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Vol. 48, no. 1, pp. 1–80, June 2021

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CONTENT

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Date of issue: 30 JUNE 2021

UDC: 595.79(594)

Danu Dwi Sutanto

To the knowledge of the velvet ant genus *Bischoffitilla* Lelej (Hymenoptera: Mutillidae) in Indonesia

TREUBIA, June 2021, Vol. 48, No. 1, pp. 1–12.

Seven species of the genus *Bischoffitilla* Lelej were previously known from Indonesia. *Bischoffitilla selangorensis* (Pagden, 1934) is newly recorded from Indonesia. *Bischoffitilla palaca* (Cameron, 1902) is newly recorded from Java, and *B. saffica* (Zavattari, 1914) from Sumatra. Keys to the Indonesian species of *Bischoffitilla* are given.

(Danu Dwi Sutanto, Kevin A. Williams, Hari Nugroho, and Arkady S. Lelej)

Keywords: Java, mutillid wasps, Myrmillinae, Sumatra, Wallace

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UDC: 595.725(594)

Philip Edward Bragg

Records of praying mantids (Insecta: Mantodea) from two areas of Central Kalimantan, and notes on Bornean *Odontomantis* and *Hierodula*

TREUBIA, June 2021, Vol. 48, No. 1, pp. 13–36.

Results are presented for a collection of praying mantids from two different habitats in Kalimantan Tengah: an area of peat-swamp forest and an area of hill forest. Forty-one specimens are recorded, representing 20 species; this is the first such collection to be recorded from Kalimantan after more than 70 years. Photographs are included for a number of species, concentrating on species which have not previously been illustrated. Some issues with the Bornean *Odontomantis* are highlighted and a key to Bornean species is provided. The status of *O. micantula* Beier, 1937 is clarified, the syntypes are located, and the species is illustrated; the synonymy of *O. planiceps* and *O. javana* is questioned. Some historical issues relating to Bornean members of *Hierodula* are reviewed; the synonymy of *H. athene* Rehn, 1909 and *H. hybrida* Burmeister, 1838 and *H. venosa* (Olivier, 1792) is considered doubtful. Issues with identification of *H. venosa* and *H. vitrea* (Stoll, 1813) leave their presence in Borneo questionable.

(Philip Edward Bragg)

Keywords: Borneo, Central Kalimantan. *Hierodula*, Mantodea, *Odontomantis*

UDC: 595.734(594.81)

Thomas Kaltenbach

Discovery of a new mayfly species (Ephemeroptera, Baetidae) near Cenderawasih University campus in Papua, Indonesia

TREUBIA, June 2021, Vol. 48, No. 1, pp. 37–54.

Material collected just behind the Cenderawasih University campus in Jayapura, Papua Province, Indonesia, revealed a new species of the *Labiobaetis claudiae* group, which is here described and illustrated based on larvae, subimago, male and female imagos. The total number of *Labiobaetis* species on the island New Guinea increased to 33, the total number for Indonesia increased to 26, and the total number of *Labiobaetis* species worldwide is augmented to 147. A key to the larvae of the *L. claudiae* group is provided. The interspecific K2P distances between species of the *L. claudiae* group are between 20% and 23%.

(Thomas Kaltenbach, Suriani Surbakti,
Jean-Luc Gattolliat, Michel Sartori,
and Michael Balke)

Keywords: Integrative taxonomy, New Guinea, species discovery

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UDC: 595. 789(594.31)

Djunijanti Peggie

Assessing in-situ semi-natural butterfly breeding approach of *Ornithoptera croesus* (Papilionidae) on Bacan Island, Maluku Utara, Indonesia

TREUBIA, June 2021, Vol. 48, No. 1, pp. 55–68.

Indonesia is rich in endemic species of flora and fauna. One of them is *Ornithoptera croesus* butterfly, which is endemic to North Maluku. Habitat degradation and trade of this species have caused the populations to decline. To avoid the collection of butterfly specimens from nature and to preserve their habitat and population in nature, a semi-natural butterfly breeding practice at Bacan Island was initiated in 2013. This research was conducted to assess the breeding approach for *O. croesus lydius* using a qualitative descriptive method. The assessment was based on these variables: the specific ecology of the butterfly; the suitability of the breeding site and development model; the utilization of larval host plants and butterfly nectar plants; and the establishment of the birdwing population at the site. The observations and results are presented here. Based on the assessment, the in-situ semi-natural breeding approach is one of the solutions for sustainable use of this protected species.

(Djunijanti Peggie, Duncan Neville,
Sarino, and Sih Kahono)

Keywords: birdwing butterfly, breeding, conservation, *Ornithoptera croesus*, sustainable use

UDC: 595.132:599.323.4(594.1)

Hideo Hasegawa

Larvae and adults of *Ascarops* sp. (Nematoda: Spirocercidae) collected from the stomach of *Maxomis whiteheadi* (Rodentia: Murinae) in Kalimantan, Indonesia

TREUBIA, June 2021, Vol. 48, No. 1, pp. 69–80.

Third-stage larvae and adults of spiruroid nematodes were found from the stomach wall and stomach lumen, respectively, of *Maxomys whiteheadi* (Rodentia: Murinae) captured in Bukit Soeharto, Kalimantan, Indonesia. Close observation using light microscope and scanning electron microscope (SEM) revealed that it belongs to the genus *Ascarops* (Nematoda: Spirocercidae), possibly to *Ascarops strongylina* (Rudolphi, 1819). It is presumed that this species is parasitic in wild boars, *Sus barbatus*, in the forest of Kalimantan, and utilizes the murine as paratenic host, in which it usually remains as third larval stage but can occasionally develop to adult stage.

(Hideo Hasegawa & Kartika Dewi)

Keywords: *Ascarops,* Kalimantan, *Maxomys whiteheadi,* Nematoda

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TO THE KNOWLEDGE OF THE VELVET ANT GENUS *BISCHOFFITILLA* LELEJ (HYMENOPTERA: MUTILLIDAE) IN INDONESIA

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ABSTRACT

Seven species of the genus *Bischoffitilla* Lelej were previously known from Indonesia. *Bischoffitilla selangorensis* (Pagden, 1934) is newly recorded from Indonesia. *Bischoffitilla palaca* (Cameron, 1902) is newly recorded from Java, and *B. saffica* (Zavattari, 1914) from Sumatra. Keys to the Indonesian species of *Bischoffitilla* are given.

Keywords: Java, mutillid wasps, Myrmillinae, Sumatra, Wallace

ABSTRAK

Tujuh spesies dari marga *Bischoffitilla* Lelej sebelumnya telah diketahui berasal dari Indonesia. *Bischoffitilla selangorensis* (Pagden, 1934) merupakan catatan baru dari Indonesia. *Bischoffitilla palaca* (Cameron, 1902) merupakan catatan baru dari Jawa, dan *B. saffica* (Zavattari, 1914) dari Sumatera. Kunci identifikasi untuk spesies *Bischoffitilla* dari Indonesia diberikan.

Kata kunci: Jawa, tawon mutillid, Myrmillinae, Sumatera, Wallace

INTRODUCTION

The study of Mutillidae in Indonesia was started by the eminent naturalist Alfred Russel Wallace (*Wallacidia* Lelej et Brothers, 2008 is a mutillid genus dedicated to him). Alfred Wallace spent several years in the Netherlands-Indies collecting specimens and gathering data regarding geographical distribution of animals (Mickel, 1935). Based on the insect specimens collected by Wallace, Frederick Smith described and recorded 37 species of Mutillidae from the East Indian Islands (Smith, 1858, 1859, 1860a, 1860b, 1861-1862, 1863, 1865, 1879).

Currently, 91 species in 25 genera of mutillid wasps are known from Indonesia (Mickel, 1935; Pagden, 1949; Lelej, 2005; Pagliano et al., 2020). Most of these species were described from the island of Java. Here we summarize data on the genus *Bischoffitilla* Lelej from Indonesia with one newly recorded species and provide a key to the eight species that are distributed in the islands of Indonesia.

MATERIALS AND METHODS

Specimens were photographed using a Leica MC170 HD camera attached to a Leica MC165 C stereoscope.

The following codens are used for collections housing the material studied herein.

BMNH – The Natural History Museum, London, Greater London, U.K.

EMUS – Department of Biology Insect Collection, Utah State University, Logan, Utah, USA.

MZB – Museum Zoologicum Bogoriense, Indonesian Institute of Sciences, Cibinong, Indonesia.

RMNH – Naturalis Biodiversity Center, Leiden, South Holland, the Netherlands.

SKYC – Seiki Yamane Collection of Mutillidae, temporarily deposited in Federal Scientific Center of the East Asia Terrestrial Biodiversity (formerly Institute of Biology and Soil Science), Vladivostok, Russia.

UMSP – University of Minnesota Insect Collection, St. Paul, Minnesota, USA.

RESULTS

Systematics

Genus *Bischoffitilla* Lelej, 2002

Bischoffitilla Lelej, 2002: 126. Type species: *Squamulotilla exilipunctata* (Chen, 1957), by original designation.

Squamulotilla: Mickel, 1935: 183.

Diagnosis. MALE. Mandible not widened apically, inner border with two small preapical denticles and larger basal one. Length of flagellomere 1 almost equal to flagellomere 2. Metasomal sternum 2 often with highly elevated median carina. Metasomal sternum 8 (hypopygium) not membranous laterally, with medial carina (tubercle) or lateral carinae (tubercles). FEMALE. Mesopleural suture complete and connecting with mesonotal tubercle; inner margin of mandible with distinct tooth in basal third; metasomal tergum 1 with apicomedial setal spot that sometimes extending to base of tergum 2; and tergum 2 with thick apical setal or cuticular band or medial spot. For additional diagnostic features, see Lelej (2002) .

Species included. The genus *Bischoffitilla* currently includes 75 described species, 70 of them are known from the Oriental region and five from the Palaearctic (Lelej, 2002 update, 2005; Williams et al., 2019). Seven species are known from Indonesia: *Bischoffitilla aesyca* (Cameron, 1902), ♀; *B. deserta* (Smith, 1879), ♀; *B. facilis* (Smith, 1860), ♂; *B. muiri* (Mickel, 1935), ♂; *B. multidentata* (André, 1896), ♀; *B. palaca* (Cameron, 1902), ♂; *B. saffica* (Zavattari, 1914), ♀, and in this paper we add newly recorded from Indonesia the eighth species *B. selangorensis* (Pagden, 1934) (Sumatra).

Key to the species of *Bischoffitilla* from Indonesia

Females (unknown for *B. facilis*, *B. muiri*, and *B. palaca*)

1. Propodeum with a transverse row of long vertical teeth at the junction of the posterior and dorsal surfaces ………………………………………………………………….... 2

– Propodeum slightly serrate, but without a transverse row of long, vertical teeth at the junction of the posterior and dorsal surfaces ……………………………………….. 3

2. Metasomal terga 3–5 with small apicomedial spot of golden setae. Teeth of propodeal transverse row more or less equal in the length. Metasomal tergum 1 with medial spot and metasomal tergum 2 with apical band of silvery or golden setae only, cuticle mostly black beneath markings. Gena without distinct, dentate carina. Posterior propodeal face broadly areolate …………………………………………………..……. **B. deserta** (Smith)

– Metasomal terga 3–5 without small apicomedial spot of golden setae. Teeth of propodeal transverse row differing in length: median and lateral longest, teeth between them short ……………………………………………………..… **B. selangorensis** (Pagden)

3. Head with vertex largely reddish. Metasomal markings formed of silvery setae ……….... ……………………………………………………………... **B. aesyca** (Cameron)

– Head entirely black. Metasomal markings formed of pale-yellow setae ………………. 4

4. Propodeum dorsally with prominent medial tooth. Metasomal terga 4–5 with medial spot of pale setae ……………………………………………………. **B. saffica** (Zavattari)

– Propodeum dorsally without prominent medial tooth, at most with transverse, slightly serrate carina at posterior margin. Mesoscutum with distinct, medial, longitudinal carina. Scape and tibiae blackish ………………………..…… **B. multidentata** (André)

Males (unknown for *B. aesyca*, *B. deserta*, *B. multidentata*, *B. saffica*, and *B. selangorensis*)

1. Fore wing with two submarginal cells. Hypopygium armed with two oblique raised carinae baso-laterally ……………………………..………….. ***B. palaca*** (Cameron)

– Fore wing with only one submarginal cell. Hypopygium unarmed or with obscure medial arcuate swelling basally ……………………………………………..………………. 2

2. Metasomal terga 2-4 each with yellow apicomedial cuticular spot. Hypopygium with medial arcuate swelling ……………………………..…………….. ***B. muiri*** (Mickel)

– Only metasomal tergum 2 with yellow apical cuticular band. Hypopygium flat, without arcuate swelling ……………………………………………………. ***B. facilis*** (Smith)

Catalogue of the species

1. ***Bischoffitilla aesyca*** (Cameron, 1902). Figs 1, 2.

Mutilla aesyca Cameron, 1902: 208, ♀ (Malaysia: "Borneo").
Squamulotilla aesyca: Mickel, 1935: 194, ♀ (Malaysia: Sarawak, Sabah), Indonesia (Borneo: West Kalimantan); Pagden, 1949: 226, ♀ (West Java).
Bischoffitilla aesyca: Lelej, 2005: 23.

Diagnosis. FEMALE. Propodeum slightly serrate, without transverse row of long, vertical teeth at the junction of the posterior and dorsal surfaces. Median spot on metasomal tergum 1 and apical band on metasomal tergum 2 white, maculations formed only by silvery setae. Metasomal tergum 3 entirely with black setae. Head largely ferruginous; apical margin of metasomal tergum 5 with band of appressed, silvery setae. MALE. Unknown.

Material examined. INDONESIA: Borneo [*West Kalimantan*], Pontianak, 1♀, leg. F. Muir (UMSP, compared with type by C.E. Mickel in 1931).

Distribution. Indonesia (West Java, West Kalimantan), Malaysia (Sarawak, Sabah) (Mickel, 1935).

2. ***Bischoffitilla deserta*** (Smith, 1879). Figs 3, 4.

Mutilla deserta Smith, 1879: 200, ♀ "Celebes".
Squamulotilla deserta: Mickel, 1934: 109, ♀ (Philippines, Luzon); Pagden, 1949: 225, ♀ (Java, Kangean Islands).
Bischoffitilla deserta: Lelej, 2005: 25.

Diagnosis. FEMALE. Propodeum with a transverse row of three long vertical teeth at the junction of the posterior and dorsal surfaces. Median spot on metasomal tergum 1 and apical band of metasomal tergum 2 pale, the maculations formed by silvery or golden pubescence only, cuticle mostly black beneath markings. Posterior margin of gena without a distinct, dentate carina. Metasomal terga 3-5 each with a small, apical, median spot of pale setae. Posterior propodeal face broadly areolate. MALE. Unknown.

Material Examined. INDONESIA: *West Java*: Cibinong, Bogor, 6,494361°S 106,852545°E, 27.XI.2017, 1♀, leg. D. Sutanto (MZB); Jasinga near Bogor, 5.XI.1985, 1♀, leg. Sk. Yamane (SKYC). PHILIPPINES: *Rizal*, Antipolo, 6.IX.1952, 1♀, leg. Townes Family (EMUS).

Distribution. Indonesia (Sulawesi, Kangean Islands, Java), Philippines (Luzon) (Mickel, 1935; Pagden, 1949; Lelej, 2005).

3. ***Bischoffitilla facilis*** (Smith, 1860). Figs 5, 6.

Mutilla facilis Smith, 1860: 76, ♂ ("Makassar").
Squamulotilla facilis: Mickel, 1935: 186, ♂.
Bischoffitilla facilis: Lelej, 2005: 26.

Diagnosis. MALE. Fore wing with one submarginal cell. Lateral margins of pronotum prominently angulate medially. Only metasomal tergum 2 with a narrow, pale yellow, integumental stripe at the apical margin. Hypopygium flat, lacking basal carina or swelling. FEMALE. Unknown.

Material examined. INDONESIA: *Southwest Sulawesi*, Gn. Bulusaraung, near Camba Malawa, Malaise trap 3, 750 m, 7.II-28.III.1995, 1♂, leg. C.v. Achterberg and Y. Yasir (RMNH).

Distribution. Indonesia (Sulawesi) (Mickel, 1935).

4. ***Bischoffitilla muiri*** (Mickel, 1935). Figs 7, 8.

Squamulotilla muiri Mickel, 1935: 186, ♂ ("Java, Buitenzorg" [Cibinong]).
Bischoffitilla muiri: Lelej, 2005: 27.

Diagnosis. MALE. Fore wing with one submarginal cell. Lateral margins of pronotum prominently angulate medially. Metasomal terga 2–4 with a narrow, pale yellow, integumental stripe at the apical margin, not extending to the lateral margins. Hypopygium basally with obscure raised arch-like medial shelf. FEMALE. Unknown.

Material examined. INDONESIA: *Java*, Goenoeng Gedeh, III.1911, 1♂, leg. E. Jacobson (RMNH).

Distribution. Indonesia (Java) (Mickel, 1935).

Figures 1-6. Photographs of : **1, 2.** *Bischoffitilla aesyca*, female; **3, 4**. *B. deserta*, female; **5, 6.** *B. facilis*, male; 1, 3. Habitus, dorsal view; 2, 4, 6. Habitus, lateral view; 5. Head, frontal view.

5. ***Bischoffitilla multidentata*** (Andre, 1896). Figs 9, 10.

Mutilla multidentata André, 1896: 76, ♀ ("Si-Rambé" [North Sumatra], "Perak" [Malaysia]).
Odontomutilla multidentata: Zavattari, 1914: 68, ♀ (Simalu [=Simeulue Island, westward of Sumatra]).
Squamulotilla multidentata: Mickel, 1935: 193, ♀.
Bischoffitilla multidentata: Lelej, 2005: 27.

Diagnosis. FEMALE. Propodeum slightly serrate, without a transverse row of long, vertical teeth at the junction of the posterior and dorsal surfaces. Median spot on metasomal tergum 1 and apical band of metasomal tergum 2 white. Propodeum dorsally without a median tooth, at the most with a transverse, slightly serrate carina at the posterior margin. Lateral margins of mesonotum conspicuously dentate. Mesonotum with a distinct, median, longitudinal carina. MALE. Unknown.

Material examined. INDONESIA: *North Sulawesi*, Dumoga-Bone National Park, ca. 220 m, near Base Camp Toraut River, 0°34′N 123°54′E, 22.XI.1985, 1♀, leg. C. v. Achterberg (RMNH).

Distribution. Indonesia (Simeulue, Sulawesi, Sumatra), Malaysia (Perak) (André, 1896; Zavattari, 1914; Mickel, 1935).

6. ***Bischoffitilla palaca*** (Cameron, 1902). Figs 11, 12.

Mutilla palaca Cameron, 1902: 80, ♂ ("Kuching" [Malaysia: Sarawak]).
Squamulotilla palaca: Mickel, 1935: 188, ♂.
Bischoffitilla palaca: Lelej, 2005: 28; Lo Cascio, 2015: 546 (Sumatra).

Diagnosis. MALE. Fore wing with two submarginal cells. Lateral margins of pronotum not angulate medially. Metasomal tergum 2 with a narrow, pale yellow, integumental stripe at the apical margin, not extending to the lateral margins. Hypopygium basally with two oblique raised carinae. FEMALE. Unknown.

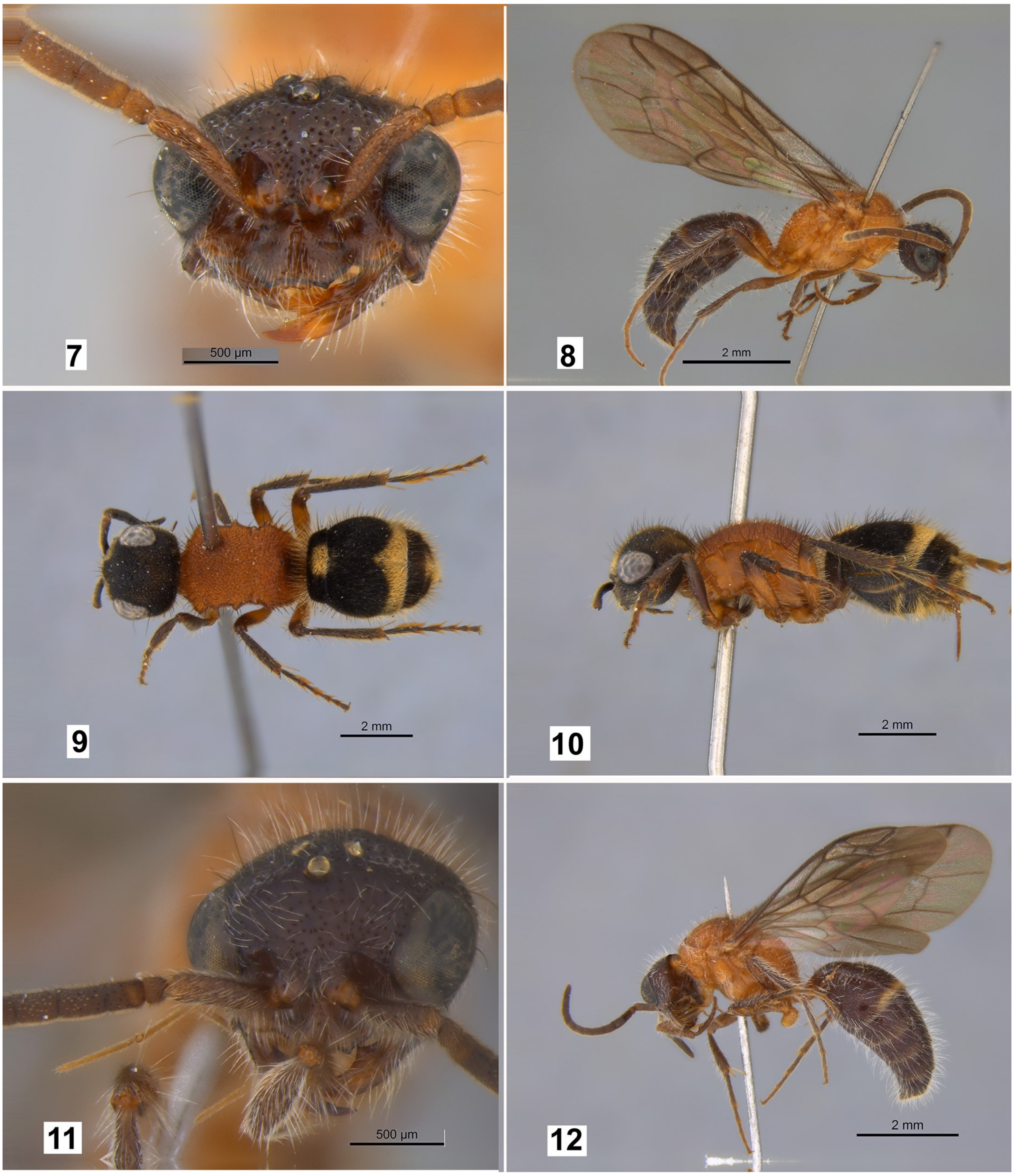
Material examined. INDONESIA: *West Java*, West Priangan, 1800 to 2400 ft., 4-12.XI.1941, 1♂, leg. J.M. A.V. Groenendael (RMNH).

