impressions. All eggs observed of *Ph. (Ph.) rubrum* n. sp., showed a stable morphology, very different from the widely variable eggs of *Ph. (Ph.) hausleithneri*, which ranged from straight to intricate irregular shapes. This pattern of circular bare impressions is a feature that is more similarly expressed in *Ph. (Ph.) philippicum* eggs. *Phyllium (Ph.) rubrum* n. sp., eggs however can be differentiated from *Ph. (Ph.) philippicum* eggs by the micropylar plate which is narrow and covers approximately 5/6th of the dorsal view (in *Ph. (Ph.) philippicum* the micropylar plate only covered around 2/3rds of the dorsal view and is wider with each side from the micropylar cup tapering evenly).

Description of female

Coloration. – Overall coloration green, with orange antennae and highlights of the protibiae and profemora. Venation of the tegmina also with an orange color with a notable red marking near the branching point of the media anterior from the media vein (Ragge, 1955). Meso- and metacoxae with red-orange coloration.

Morphology

Head. – Capsule slightly longer than wide, with a granulose vertex with 27-30 nodes relatively evenly spaced and of slightly varying sizes on each side of the sagittal plane. – *Posteromedial tubercle* is broad,



Fig. 5. - *Phyllium (Pulchriphyllium) giganteum* Hausleithner, 1984, historic males from the Natural History Museum United Kingdom collection. - A: Record from Sarawak, Borneo, 1909, J.E.A Lewis [Catalogue# NHMUK012500164]. - B: Original data labels for Sarawak Borneo male. - C: Record from Benkulu Province, Sumatra, 1912-1919, C.J. Brooks [Catalogue# NHMUK012500165]. - D: Original data label for Sumatra male. Photo credits NHMUK, used under the license CC0-1.0.

but not prominent. – *Frontal convexity* stout, not exceeding the length of the first antennomere, and with 13-18 tan setae throughout. – *Antennae* consisting of nine segments, with I-VII sparsely marked with tan setae of varying lengths, and segments VIII-IX covered in dense tan setae of relative uniform length (fig. 9C). – *Compound eyes* moderately protruding from head capsule (fig. 9C) and *ocelli* are absent. – *Antennal field* wider than the first antennomere but about as long as the first antennomere is tall.

Thorax. – *Pronotum* with anterior margin slightly concave with a distinct rim; lateral margins with moderate rims and relatively straight sides that are prominently converging to the stout posterior margin which lacks a rim and that is only about half the length of the anterior margin (fig. 9C). The pronotum surface is irregularly marked with small granules and slight pits with the only notable feature being the prominent pit in the center. – *Mesopraescutum* slightly wider than long, with lateral margins running parallel to the posterior. – *Lateral rims* with 7-8 irregularly shaped nodes, which steadily increase in size from the anterior to the posterior, with the posterior most being rather prominent tubercles of a similar size to those found on the mesopraescutum crest or the mesopraescutum anterior rim. – *Mesopraescutum anterior rim* prominent with a lumpy/granulose surface, marked by a prominent tubercle on the sagittal plane. – *Mesopraescutum crest* with five evenly sized tubercles, which are prominent due to the surface of the mesopraescutum being rather flat with only very small granulation (fig. 9C). – *Mesopleurae* uniformly diverging; lateral margin marked with 14 to 17 nodes of relatively even size and shape all pointed slightly to the posterior. Face of the mesopleurae mostly smooth, with only small granulation near the nodes of the lateral margins, and two distinct pits, one near the anterior and one closer to the center. – *Tegmina*, nearly extending to the posterior margin of abdominal segment VII.

Alae. – Rudimentary.

Abdomen. – Abdominal segments II through the anterior two-thirds of IV gradually diverging, posterior third of IV through VII gradually converging, with segments VIII-X converging more strongly. – *Apex* of abdomen appears relatively slender and long likely due to the long cerci protruding from under the anal abdominal segment which itself is not particularly broad. – *Subgenital plate* starting at the anterior margin of segment VIII and extending halfway into segment X. The subgenital plate is rather broad but near the apex converges to a fine pointed tip. – *Gonapophyses* long, reaching the apex of the anal abdominal segment and rather broad, the same width as the cerci which are flat and with irregular, lumpy surfaces but no prominent granulation (fig. 9D).

Legs. – *Profemora exterior* lobe slightly narrower than the interior lobe, and smoothly arcing end to end. Interior lobe of the profemora with an angle that is slightly obtuse and marked with three to four smoothly serrate teeth that are unevenly spaced with notable looping gaps between each tooth. – *Interior lobe of mesofemora* narrow, only as wide as the mesofemora shaft and arcs from end to end. – *Interior lobe of mesofemora* marked with five small serrate teeth on the distal half. – *Exterior lobe of the mesofemora* also only about as wide as the mesofemora shaft and reaches end to end with a slight angle, marked only by a single small serrate tooth on the distal third. Exterior lobe of metafemora thin, lacks dentition, and follows the slight curve of the metafemora shaft. – *Metafemora interior lobe* with seven serrate teeth on the distal half, and only slightly wider than the exterior lobe. – *Protibiae* with no exterior lobe, and an interior lobe spanning the length of the protibiae in a gentle arcing triangle. – *Meso-* and *metatibiae* simple, lacking interior and exterior lobes.

Measurements of holotype [mm]

– length of body (including cerci and head, excluding antennae): 90.5
 – length/greatest width of head: 7.1/6.4
 – pronotum: 5.2
 – mesonotum: 7.7
 – length of tegmina: 53.6
 – greatest width of abdomen: 33.2
 – profemora: 16.5
 – mesofemora: 14.5
 – metafemora: 19.6
 – protibiae: 10.1

– mesotibiae: 9.8
 – metatibiae: 16.2
 – antennae: 4.1.

Description of egg (Figs. 10D-E). – The lateral surfaces are flattened and the dorsal surface slightly convex, which gives the egg a general kidney shape, which is strengthened by the long pinnae on the dorsal surface margins. When viewed from the lateral aspect the anterior width of the capsule is of a similar size to that of the posterior, with the center width only slightly wider. When viewed from the lateral view, longitudinal carinae along the dorsal and posterior margins are each set with a row of long pinnae which each ends in at least a single split, occasionally with two larger branches and several smaller ones. Lateral surfaces with three relatively parallel rows of circular bare impressions, with the spaces between densely covered with short, singly branched pinnae. Micropylar plate reaching almost end to end on the dorsal surface (approximately 5/6th the length) slightly more situated towards the anterior margin. Shape of micropylar plate thin and long, only notably wider around the micropylar cup. Micropylar cup of moderate size and placed just off of center, on the posterior end of the midline. Operculum ovular, with the outer margin with a row of pinnae similar to those along the longitudinal outer edges of the capsule but slightly longer. Overall color brown with little variation.

Etymology. – Due to the trend within the phasmid breeding community to refer to this then undescribed species as *Phyllium* “red coxae” the name “*rubrum*” was chosen referring to this unique color.

***Phyllium (Pulchriphyllium) rimiae* Seow-Choen, 2017a.**

(Fig. 10A-C)

Type locality. – MALAYSIA, Borneo, Sabah State.

Range expansion. – MALAYSIA: “Cameron Highlands” assumed to be Perak State.

Material examined [5 ♂]

MALAYSIA:

- 1 ♂: Sabah, North Borneo, Mt. Trus Madi, [Coll RC 17-281]
- 1 ♂: Malaysia, Cameron Highlands, June, 2016 [Coll RC 17-223]
- 1 ♂: Sabah, North Borneo, Mt. Trus Madi, May 14th, 2006 [Coll RC 17-282]
- 1 ♂: Crocker Range, Sabah, Nord Borneo, Est Malaisie, 15.I.2004 [Within the collection of the second author]
- 1 ♂: Sabah, North Borneo, Mt. Trus Madi [Within the collection of the second author].

Variation

Males. – Males show variation with robust and slender individuals with clear intermediate forms between. The size of the lobes of the abdominal segments VII and VIII varied with more slender individuals having less pronounced lobes and robust individuals with clear notable lobes. Maximum abdomen width was somewhat positively linked to the size of the eyespots in abdominal segment V with abdominal widths ranging from 17.9-22.1 mm and eye spots ranging from 1.6-3.2 mm. The serration of the exterior lobe of the profemora was also variable and linked to maximum abdominal width, with wider, more robust specimens having stronger serration of the exterior lobe.

The Peninsular Malaysian male examined fell within the range of the intermediate specimens from Borneo and although examined in detail, no consistent morphological features could be identified between the two populations.