Distribution. Indonesia (Sumatra, Java), Malaysia (Sarawak) (Cameron, 1902).

Remarks. This species is newly recorded from Java.

7. ***Bischoffitilla saffica*** (Zavattari, 1914). Figs 13, 14.

Odontomutilla saffica Zavattari, 1914: 68, ♀ ("Celebes: Minahassa, Pangie").
Squamulotilla saffica: Mickel, 1935: 193, ♀ (Sulawesi).
Bischoffitilla saffica: Lelej, 2005: 28.



Figures 7-12. Photograph of: 7, 8. *Bischoffitilla muiri*, male; 9, 10. *B. multidentata*, female; 11, 12. *B. palaca*, male; 7, 11. Head, frontal view; 8, 10, 12. Habitus, lateral view; 9. Habitus, dorsal view.

Diagnosis. FEMALE. Propodeum slightly serrate, without a transverse row of long, vertical teeth at the junction of the posterior and dorsal surfaces. Median spot on metasomal tergum 1 and apical band of metasomal tergum 2 white. Propodeum dorsally with a prominent, median tooth. Metasomal terga 4–5 with a median spot of pale pubescence. MALE. Unknown.

Material examined. INDONESIA: *West Sumatra*, Payakumbuh, Harau Valley, 1000 m, 9-29.X.1991, 1♀, leg. A. Riedel (SKYC); *Northeast Sulawesi*, 47 km WSW Kotamobagu Dumoga-Bone National Park, Toraut (base camp), 211 m, IV.1985, G.R. Else, Project Wallace (BMNH).

Distribution. Indonesia (Sulawesi, Sumatra).

Remarks. This species is newly recorded from Sumatra.

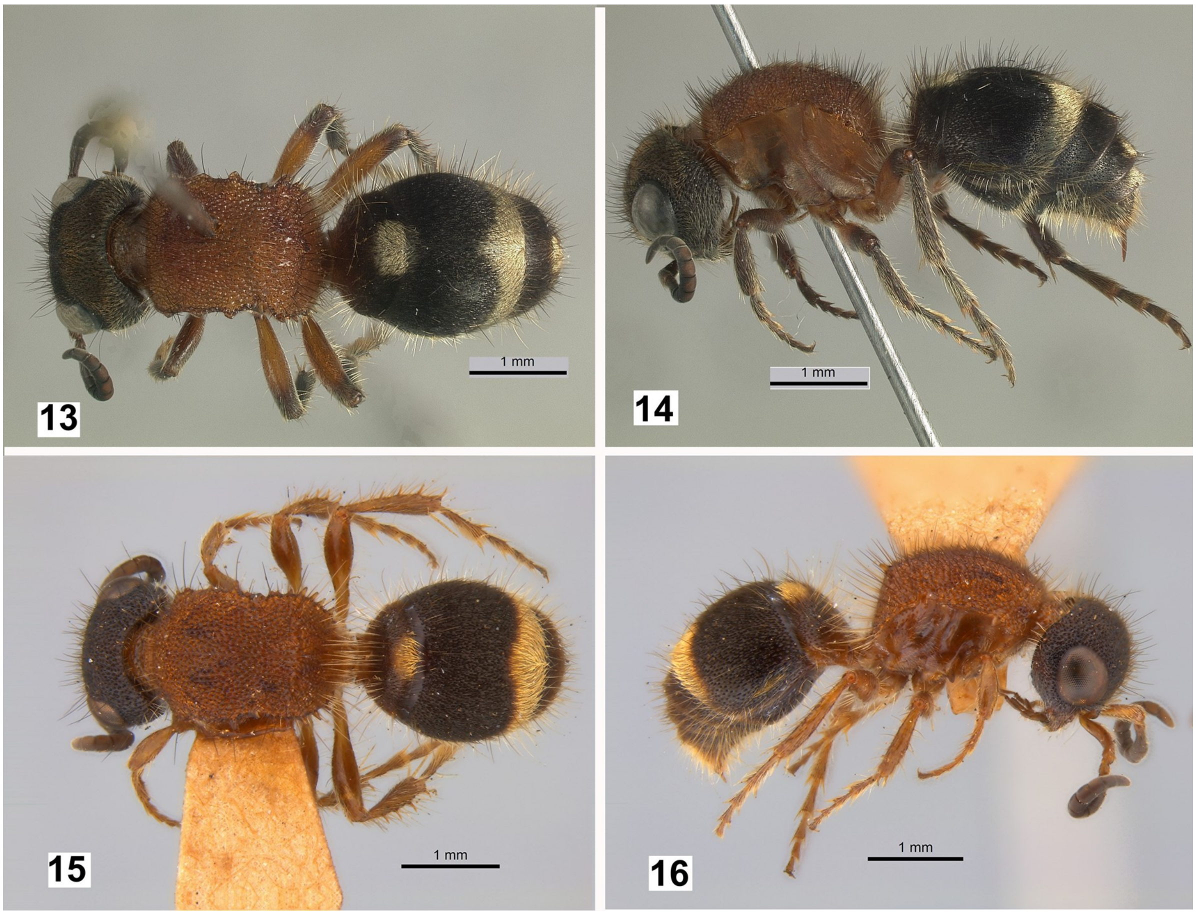
8. ***Bischoffitilla selangorensis*** (Pagden, 1934). Figs 15, 16.

Squamulotilla selangorensis Pagden, 1934: 452, ♀ ("Bukit Kutu" [Malaysia, Selangor]); Mickel, 1935: 196.
Bischoffitilla selangorensis: Lelej, 2005: 29.

Diagnosis. FEMALE. Head black, closely punctate, mandible ferruginous, clypeus, scape and pedicel pale ferruginous, antennal scrobes strongly carinate above. Gena posterad with weak irregular carina. Mesosoma dorsally densely confluently punctate with median pronounced ridge from pronotal area to median spine of propodeal brow; propodeal brow with strong median spine, denticulate laterally, lateral propodeal margin strongly spinose. Metasoma with median apical pale golden spot on tergum 1 and pale golden apical band on tergum 2. MALE. Unknown.

Material examined. INDONESIA: *West Sumatra*, Payakumbuh, Harau Valley, 1000 m, 9–29.X.1991, 1♀, leg. A. Riedel (SKYC). MALAYSIA: *Selangor*, Bukit Kutu, 31.I.1930 (Holotype, BMNH).

Distribution. Indonesia (new record) (Sumatra), Malaysia (Selangor) (Pagden, 1934).



Figures 13-16. Photographs of : 13, 14. *Bischoffitilla saffica*, female; 15, 16. *B. selangorensis*, female; 13, 15. Habitus, dorsal view; 14, 16. Habitus, lateral view.

DISCUSSION

The current number of mutillid species recorded from Indonesia is 93 species in 25 genera, but the true diversity is likely much higher. Recent faunistic studies of velvet ants in other countries have raised their known species diversity. In Thailand, for example, the number of recorded species raised from 33 to 63 (Williams et al., 2019). Furthermore, 68 velvet ant species have been recognized in the Malaysian portion of Borneo (Lelej, 2005); many of these species likely also occur in the Indonesian provinces of East, North, South, and West Kalimantan. A similar situation occurs on the island of New Guinea, where 15 species are known from Papua New Guinea that may also be found in the Indonesian provinces of Papua and West Papua. The true diversity of Indonesia may easily surpass 200 species after further investigation.

As seen above, many velvet ant species are known from a single sex: males only or females only. Of the 93 species in Indonesia, fewer than 20 are recognized from both sexes (Lelej, 2005). Being composed of multiple separated islands, Indonesia provides a unique opportunity for associating males and females of various species because the potential matches can be more easily narrowed down. For example, based on its distribution in Sulawesi, the male of *Bischoffitilla facilis* (Smith, 1860) can be narrowed down to a match with either *B. multidentata* (André, 1896) or *B. saffica* (Zavattari, 1914). Further collecting efforts and documentation of species from specific islands and localities will be vital for better understanding the diversity and variation of these sexually dimorphic wasps.

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RECORDS OF PRAYING MANTIDS (INSECTA: MANTODEA) FROM TWO AREAS OF CENTRAL KALIMANTAN, AND NOTES ON BORNEAN *ODONTOMANTIS* AND *HIERODULA*

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ABSTRACT

Results are presented for a collection of praying mantids from two different habitats in Kalimantan Tengah: an area of peat-swamp forest and an area of hill forest. Forty-one specimens are recorded, representing 20 species; this is the first such collection to be recorded from Kalimantan after more than 70 years. Photographs are included for a number of species, concentrating on species which have not previously been illustrated. Some issues with the Bornean *Odontomantis* are highlighted and a key to Bornean species is provided. The status of *O. micantula* Beier, 1937 is clarified, the syntypes are located, and the species is illustrated; the synonymy of *O. planiceps* and *O. javana* is questioned. Some historical issues relating to Bornean members of *Hierodula* are reviewed; the synonymy of *H. athene* Rehn, 1909 and *H. hybrida* Burmeister, 1838 and *H. venosa* (Olivier, 1792) is considered doubtful. Issues with identification of *H. venosa* and *H. vitrea* (Stoll, 1813) leave their presence in Borneo questionable.

Keywords: Borneo, Central Kalimantan, *Hierodula*, Mantodea, *Odontomantis*

ABSTRAK

Hasil yang disajikan di sini merupakan koleksi belalang sembah dari dua habitat berbeda di Kalimantan Tengah: kawasan hutan rawa gambut dan kawasan hutan perbukitan. Empat puluh satu spesimen dicatat, mewakili 20 spesies; ini adalah koleksi pertama yang dicatat dari Kalimantan setelah lebih dari 70 tahun. Foto-foto disertakan untuk sejumlah spesies, berkonsentrasi pada spesies yang belum pernah diilustrasikan sebelumnya. Beberapa masalah dengan *Odontomantis* Kalimantan disorot dan kunci spesies Borneo disediakan. Status *O. micantula* Beier, 1937 diklarifikasi, sintipe disebutkan, dan spesies diilustrasikan; sinonim *O. planiceps* dan *O. javana* dipertanyakan. Beberapa masalah historis yang berkaitan dengan anggota *Hierodula* di Borneo ditinjau; sinonim *H. athene* Rehn, 1909 dan *H. hybrida* Burmeister, 1838 dan *H. venosa* (Olivier, 1792) dianggap meragukan. Masalah dengan identifikasi *H. venosa* dan *H. vitrea* (Stoll, 1813) membuat keberadaan mereka di Borneo dipertanyakan.

Kata kunci: Borneo, Kalimantan Tengah, *Hierodula*, Mantodea, *Odontomantis*

INTRODUCTION

Praying mantids are one of the most readily recognized type of insect, and are likely to be identified by the general public even in countries where mantids do not occur. Although mantids do use their fore legs when climbing, they are distinguished by their habit of standing on only four legs with their heavily spined fore legs raised above the ground and folded ready to strike at their prey; this behavior is almost unknown in other insect orders. The general public often associate mantids with sexual cannibalism: the females have a reputation for eating the male during copulation; although cannibalism can occur when they are disturbed, the frequency of this under natural conditions is unclear. Mantids will feed both in daylight and at night; they feed mainly on insects, although some large species have been recorded eating birds, mammals and lizards. Females lay their eggs in large batches which are surrounded by a foam which hardens into a protective casing known as an ootheca. Females are heavier than males because of the eggs and therefore generally do not fly as readily as males; this is most evident in large species where a heavily laden female may be incapable of true flight. In some species females are brachypterous or apterous while the males may be macropterous. Mantids are predominantly tropical insects although a considerable number occur in subtropical regions, and a few occur in cooler temperate regions of the world. Of about 2500 species worldwide, over 120 species are known to occur on Borneo, but the records are so sparse that many species have only been recorded once.

In August 1993 I joined a botanical team from Nottingham University, who were working on the "For Peat's Sake" research project in collaboration with Palangkaraya University. At the time I was studying for a PhD in entomology, specialising in the stick insects (Phasmida) of Borneo. The main aim in joining the botanical group was to evaluate the phasmid diversity in the area; however, my interest in mantids led me to collect any that were encountered by chance. Specimens were collected in the botanical research area near Kelembenkari (Fig. 1) over five nights. I then traveled upriver to Tewah and, following a chance meeting with the foreman, was invited to stay at Ratu Miri Logging Camp (Fig. 1) where I collected for six nights before rejoining the group at Palangkaraya and collected for a further four nights. One phasmid was also collected from a garden in Palangkaraya shortly before my return to the UK. Some Blattodea and Orthoptera were also collected at Ratu Miri. In 1994 some mantids were collected at Kelembenkari by Paul Jenkins, a long-term member of the Nottingham botanical group, and sent to me for identification. Records for many of the phasmids have already been published (Bragg, 2001, 2005, 2008a), as has a record for one species of cockroach (Bragg, 1997a). Results for mantid specimens in the genera *Humbertiella,* and *Theopompa* have already been recorded elsewhere (Bragg, 2010). A total of 41 specimens of mantids were recorded: 15 from Ratu Miri and 26 from Kelembenkari. While attempting to identify some species of *Hierodula* Burmeister, 1838 a review of the oldest supposed Bornean species of the genus was found to be necessary.

MATERIALS AND METHODS

All specimens recorded here are in my personal collection. Specimens in my collection have individual accession numbers prefixed by PEB-M; this numbering system was not introduced until some years after the specimens were collected so the numbering is not sequential for the material from Kalimantan. Species collected in 1994 by Paul Jenkins were also given code numbers by him at the time of collection. Partly due to the variety of languages in use, spellings of place names in Borneo vary on different maps; here I use the spellings which were originally given to me, and used on my data labels: I also give known alternatives in brackets.

The base for the botanical research group was a logging camp about 1 km downstream from Kelembenkari (Kelem Benkari = Kereng Benkirai), a village on the banks of the Sungai Sebangau, about 10km south of Palangkaraya (Palangka Raya). The collecting area was mainly logged peat swamp forest, or primary low pole forest. I collected material at two locations: close to the base camp (eight nights), and at “Bukit Jak” (one night). Bukit Jak is a small granite outcrop rising about 50 m above the surrounding swamp forest located about 10 km south of the base camp and accessed by a narrow-gauge railway line; it was named Bukit Jak after Dr. Jack Rieley, the organiser of the botanical research group from Nottingham University. Material later collected by Paul Jenkins was from near the base camp. Latitude and longitude for the two sites near Palangkaraya were obtained by use of a GPS unit by a member of Palangkaraya University; Base camp: 113°54’30”E 02°19’02”S; Bukit Jak: 113°52’34”E 02°23’43”S.

The location of Ratu Miri logging camp has only been estimated, neither the Sungai Ratu Miri nor the logging camp have been located on any map. While there, I was told Sungai Ratu Miri is a tributary of Sungai Mirih. To reach the logging camp from Tewah, I travelled upstream for a short distance, landing on the north bank of the river Kahajan (=Kahayan), then overland on a logging truck for several hours in a northerly direction. A recent search on the internet showed the company, PT Ratu Miri, was given a logging rights to 42,000 hectares in the Sungai Mirih area in 1988 (Supreme Court, 2008) but I have been unable to find any precise location. For data labels, and previously published results, I have estimated the camp to be near 113°35’E 00°40’S. The area was primary hill forest but some of the area near the camp had been recently logged.

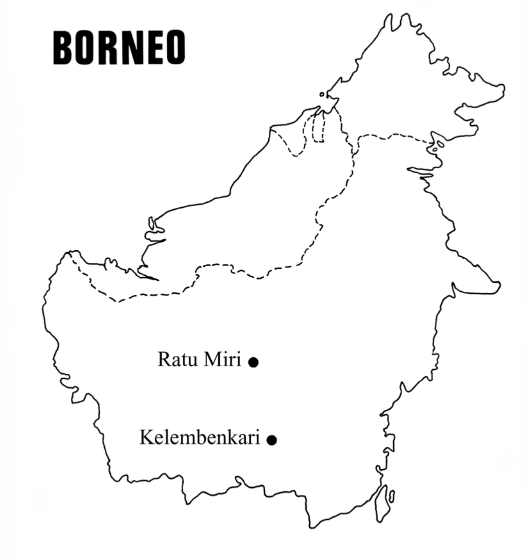


Figure 1. Map showing collecting sites.

In both areas specimens of mantids were collected in a casual manner, i.e. not by actively searching for mantids, but by collecting them when they were encountered while searching for phasmids. Phasmids are predominantly nocturnal but rarely attracted to light, however, the illuminated areas of the logging camp were checked at least once each night. Mantids are also very active at night and often attracted to lights; most of the mantids were found at lights. The record for one specimen is based on a photograph only, the specimen was not collected.

Identification of mantids in the genus *Hierodula* Burmeister, 1838 presents significant problems due to inadequate original descriptions. Preparations of the genitalia have allowed three species to be associated with recently published material collected elsewhere in Borneo (Schwarz & Roy, 2019); however, I have retained my numbering for species for which I consider the identification doubtful.

Genitalia were removed, cleared in 10% potassium hydroxide (KOH), and mounted in Euparal (for method see Bragg, 2008b: 193). Photographs of the genitalia slides were taken with a tripod-mounted Canon digital SLR fitted with a 60 mm “macro” lens and a 25 mm extension tube. Genitalia photographs were cleaned up using Adobe Photoshop Elements software to reposition elements of the genitalia which moved out of position during slide preparation; air bubbles surrounding the genitalia were also removed, but were left if under or over the genitalia. Photographs of the genitalia show the conventional ventral view.

Photographs of whole insect specimens were taken with a Canon digital SLR and 60 mm lens. The photographic record of *Haania* sp. was made with a Praktica MTL3 fitted with a 50 mm lens, using 100 ASA slide film; this was transferred to digital format using a flatbed scanner. Scale lines on photographs are 1 cm on whole insects, and 1 mm on genitalia.

Stoll (1787) illustrated two species which are currently treated as Bornean *Hierodula.* The only potentially useful measurements that can be taken from Stoll's drawings are the lengths of the pronotum (p) and elytra (e). To evaluate the reliability of measurements from Stoll's drawings a readily identifiable species, *Hymenopus coronatus* (Olivier, 1792), was chosen and measurements taken from my specimens (two from Sabah PEB-217, PEB-218; and one from peninsular Malaysia, PEB-116), and from Stoll's drawings. In addition to the material from Kalimantan, measurements of *Hierodula* species H3 and H5 were taken from all the specimens in my personal collection. Measurements of *Hierodula* specimens were made using digital calipers. Measurements were made to the nearest 1 mm for elytra length and the nearest 0.5 mm for pronotum length, and the e/p values calculated (Table 1).

Outline drawings of the pronota of *Odontomantis micantula* Beier, 1956 were made with a binocular microscope fitted with a camera lucida. An outline drawing of the pronotum of *O. rhyssa* Werner, 1930 was made from a photocopy of Werner's illustration, then Werner's measurements and photoshop software was used to adjust it to the same scale. A similar process was carried out with printouts from scanned illustrations of *O. planiceps* (De Haan, 1842) and *O. javana* (Saussure, 1870). The illustration by De Haan (1842: plate 17 fig. 10) was produced life-size, and the digital copy available to me is fairly low quality, so this outline in particular should be treated with some caution. Measurements of *Odontomantis* specimens were made using an eyepiece graticule and recorded to the nearest 0.1 mm.

RESULTS

The specimens were collected almost exclusively at night, with the majority having been attracted to lights around buildings. Male mantids generally fly more readily than females, consequently 34 of the 41 specimens are male. Of the seven females only one (*Haania* sp.) is known to have been found in daylight, the other females are all small species which fly well. Within each of the three collection areas (Ratu Miri, Kelembenkari Base camp, Bukit Jak), the specimens are listed alphabetically by genus, then species.

Ratu Miri (113°35’E 00°40’S).

Amorphoscelis rufula Roy, 1967
♂ PEB-M62, to light, P.E. Bragg, viii.1993.

Camelomantis giraffa (Giglio-Tos, 1912) (Fig. 2)
♂ PEB-M43 to light, P.E. Bragg, viii.1993.

Creobroter episcopalis Stål, 1877 (Fig. 3)
♂ PEB-M51, ♂ PEB-M52, to light, P.E. Bragg, viii.1993.
This species appears to be the same as the *Creobroter* sp. illustrated by Helmkampf et al. (2007: Plate 1, middle-right).

Deroplatys desiccata Westwood, 1839
♂ PEB-M13, ♂ PEB-M14, P.E. Bragg, viii.1993.
Specimen PEB-M14 is illustrated in Bragg, 1997b: fig 6, & Bragg in Prete et al., 2000: fig. 2.3b.

Euchomenella heteroptera (De Haan, 1842)
♂ PEB-M11 to light, P.E. Bragg, viii.1993.

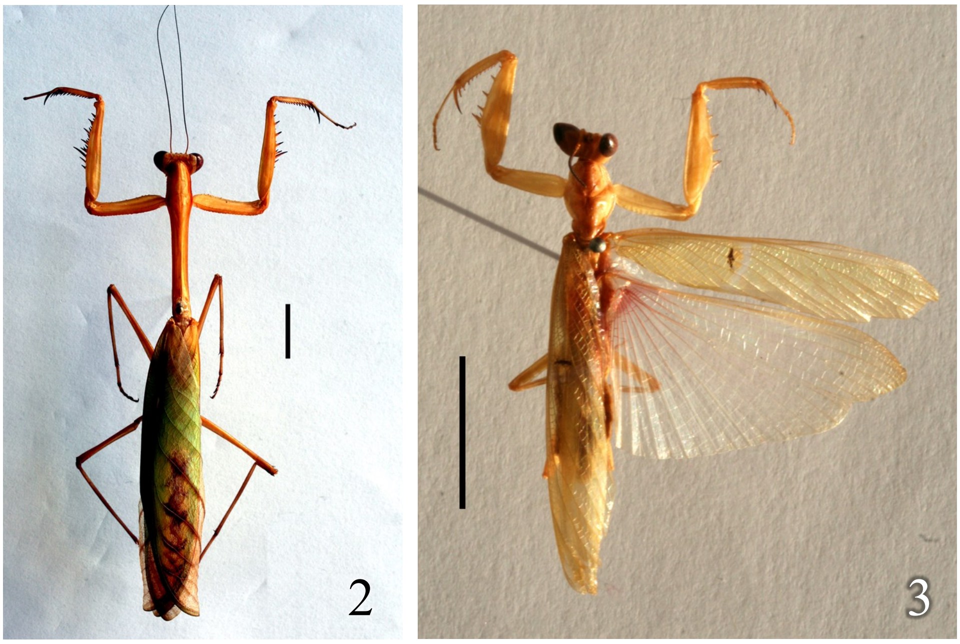
Hierodula gracilicollis Stål, 1877 (Figs. 12A & 13)
♂ PEB-M32, ♂ PEB-M33 to light, P.E. Bragg, viii.1993.
The genitalia agrees with the illustration of Schwarz & Roy (2019: fig. 23f), and with *Hierodula* sp. 3 (Helmkampf et al., 2007: plate 1 top left), and is compatible with the female holotype illustrated by Sjöstedt (1930: fig. 10.4).

Hierodula sp. H5 (Figs. 12D & 16)
♂ PEB-M44, ♂ PEB-M45 to light, P.E. Bragg, viii.1993.
The genitalia agree with the “*H. venosa* (Olivier, 1792)” of Schwarz & Roy (2019 fig. 23g).

Humbertiella ocularis Saussure, 1872
♂ PEB-M124 P.E. Bragg, viii.1993.

Statilia maculata (Thunberg, 1784)
♂ PEB-M47 to light, P.E. Bragg, viii.1993.

Theopompa tosta Stål, 1877
♂ PEB-M53, ♂ PEB-M54, to light, P.E. Bragg, viii.1993.



Figures 2-3. Dorsal view of: **2.** *Camelomantis giraffa* (Giglio-Tos, 1912) ♂ PEB-M43, **3.** *Creobroter episcopalis* Stål, 1877 ♂ PEB-M52. Scale: 1 cm.

Kelembenkari, Base camp (113°54’30”E 02°19’02”S).

Acromantis moultoni Giglio-Tos, 1915
♂ PEB-M78 to light. code M5, P. Jenkins, viii.1994.

Catestiasula moultoni Giglio-Tos, 1915
♀ PEB-M21 P. Jenkins, 23.viii.1993.

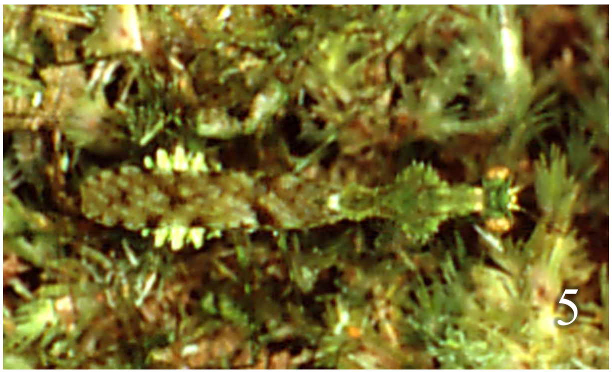
Creobroter episcopalis Stål, 1877
♂ PEB-M76 to light code M3, P. Jenkins, viii.1994.

Deroplatys truncata (Guérin, 1843)
♂ PEB-M19 P. Jenkins, 20.viii.1993.

Euchomenella heteroptera (De Haan, 1842)
♂ PEB-M20, ♂ PEB-M73 P. Jenkins, 20.viii.1993.
♂ PEB-M80 to light, code M7, P. Jenkins, viii.1994.

Haania sp. (Figs. 4-5)
Photographic record only, P.E. Bragg, viii.1993. The specimen was out of reach and was photographed at arms length, with the focus distance estimated, consequently the

photograph is of relatively low quality so identification to species level is not practicable. The photograph and enlargement are included here to illustrate how well the insect is camouflaged.



Figures 4-5. *Haania* sp.: **4.** on moss covered tree trunk, **5.** the same photograph enlarged and rotated.

Hierodula sp. H3 (Figs. 12B & 14)
♂ PEB-M74 code M1, P. Jenkins, ix.1994.
The genitalia of this specimen agree with the "*H. vitrea* (Stoll, 1813)" of Schwarz & Roy (2019: 23h). There is no stigma present on the elytra of this specimen; all other specimens of this species in my collection possess a white stigma.

Hierodula sp. H4 (Figs. 12C & 15)
♂ PEB-M40 P.E. Bragg, viii.1993.

Humbertiella ocularis Saussure, 1872
♂ PEB-M79 to light. code M6, P. Jenkins, viii.1994.

Odontomantis micantula Beier, 1956 (Figs. 7A, 7B & 8-11)
♂ PEB-M28 P. Jenkins 20.viii.1993.
♀ PEB-M29, ♂ PEB-M30, P.E. Bragg, viii.1993.
♀ PEB-M77 code M4. P. Jenkins, viii.1994.
♂ PEB-M81, ♂ PEB-M82, code M8 P. Jenkins, 06.ix.1994.
Specimen, PEB-M29 was illustrated in Bragg, 1997b: fig 4, and Bragg in Prete et al., 2000, fig 2.3A, under the name *Odontomantis micans*.

Sceptuchus simplex Hebard, 1920 (Fig. 6)
♂ PEB-M31 P. Jenkins 20.viii.1993.

Theopompa borneana Giglio-Tos, 1917
♂ PEB-M72, P. Jenkins, 20.viii.1993.

Theopompa tosta Stål, 1877
♂ PEB-M71, P. Jenkins, 20.viii.1993.
♂ PEB-M75, to light. code M2, P. Jenkins, viii.1994.

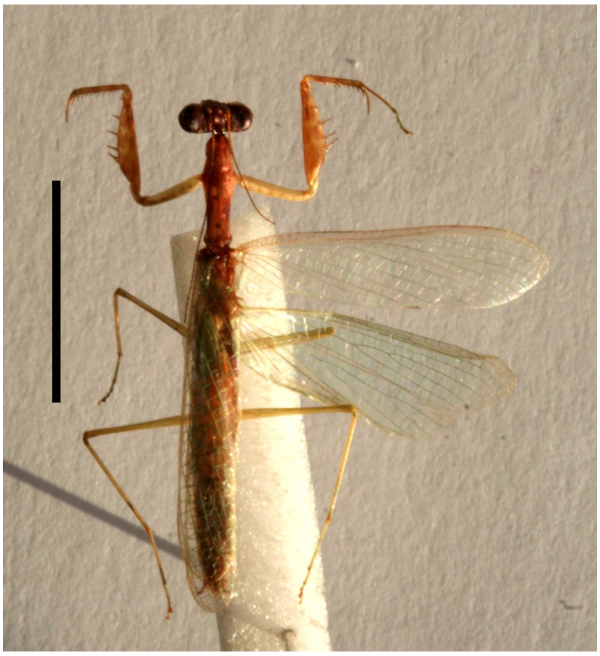


Figure 6. Dorsal view of *Sceptuchus simplex* Hebard, 1920 ♂ PEB-M31. Scale: 1 cm.

Kelembenkari, Bukit Jak (113°52’34”E 02°23’43”S).

Acromantis moultoni Giglio-Tos, 1915
♀ PEB-M23 to light, P.E. Bragg, 09.viii.1993.

Theopompa borneana Giglio-Tos, 1917
♂ PEB-M22 to light, P.E. Bragg, 09.viii.1993.

Tropidomantis tenera (Stål, 1860)
♀ PEB-M24, ♀ PEB-M25, ♀ PEB-M26 to light, P.E. Bragg, 09.viii.1993.

Table 1. Elytra / pronotum ratios for *Hierodula* and *Hymenopus* specimens and Stoll's drawings

Species	Elytra / Pronotum	Notes
Hierodula sp. H3	2.37	n=8. Range = 2.19-2.45.
Hierodula sp. H4	2.21	n=1.
Hierodula sp. H5	2.28	n=6. Range = 2.22-2.32.
Stoll – plate 5 figure 19	2.6	*Hierodula vitrea* (Stoll)
Stoll – plate 15 figure 60	1.8	*Hierodula venosa* (Olivier)
Hymenopus coronatus ♀ specimens	3.98	n=3. Range = 3.86-4.01.
Stoll – plate 11 figure 44	3.0	*Hymenopus coronatus* (Olivier)

DISCUSSION

The last published record for a significant number of mantids from Kalimantan was based on material in Museum Zoologicum Bogoriense (Beier, 1958). Beier recorded 82+ specimens of 21 species, the exact number of specimens from Borneo is unclear as material from other islands was included. Since then records for Kalimantan have mostly been limited to mention of a few specimens included as part of a taxonomic revision of a small groups e.g. the *Theopompa* and *Humbertiella* specimens listed above (Bragg, 2010), and most recently a specimen of *Astyliasula* which was collected on the Borneo-Expedition of Dr. Nieuwenhuis in 1894 (Schwarz & Shcherbakov, 2017). Other genera with post-1958 records from Kalimantan include one species of *Euchomenella,* (Roy, 2001)*,* one species of *Amorphoscelis* (Roy, 1967, 2011)*;* one species of *Pachymantis (*Roy, 2013), two species of *Metallyticus* (Wieland, 2008); one species of *Deroplatys* (Delfosse, 2009); in their checklist of Bornean species, Schwarz & Konopik (2014) also record localities from museum specimens for: one species of *Theopropus*, two of *Theopompa*, and three additional *Deroplatys*. In recent years there has been an explosion in interest in Bornean mantids, resulting in several small collecting expeditions, but all those reported: Helmkampf et al. (2007), Ling et al. (2013), Schwarz & Konopik (2014), Nazirah et al. (2015), have been in Sabah or Sarawak.

The material recorded here comprises 41 specimens of 20 different species which were collected in two strikingly different habitats: peatswamp forest and hill forest. No assessment has been made of the mantid fauna in different habitats in Borneo. The results here show only four species were found in both the peat swamp near Palangkaraya and the hill forest at Ratu Miri. The Bornean mantids in my personal collection were all collected in the same casual manner, i.e. while searching for phasmids, so some comparison can be made. Of the four species found in both areas, *E. heteroptera, T. tosta* and *H. ocularis* are respectively the first, third, and sixth most common species in my personal collection; the other species, *C. episcopalis*, is one which I have not collected elsewhere. The most abundant species in this small collection is *O. micantula* which is represented by six specimens. The small number of specimens found: 26 (14 species) at Kelembenkari, and 15 (10 species) at Ratu Miri, is too few to reach any conclusion regarding possible differences in the mantid fauna in peat swamp and hill forest; it does however, suggest that further investigation is warranted.

Efforts to confirm the identity of the *Hierodula* and *Odontomantis* specimens led to the finding that both genera suffer from significant problems due to the inadequate description of the species, lack of suitable illustrations, and conflicting subjective synonyms. In both cases the problems with the Bornean species can only be resolved by redescribing the type specimens (if they can be located). Copies of the original publications have been examined for the first descriptions and for all subsequent records of Bornean *Odontomantis*. Some of the issues are discussed below.

Notes on *Odontomantis* Saussure, 1871

The type species is *Acromantis javana* Saussure, 1870. Saussure (1871: 32) established *Odontomantis* as a subgenus of *Micromantis* Saussure, 1870 with only one species, *O.* (*M.*) *javana* (Saussure, 1870), included; Kirby (1904: 223) also clearly stated *javana* to be the type species. Ehrmann (2002: 243) incorrectly gives the type species as *O. planiceps* (De Haan, 1842), presumably because *javana* had been synonymized with *planiceps*.

Three species of *Odontomantis* are currently treated as Bornean. However, there are very few definite records for any of the species and it is possible that some of these records are misidentifications; in particular the subjective synonym of *planiceps* and *javana* seems doubtful. Part of the problem with the genus, as with many genera, is the very brief nature of early descriptions and a lack of suitable illustrations. The distinctions between the earlier species of *Odontomantis* often relies on the coloration; this presents potential problems due to possible discoloration of specimens which may have been sun-dried, compared to specimens dried in the dark. Illustrations by De Haan (1842) were hand-colored, often by students, and have been found to vary (Bragg, 2001: 358); this opens the possibility that different authors worked from slightly different coloring on the illustrations of De Haan's species. The only illustration De Haan provided is a fairly small habitus drawing which is of limited value for distinguishing between similar species; Saussure's (1871, plate 4 figure 11) illustration of *javana* is at a larger scale and more reliable.

The key below to females of the known Bornean members of the genus is based on the original description and illustration of *O. rhyssa* Werner, 1930 (p. 7, pl. 3.1), Beier's 1956 comments and my own material of *O. micantula,* and the illustration of *O. planiceps* (De Haan, 1842: plate 17, fig 10).

Key to female Bornean *Odontomantis* species

1. Pronotum granulose. Pronotum sides (at least in the female) not straight, clearly wider at the junction of the prozone & metazone (Fig. 7E) .... *O. rhyssa* Werner, 1930
– Dorsal surface of pronotum smooth (although the margin may be cranulate). Sides of the pronotum straight or with only a smooth curve, not significantly wider at the prozone-metazone junction (Figs 7A-7D) 2

2. Pronotum wide, only just twice as long as wide (figs 7A & 7B); frontal plate of head almost triangular, about half as high as wide (Fig. 10) .... *O. micantula* Beier, 1956
– Pronotum more slender, distinctly more than twice as long as wide (Fig. 7C) .... *O. planiceps* (De Haan, 1842)

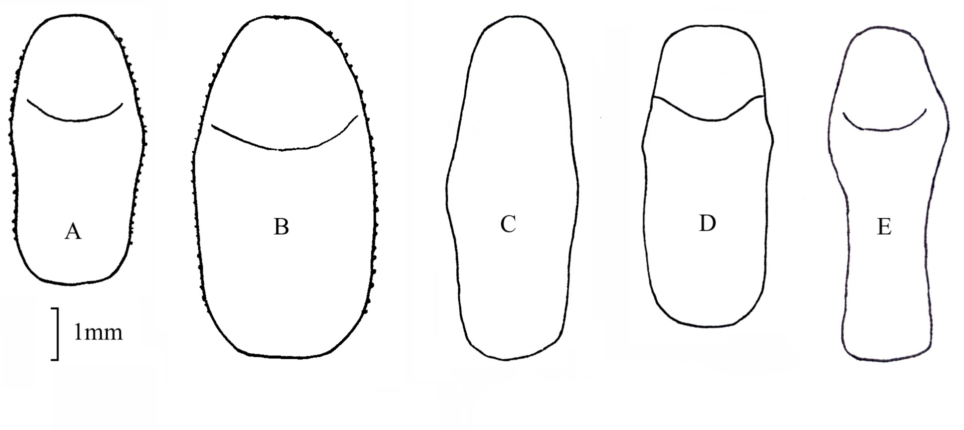


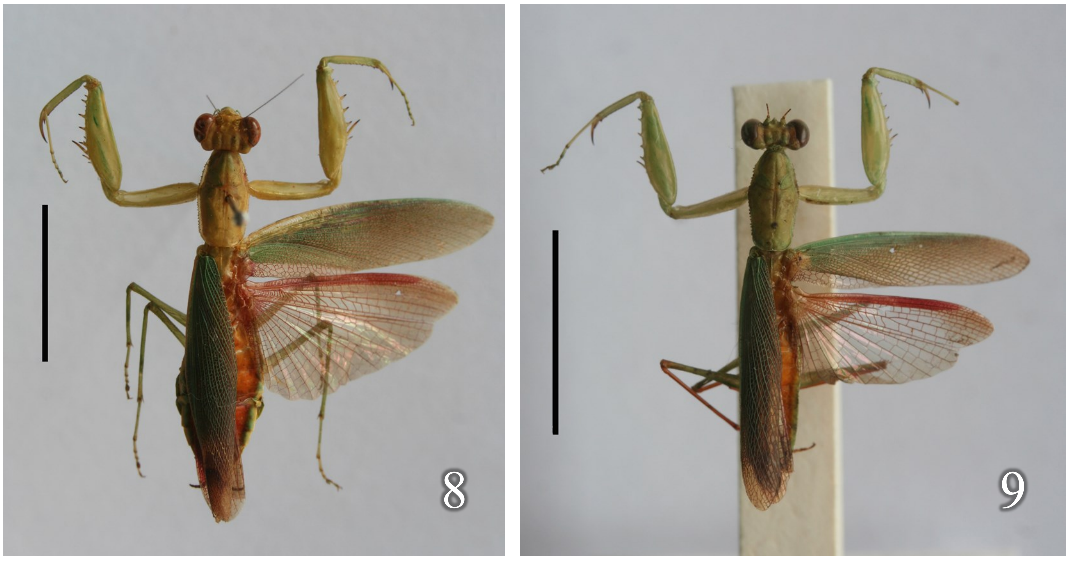
Figure 7. Pronota of *Odontomantis* spp. – **A.** ♂ *O. micantula*, **B.** ♀ *O. micantula*, **C.** ♀ *O. planiceps*, **D.** ♀ *O. javana*, **E.** ♀ *O. rhyssa*.

Odontomantis micantula **Beier, 1956**

Odontomantis micans [Not *micans* Saussure] Giglio-Tos, 1927: 542 [in part]; Werner, 1930: 7; Beier, 1934: 16 [in part]; Beier, 1937: 180; Bragg, 1997b: fig 4 (♀); Bragg in Prete et al., 2000, fig 2.3A (♀); Ehrmann, 2002: 244 [in part].

Odontomantis micantula Beier, 1956: 39; Schwartz & Konopik, 2014: 141.

Syntypes: 1♂, 1♀ SARAWAK, foot of Mt. Dulit, junction of rivers Tinjar and Lejok, 19.ix.1932 & 5.x.1932 (BMNH).



Figures 8-9. Dorsal view of *Odontomantis micantula* Beier, 1956: **8.** ♀ PEB-M29, **9.** ♂ PEB-M28. Scale: 1 cm.

Figures 10-11. *Odontomantis micantula* Beier, 1956: **10.** head of ♀ PEB-M29, **11.** cerci, subgenital plate and genitalia ♂ PEB-M81. Scale: 1 mm.

Schwarz & Konopik (2014: 141) recently highlighted that *Odontomantis micantula* Beier, 1956 had been overlooked by all subsequent authors. Beier (1956: 38-39) in his paper on mantids from Ceylon (now Sri Lanka) blames Giglio-Tos for confusing two species as he was the first to include Borneo as a locality for "*micans*", along with Sumatra and Mentawai Island. Beier declared the previous records of "*Odontomantis micans* (Saussure, 1871)" from "Malacca and the Sunda Islands" to be in error and said "Ich schlage für sie den Namen *micantula* vor." ["I suggest the name *micantula* for them"]. Clearly, Beier considered he was re-naming the "Malacca and Sunda Islands" species rather than describing it as new. Beier did not designate any type material, or mention any specimens: he just gave brief distinction between *micans* and *micantula.* This presents a problem regarding the type material. He states the name applies to all "*micans*" from Malacca and the Sunda Islands. As he did not specify the type material, any specimens which he is known to have examined from the Sunda Islands should be regarded as syntypes.

I have only been able to find one publication by Beier in which he records locality data for *O. micans* from the Sunda Islands (Beier, 1937: 180); these two specimens from Borneo must therefore be regarded as the syntypes of *micantula.* Although Beier may well have examined other specimens of "*micans*" from "Malacca and the Sunda Islands" in the absence of any published evidence, the two specimens recorded in 1937 should be regarded as the only syntypes. The two specimens from his 1937 paper are in the Natural History Museum, London (BMNH). His 1956 paper states the material he was working on from Ceylon is in the Naturhistorischen Museum, Basel (NHMB) but he gives no indication of any specimens of *micantula* in NHMB. The only other pre-1956 record for *micans* from Borneo that I have found is for one female recorded by Werner (1930: 7) from 1700m on Mt. Tibang, collected by Mjöberg; this I exclude as a syntype as there is no evidence that Beier had seen it.

The material I have from Kelembenkari keys out as *micans* using Giglio-Tos's key (1927: 541) but is clearly different to the illustrations of *Odontomantis micans* (Saussure, 1871) presented by Beier (1956: fig 1b). My material agrees with the differences mentioned by Beier for *micantula*, most notably the shape of the frontal shield (fig. 10), therefore I am able to confirm Beier was correct in declaring the Bornean "*micans*" to be a different species.

Schwarz & Konopik (2014) recorded specimens from Sarawak: Marudi, Sabah: Crocker Range, Mesilau.

Table 2. Measurements of *Odontomantis micantula*

Odontomantis micantula	**Females (mm)**	**Males (mm)**
Total length	23.8-24.2	16.2-18.2
Pronotum	6.1	4.4-4.7
Prozone	2.5	1.7
Metazone	3.6-3.7	2.7-3.0
Pronotum maximum width	3.1	2.2-2.5
Elytra	17.6-18.2	11.7-12.9
Fore coxa	5.4	3.4-4.0
Fore femora	6.9	4.5-5.1
Mid femora	5.6	3.9-4.5
Hind femora	6.3	4.4-5.1

O. planiceps (De Haan, 1842)

Mantis (*Oxypillus*) *planiceps* De Haan, 1842: 88, plate 17, fig 10 (♀) [not the described “male” or fig 11 (♂)].