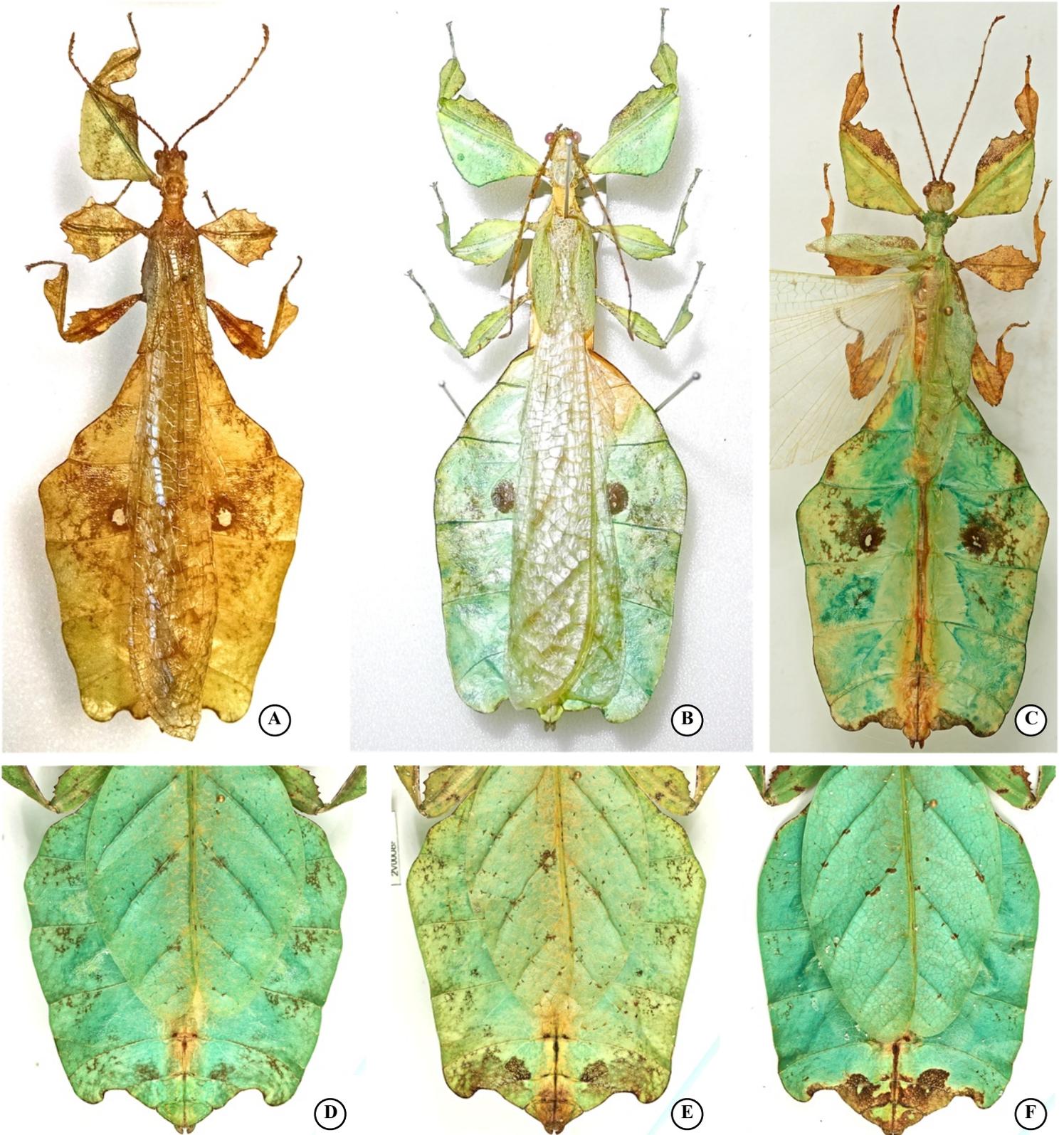


Fig. 6. - *Phyllium (Pulchriphyllium) giganteum* Hausleithner, 1984; A-C males, D-F females, dorsal views. - **A:** Sabah, Borneo record, Collection of Jerri Larsson. - **B:** Sumatran record from the Miyashita collection, Japan. - **C:** Sarawak, Borneo, [Coll RC 16-048]. - **D:** Malaysia, Perak, broad abdominal variation [Coll RC 16-042]. - **E:** Malaysia, Perak, [Coll RC 16-044]. - **F:** Malaysia, Perak, slender abdominal variation [Coll RC 16-043].

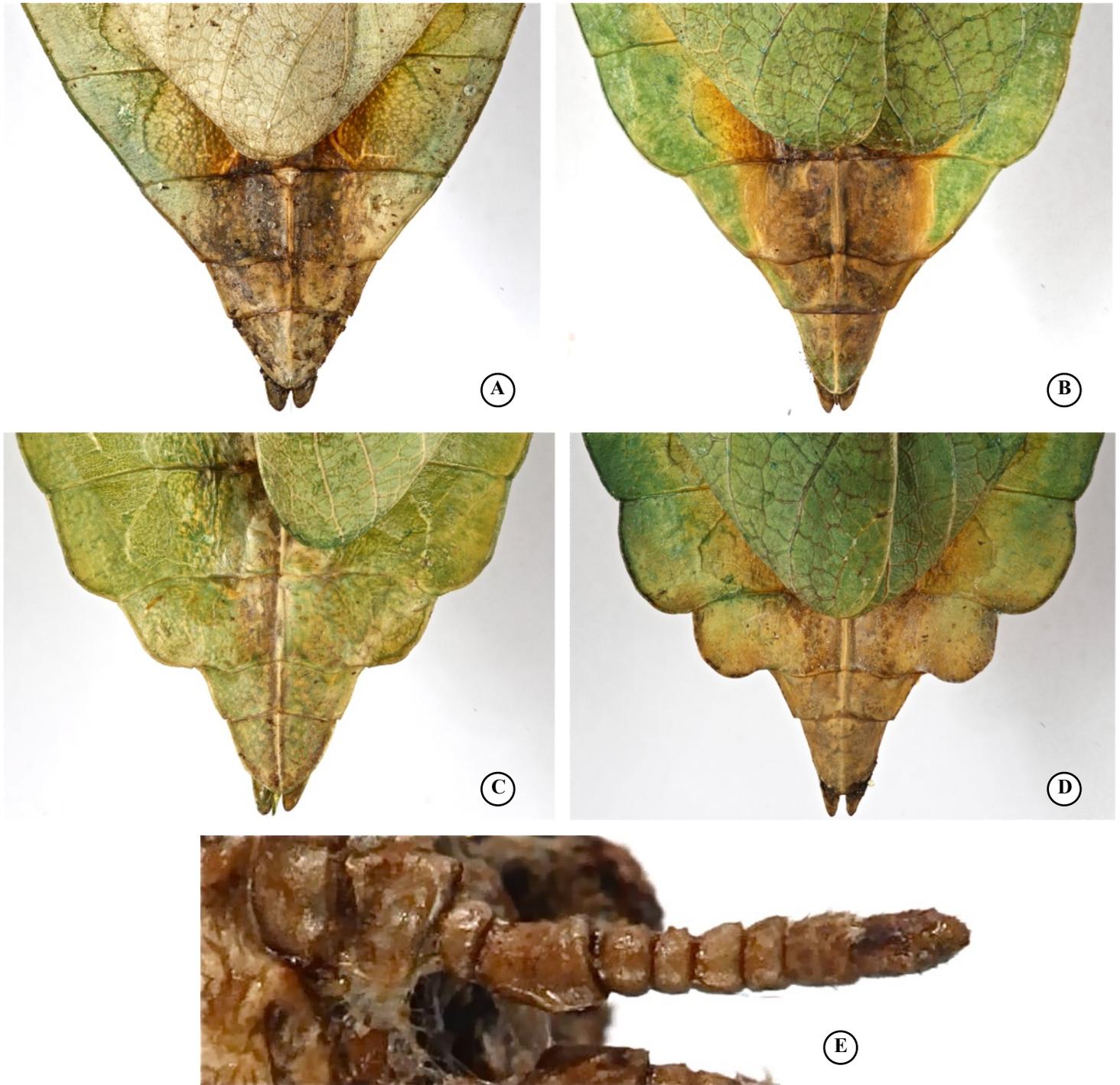


Fig. 7. - *Phyllium (Phyllium) hausleithneri* Brock, 1999; females, dorsal views. - **A:** Slender, smooth abdomen [Coll RC 17-083]. - **B:** Slender, slightly lobed abdomen [Coll RC 17-085]. - **C:** Broad, moderately lobed abdomen [Coll RC 17-216]. - **D:** Broad, strongly lobed abdomen [Coll RC 17-084]. - **E:** Left antennae, showing nine segments, dorsal view, from female [Coll RC 17-085].