Micromantis planiceps (De Haan); Saussure, 1871: 31 [♀ not ♂]

Odontomantis planiceps (De Haan); Kirby, 1904: 223 [Kirby also states only fig 10, not fig 11]; Giglio-Tos, 1927: 542; Werner, 1933: 270; Beier, 1934: 16, plate 2 fig. 9 (♀); Ehrmann, 2002: 244; Schwarz & Konopik, 2014: 140; Shcherbakov et al., 2016: 137, fig. 6F (♀ pronotum).

Acromantis javana Saussure, 1870: 230. Synonymized by Giglio-Tos, 1927: 542 [not *Acromantis javana* Giglio-Tos, 1915]

Micromantis (Odontomantis) javana; Saussure, 1871: 32, plate 4 fig, 11 (♀).

Odontomantis javana; Stål, 1877: 87; Kirby, 1904: 223.

Odontomantis javana javana; Hebard, 1920: 76.

De Haan described *planiceps* and illustrated the female (plate 17, fig 10) and the “male” (plate 17, fig 11). The “two sexes” of *planiceps* have long been recognized as different species (Saussure, 1871: 32; Kirby, 1904: 223), with the illustrated female (fig. 10) being treated as the Lectotype (although not formally designated), and the “male” being treated as a female *Tropidomantis tenera* Stål, 1858 (Kirby, 1904: 227). A reference to *Mantis* (*Oxypillus*) *planiceps* by Giebel (1861: 112) was excluded by Kirby who considered Giebel was describing a different species; Giebel did not give any locality data. Although

Kirby did not include Giebel's reference under his entry for *T. tenera*, Kirby included Giebel in the same brackets he used to exclude De Haan's figure 11 from *planiceps*, so it is reasonable to assume Kirby considered Giebel's record to relate to *T. tenera.*

To ensure stability of the name *planiceps* a Lectotype needs to be selected; it should be the species illustrated in De Haan's plate 17, figure 10, and not the species in figure 11. Unfortunately, due to the current Covid-19 pandemic and resulting museum closures, I am unable to check the specimen details, and when a Lectotype is selected a redescription would be essential. The number of specimens available to De Haan is not stated and his use of "de mannetjes" (the males) and "de wijfjes" (the females) in the Dutch description does not mean he had more than one of each: De Haan could be using the plural in the sense of "in the females of this species" rather than "the females I have in front of me". This usage would be consistent with his usage of "de wijfjes" when discussing *Phasma galacpterum* (De Haan, 1842: 127), a species for which only one of the syntypes is female (Bragg, 1996: 111). Some differences in coloration, or even pattern on the wings should not exclude a specimen from being selected as the illustrated specimen in view of variations that are known occur between different copies of De Haan's book.

Ehrmann's (2002: 244) entry for *planiceps* contains several errors. Ehrmann lists the types as "Holotypus ♂ RMNH, Allotypus ♀ RMNH. Locus typicus: Java (♂), Borneo (♀)", but later (Ehrmann, 2002: 362) correctly lists De Haan's "male" (fig. 11) as a synonym of *T. tenera*. Clearly neither specimen can be a holotype as De Haan did not designate a holotype and had at least two specimens. It is not clear why Ehrmann considered the female to be from Borneo, and the "male" from Java: De Haan does not specify which specimen is from which island. Ehrmann then lists *Acromantis javana* Giglio-Tos, 1915 as a synonym, but indicating that it was "In Saussure, 1870: 230", then repeats the error with Saussure's 1871 and Stål's 1877 records. *Acromantis javana* Giglio-Tos, 1915 is an invalid name because it is a primary homonym which was replaced with the name *Acromantis lilii* Werner, 1922 (Werner, 1922: 155).

Stål (1877) records *O. javana* from Java. Hebard (1920: 76) recorded *O. javana javana* (Saussure, 1870) from Labuan, Sandakan, and also from Palawan. Hebard (1920: 77) commented on the brevity of the original description of *O. euphrosyne* Stål, 1877 and said he considered it "represents a geographic race of *javana*", recording it from the Philippines as *Odontomantis javana euphrosyne* Stål. Giglio-Tos (1927: 543), Beier (1934: 16), and

Ehrmann (2002: 243) all overlooked this and listed *euphrosyne* as a distinct species. Giglio-Tos (1927: 543) said he thought *euphrosyne* might be the same species as "*micans*" (i.e. what is now *micantula*).

The female described by De Haan could be from either Borneo or Java; the type material might clarify this, but often De Haan's labels were not on the actual specimens, they were placed above or below the specimens for display purposes. Hebard's records are for *javana,* and are only treated as *planiceps* due to Giglio-Tos subsequently synonymising the two species. The synonymy of *javana* and *planiceps* appears doubtful based on the illustrations of De Haan and Saussure (see figs 7C-D). Additionally, Saussure (1871: 32) clearly states that *javana* differs from *planiceps* by having a broader prothorax. It seems unlikely that *javana* and *planiceps* are the same species. The pronotum illustrations of Beier (1934, plate 2 fig. 9), and Shcherbakov et al. (2016, fig 6F), do not agree with De Haan's: they are much wider, closer to that of Saussure's *javana.* Neither Beier, nor Shcherbakov et al., give any data for their material.

The only clear distribution records for *planiceps* in Borneo are those of Werner (1933) and Schwarz & Konopik (2014). Werner recorded specimens from West Java, and specimens from the Central East Borneo Expedition, and from Long Petak, collected by H.C. Siebers. Schwarz & Konopik recorded material from Kuching, Matang, Santubong, Kilingkang and Sorinsim. All identifications made while *planiceps* and *javana* are considered synonyms may need checking once the Lectotype of *planiceps* has been redescribed and the synonym reassessed.

O. rhyssa Werner, 1930

Odontomantis rhyssa Werner, 1930: 7, plate 3 figure 1 (♀); Sjöstedt, 1930: 14; Beier, 1934: 16; Beier, 1937: 180; Ehrmann, 2002: 244; Schwarz & Konopik, 2014: 141; Shcherbakov et al., 2016: 136-137, figs 6G (pronotum) & 9B (elytron).

The original description is based on one female from "Borneo" collected by Eric Mjöberg. Beier records "1♂, 1♀ foot of Mt Dulit, junction of rivers Tinjar and Lejok, 22.viii.1932 & Mt. Dulit, 4,000ft., Moss forest, 14.x.1932". Beier (1937) comments that this is an easily recognizable species because of the granulose pronotum. Shcherbakov et al. (2016) illustrate the species but do not give any data about their specimen.

Notes on *Hierodula* Burmeister, 1838

The genus *Hierodula* is the largest genus of mantids, with 104 species listed by Ehrmann (2002). Subsequently a few new species have been described and a few others have been transferred elsewhere, but the genus remains the largest. The number of species from Borneo is unclear. Schwarz & Konopik (2014: 149) stated "Sixteen species currently known from Borneo" but listed only 12, with two further species listed in the "Doubtful species without confirmed Bornean records"; I understand the count of 16 should have been corrected following some taxonomic changes (Schwarz, pers. com. 2021). *Ephierodula heteroptera* (Werner, 1906) was recently removed from *Hierodula* by Schwarz & Roy (2018), leaving eleven Bornean species, of which six are endemic. However the majority of Bornean species are so poorly described that it is impossible to identify them from the descriptions alone, the issue is further complicated by historical issues surrounding the oldest two species. Even with relatively recently described species, the distinction given between species often relies on comparative statements: for example, Werner (1933) described seven new species of *Hierodula*, three from Borneo, and almost every description relates it to another one or two species which he was describing as new in the same paper: none are illustrated. The stated distinction between species may often rely on the color of spines on the fore femora, or the presence of spots on the fore femora: both these characters seem to be variable within species. Brunner (1898) illustrated the femoral spots for three of his new Bornean species but did not illustrate the rest of the insects. Werner illustrated the pronotum of one species (1930, plate 1, fig 3), but again the species is defined by spots on the femora. Descriptions of new species prior to about 1840 were particularly brief and as a consequence, many differing subjective synonyms have been published over the past 200 years.

Stoll (1787) described the first Bornean mantids that are now in the genus *Hierodula.* Stoll's publication on mantids and phasmids was published in two parts; the first part (pages 1-56 and plates 1-18) was published in either 1787, or 1788; the title page, and remaining pages and plates, including the index were published posthumously in 1813. I have been unable to confirm the publication date for the first part: here I use the date given by Lichtenstein (1802: 2), but Woodward (1915: 2028) gives 1788 as the date; however, it is possible that the copy cataloged by Woodward was printed in 1787 but did not reach the UK until 1788. Binomial names were not used until the index which was published in 1813; all the mantids were described in the genus *Mantis*. In the intervening years Olivier (1792) and Lichtenstein (1796) had named several of the illustrated phasmids and mantids so many of

Stoll's names became junior objective synonyms (Bragg, 1995). The current location of many of the specimens illustrated by Stoll is unknown, however, I located some of his phasmids in Leiden Museum (Bragg, 1996) and it is very likely that some of his mantids are also in Leiden.

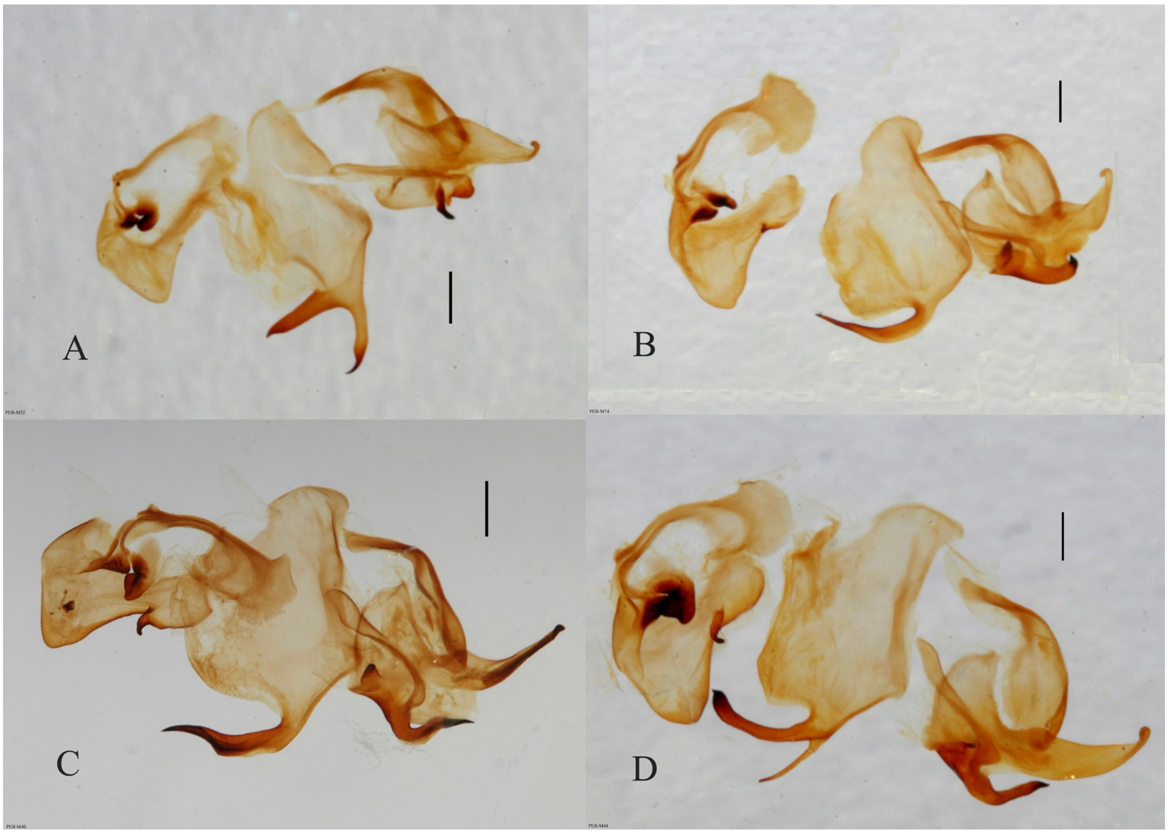


Figure 12. *Hierodula* spp. ♂ genitalia – **A.** *H. gracilicollis* Stål, 1877, **B.** H3, **C.** H4, **D.** H5. Scale: 1 mm.

Three of Stoll's species are currently in the genus *Hierodula*. Two of these: *H. venosa* (Olivier, 1792) [= *M. punctata* Stoll, 1813; = *M. conspurcata* Lichtenstein, 1796 – both objective synonyms] and *H. unimaculata* (Olivier, 1792) [= *M. notata* Stoll, 1813 – objective synonym] were described from Tranquebar on the East coast of India. *Hierodula vitrea* (Stoll, 1813) was described from "Surinam" but this was considered unlikely by Kirby (1904: 246) and subsequent authors. Identification of Bornean *Hierodula* tends to be based on the keys and brief descriptions provided by Giglio-Tos (1927). Currently, *vitrea* is treated as Bornean (Schwarz & Konopik, 2014) but the status of *H. vitrea* is very confused because of differing subjective synonyms published by various authors, and the questions surrounding the origin of Stoll's specimen. There is even some doubt about the generic placement of *vitrea*: Stoll's illustration (plate 5, figure 19) was treated as *Mantis oratoria* Fabricius, 1775 by Lichtenstein (1876: 80; 1802: 28), a species which has subsequently been treated as a synonym of *Mantis religiosa* Linnaeus, 1758 (e.g. Kirby, 1904: 250; Ehrmann, 2002: 216). Holthuysen's collection was in Hamburg when Lichtenstein was working on it (Lichtenstein, 1802: 1 & 3) but, although Lichtenstein had certainly seen the type specimen of *venosa*, it is not clear if he had seen the specimen of *vitrea* as this was not mentioned as being in L.F. Holthuysen's collection. Hebard (1920: 56) considered *vitrea* and *venosa* could be the male and female of one species, and said of the confused synonymy in *Hierodula* "Consequently many features usually considered of specific diagnostic value, will probably be found worthless for the species under consideration"; Beier (1935: 81) and Ehrmann (2002: 184) both listed *vitrea* as a synonym of *venosa*.

Hierodula hybrida Burmeister, 1838 was recorded from Borneo by De Haan (1842: 68). Saussure (1871:76) synonymized *vitrea* Stoll and *H. hybrida*: a synonym rejected by Kirby (1904: 246), but reinstated by subsequent authors. *Hierodula venosa* was synonymized with *hybrida* and *vitrea* by Beier (1935: 81). In addition, *H. athene* Rehn, 1909 described from Sumatra, has been synonymized with *venosa* by Beier (1935: 81). With so many differing opinions on the synonymy the examination of the type material is essential. The holotype of *hybrida* is present in Berlin Museum (Ehrmann, 2002: 184), however, it is a female so is unlikely to be of much use for distinguishing species because the only reliable method of distinguishing species at present is by comparing the male genitalia. The locations of the type specimens of *vitrea* and *venosa*, are unknown; I am not aware of any attempts to locate them.

Stoll (1787 & 1813), Olivier (1792), and Lichtenstein (1796 & 1802), did not give any measurements of specimens. The only potentially useful measurements that can be taken from the drawings are the lengths of the pronotum (p) and elytra (e). Measurements taken from my material and Stoll's drawings (Table 1) have proven to be of no assistance in identifying the *Hierodula*; the *Hymenopus* results show proportions taken from Stoll's drawings can differ from reality by at least 30%. This is a result of the drawings having been made to show them in a life-like perspective, rather than inaccuracies in the drawings. However, whilst the drawings are good representations of the species, they are not scientific illustrations and consequently cannot be used to determine accurate proportions of species.

The six specimens of *Hierodula* recorded in this paper represent four species. The two specimens of *H. gracilicollis* Stål, 1877 from Ratu Miri agree with both the illustration of

"*Hierodula* Spec. 3" (Helmkampf et al. 2007: Plate 1, top left), and the genitalia illustrated by Schwarz & Roy (2019: fig 23f); the slender, smooth pronotum of these males is in agreement with Stål's female holotype (Sjöstedt, 1930: fig. 10.4). The other three species (H3, H4, & H5) all have the general form of *venosa* – *vitrea* – *hybrida* – *athene,* and of a number of other species from the Sunda Islands. Species H3 agrees with the genitalia illustrations of Schwarz & Roy's *H. vitrea* (the illustration here (Fig. 12B) appears slightly different because the genitalia were mounted using slide spacers, consequently the genitalia have retained some of the original three-dimensional shape: viewing the slide at an angle shows it to be identical). Species H5 (Fig. 12D) agrees with Schwarz & Roy's *H. venosa.* However, the identifications as *venosa* and *vitrea* are based on the interpretation of Giglio-Tos (1927). In view of the number of similar species in the region, and the stated localities of Stoll's specimens (Surinam and India), and the absence of type material of *vitrea* and *venosa*, these names are little more than speculative and I regard these two names as *nomen dubia*. It is quite likely examination of the genitalia of Brunner's and Werner's Bornean types will provide reliable names for these species.

Figures 13-14. Dorsal view of: **13.** *Hierodula gracilicollis* Stål, 1877 ♂ PEB-M32, **14.** *Hierodula* sp. H3 ♂ PEB-M74. Scale: 1 cm.

Figures 15-16. Dorsal view of: **15.** *Hierodula* sp. H4 ♂ PEB-M40, **16.** *Hierodula* sp. H5 ♂ PEB-M45. Scale: 1 cm.

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DISCOVERY OF A NEW MAYFLY SPECIES (EPHEMEROPTERA, BAETIDAE) NEAR CENDERAWASIH UNIVERSITY CAMPUS IN PAPUA, INDONESIA

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ABSTRACT

Material collected just behind the Cenderawasih University campus in Jayapura, Papua Province, Indonesia, revealed a new species of the *Labiobaetis claudiae* group, which is here described and illustrated based on larvae, subimago, male and female imagos. The total number of *Labiobaetis* species on the island New Guinea increased to 33, the total number for Indonesia increased to 26, and the total number of *Labiobaetis* species worldwide is augmented to 147. A key to the larvae of the *L. claudiae* group is provided. The interspecific K2P distances between species of the *L. claudiae* group are between 20% and 23%.

Keywords: Integrative taxonomy, New Guinea, species discovery

ABSTRAK

Spesies baru dari kelompok *Labiobaetis claudiae* diungkap berdasarkan spesimen yang dikumpulkan dari belakang kampus Universitas Cenderawasih di Jayapura, Provinsi Papua, Indonesia. Spesies baru dideskripsikan dan diilustrasikan berdasarkan larva, subimago, imago jantan, dan betina. Jumlah total spesies *Labiobaetis* di pulau Papua meningkat menjadi 33, jumlah total untuk Indonesia meningkat menjadi 26, dan jumlah total spesies *Labiobaetis* di seluruh dunia bertambah menjadi 147. Kunci identifikasi larva untuk kelompok *L. claudiae* disediakan. Jarak antar spesies K2P antar spesies dari kelompok *L. claudiae* adalah antara 20% dan 23%.

Kata kunci: Taksonomi integrative, Papua, penemuan spesies baru

INTRODUCTION

The family Baetidae has the highest species diversity among mayflies, comprising 1,070 species in 110 genera (Sartori & Brittain, 2015; Jacobus et al., 2019), which is approximately one quarter of all mayfly species worldwide (Gattolliat & Nieto, 2009; Cruz et al., 2020). They have a cosmopolitan distribution except Antarctica, New Zealand, New Caledonia and a few remote islands. The genus *Labiobaetis* Novikova & Kluge (Novikova & Kluge, 1987) is one of the richest genera of mayflies with 146 named species (Kaltenbach et al., 2020 and citations therein, Kaltenbach & Gattolliat, 2021a, b). Recently, 65 new species were described from the highly diverse and poorly explored Southeast Asia and New Guinea regions, based on integrative taxonomy (Kaltenbach & Gattolliat, 2018, 2019, 2020; Kaltenbach et al., 2020). *Labiobaetis* has a nearly worldwide distribution, excluding only the Neotropical realm, New Zealand and New Caledonia. The history and concept of the genus *Labiobaetis* were recently summarized in detail (Shi & Tong, 2014; Kaltenbach & Gattoliat, 2018).

The diversity of *Labiobaetis* in New Guinea was previously studied in two papers (Lugo-Ortiz et al., 1999; Kaltenbach & Gattolliat, 2018) and a total of 32 species were described. Here, we describe another New Guinea species of the *Labiobaetis claudiae* group based on larvae, subimago, male and female imagos. So far, this group was known from larvae of two species, *L. claudiae* Kaltenbach & Gattolliat, 2018 and *L. stagnum* Kaltenbach & Gattolliat, 2018. The group is well distinguished from other groups or species not assigned to a group by the following characters: labial palp segment II with a narrow thumb-like distomedial protuberance, segment III rather large; maxillary palp apically constricted, without excavation at segment II; six pairs of tergalii, margin of tergalii with both longer and shorter setae; hind protoptera absent; scape process absent; femoral patch present on all legs; setae on dorsal margin of femur short (0.12–0.16x maximum width of femur).

MATERIALS AND METHODS

The larvae were collected by kick-sampling by a team of Cenderawasih University (UNCEN) staff and visiting scientists during field practicals, and preserved in 96% ethanol.

Subimagines were reared from mature larvae in cages placed in the river. Subsequently, imagines of both sexes were reared from subimagines placed in containers with wet air, but without water. Imagos and subimagos were individually associated with larval and subimaginal exuviae.

The dissection of larvae was done in Cellosolve (2-Ethoxyethanol) with subsequent mounting on slides with liquid Euparal, using an Olympus SZX7 stereomicroscope.

The DNA of part of the specimens was extracted using non-destructive methods allowing subsequent morphological analysis (see Vuataz et al., 2011 for details). We amplified a 658 bp fragment of the mitochondrial gene cytochrome oxidase subunit 1 (COI) using the primers LCO 1490 and HCO 2198 (Folmer et al., 1994, see Kaltenbach & Gattolliat 2020 for details). Sequencing was done with Sanger's method (Sanger et al., 1977). The genetic variability between specimens was estimated using Kimura-2-parameter distances (K2P) (Kimura, 1980), calculated with the program MEGA 7 (Kumar et al., 2016; http://www.megasoftware.net).

Drawings were made using an Olympus BX43 microscope. In order to facilitate the determination and the comparison of important structures, we partly used a combination of dorsal and ventral aspects in one drawing. Explanations are given in Kaltenbach et al., 2020: fig. 1.

Photographs were taken using a Canon EOS 6D camera and other digital cameras and processed with the programs Adobe Photoshop Lightroom (http://www.adobe.com) and Helicon Focus version 5.3 (http://www.heliconsoft.com). Photographs were subsequently enhanced with Adobe Photoshop Elements 12 and 13.

The distribution map was generated with SimpleMappr (https://simplemappr.net; Shorthouse, 2010). Google Earth (http://www.google.com/earth/download/ge/) was used to attribute approximate GPS coordinates to the sample location.

The dichotomous key was elaborated with the support of the program DKey version 1.3.0 (http://drawwing.org/dkey; Tofilski, 2018).

The terminology follows Hubbard (1995) and Kluge (2004). Consequently, the term tergalius/tergalii is used for gill/gills. For the explanations of the character states of selected larval characters, we refer to Kaltenbach et al., 2020: fig. 2.

RESULTS

Abbreviations:

KSP: Koleksi Serangga Papua, Department of Biology, Cenderawasih University (UNCEN) (Indonesia)

MZB: Museum Zoologicum Bogoriense (Indonesia)

Diagnosis of *Labiobaetis claudiae* group of species (larvae) (Kaltenbach and Gattoliat 2018)

Following combination of characters: A) dorsal surface of labrum with submarginal arc of simple setae; B) labial palp segment II with rather narrow thumb-like distomedial protuberance; C) maxillary palp segment II without distolateral excavation, apex constricted; D) six pairs of tergalii; E) tergalii margin with both shorter and longer setae; F) hind protoptera absent; G) distolateral process at scape absent; H) femur dorsally with relatively short setae (length 0.12–0.16x maximum width of femur); I) femoral patch present.

The *L. claudiae* group is known from New Guinea only, with the following species:
Labiobaetis claudiae Kaltenbach & Gattolliat, 2018
Labiobaetis stagnum Kaltenbach & Gattolliat, 2018

Labiobaetis academicus **Kaltenbach, Surbakti & Kluge sp. nov.**

Figures 1–3, 5–8

Differential diagnosis. Larva. Following combination of characters differentiate the new species from *L. claudiae* and *L. stagnum*: A) maxilla medially with 7–9 medium to long, spine-like setae; B) shape of labial palp segment II as Fig. 1h; segment III slightly pentagonal; C) shape of tergalius IV as Fig. 2d; F) paraproct distally not expanded, with 20–25 stout, marginal spines.

Description. Larva (Figs 1–3). Cerci ca. 2/3 of body length, paracercus ca. 2/3 of cerci length, antenna approx. twice as long as head length.

Coloration. Head, thorax and abdomen dorsally brown, with pattern as in Fig. 3a. Fore protoptera brown with bright striation. Head, thorax and abdomen ventrally light brown. Legs light brown; femur with a large, distomedial brown spot, dorsal margin and apex brown; tibia in basal part with brown spot, bordered by patellotibial suture. Caudalii light brown.

Antenna (Fig. 2h) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 1a). Rectangular, length 0.7x maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus 5–7 long, simple setae. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. seven short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 1b, c). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with four denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex. Tuft of setae at apex of mola present.

Left mandible (Fig. 1d, e). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with four denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola slightly convex, with minute denticles toward subtriangular process. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 1f). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, short; distal half laterally expanded. Superlinguae distally rounded; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 1g). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and 7–9 medium to long, simple setae. Maxillary palp approx. as long as length of galea-lacinia; 2-segmented; palp segment II 1.1x length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment constricted, without excavation at inner distolateral margin.

Labium (Fig. 1h, i). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. 12 short, stout, spine-like setae increasing in length distally; apex with two long and one short, robust setae; outer margin with six spine-like setae; ventral surface with few fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; ventrally with three rows of long, robust, distally pectinate setae in apical area and one medium, simple seta in anteromedial area; dorsally with a row of four long, spine-like setae near inner margin. Labial palp with segment I approx. as long as segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with narrow, thumb-like distomedial protuberance; distomedial protuberance 0.5x width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of 3–6 medium, spine-like, simple setae near outer margin. Segment III slightly pentagonal; length 0.9x width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera absent.

Legs (Fig. 2a, b). Ratio of foreleg segments 1.3:1.0:0.6:0.2. *Femur*. Length ca. 3x maximum width. Dorsal margin with a row of 25–32 medium, curved, spine-like setae; length of setae 0.12x maximum width of femur. Apex rounded, with medium to short, curved, spine-like setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch present. *Tibia.* Dorsal margin with a row of short to medium, stout, spine-like setae. Ventral margin with a row of short, curved, spine-like setae, on apex some longer, spine-like setae and a tuft of fine, simple setae. Anterior and posterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal 1/2 area. *Tarsus.* Dorsal margin with a row of short, spine-like setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of 10–12 denticles; distally pointed; with 4–5 stripes; subapical setae absent.

Abdomen (Fig. 2c). Surface with dense, irregular rows of U-shaped scale bases. Posterior margin of terga II–IX with triangular spines, approx. as long as wide; spines diminished on middle of posterior margin of tergum IX behind pair of submedian setae. Posterior margin of tergum X with longer and narrower spines. Posterior margins of sterna VII–IX with shorter triangular spines.

Tergalii (Fig. 2d–f). Present on segments II–VII. Margin with denticles of different sizes, intercalating both medium and long, fine simple setae. Tracheae extending from main trunk to inner and outer margins. Tergalius IV as long as length of segments V and VI combined. Tergalius VII as long as length of segments VIII and 1/2 IX combined.

Paraproct (Fig. 2g). Distally not expanded, with 20–25 stout, marginal spines. Surface scattered with U-shaped scale bases and fine, simple setae. Cercotractor with numerous small, marginal spines.

Subimago (both sexes; Fig. 6d, e). *Cuticular coloration*. Pronotum brown with lighter areas. Mesonotum brown with medioparapsidal suture contrastingly colorless, other sutures darker brown (Fig. 6d). Thoracic pleura with brown sclerites and colorless membranes (Fig. 6e). Legs mostly colorless; femur colored with brown at base, outer and inner margins, with indistinct brownish spot in distal part; tibia colored with brown at base. Abdominal terga uniformly light brown, sterna lighter. Cerci uniformly colorless.

Hypodermal coloration. As in imago (see below).

Texture. On all legs of both sexes, all tarsomeres covered with blunt microlepides.

Imago, male (Fig. 5a–d, 6c). Head ocher. Turbinate eyes high widened apically, orange. Thorax light brown with ocher areas. Wing membrane colorless, veins ocher; costal brace and adjacent areas with contrasting dark brown stripes. Pterostigma with several oblique veins. Hind wing absent. Legs of all pairs with similar coloration (Fig. 6c): femur light ocher, with inner margin and apex bordered with brown, with reddish macula near apex; tibia with base and apex whitish, other part light brownish on inner side, lighter on outer side; tarsus light brownish. Tarsus of middle and hind legs with two apical spines, on segments 1st+2nd and 3rd. Abdominal segments I–VI whitish, with peculiar maculae: each tergum II–VII with pair of lateral brown maculae on spiracles; each tergum III–VI with pair of sublateral brown maculae; each tergum III–IV with unpaired reddish stripe on posterior margin and with more or less expressed triangular macula arising from this stripe in anterior direction. Abdominal segments VII–VIII uniformly brown. Abdominal terga IX–X lighter. Each segment of cerci white at base and at apex, contrastingly brown at middle; segments with longer and shorter brown areas irregularly alternating (Fig. 5d).

*Male genital structure and development***.** Imaginal genitals as in Fig. 5e. Sterno-styligeral muscle completely absent. Each gonovectis with small hook at apex. Penial bridge without prominent median projection. Unistyligers cylindrical, with straight inner margins. Gonostylus with 1st segment smoothly narrowed toward apex; 2nd segment slightly widened toward apex; 3rd segment short.

Protogonostyli of male larva represent very shallow convexities of posterior margin of abdominal sternum IX. In mature larva ready to molt to subimago, subimaginal gonostyli packed under larval cuticle in «*Labiobaetis*-pose» (Kluge, 2004: fig. 29I): second segments directed medially and bent (Fig. 5f).

Imago, female (Fig. 6a, b). Head ocher with brownish. Prothorax and antero-lateral areas of mesonotum with contrasting light ocher and dark brown markings; other areas of mesonotum and metanotum light brown; ventral side of thorax light uniformly ocher. Wings as in male. Leg coloration as in male. Tarsus of fore leg with two apical spines, on 2nd and 3rd segments (as on middle and hind legs). Each abdominal tergum III and IV with reddish median macula as in male; other markings of abdominal terga and sterna vary individually. Cerci as in male.

Dimension. Body length of larvae 4.2–6.5 mm. Fore wing length (and approximate body length) of subimagos, male and female imagos ca. 5 mm.

Etymology. Refering to the fact that the specimens were collected just behind the campus of Cenderawasih University (UNCEN) in Jayapura.

Distribution. Indonesia: Papua Province (Fig. 7).

Biological aspects. The specimens were collected at an altitude of 160 m in a medium sized, shallow, moderately flowing river with stones and mud on the bottom, with few vegetation (Fig. 8). The new species was collected together with 12 other mayfly species: four other, yet undescribed species of *Labiobaetis* Novikova & Kluge, 1987;

Mystaxiops venatoris McCafferty & Sun, 2005; two species of *Papuanatula* Lugo-Ortiz & McCafferty, 1999; two species of *Centroptella* Braasch & Soldán, 1980; one *Cloeon* sp.; one *Caenis* sp. and *Nonnullidens reductus* Kluge, 2013.

Type-material. Holotype. INDONESIA • larva; Papua Province, Jayapura, Waena, Kamp Wolker; near UNCEN campus; 02°34'07"S, 140°38'51"E; 160 m; 26.v.2019; leg. Surbakti, Kellis & Sumoked; (PAP080); on slide; GBIFCH00592382; MZB. **Paratypes.** INDONESIA • 17 larvae; same data as holotype; 3 on slides; GenBank MW041241, MW041242; GBIFCH00673069, GBIFCH00673081, GBIFCH00592381; KSP, MZB; 14 in alcohol; GBIFCH00515503; KSP, MZB • 4 ♂ and 2 ♀ imagos with individually associated larval and subimaginal exuviae, 1 ♀ subimago with its larval exuviae, 1 ♀ imago, 11 ♂ and 8 ♀ larvae ready to molt to subimagoes, 22 larvae; same locality as holotype; 9–13.viii.2012; leg. N. Kluge & L. Sheyko; Saint-Petersburg State University.

Key to the species of the *Labiobaetis claudiae* group (larvae)

1. Paraproct distally expanded (Fig. 4a) .... *L. stagnum*
- Paraproct distally not expanded (Figs 2g, 4b) 2

2. Labial palp segment II with rather broad protuberance and segment III subquadrangular (Fig. 4f) .... *L. claudiae*
- Labial palp segment II with narrow protuberance and segment III slightly pentagonal (Fig. 1h) .... ***L. academicus* sp. nov.**

Genetics

The genetic distances (K2P) between the species of the *L. claudiae* group are between 20% and 23%, and therefore much higher than 3.5%, which is generally considered as a likely maximal value for intraspecific divergence (Hebert et al., 2003; Ball et al., 2005; Zhou et al., 2010) (Table 1).

Table 1. Sequenced specimens and genetic distances (COI, Kimura 2-parameter, %)

		Specimens catalog #	**GenBank #**	**1**	**2**	**3**
1	*L. academicus* sp. nov.	GBIFCH 00673069	MW041241			
2	*L. academicus* sp. nov.	GBIFCH 00673081	MW041242	0		
3	*L. claudiae*	GBIFCH 00508144	MH619479	21	21	
4	*L. stagnum*	GBIFCH 00465168	MH619491	20	20	23

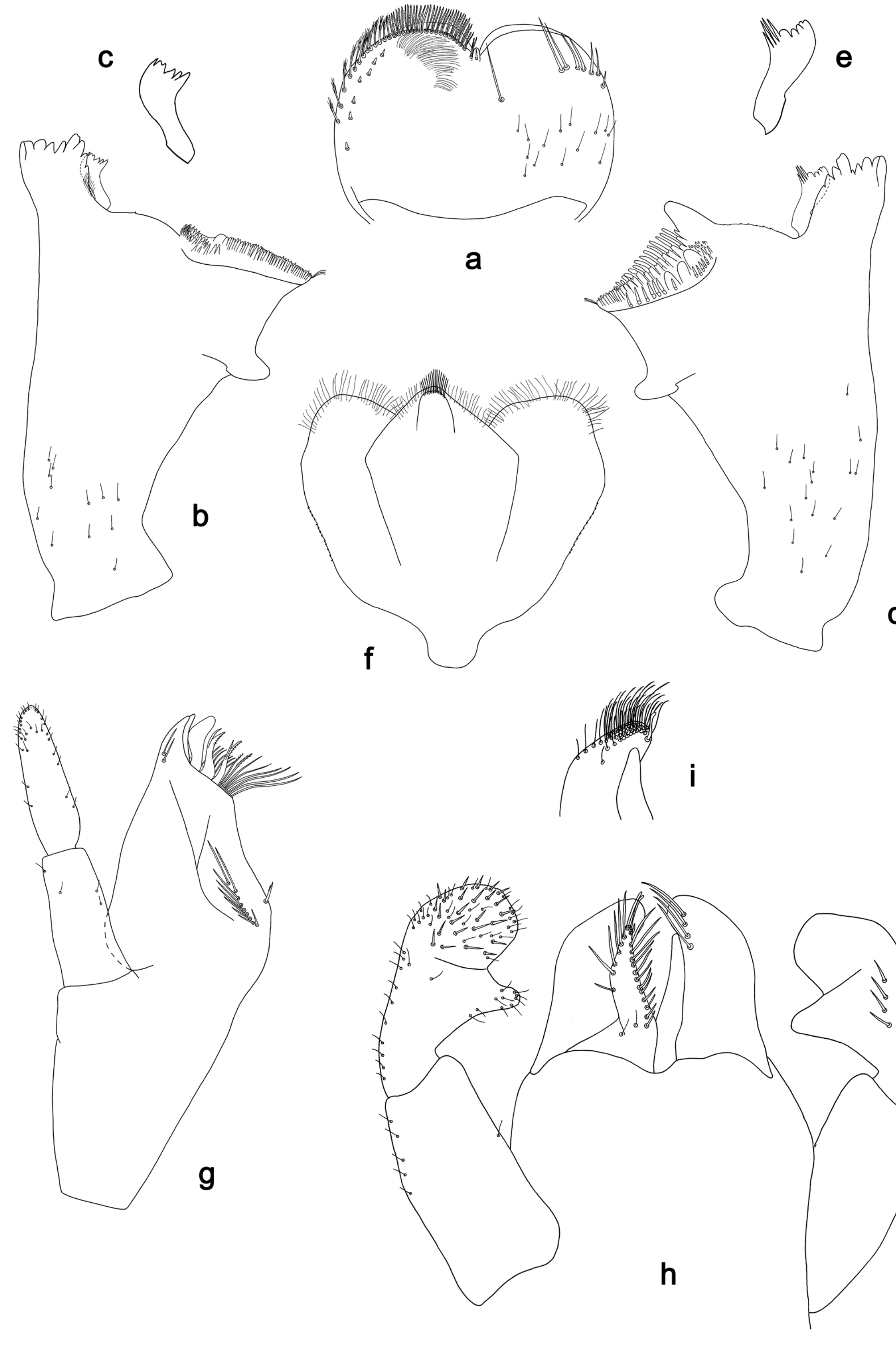

Figure 1. *Labiobaetis academicus* sp. nov., larva morphology: **a** Labrum (left, ventral view; right, dorsal view) **b** Right mandible **c** Right prostheca **d** Left mandible **e** Left prostheca **f** Hypopharynx and superlinguae **g** Maxilla **h** Labium (left, ventral view; right, dorsal view) **i** Apex of paraglossa.

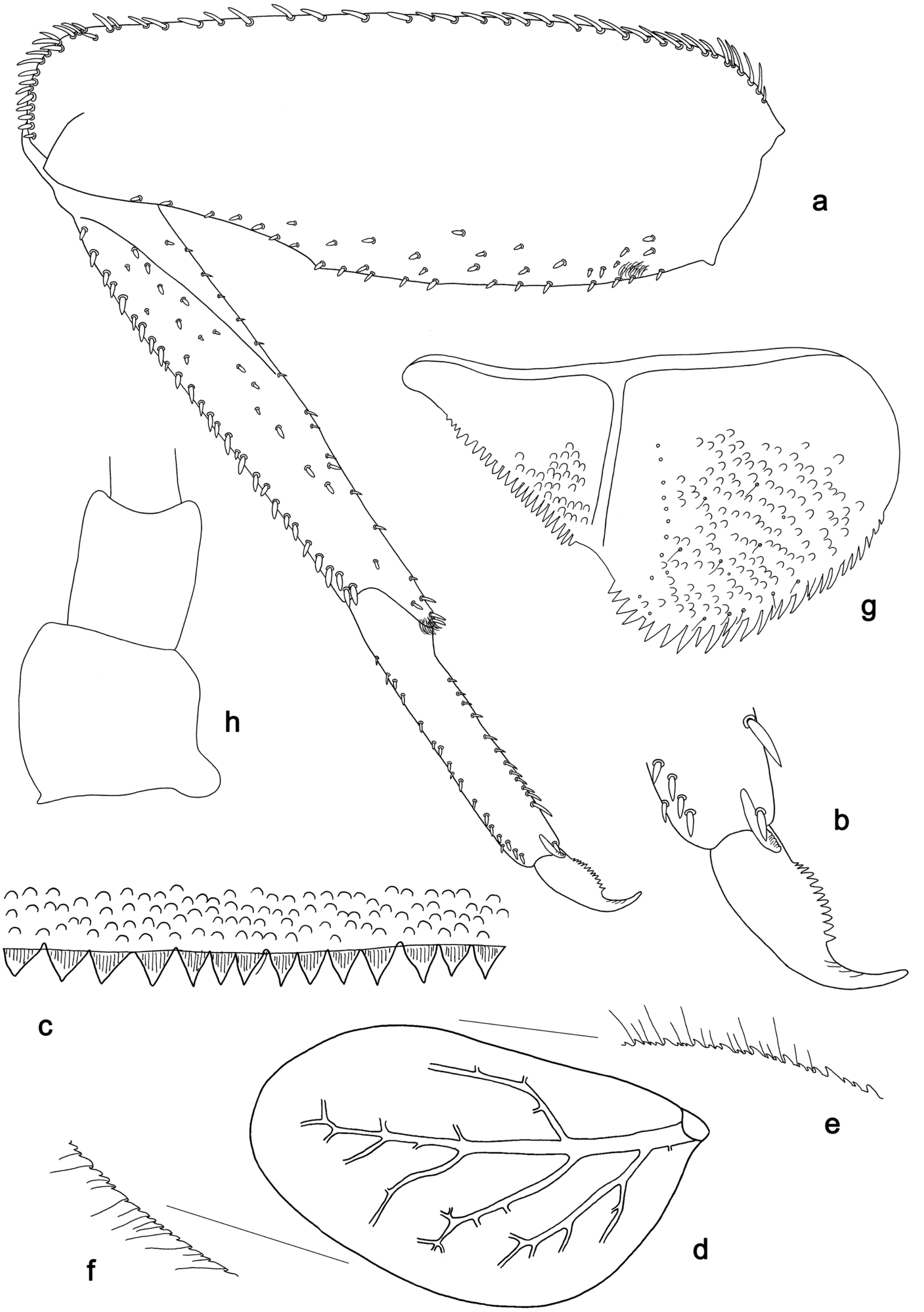

Figure 2. *Labiobaetis academicus* sp. nov., larva morphology: **a** Foreleg **b** Fore claw **c** Tergum IV **d** Tergalius IV **e, f** margin of tergalius IV **g** Paraproct **h** Base of antenna.

Figure 3. *Labiobaetis academicus* sp. nov., habitus, larva: **a** Dorsal view **b** Ventral view.

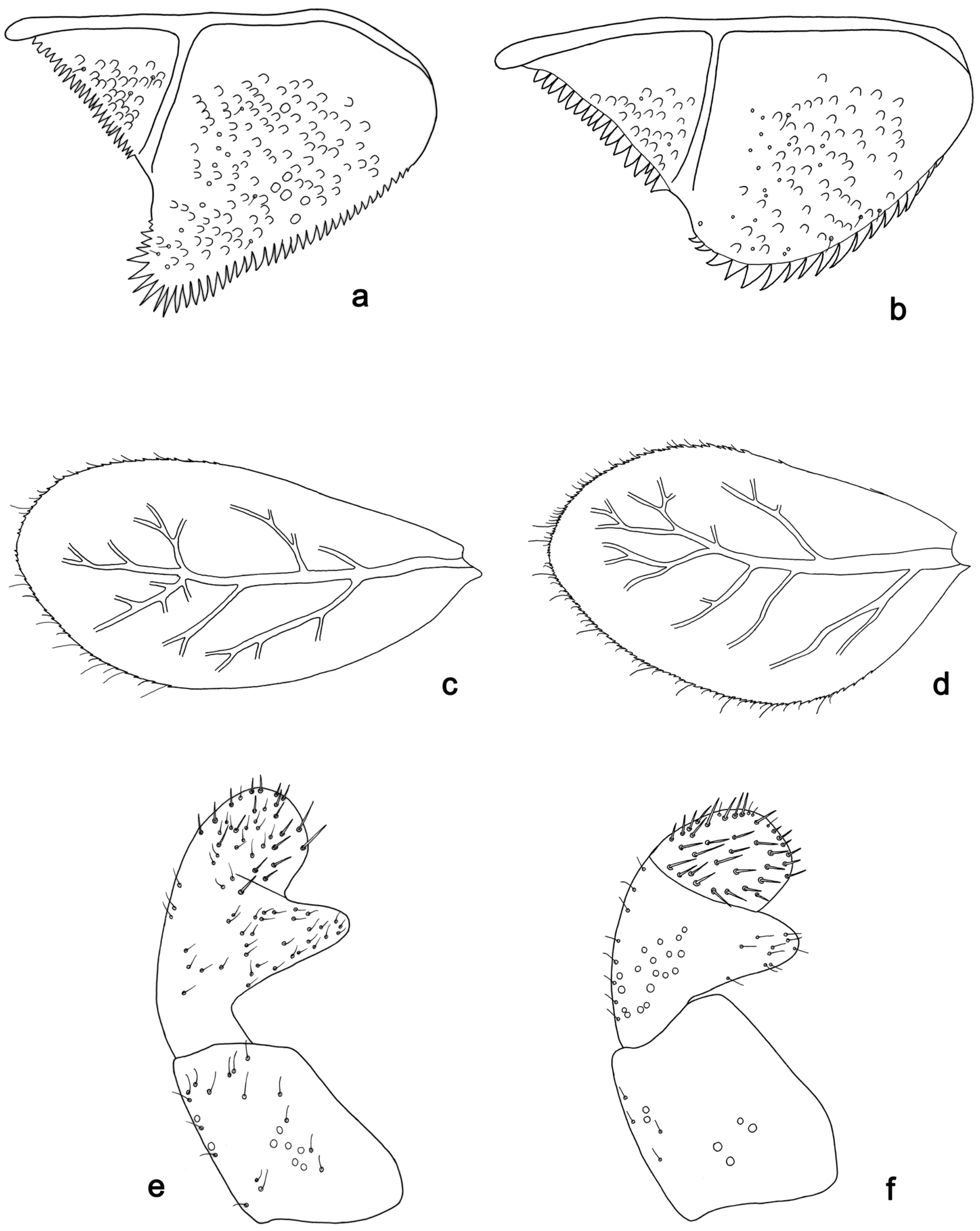

Figure 4. Larvae morphology: **a, c, e** *Labiobaetis stagnum* **a** Paraproct **c** Tergalius IV **e** Labial palp; **b, d, f** *Labiobaetis claudiae* **b** Paraproct **d** Tergalius IV **f** Labial palp.