***Phyllium (Pulchrphyllium) mannani* Seow-Choen, 2017a.**

Type locality. – MALAYSIA, Borneo, Sabah State.

Range expansion. – MALAYSIA: “Cameron Highlands” assumed to be Perak State.

Material examined [12 ♂]

MALAYSIA:

– 4 ♂: NE Borneo, Sabah, Tambunan reg., Trus Madi Mts. 1,200 meters, May 13-26, 2007, leg. A Sochivko [Coll RC 16-106, 16-133-134, 16-136]

– 2 ♂: N. Borneo, Sabah, Keningau Dist. Trus Madi Mt., 1,160 meters, 8.XI.2015, A. Klimenko leg. [Coll RC 16-112, 16-131]

– 1 ♂: N. Borneo, Sabah, Keningau Dist. Trus Madi Mt., 1,160 meters, 23.VI.2014, A. Klimenko leg [Coll RC 16-108]

– 1 ♂: Borneo, Sabah, Crocker Range, Gunung Alab, 1,700 meters, 3.VI.2014, A. Klimenko leg [Coll RC 16-132]

– 1 ♂: N. Borneo, Sabah, Keningau Dist. Trus Madi Mt., 1,160 meters, 24.VIII.2012, A. Abramov leg [Coll RC 16-210]

– 1 ♂: NE Borneo, Sabah, Tambunan reg., Trus Madi Mts. 1,200 meters, Jan. 12-24, 2007, leg. A. Sochivko

– 1 ♂: Cameron Highlands, June, 2015 [Coll RC 16-231]

– 1 ♂: Cameron Highlands, June, 2016 [Coll RC 17-219].