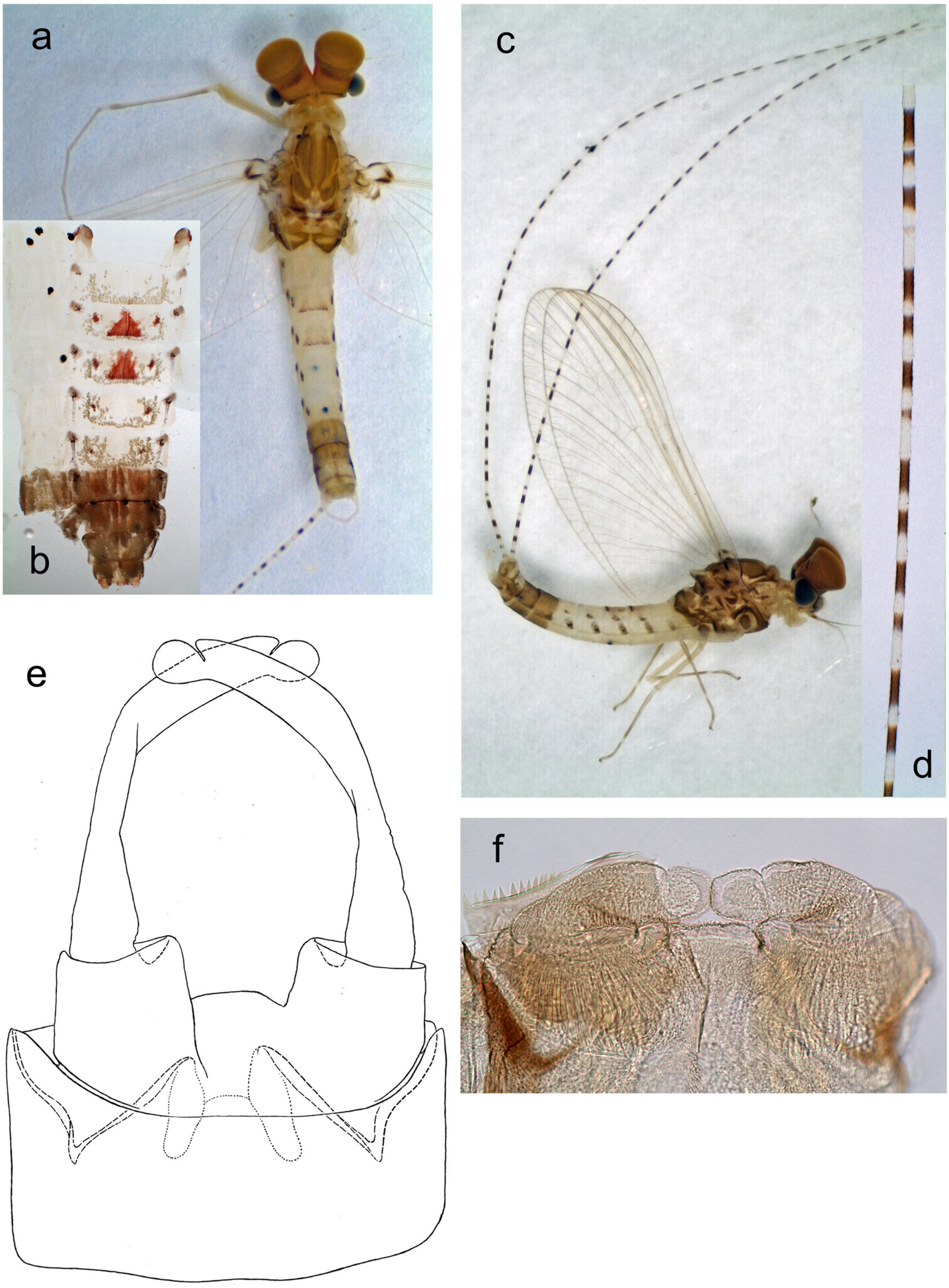

Figure 5. *Labiobaetis academicus* sp. nov., male imago: **a** Habitus, dorsal view **b** Abdomen **c** Habitus, lateral view **d** Cercus **e** Genital structure **f** Subimaginal gonostyli extracted from mature male larva with fragment of larval protogonostylus.

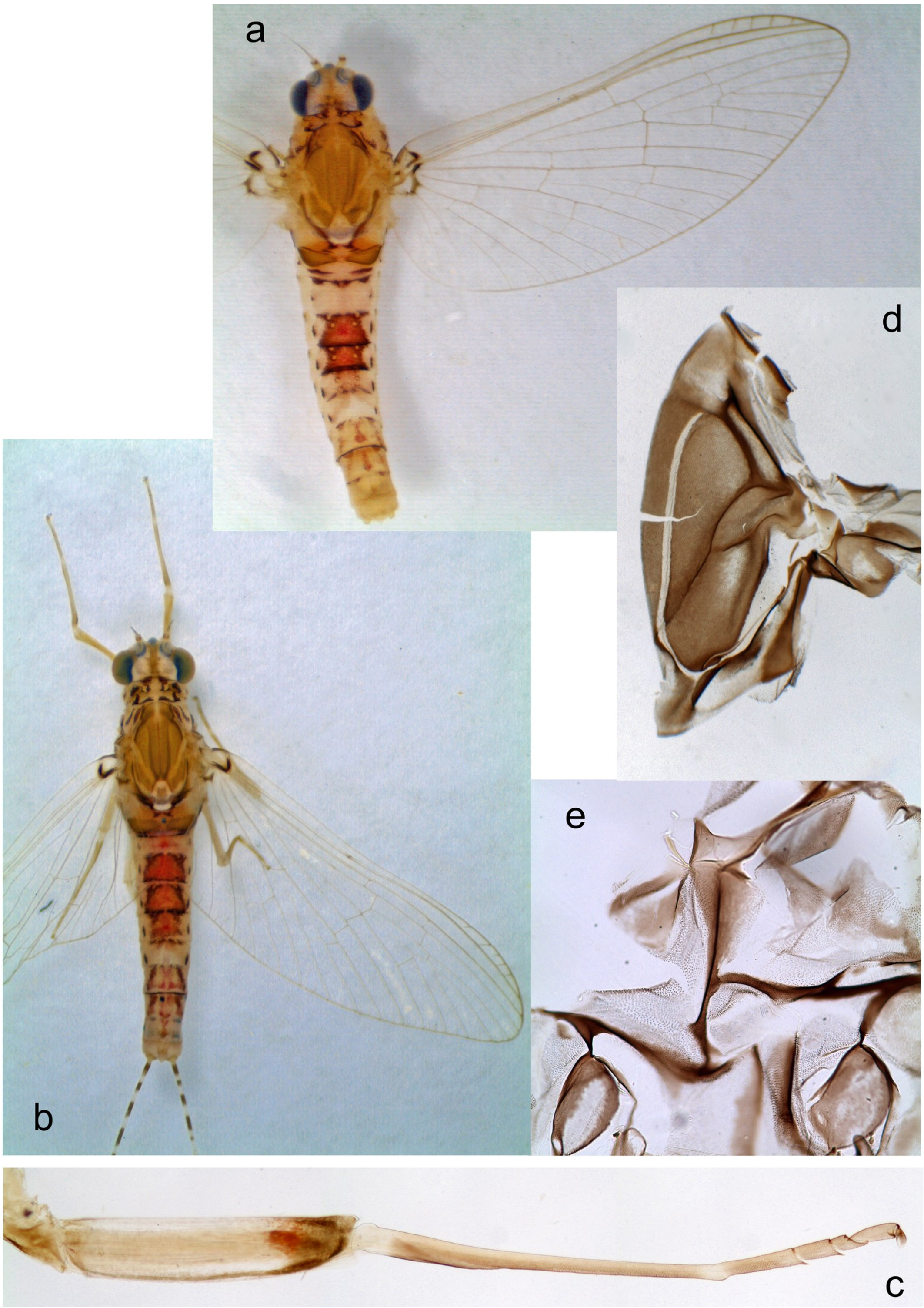

Figure 6. *Labiobaetis academicus* sp. nov., female imago: **a, b** Habitus, dorsal view; male imago: **c** Middle leg; subimago (same in male and female): **d** Mesonotum **e** Mesopleuron.

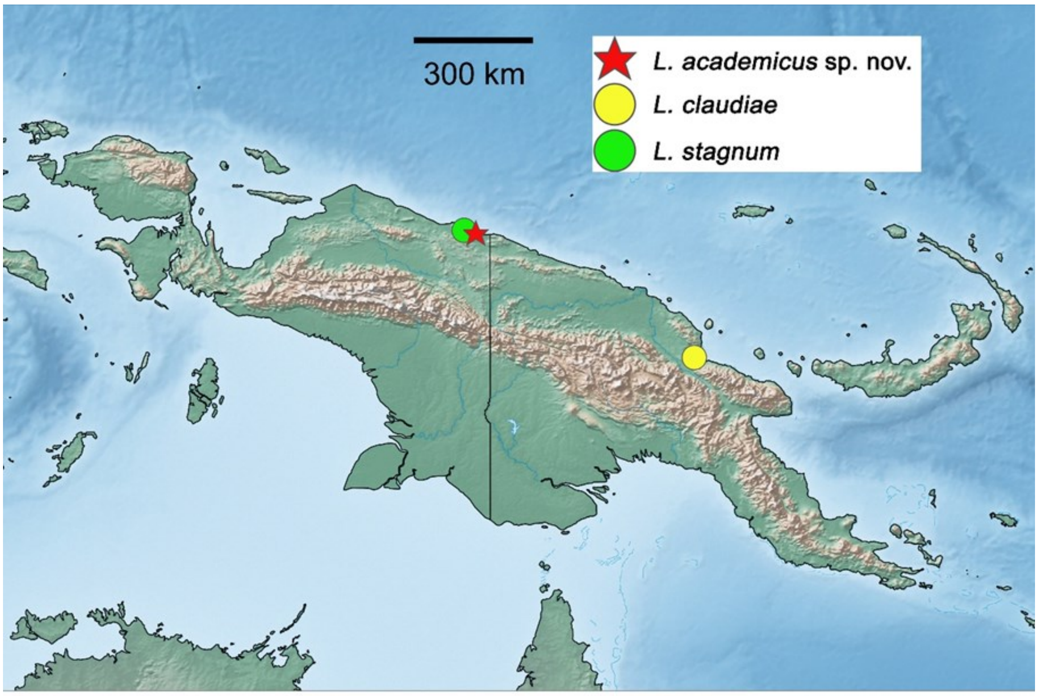

Figure 7. Distribution of *Labiobaetis claudiae* group in New Guinea.

Figure 8. Habitat of *L. academicus* sp. nov. (photo N.J. Kluge).

DISCUSSION

For the assignment of the new species to *Labiobaetis* we refer to Kluge & Novikova (2014), and also to Kaltenbach & Gattolliat (2018; 2019), where the concept of *Labiobaetis* was summarized and discussed.

Based on the morphological characters as described above, there is no doubt that *L. academicus* sp. nov. belongs to the *L. claudiae* group and is closely related to *L. claudiae* and *L. stagnum*. The morphological groups within *Labiobaetis* are primarily a working tool but could also serve as a basis for future studies on the generic delimitation and phylogeny of this genus. The inclusion of nuclear gene sequences may prove that some are natural groups.

The genetic distances between the species of the *L. claudiae* group are rather high, between 20% and 23% (K2P, Table 1), which is in line with the genetic distances found between other species in New Guinea (average 22%; Kaltenbach & Gattolliat, 2018), Indonesia (11%–24%; Kaltenbach & Gattolliat, 2019) and Borneo (19%–25%; Kaltenbach & Gattolliat 2020). Ball et al. (2005) reported a mean interspecific, congeneric distance of 18% for mayflies from the United States and Canada.

Astonishingly, the new species was collected in an easily accessible location just behind the Cenderawasih University (UNCEN) campus, together with other mostly undescribed species of mayflies. This underlines that the Indonesian part of the island of New Guinea is still very poorly sampled and that further collections in whatever part of the island will reveal many more unknown species of aquatic insects and Ephemeroptera in particular and especially of Baetidae. Until recently, traditional taxonomic identification posed a serious bottleneck for the sustainable and objective assessment of megadiverse, mostly undescribed faunas. Integrative approaches can help to tackle this issue by flanking taxonomic work with state of the art imaging technology as well as high throughput DNA sequencing. The underlying concepts have been outlined by Balke et al. (2013), with a plea for molecular biodiversity assessment of the Asian freshwater invertebrate fauna. It would be highly justified to develop a focussed national Indonesian collection program for aquatic insects using such approaches in order to obtain a better view on their megadiversity.

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ASSESSING IN-SITU SEMI-NATURAL BUTTERFLY BREEDING APPROACH OF *ORNITHOPTERA CROESUS* (PAPILIONIDAE) ON BACAN ISLAND, MALUKU UTARA, INDONESIA

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ABSTRACT

Indonesia is rich in endemic species of flora and fauna. One of them is *Ornithoptera croesus* butterfly, which is endemic to North Maluku. Habitat degradation and trade of this species have caused the populations to decline. To avoid the collection of butterfly specimens from nature and to preserve their habitat and population in nature, a semi-natural butterfly breeding practice at Bacan Island was initiated in 2013. This research was conducted to assess the breeding approach for *O. croesus lydius* using a qualitative descriptive method. The assessment was based on these variables: the specific ecology of the butterfly; the suitability of the breeding site and development model; the utilization of larval host plants and butterfly nectar plants; and the establishment of the birdwing population at the site. The observations and results are presented here. Based on the assessment, the in-situ semi-natural breeding approach is one of the solutions for sustainable use of this protected species.

Keywords: birdwing butterfly, breeding, conservation, *Ornithoptera croesus*, sustainable use

ABSTRAK

Indonesia kaya akan spesies endemik flora dan fauna. Salah satunya adalah *Ornithoptera croesus*, spesies kupu-kupu endemik Maluku Utara. Degradasi habitat dan perdagangan spesies ini menyebabkan populasinya menurun. Untuk menghindari pengambilan spesimen kupu-kupu dari alam dan untuk menjaga kelestarian habitat dan populasinya di alam, telah dimulai penangkaran semi-alami di Pulau Bacan pada tahun 2013. Penelitian ini dilakukan untuk menilai pendekatan pengembangan semi alami untuk *O. croesus lydius* dengan menggunakan metoda deskriptif kualitatif. Penilaian dilakukan berdasarkan variabel berikut: kondisi ekologi bagi kupu-kupu ini; kesesuaian tempat penangkaran dan model pengembangan; penggunaan tanaman pakan larva dan pakan sumber nektar bagi kupu-kupu; dan keadaan populasi kupu-kupu sayap burung di lokasi penangkaran. Observasi dan hasil dipaparkan di sini. Berdasarkan penilaian, pendekatan penangkaran semi-alami merupakan sebuah solusi bagi pemanfaatan berkelanjutan kupu-kupu dilindungi ini.

Kata kunci: kupu-kupu sayap burung, penangkaran, konservasi, *Ornithoptera croesus*, pemanfaatan berkelanjutan

INTRODUCTION

As many as 2000 butterfly species are estimated to occur in Indonesia (Peggie, 2014). Some are endemic to certain islands or island groups, and others are commonly distributed throughout the archipelago. Some species of Indonesian papilionids have been flagged as threatened (Collins & Morris, 1985; Endo & Ueda, 2004) and conservation action plan has been suggested (New & Collins, 1991). The understanding of the butterfly ecology, distribution, and threats should be the foundation of conservation programs (Sands & New, 2013) and we are still in the effort of achieving basic data for Indonesian butterfly species.

On the island of Bacan, North Maluku, there are some endemic species (Peggie et al., 2005) including the beautifully brilliant-colored and highly demanded Wallace's Golden Birdwing, *Ornithoptera croesus* Wallace, 1859. This species has different subspecies on Bacan, Halmahera, and Morotai. Some even recognized distinct subspecies from the island of Kasiruta and Mandioli. The subspecies in Bacan is *Ornithoptera croesus lydius* (Felder & Felder, 1865) which is the focus of this paper. A further research, such as using mitochondrial and nuclear genes, may reveal speciation and diversification rates (Condamine et al., 2015) which may affect the conservation strategies. The strategies would be different if they in fact constitute same or different subspecies, in term of breeding and avoiding extirpation.

A study of the diversity of papilionid butterflies at Gunung Sibela Nature Reserve, Bacan (Mas'ud et al., 2016) showed that *O. croesus lydius* was found in very few numbers, only 1-2 individuals seen each sighting time, at four sites of altitude 20 m, 200 m, 400 m, and 800 m asl. Tropical forests have experienced human disturbance from mild to severe conditions (Laurance et al., 2001). The most common disturbances are logging and land clearing for agriculture, and hunting (Whitworth et al., 2018).

Butterflies require at least two kinds of plants: leaves as food for the larvae and flower nectars as food for the adults. Butterflies and their larvae have specific associations that vary among species and groups (Feeny et al., 1983; Jermy, 1984; Bernays, 1992; Ferrer-Paris et al., 2013). Similarly, the abundance of these food sources determines the abundance of the butterfly population (Curtis et al., 2015). Therefore, the diversity and population of butterflies are highly dependent on the diversity and population of the host plants.

Though all birdwing butterflies are included in the Appendix II of CITES and are protected under Indonesian regulation (BKSDA, 1999; Peggie, 2011; KLHK, 2018), the high economic value of birdwing butterflies has attracted some people to obtain butterfly individuals in high numbers. In certain cases of endemic and rare species of Indonesian butterflies, declining populations due to habitat changes can be worsened by domestic and international trading (Soehartono & Mardiastuti, 2002). In recent years, *O. croesus* butterfly is included as one of the candidates of Review of Significant Trade by CITES due to high volume of trades and the source code usage (CITES, 2020).

Considering the IUCN status of *O. croesus* which has been classified as NT – near threatened (Böhm, 2018), direct collections of adults and pupae from the natural habitats should be avoided. For species with declining populations, conservation strategies need to be assessed (Schultz et al., 2008). A breeding facility exists on Bacan Island, in which an environmentally friendly method of semi-natural breeding of *O. croesus lydius* and a few other butterfly species was developed. The facility has created an environment to attract wild butterflies from nature to come to lay eggs, the larvae grow and develop to pupae, adults emerge out of the pupae, and population can establish well there. Captive breeding facilities can also provide the much-needed data on life history and other aspects of the species (Matsuka, 2001; Daniels et al., 2020). However, there has been no report on the breeding of *O. croesus lydius* in the facility. Therefore, this study aims to assess the breeding approach whether in-situ semi-natural breeding method meet the criteria for sustainable use of *O. croesus lydius*.

This research is part of our contribution to support the institutional role of LIPI as Indonesian Scientific Authority of CITES and also to provide insights to the Ministry of Environment and Forestry as Indonesian Management Authority of CITES.

MATERIALS AND METHODS

This research was conducted in April 2018 and September 2019 on Bacan Island, North Maluku using a qualitative descriptive method. We had background knowledge about the butterfly breeding facility prior to the surveys. Specific ecological aspects of *O. croesus lydius* were observed both in natural habitat at two different sites at Gunung Sibela (Fig. 1) and at the butterfly breeding facility. Basic ecological data is necessary to be obtained for better understanding of the butterfly conservation.

The study to assess the butterfly breeding approach was primarily carried out at an in-situ semi-natural butterfly breeding facility at Labuha, Bacan Island (Fig. 2a). In-situ means that the facility is located within the range of the subspecies. Semi-natural refers to the condition that larval host plants, nectar-providing plants, and other supporting plants were planted to enrich the area as to attract butterflies.

The variables to assess the breeding approach include: the specific ecological requirement of the *O. croesus lydius* that supports its breeding; the suitability of the breeding site and development model; the utilization of larval host plants and butterfly nectar plants; and the establishment of the birdwing population at the site. Additionally, the diversity of other butterflies that came to the area was also observed.

Existing conditions of the facility were observed and recorded, including: the size of the facility, the size of the cage area or the butterfly enclosure, the condition of the surrounding, the butterfly species occurred inside the enclosure, the species and the number of larval host plants, the species and the number of nectar-providing plants. The occurrence of *O. croesus lydius* inside and outside the enclosure (Fig. 2b) was noted and recorded during the study from morning to afternoon for 3 days in 2018 and 2 days in 2019. Additional information was available from photographs taken several times in the past 5 years.