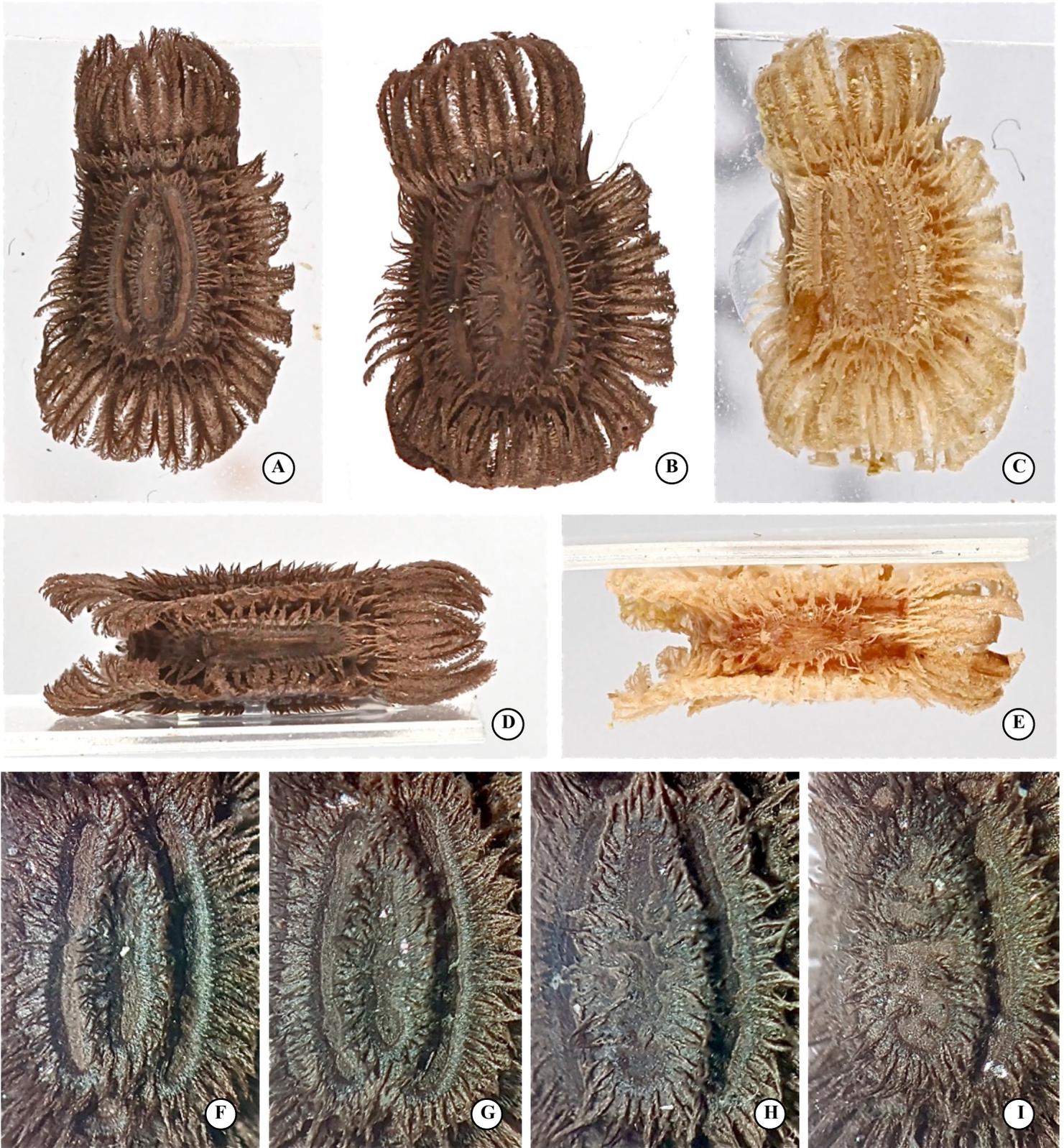


Fig. 8. - *Phyllium (Phyllium) hausleithneri* Brock, 1999; eggs. - **A:** Lateral, Tapah, Malaysia [Coll RC 18-003]. - **B:** Lateral, Tapah, Malaysia [Coll RC 18-004]. - **C:** Lateral, Sumatra [Coll RC 17-380]. - **D:** Dorsal, Tapah, Malaysia [Coll RC 18-003]. - **E:** Dorsal, Sumatra [Coll RC 17-377]. - **F-I:** Lateral close up views of the variable pattern in the center, Tapah, Malaysia [Coll RC 18-002--18-005].

Variation

Males. – Males show moderate variation, mostly notable in the abdomen, with the legs and thorax with a rather uniform morphology. Abdominal width ranged from 23.0-27.3 mm, with those with wider abdomens having slightly more pronounced rounded edges but not by a notable amount. Size of eye spots on abdominal segment V ranged from 1.1 mm to 2.5 mm, with centers that could be brown or slightly transparent. Size of eye spots on abdominal segment V did not necessarily correspond to the width of the abdomen, as moderate width individuals had a wide range of eye spot sizes. Another feature that was only weakly variable was the size of the small serration of the exterior lobe of the profemora, which ranged from almost not noticeable to small finely pointed teeth. This feature did not appear to be linked to the robustness of the body as all moderately size individuals expressed this feature differently.

The two males examined from Peninsular Malaysia showed an average range of features with all variable features clearly falling within the range of those noted from the Bornean population. With *Ph. (Pu.) mannani* now also known from Peninsular Malaysia, it will be interesting to see if Sumatra has *Ph. (Pu.) mannani* as well, or has the recently described species *Phyllium (Pu.) shurei* Cumming and Le Tirant, 2018, or a yet to be described adelphotaxon.

Phyllium (Pulchrphyllium) bioculatum Gray, 1832

(Fig. 11)

Material examined [6 ♂]

MALAYSIA:

- 2 ♂: Perak, Cameron Highlands, March, 2012 [Coll RC 16-001,002]
- 1 ♂: Cameron Highlands, June, 2010 [Coll RC 16-149]
- 1 ♂: Cameron Highlands, August, 2016 [Coll RC 17-224]
- 1 ♂: Cameron Highlands, April, 2016 [Coll RC 17-225].

INDONESIA:

- 1 ♂: Sumatra: Lebong Tandai. 14.VII.1921. C.J.Brooks. B.M. 1936-681 [Catalogue# NHMUK012497233].

Variation

Males. – Males exhibit moderate variation in the abdomen (general shape and size of eye spots on abdominal segment V) and lobes of the pro-, meso-, and metafemora. As expected from these moderately variable features, not only were both extremes observed, but also intermediate forms from throughout the spectrum. Other morphological features were less variable between individuals, even between individuals with variable features which were expressed on opposite ends of the spectrum.

Maximum abdominal width varied little, ranging from 24.1-25.3 mm, instead the variation was observed in the lateral margins of segments V-VII ranging from distinctly parallel to subparallel. This feature is only worth mentioning because of the size of the abdomen and this slight variation quickly catches the eyes attention, despite the only slight variation that is measurable. Size of eye spots on abdominal segment V were more distinct however, and ranged from 1.9 mm to 3.9 mm, all with coloring that was brown with a slightly transparent center, which varied in size depending on the overall eye spot diameter. The pro-, meso-, and metafemora exhibited some of the most drastic variation of morphologies, with the size of serration present on the lobes consistently larger or consistently smaller between the various lobes of individuals. As with the

other variable features, this range in serration size was also noted to have intermediate individuals with serration of medium size.

The male examined from Sumatra clearly fell within the intraspecies variation of the specimens examined from Peninsular Malaysia and due to the proximity of the two localities it is not surprising that *Ph. (Pu.) bioculatum* is also found on Sumatra. As a species which has shown a moderate range of morphologies, even within only relatively small sample sizes, it must be stressed that future authors should examine series of specimens whenever possible to better understand intraspecies variation to avoid the naming of synonyms based solely on common, easily detectable variations.

Other likely species found on Sumatra as noted from past authors

Klante, 1976

The female specimen figured by Klante in 1976 (page 75, fig. 11) appears likely to be *Ph. (Ph.) hausleithneri* but without seeing the specimen in person this observation cannot be confirmed. Hennemann *et al.* 2009 believe this was a separate species from the limited morphology shown in Klante's illustration. However, when a wide range of *Ph. (Ph.) hausleithneri* are observed the features shown on the illustration do not seem out of the range of common features exhibited in the moderately lobed forms of the population. Without seeing the specimen in person it is impossible to positively identify the species, however based on observations of a wide range of individuals, the specimen illustrated in Klante is likely the Sumatran population of *Ph. (Ph.) hausleithneri*.