Figure 1. Habitat of *O. croesus lydius* at Gunung Sibela, Bacan.

Figure 2. In-situ semi-natural butterfly breeding facility at Labuha, Bacan Island: **a.** butterfly cage or enclosure; **b.** area outside the enclosure with trees of *Mussaenda* sp. and a good spot to see incoming butterflies from the neighboring forest.

RESULTS

Specific ecological aspects of the butterfly in natural habitat and at the breeding facility

The natural habitat of this butterfly is pristine forests of Gunung Sibela. We do not disclose the exact locality because of the rarity of the butterfly and it is a protected species. We walked up the river for about three hours in the first survey to reach a grand spot of flowering plants up the river, and two hours in the second survey to a different spot with similar condition.

There were two large trees of white petal-like calyx lobes *Mussaenda* sp. and some plants of red-flowered *Hibiscus* sp. at the first observation spot. The birdwing butterfly flew fast across a vast area of the forest five times (on April 14, 2018 between 10:30 and 13:15) and came to *Mussaenda* flowers twice (at 12:10 and 12:20) during a three-hour observation in the first survey. Like other swallowtails, they keep moving their wings while taking nectar on a flower (Fig. 3a). We observed that *Hibiscus* flowers were not visited by any butterfly. After the observation of the butterfly, we were shown the location of the native host plants, *Pararistolochia* sp., on the hill across the river from the *Mussaenda* trees.

At the second observation site, there were four large trees of *Mussaenda* sp. and no other flowering plants. During a three-hour observation in the second survey, on September 4, 2019, a male individual was observed taking nectar quickly on *Mussaenda* flowers at 9:39, was perching for a few seconds on a leaf of a high tree at 11:08, was seen taking nectar on *Mussaenda* at 12:28; and one female was seen taking nectar on *Mussaenda* at 12:40 (Fig. 3b). We could not be certain whether the male is the same individual or different one.

The observation on September 5, 2019 at the breeding facility revealed that this butterfly was active at 8:30, seen on *Mussaenda* flowers, both inside the enclosure and outside. During their search for nectar, they could meet their partners to conduct mating (Fig. 3c). A female outside the enclosure was also observed seeking host plant leaves at 16:03. However, we could not see as to where she flew among the trees and vines, so we could not observe the ovipositing behavior.

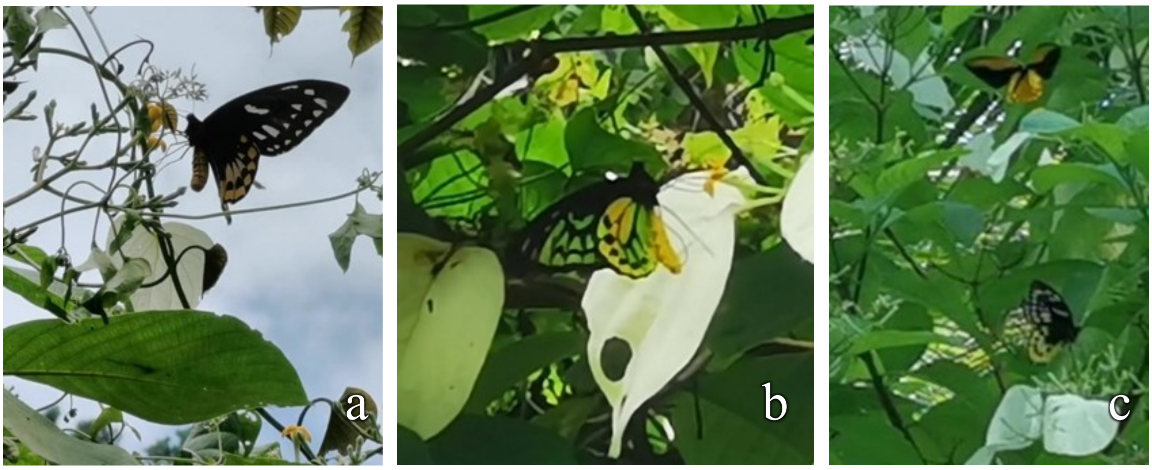

Figure 3. Observation of *O. croesus*: **a.** male on *Mussaenda* flowers at the natural habitat of Gunung Sibela, Bacan; **b.** female on *Mussaenda* flowers at Gunung Sibela; **c.** male (above) approached female (below) on *Mussaenda* flowers at the butterfly breeding facility at Labuha, Bacan.

The site of in-situ semi-natural breeding facility

The in-situ semi-natural breeding facility was started in 2013 on a piece of land, that was enriched with numerous larval host plants and nectar-providing plants. The overall size of the area is quite large, approximately three hectares. The land consists of mixed plantations, predominantly coconut trees, *Mussaenda* trees, palms, and over 50 plants of *Aristolochia* spp. climbing mainly on coconut trees. The trees of *Mussaenda* sp. reach on average 7 meters in height and 8 meters in canopy spread and have numerous flowers. At the further end of the land, which borders with a secondary forest, a butterfly enclosure was built. The size of the enclosure is about 500 m^2 (28 m long x 18.5 m wide), and about 8 m high, covered by insect net. This large size is necessary to allow wider area for the birdwings to fly inside the enclosure. The top of the enclosure is not fully closed, some areas are left open, allowing butterflies from the wild to enter the enclosure to lay eggs on the host plants.

Prior to the initiation of the enclosure in 2013, the area was enriched with host plants and nectar plants to attract butterflies to the area. Female butterflies laid eggs on the host plants. Then parts of plants which had eggs or caterpillars were covered with large net sleeve (Fig. 4) to avoid any predators and parasites. Every day, the breeder would check if the caterpillars had enough leaves and would move the caterpillars to other branches if needed. This ranching practice is quite common among breeders to optimize the usage of host plants. After the pupae emerge into adults, they can be harvested and some are released to the wild for restocking. This practice meets the criteria for ranching of controlled environment.

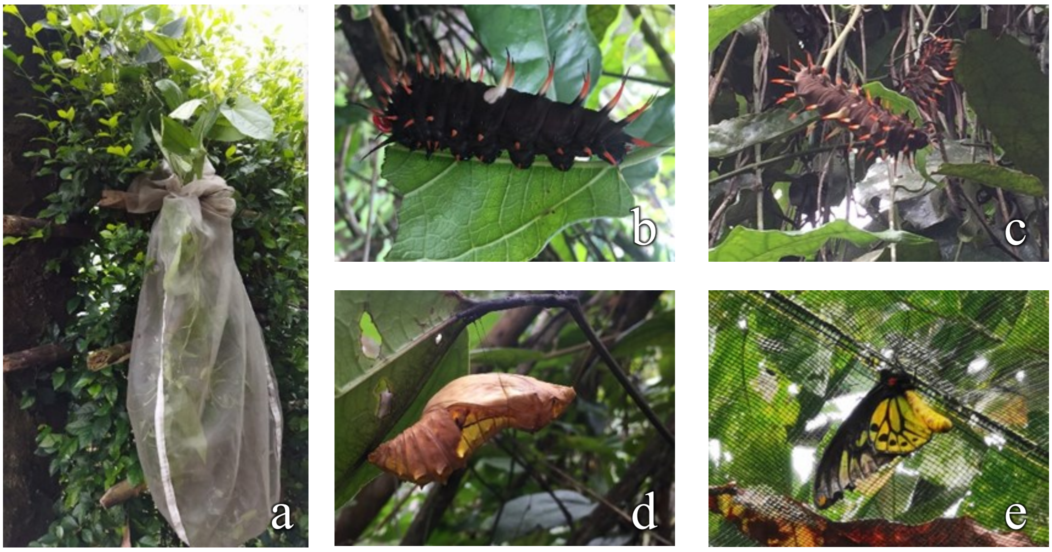

Figure 4. Approach to breeding butterflies: **a.** The ranching practice of keeping pre-adult stages on host plants covered with a large net sleeve; **b-e.** the captive breeding practice of keeping pre-adult and adult stages inside a butterfly enclosure: **b.** 4th instar larva on a leaf of *A. acuminata*, **c.** 5th instar larvae on leaves of *Pararistolochia* sp., **d.** pupa, **e.** adult male of *O. croesus lydius*.

Utilization of larval host plants and butterfly nectar plants

Inside the enclosure, as many as 412 plants of *Aristolochia acuminata* (previously known as *A. tagala*, see Yao, 2015) from Bali, 375 plants of *Aristolochia* sp. from Obi, 346 plants of *A. gaudichaudii* from Papua, and 54 plants of *Pararistolochia* sp. (Fig. 5) were planted in 30 rows and 20 clusters. In addition to the host plants for *O. croesus*, in the enclosure there were also host plants for other butterfly species such as *Papilio ulysses*, *P. lorquinianus*, *P. polytes*, *P. deiphobus*, *P. tydeus*, and *Graphium* spp. Outside the enclosure, more than 50 plants of *Aristolochia* sp. were planted to support incoming butterflies.

The leaves of *Aristolochia* spp. were eaten by larvae of *O. croesus lydius* inside the enclosure. Additionally, the leaves of *A. acuminata* were also eaten by larvae of *Troides criton*, and *Pachliopta polyphontes*. We observed that *A. acuminata* was utilized as the primary host plants in the breeding site (Fig. 5a), but *Pararistolochia* sp. was found as the native host plants in the wild (Fig. 5b). At the breeding facility, *O. croesus lydius* prefers *A. acuminata* and thrives well on it. Nevertheless, we saw two larval individuals on *Pararistolochia* sp. (Fig. 4c).

Some flowering plants such as *Clerodendrum* sp., *Ixora* sp., and 84 plants of *Mussaenda* sp. (Fig. 6) are available inside the enclosure. We observed that only flowers of *Mussaenda* sp. were visited by *O. croesus lydius*. Other nectar plants were used by other smaller butterfly species.

Figure 5. The larval host plants inside the butterfly breeding facility at Labuha, Bacan: **a.** rows of *Aristolochia acuminata*; **b.** rows of the native host plants, *Pararistolochia* sp.

Figure 6. The flowering plants inside the butterfly breeding facility at Labuha, Bacan: a. *Mussaenda* sp.; b. *Clerodendrum* sp.

Birdwing population at the breeding site

In our first survey in 2018, inside the enclosure we found more than 50 individuals of 4th and 5th instar larvae and more than 30 individuals of pupae of the butterfly. The numbers only included those we could see up to 2 meters. There would be many more on leaves above 2 meters as the vines of *Aristolochia* spp. reached the roof of the enclosure. There were no eggs and early stage larvae during our surveys. In our second survey in 2019, we found similar numbers, with 3 adults seen inside the enclosure. These surveys confirmed the condition reported to us through photographs taken several times in the past 5 years prior to the surveys. Therefore, we could determine that *O. croesus lydius* has established the population at the site because of the numerous host plants and nectar plants, and also because of the supporting condition from the neighboring forest.

At the breeding site, outside the enclosure, we observed adults of the species flew fast in and out of the area from the neighboring forest (Peggie et al., in prep.). At least nine other butterfly species were seen visiting flowers of *Mussaenda* trees, i.e. 6 species of Papilionidae: *Pachliopta polyphontes*, *Papilio deiphobus*, *P. polytes*, *P. tydeus*, *P. ulysses* and *Troides criton*; and 3 species of Nymphalidae: *Danaus* sp., *Idea durvillei* and *Parthenos sylvia*. *Danaus* was only identified to generic level as the butterfly was not collected and was only seen from afar.

DISCUSSION

Our encounters with *O. croesus lydius* at its natural habitat at Gunung Sibela Nature Reserve in both surveys confirmed the finding of Mas'ud et al. (2016) that *O. croesus* could only be found in very few numbers. We saw two to four individuals each time. Another issue to consider here is the question of whether the individuals seen flying across or towards the *Mussaenda* trees were the same individuals. In the case of *Troides aeacus,* radio telemetry was used to track the dispersal flight patterns (Wang et al., 2019). The distribution of this birdwing butterfly on Bacan Island is limited only to Gunung Sibela and perhaps two other farther locations (Alisi, pers. comm.). Thus, the rarity of this species should raise an alarm and become a major concern to all stakeholders.

Land clearings and cutting down trees at lower elevation of Gunung Sibela have probably affected the spatial distribution of this species as indicated by Mas'ud et al. (2016). In general, populations of numerous butterfly species have recently declined primarily due to habitat deterioration (Van Swaay et al., 2005; Van Dyck et al. 2009; Nakamura, 2011).

Our observation indicates that *Mussaenda* is the most preferred by *O. croesus lydius* and many other butterfly species. *Mussaenda* has large white petal-like calyx lobes (Claβen-Backhoff, 1996) that can be detected from long distances by butterflies, as shown in long-ranging *Troides minos* at a lowland forest in Western Ghats, India (Borges et al., 2003). We confirmed that the large white petal-like lobes can be very attractive for butterflies (Naiki & Kato, 1999; Naiki, 2008) including *O. croesus lydius* to come for nectar.

The native host plants, *Pararistolochia* sp. were found across the river from the *Mussaenda* trees of the first observation site at Gunung Sibela. The presence of *Pararistolochia* sp. and *Mussaenda* sp. at Gunung Sibela confirmed that the specific ecological requirements for this species have been met. It has been reported by Igarashi & Fukuda (1997, 2000) that *O. croesus* utilized *Aristolochia gaudichaudii* and two species of *Pararistolochia*. Although *Pararistolochia* spp. was thought to be the primary host plants

(Igarashi & Fukuda, 2000), when presented with some choices at the breeding facility, *O. croesus lydius* prefers *A. acuminata*, though two larval individuals were seen also on *Pararistolochia* sp. The requirement for plants in the breeding facility has been fulfilled by the presence of hundreds of plant individuals planted to enrich the area to attract butterflies.

Field observation revealed that this butterfly is a strong long-range flyer, thus requires extensive area to maneuver. The natural habitat fulfills this requirement very well, with vast area in the pristine forest. The requirement for extensive space can be fulfilled in the butterfly breeding facility as well. The size of the enclosure is quite large and high enough to allow space for flying inside the enclosure. The area outside the enclosure also provides ample space for the birdwing to fly, especially with the existence of neighboring forest. Therefore, specific ecological aspects, its requirements for plants and for movement area can be fulfilled both in the natural habitat and at the breeding facility.

Butterflies move from place to place to get enough food for themselves (D'Abrera, 1990), usually over long distances, so butterflies spend much energy to find nectar plants and host plants. Development of in-situ butterfly breeding model can be beneficial where the butterflies can find larval host plants and nectar-providing plants at the same place.

Some birdwing butterflies are known to be unpalatable to birds due to their noxious compounds derived from the host plants (Parsons, 1999). It is yet to be found out if *O. croesus lydius* is vulnerable to bird attack. Butterflies are prone to natural enemies, including parasitoids (Vinson, 1998; Santhosh & Basavarajappa, 2019). The usage of butterfly enclosure as controlled environment can reduce the risk of death by natural enemies. However, even within the enclosed environment, some natural enemies were reported (Nacua et el., 2020) and need to be handled by butterfly breeders. While the openings at the top of the enclosure allowed incoming butterflies to enter, they also allowed the butterflies inside to escape and increase the risk of natural enemies.

To be categorized as a captive breeding facility, the openings at the top of the enclosure will need to be closed tightly. The totally closed enclosure involves more work of collecting eggs and early stage larvae from the plants outside of the enclosure and putting them into the enclosure to be protected from natural enemies.

Another model to facilitate sustainable trade of the birdwings would be a butterfly ranching operation, but this requires the facility to be in-situ at the natural habitat. The butterfly ranching operation such as that implemented by WWF at many scattered locations at the Arfak Mountain, Papua in 1990s emphasized on habitat enrichment (Neville, 1993).

Adults emerged from pupae were harvested for trade with consideration that some were allowed to fly to replenish the area so populations are not diminished by the practice (Neville, 1993).

The suitability of the butterfly breeding site and the development model will influence the success of a breeding program. The elevation of the breeding site is very low, much lower than the natural habitat of *O. croesus* at about 300-400 m. Despite the low elevation of the butterfly breeding facility, we observed that it can support some butterfly species, even *O. croesus*. Apparently, the adjacent forest provides the nature stocks of the butterflies. In addition, adequate sunlight, ideal humidity and temperature need to be considered also in the controlled environment. On the second visit to the facility, we found similar condition of thriving population of *O. croesus* as in the first visit. Thus, the second variable of the assessment, i.e. the suitability of site and development model, is fulfilled, though a higher elevation would be better.

Increasing the availability of food sources in a controlled environment will reduce inter- and intra-species competition (Borror et al., 1996). With plentiful leaves of host plants and flowering plants available inside and outside the enclosure, the butterflies can be supported for the needs. Based on our observation, the third variable of the assessment, i.e. suitability of larval host plants and nectar-providing plants, is also fulfilled.

The fourth variable of the assessment is to determine whether the birdwing has established its population at the site. The number of pre-adults inside the enclosure and adults outside the enclosure showed that the birdwing has established its population at the breeding facility. The presence of some other butterfly species at the facility in both surveys indicated the diversity of butterflies. This was confirmed by the presence of larvae and pupae of *Troides criton*, *Pachliopta polyphontes* and *Papilio* spp. in the enclosure. Some other butterfly species were also sighted outside the enclosure.

We would like to reiterate that in-situ semi-natural butterfly breeding approach can be developed and recommended for butterfly conservation and sustainable use of *O. croesus lydius* on Bacan Island. Planting *Mussaenda* trees side by side with *Aristolochia* sp. is preferred so that the can get resources for both pre-adult and adult stages at the same place. The suitability of a site is an important factor to consider, in this case the adjacent forest provides suitable environment even for *O. croesus* to flourish. As observed at the natural habitat, *O. croesus* flies fast, high, and far, so the height of the enclosure is crucial for the success of the breeding operation. Therefore, having assessed the variables, we have come to the conclusion that in-situ semi-natural breeding approach for *O. croesus* is a viable option and meet the criteria for sustainable use of *O. croesus lydius*. This approach should be pursued with some improvements to be an effective model for sustainable use of the butterfly species.

Cooperation among all stakeholders is needed to conserve butterfly diversity and habitat preservation. Conservation measures can be taken through environmental friendly operations that satisfy stakeholders. Approach such as ranching and captive breeding practices need to be encouraged and supported. More importantly, the remaining forests on Bacan Island need to be preserved and the capacity to be increased to maintain the habitat and diversity of butterflies.

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LARVAE AND ADULTS OF *ASCAROPS* SP. (NEMATODA: SPIROCERCIDAE) COLLECTED FROM THE STOMACH OF *MAXOMYS WHITEHEADI* (RODENTIA: MURINAE) IN KALIMANTAN, INDONESIA

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ABSTRACT

Third-stage larvae and adults of spiruroid nematodes were found from the stomach wall and stomach lumen, respectively, of *Maxomys whiteheadi* (Rodentia: Murinae) captured in Bukit Soeharto, Kalimantan, Indonesia. Close observation using light microscope and scanning electron microscope (SEM) revealed that it belongs to the genus *Ascarops* (Nematoda: Spirocercidae), possibly to *Ascarops strongylina* (Rudolphi, 1819). It is presumed that this species is parasitic in wild boars, *Sus barbatus*, in the forest of Kalimantan, and utilizes the murine as a paratenic host, in which it usually remains as third larval stage but can occasionally develop to adult stage.

Keywords: *Ascarops*, Kalimantan, *Maxomys whiteheadi,* Nematoda

ABSTRAK

Larva tahap ketiga dan dewasa dari nematoda spirurida ditemukan berturut-turut dari dinding dan lumen lambung *Maxomys whiteheadi* (Rodentia: Murinae) yang ditangkap di Bukit Soeharto, Kalimantan, Indonesia. Berdasarkan hasil pengamatan menggunakan mikroskop cahaya dan mikroskop elektron mengungkapkan bahwa nematoda tersebut masuk dalam genus *Ascarops* (Nematoda: Spirocercidae), kemungkinan adalah *Ascarops strongylina* (Rudolphi, 1819). Diduga spesies tersebut merupakan parasit pada babi liar, *Sus barbatus,* yang terdapat di hutan Kalimantan, dan menggunakan tikus sebagai inang perantara.

Kata kunci: *Ascarops*, Kalimantan, *Maxomys whiteheadi,* Nematoda

INTRODUCTION

Ascarops strongylina (Rudolphi, 1819) (Nematoda: Spirocercidae) is a cosmopolitan species usually parasitic in pigs and wild boars (Shmitova, 1964). It utilizes insects such as dung beetles as intermediate hosts and various vertebrates as paratenic hosts (Ono, 1933; Alicata, 1935; Shmitova, 1964). Rats and mice have been known to play a role as paratenic hosts (Ono, 1933; Varma et al., 1976). Meanwhile, Hasegawa et al. (1994) first found adults of this nematode in the stomach of *Rattus rattus* on Lan Yu, a remote island of Taiwan. By checking nematode specimens collected from murine rodents captured in Kalimantan, Indonesia, some adult worms belonging to the genus *Ascarops* were found from *Maxomys whiteheadi* along with the third-stage larvae encysted in the stomach wall. We conducted detailed observation using light microscope and scanning electron microscope to elucidate the precise morphology of the worms.

MATERIALS AND METHODS

The host murines were captured in Bukit Soeharto Preserved Forest, Kalimantan, Indonesia, in August 1993. Methods of trapping and examination were given in Hasegawa and Syafruddin (1997). The viscera were excised and fixed in 70% ethanol and then transferred to 5% formalin. The alimentary canal was incised and the contents were washed with running water on a fine sieve with aperture size of 75µm. Then, the residues on the sieve were transferred to a petri dish with the proper amount of water, and examined for nematodes under a stereomicroscope. The alimentary canal wall was also examined for the presence of nematode cysts. Cysts were incised using fine needles to recover larva inside. Collected nematodes were rinsed in 70% ethanol, cleared in glycerol ethanol solution by evaporating ethanol, and mounted in 50% glycerol for observation under a light microscope Olympus BX50 equipped with a differential interference contrast apparatus. Some worms were examined using a JEOL JSM-IT 200 scanning electron microscopy (SEM) at an accelerating voltage of 5 kV. Before observed, nematodes were fixed in glutaraldehyde and cacodylate buffer, dehydrated in alcohol concentration series beginning from 70% to absolute, vacuum-dried using TAITEC VC-96N, at least for 30 minutes, mounted on specimen stub, and then coated with gold at 5–8 mÅ for 5 min. Voucher specimens were deposited in the Museum Zoologicum Bogoriense (MZB).