Klante also illustrates a female that appears to be a member of the *celebicum* species-group (page 75, fig. 5) which he lists as *Phyllium (Ph.) westwoodii* Wood-Mason, 1875. This female instead likely represents a female *Phyllium (Ph.) chrisangi* Seow-Choen, 2017b., which at present is confirmed as occurring in the country of Singapore, a short distance from Sumatra. Without fresh material from the *celebicum* species-group from Sumatra, this identification and presence cannot be confirmed.

Lucas, 1857

In 1857 Lucas described the species *Phyllium magdelainei* Lucas, 1857 which he appears to have named in honor of a Mr. Magdelaine, marine officer on the ship Duroc. Despite the ship's unfortunate sinking, Magdelaine still managed to bring back Sumatran specimens for Lucas to study and attempt to rear (Lucas, 1857). This species, was later synonymized with *Phyllium (Pulchrphyllium) pulchrifolium* by Klante in 1976, a synonym which has been recognized since. Examination of a photo of the holotype of *Phyllium magdelainei* (in Brock *et al.*, 2018) confirms this as a synonym of *Phyllium (Pu.) pulchrifolium* [type locality Java, just to the south of Sumatra.] The synonymy is likely to remain valid, although it would be useful to examine a series from Sumatra.

Males of *Phyllium (Pulchrphyllium) pulchrifolium* from Java show a moderate variation in morphology so it is likely that Sumatran males will also have a range of morphologies. Several features that have been noted by the authors as variable including, overall body length, size of the eyespots on abdominal segment V, and the size of the lobes of abdominal segment VIII but only moderately. All other features appear to be relatively more stable in males.



Fig. 9. - Holotype female *Phyllium (Phyllium) rubrum* Cumming, Le Tirant & Teemsma n. sp. [Coll RC 17-204]. - A: Dorsal view. - B: Ventral view. - C: Close up of antennae, head, and thorax. - D: Close up of genitalia, ventral view.

Rehn and Rehn, 1933

The female specimen illustrated in Rehn and Rehn, 1933 (plate 16, fig. 1) is stated as coming from Nias island a small island off the northwest coast of Sumatra and was listed as *Phyllium* (*Pu.*) *pulchrifolium*. This female morphologically appears more similar to *Phyllium* (*Pu.*) *agathysus* Gray, 1843 but with tegmina that are longer than average *Phyllium* (*Pu.*) *agathysus* coming from Sri Lanka. Perhaps fresh material from Nias island will clarify this.

Conclusional notes on species distribution in Sumatra

With the above species discussed and several distribution ranges expanded, a clearer picture of the biogeographical distribution of the phylliids of Sumatra is beginning to form. The presence of several Peninsular Malaysian species in Sumatra is not surprising due to the islands close proximity to the peninsula. The further distribution onto the large island of

Borneo is more surprising however, because of the greater distance of the islands. It is our hopes that a greater understanding of the phylliid diversity on Sumatra will prompt others to conduct additional research into the islands elusive species. Hopefully future genetic analysis will help reveal the underlying relationship of these widely distributed species. It should be noted that throughout this work, and within the following key, *Ph.* (*Pu.*) *bioculatum* Gray, 1832, *Ph.* (*Pu.*) *pulchrifolium* Audinet-Serville, 1838, and *Ph.* (*Pu.*) *agathysus* Gray, 1843, are referred to as separate species as per the original authors descriptions. This is based on a combination of records of overlap between distributions, and the consistent morphological characteristics expressed between the different species, which easily distinguish them. Future genetic analysis will further reveal their relationships with more clarity, but for now based upon material examined, they are treated as valid species.

Key to known female *Phyllium* of Peninsular Malaysia, Singapore, and Sumatra.

Localities are given with the following abbreviations following the species and author information: Peninsular Malaysia (PM); Singapore (SI); Sumatra (SU).

1. Meso- and metatibiae with exterior lobes: [subgenus (*Pulchriphyllium*)] 2.
– Meso- and metatibiae without exterior lobes: [subgenus (*Phyllium*)] 5.
2. Large species (106.7-117.0 mm); gonapophyses long, reaching very near to or to the apex of the anal abdominal segment
..... *Ph.* (*Pu.*) *giganteum* Hausleithner, 1984 (PM, SU)
- Medium sized species (76.1-89.8 mm); gonapophyses very short, only slightly protruding from under the anal abdominal segment, leaving most of the ventral aspect of the segment exposed 3.
3. Abdominal segment VIII lobed, not uniformly converging, giving the abdomen a broad rectangular appearance 4.
– Abdominal segment VIII uniformly converging, not lobed or broad, giving the abdomen a spade shaped appearance
..... *Ph.* (*Pu.*) *bioculatum* Gray, 1832 (PM, SI, SU)
4. Posterior margin of exterior lobe of the profemora straight, with only slight serration at most; protibiae exterior lobe thin, generally thinner than width or at most the same width as the shaft of the protibiae *Ph.* (*Pu.*) *abdufatahi* Seow-Choen, 2017a. (PM, SU)
– Posterior margin of exterior lobe of the profemora not straight, curved with obvious serration on the margin; protibiae exterior lobe wide, always wider than the width of the protibiae shaft *Ph.* (*Pu.*) *pulchrifolium* Audinet-Serville, 1838 (SU)
5. Alae developed: [celebicum species-group] *Ph.* (*Ph.*) *chrisangi* Seow-Choen, 2017b. (SI)
– Alae rudimentary: [siccifolium species-group] 6.
6. Meso- and metacoxae purple in color; mesopraescutum lateral margins with nodes that are of an even size from the anterior to the posterior *Ph.* (*Ph.*) *hausleithneri* Brock, 1999 (PM, SI, SU)
– Meso and metacoxae orange to red in color; mesopraescutum lateral margins with nodes that steadily increase in size from the anterior to the posterior *Ph.* (*Ph.*) *rubrum* Cumming, Le Tirant & Teemsma n. sp. (PM)

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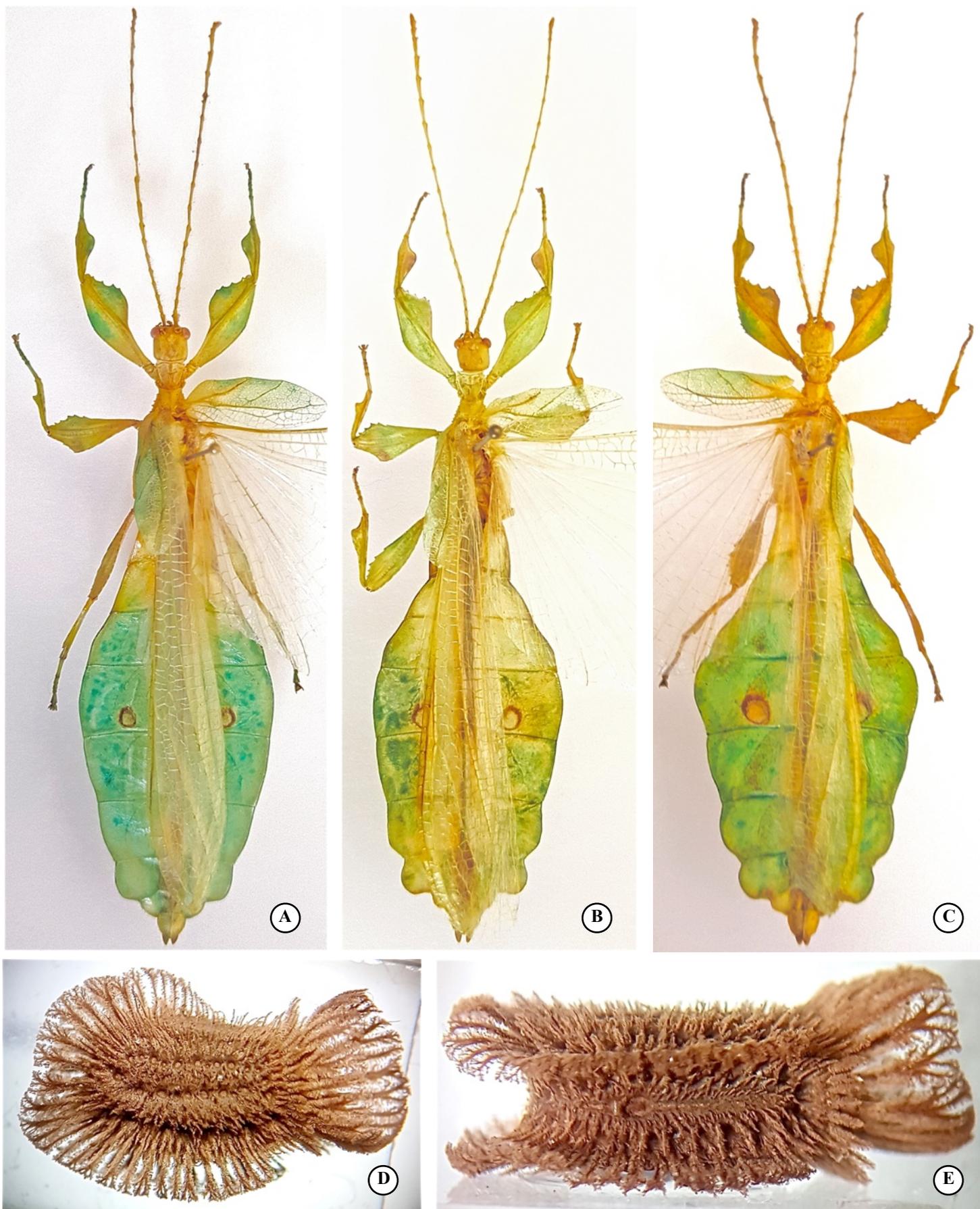


Fig. 10. - **A-C:** Male *Phyllium (Pulchriphyllium) rimiae* Seow-Choen, 2017a. - **A:** Sabah, North Borneo, Mt. Trus Madi, [Coll RC 17-281]. - **B:** Malaysia, Cameron Highlands, [Coll RC 17-223]. - **C:** Sabah, North Borneo, Mt. Trus Madi, [Coll RC 17-282]. - **D-E:** Egg of *Phyllium (Ph.) rubrum* Cumming, Le Tirant & Teemsma **n. sp.** - **D:** Lateral view, showing standard design of the pinnae [Coll RC 1-016]. - **E:** Dorsal view, showing micropylar plate [Coll RC 18-016].

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Résumé

Cumming R. T., Le Tirant S. & Teemsma S. N., 2018. – Note sur les *Phyllium* de la péninsule Malaise et de Sumatra, Indonésie, avec des informations sur la répartition géographique des espèces actuellement connues, description de la femelle de *Phyllium* (*Pu.*) *abdufatahi* Seow-Choen et description d'une nouvelle espèce *Phyllium* (*Ph.*) *rubrum* n. sp. (Phasmida : Phylliidae). *Faunitaxys*, 6(2) : 1 – 21.

La diversité des *Phyllium* de la péninsule Malaise et de Sumatra, en Indonésie, est discutée à partir de mentions récentes et de références plus anciennes. La femelle de *Phyllium* (*Pulchriphyllium*) *abdufatahi* Seow-Choen, 2017a., jusqu'alors inconnue, est décrite et illustrée, et l'aire de répartition de l'espèce est précisée. Une extension de l'aire de répartition de *Phyllium* (*Pulchriphyllium*) *giganteum* Hausleithner, 1984, à Sumatra et dans d'autres régions de Bornéo, est discutée avec les mentions correspondantes. *Phyllium* (*Phyllium*) *hausleithneri* Brock, 1999 est également nouvellement mentionnée à Sumatra, avec des notes sur la variation intraspécifique et les figures correspondantes des femelles et des œufs. Une nouvelle espèce *Phyllium* (*Ph.*) *rubrum* Cumming, Le Tirant & Teemsma n. sp. est décrite et illustrée en provenance de Perak, en Malaisie. Les distributions géographiques de *Phyllium* (*Pu.*) *mannani* Seow-Choen, 2017a. et de *Phyllium* (*Pu.*) *rimiae* Seow-Choen, 2017a. sont élargies pour inclure la péninsule Malaise, celle de *Phyllium* (*Pu.*) *bioculatum* Gray, 1832 pour inclure Sumatra, et des informations sur la variation intraspécifique des mâles sont incluses. Enfin, la nouvelle espèce *Phyllium* (*Ph.*) *rubrum* Cumming, Le Tirant & Teemsma n. sp. étant décrite à partir d'une femelle, une clé des femelles des espèces du genre *Phyllium* de Sumatra, de Singapour et de la péninsule Malaisie est incluse.

Mots-clés. – Phasmatoidea, Phasmida, Phylliinae, Phylliini, *Phyllium*, Malaisie, Sumatra, Indonésie, *abdufatahi*, *rubrum*, description, espèce nouvelle.

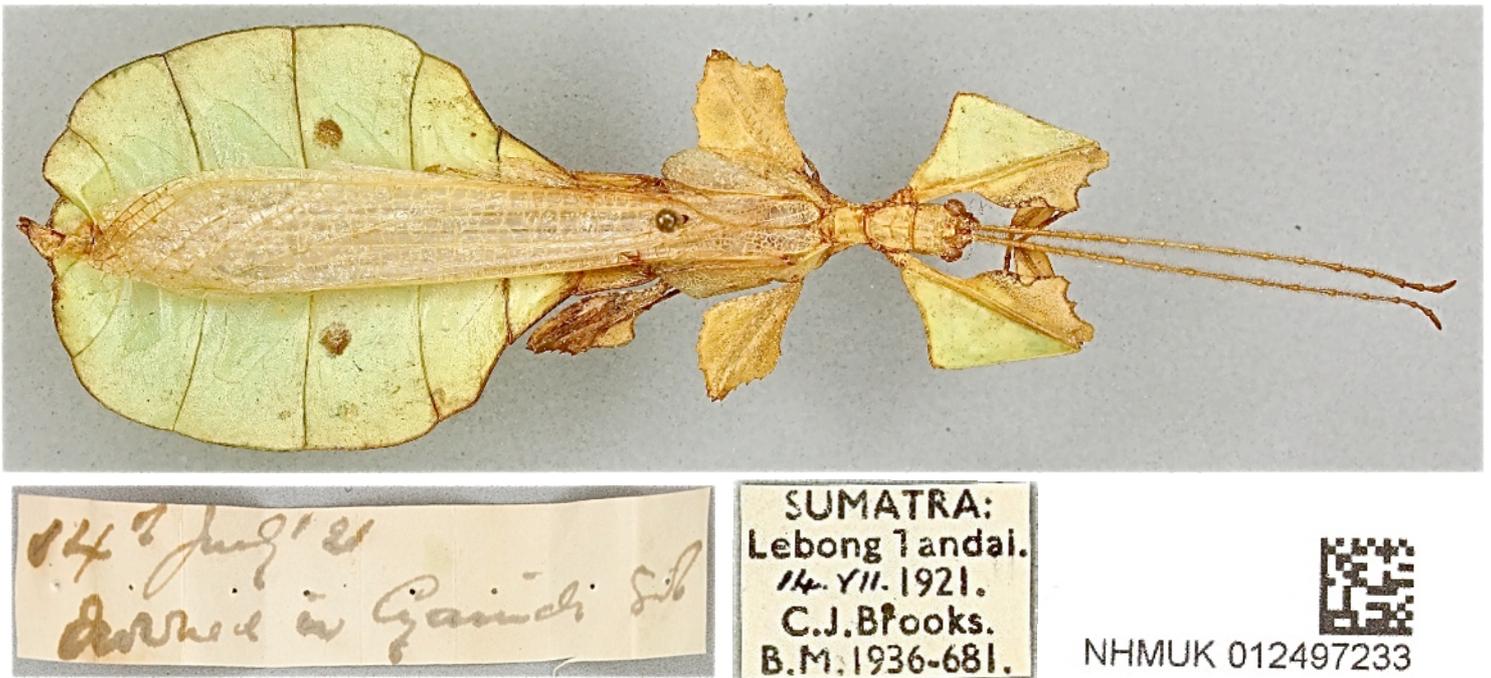


Fig. 11. - *Phyllium (Pu.) bioculatum* Gray, 1832, male (Natural History Museum United Kingdom collection).

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On the *Phyllium* of Peninsular Malaysia and Sumatra, Indonesia, with range expansions for currently known species, description of the previously unknown *Phyllium* (*Pu.*) *abdufatahi* Seow-Choen female, and description of the new species *Phyllium* (*Ph.*) *rubrum* **n. sp.** from Peninsular Malaysia (Phasmida: Phylliidae)

Royce T. Cumming, Stéphane Le Tirant & Sierra N. Teemsma 1 – 21

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