RESULTS

Four males and 1 female and 1 fragmented female of adult stage and one fourth-stage larva of *Ascarops* were recovered from the stomach of *M. whiteheadi*. Prevalence was 35% (6 out of 17) with intensity of 1 to 2 (mean 1.3). Third-stage larvae were also found forming round cyst of about 0.5 mm in diameter, in various organs, mostly the stomach wall, but also in small intestine serosa and mesentery, with prevalence of 53% (9 out of 17) (Fig. 1).

Morphological description

***Ascarops* sp.**

(Nematoda: Spirurida: Spiruroidea: Spirocercidae: Ascaropsinae)

Third-stage larvae (10 individuals): Forming round cysts of about 0.5 mm in diameter (Fig. 1). Body slender, tapering to both extremities (Figs. 2, 3, 6). Cuticle with fine transverse striations. Lateral alae absent. Mouth elongated dorso-ventrally, hexagonal, surrounded by lateral projections and dorsal and ventral elevations; lateral shields trapezoid, each with amphidial pore at upper base; four large cephalic papillae present (Fig. 4). Pharynx thickwalled; esophagus divided into short anterior muscular portion and long posterior glandular portion. Nerve ring near posterior end of muscular esophagus and excretory pore at level of junction of muscular and glandular portions (Fig. 2). Deirids small, spike-like, positioned asymmetrically: left deirid much anterior to right deirid (Fig. 5). Tail conical with terminal round tubercle (Figs. 3, 6). Phasmidial pore minute, in posterior half of tail (Fig. 6). Primordial gonad ellipsoidal, located ventral to intestine (Fig. 7). Measurements are given in Table 1 comparing with previous reports.

Fourth-stage larva (1 individual): Still within cuticle of third-stage (Figs. 8, 9). General morphology similar to third-stage larva except pharynx with faint spiral markings (Fig. 8) and string-like gonad. Deirids hardly to be observed. Tail conical, with round terminal tubercle (Fig. 9). Measurements are given in Table 1 comparing with previous data.

Adults: Body tapered anteriorly (Fig. 10). Cuticle with fine transverse striations (Fig. 11). Lateral alae indistinct. Mouth with lateral pseudolabia each with three elevations; four submedian cephalic papillae and two amphids present (Fig. 11). Pharynx with spiraled thickenings (Figs. 11, 12). Nerve ring slightly anterior to junction between muscular and glandular portions of esophagus; excretory pore slightly posterior to nerve ring. Deirids spike-like, asymmetrically positioned: left deirid anterior to right deirid.

Male (3 worms): With asymmetrical caudal ala; verrucose markings well developed; cloacal aperture encircled by hemicircular disc with serrated margin; caudal papillae 4 pairs precloacal and 6 pairs postcloacal: 1st pair of postcloacal papillae inside of hemicircular disc; 2nd pair large, situated laterally; 3rd to 5th pairs minute, lined at midlevel of tail; 6th pair near tail end; phasmidial pore between 5th and 6th postcloacal papillae (Figs. 14 – 16). Spicules unequal, left spicule slender, much longer than stout right spicule (Fig. 13). Measurements are given in Table 2 comparing with previous data.

Female (2 worms): Vulva at ventral elevation, seen only in fragmented female (Fig. 17). Tail conical. Eggs not formed. Measurements are given in Table 3 comparing with previous data.

Host: *Maxomys whiteheadi* (Rodentia: Muridae: Murinae)

Site of infection: Stomach (adult worms and fourth-stage larva); stomach wall (third-stage larvae).

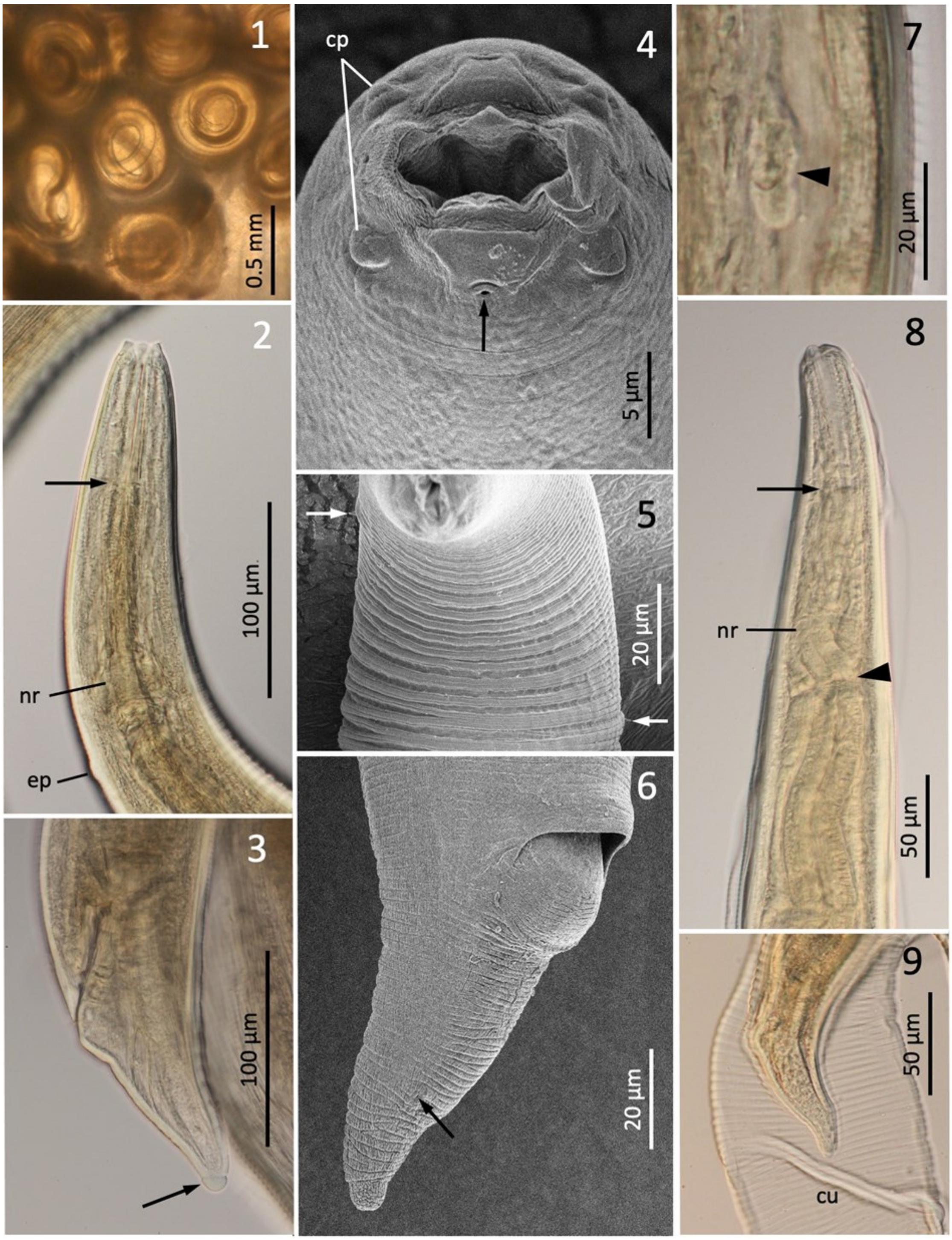
Locality: Bukit Soeharto, Kalimantan, Indonesia.

Date of collection: August 1993.

Voucher specimens: MZBNa 835.

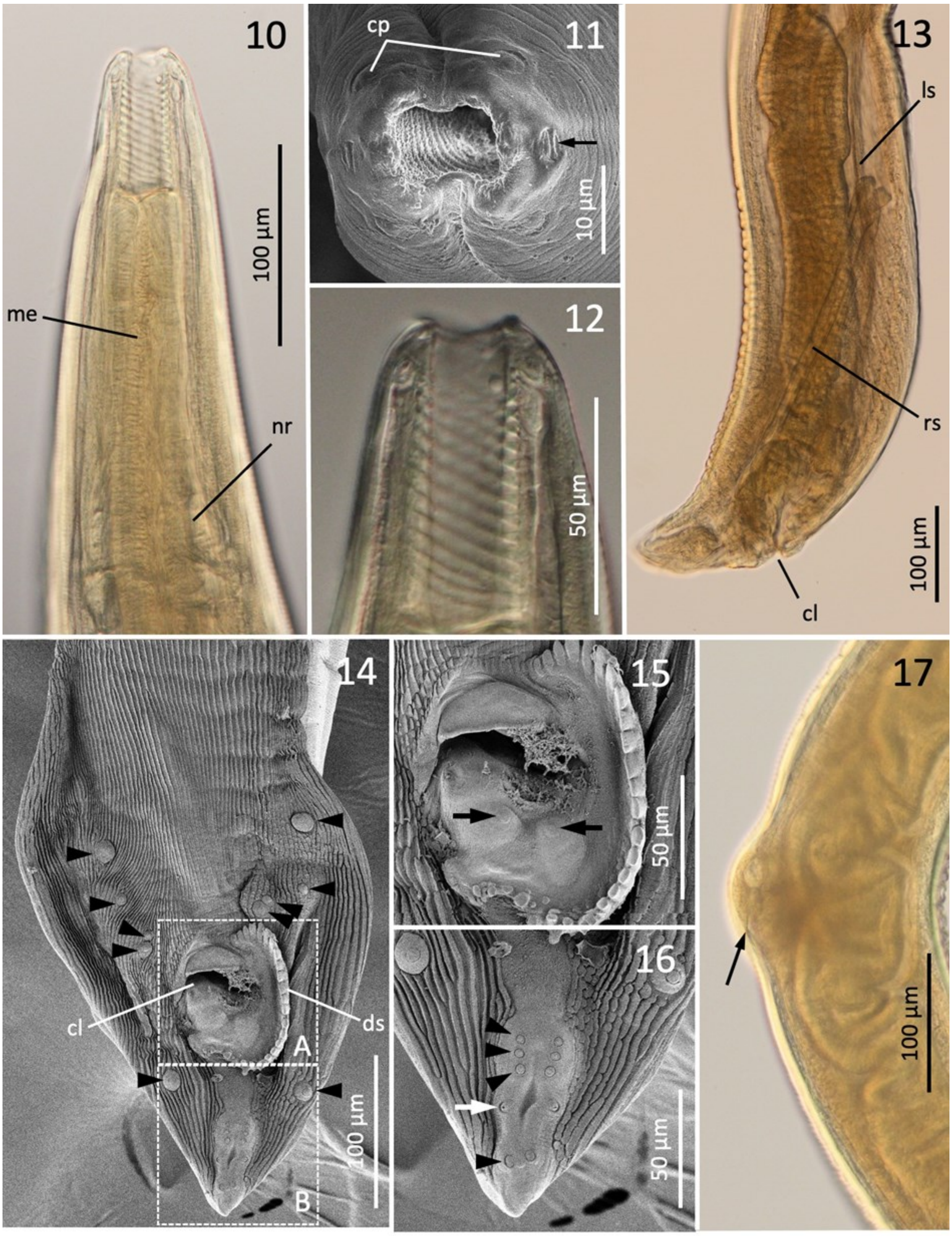
Remarks: The morphology of the third-stage larvae is identical to that of *A. strongylina* described from the intermediate hosts, dung beetles, by Alicata (1935) and Shmitova (1959). Although the body size was somewhat larger than those in the previous reports (Table 1), this difference might be due to the fact that the present larvae had somewhat grown in the paratenic mammalian host. The fourth-stage larva obtained had a body size comparable to the third-stage, much smaller than that described by Shmitova (1959) (Table 1). It was still in the cuticle of the previous larval stage and had characteristic spiral thickenings in the pharynx and elongated primordial gonad, indicating a molting stage from the third- to the fourth-stage (Shmitova, 1959).

The present adult worms were much smaller than *A. strongylina* recorded from *R. rattus* of Lan Yu, Taiwan (Hasegawa et al. 1994; Tables 2, 3). Meanwhile, two of the adult males (#1, 2) obtained had nearly comparable body size with the immature adult males recovered from a pig 26 days of experimental infection (Shmitova, 1959) (Table 2). The pharynx with clear spiral thickenings, asymmetrical caudal alae, the hemicircular disc with serrated margin guarding the cloacal aperture and the caudal papillae arrangement are identical with those of *A. strongylina* (Shmitova, 1964). The remaining male (#3) was much smaller but possessed characteristic hemicircular disc encircling cloacal aperture and developed unequal spicules (Table 2, Fig. 13), suggesting it was just after the final molt. The adult female #1 was first surmised to be a fourth-stage larva because no vulva was found. However, it was assigned to the adult stage as it had spiral thickenings much clearer than those observed in the present fourth-stage larva.



Figs. 1-7. Third-stage larva of *Ascarops* sp. found from *Maxomys whiteheadi* in Kalimantan, Indonesia. **1.** Larvae encysted in the stomach wall of *M. whiteheadi*. **2.** Anterior end, left lateral view. Arrow showing junction between pharynx and muscular portion of esophagus. **3.** Posterior end, left lateral view. Arrow showing round tubercle at tail tip. **4 - 6.** SEM images of cephalic apex, apical view, showing amphidial pore (arrow) and papillae arrangement **(4)**, anterior end, dorsal view, showing asymmetrically positioned deirids (arrows) **(5)**, and tail showing minute phasmidial pore (arrow) **(6)**. **7.** Midbody showing gentail primoudium (arrow). **Figs. 8 and 9.** Molting larva of *Ascarops* sp. recovered from the stomach contents of *Maxomys whiteheadi* in Kalimantan, Indonesia. **8.** Anterior end, left lateral view, showing pharynx with vague spiraled markings. Arrow and arrowhead indicating junction between pharynx and muscular esophagus and junction between muscular and glandular portions of esophagus, respectively. **9.** Posterior end, left lateral view, showing detached cuticle.

Abbreviations: cp. cephalic papillae; cu. cuticle; ep. excretory pore; nr. nerve ring.



Figs. 10 – 16. Male adults of *Ascarops* sp. found from *Maxomys whiteheadi* in Kalimantan, Indonesia. **10.** Anterior end, lateral view; **11.** Cephalic apex, apical view, showing amphid (arrow) and papillae arrangement. **12.** Pharynx showing spiraled markings, lateral view. **13.** Posterior body of immature worm, right lateral view, showing spicules. **14.** Posterior end with asymmetrical caudal alae, ventral view, showing hemicircular disc with serrated margin around cloacal aperture, arrangement of caudal papillae (arrowheads). **15.** Enlarged view of boxed area A of Fig. 14, showing two papillae just posterior to cloacal aperture (arrows). **16.** Enlarged view of boxed area B of Fig. 14, showing minute papillae near tail end (arrowheads) and phasmids (white arrow). **17.** Vulval region of immature female, lateral view, showing elevated condition. Arrow indicating vulva.

Abbreviations: cl. cloacal aperture; cp. cephalic papillae; ds. hemicircular disc; ls. left spicule; me. muscular portion of esophagus; r. nerve ring; rs. right spicule.

Table 1. Morphometric comparison of the third- and fourth-stage larvae of *Ascarops* sp. collected with those of *A. strongylina.* (In µm unless otherwise stated)

Species	*Ascarops* sp.	*A. strongylina*	*A. strongylina*	*Ascarops* sp.	*A. strongylina*
Larval stage	3	3	3	4	4
Host	*Maxomys whiteheadi*	*Aphodius granaries* (Dung beetle)	*Copris lunaris* etc. (Dung beetle)	*Maxomys white-headi*	*Sus scrofa* (Pig)
Source	Present study	Alicata (1935)	Shmitova (1959)	Present study	Shmitova (1959)
No. worms measured	10	9	-	1	-
Worm length, mm	2.21 – 3.14 (2.68)	1.91 – 2.32	2.14 – 2.48	2.56	4.48 – 5.7
Worm width	98 – 123 (116)	53 – 91	56 – 78	75	133 – 165
Pharynx length	58 – 70 (63)	45 – 70	59 – 65	68	70 – 73
No. spirals in pharynx	0	0	0	>14(vague)	14 – 18
Muscular esophagus length	98 – 135 (115)	114 – 200	151 – 164	100	
Muscular esophagus width	18 – 25 (21)			20	
Glandular esophagus length	650 – 816 (735)	296 – 800	571 – 818	647	
Glandular esophagus width	48 – 60 (56)			47	
Nerve ring*[1]	118 – 168 (151)	129 – 152	138 – 149	141	132 – 202
Excretory pore*[1]	145 – 210 (183)	150 – 205	169 – 197	190	167 – 226
Left deirid*[1]	108 – 135 (120) [n=5]	91 – 132		170?	
Right deirid*[1]	158 – 198 (180) [n=5]	159 – 195		?	
Primordial gonad, mm*[1]	1.24 – 1.91 (1.64)		1.41 – 1.674	1.68	
Primordial gonad, mm*[2]	0.88 – 1.23 (1.05)	0.60 – 0.835		0.88	
Gonad size	16 – 28 x 5 – 10	15–18 x 9–11	17–23 x 9–12		
Tail length	89 – 108 (96)	76 – 96	72 – 87	75	105 – 119

*[1] Distance from cephalic end.
*[2] Distance from caudal end.

Table 2. Morphometric comparison of the adult male of *Ascarops* sp. collected with those of *A. strongylina*. (In µm unless otherwise stated).

Species	*Ascarops* sp.			*A. strongylina*	*A. strongylina**[1]
ID/No. worms examined	#1	#2	#3	(n=1)	
Host	*Maxomys whiteheadi*			*Rattus rattus*	*Sus scrofa* (Pig)
Source	Present study			Hasegawa et al. (1994)	Shmitova (1959)
Worm length, mm	7.66	7.19	4.20	13.5	7.8 – 9.2
Worm width	160	190	155	253	290 – 300
Pharynx length	80	68	58	86	
No. spirals in pharynx	15	13	10 (vague)	15	
Muscular esophagus length	255	270	190	336	288 – 320
Muscular esophagus width	38	45	33	46	
Glandular esophagus length, mm	1.99	1.79	1.14	2.83	1.60 – 1.76
Glandular esophagus width	88	85	73	110	
Nerve ring*[2]	260	250	183	316	245 – 282
Excretory pore*[2]	310	310	223	363	300 – 330
Left deirid*[2]	?	148	118	120	338 – 370*[3]
Right deirid*[2]	325	330	218	386	240 – 272*[3]
Left spicule length, mm	2.09	2.01	1.50	2.10	1.9 – 2.3
Right spicule length	310	355	305	520	290 – 400
Gubernaculum length	?	?	45?	64	60
Tail length	200	170	138	312	-

*[1] 26th day of experimental infection.
*[2] Distance from cephalic end.
*[3] Presumably Shmitova (1959) mistook left and right.

Table 3. Morphometric comparison of the adult female of *Ascarops* sp. collected with those of *A. strongylina*. (In µm unless otherwise stated).

Species	*Ascarops* sp.		*A. strongylina*	*A. strongylina**[1]
ID/No. worms measured	#1	#2*[2]	(n=2)	
Host	*Maxomys whiteheadi*		*Rattus rattus*	*Sus scrofa* (Pig)
Source	Present study		Hasegawa et al. (1994)	Shmitova (1959)
Worm length, mm	4.48	[3.7]	17.8 – 21.3	9.40 – 13.65
Worm width	140	150	277 – 300	262 – 290
Pharynx length	75	70	90 – 102	
No. spirals in pharynx	18	16	15 – 19	
Muscular esophagus length	168	200	312 – 376	300 – 360
Muscular esophagus width	26	30	44 – 50	
Glandular esophagus length, mm	1.20	1.19	2.85 – 3.59	2.0 – 3.2
Glandular esophagus width	63	75	119 – 132	
Nerve ring*[3]	208	195	293 – 320	234 – 246
Excretory pore*[3]	254	291	343 – 395	280 – 326
Left deirid*[3]	138	158	152 – 261	266 – 288*[4]
Right deirid*[3]	?	253	339 – 394	184 – 200*[4]
Vulva, mm*[3]	?	2.68	8.3 – 10.9	5.2 – 6.4
Tail length	112	-	250 – 254	176 – 214

*[1] 26th day of experimental infection.
*[2] Fragmented lacking posterior body.
*[3] Distance from cephalic end.
*[4] Presumably Shmitova (1959) mistook left and right.

DISCUSSION

Adults of the species of the genus *Ascarops* are parasitic in pigs, wild boars, rodents, and insectivores, but rarely in birds and reptiles (Yamaguti, 1961; Yokohata & Abe, 1989). Seven species are known currently in this genus, namely *A. strongylina* Rudolphi, 1819 (type species), *A. africana* (Sandground, 1933), *A. dentata* Linstow, 1904, *A. mogera* Yokohata & Abe, 1989, *A. psittaculai* Sood & Kalia, 1975, *A. scaptochiri* Yin & Zhang, 1981 and *A. talpa* Huber, Schmidt & Kuntz, 1983 (Yamaguti, 1961; Yin & Zhang, 1981; Huber et al., 1983; Yokohata & Abe, 1989). Among them, *A. strongylina*, *A. africana*, *A. dentata* and *A. psittaculai* possess pericloacal disc with serrated margin in male adults (Sandground 1933; Shmitova, 1964; Skrjabin et al., 1967; Sood & Kalia, 1975). *Ascarops strongylina* and *A. dentata* are parasitic in pigs and wild boars usually, *A. africana* was described from African rats, *Mastomys* and *Rhabdomys*, and *A. psittaculai* was established as an avian nematode (Sandground, 1933; Skrjabin et al., 1967; Sood & Kalia, 1975). *Ascarops dentata* and *A. africana* have large, stout bodies in full grown adults, being readily distinguished from *A. strongylina* and *A. psittaculai* (Sandground, 1933; Skrjabin et al., 1967; Sood & Kalia, 1975). The pericloacal disc of *A. dentata* completely encircles the cloacal aperture, while those in the remaining three species are hemicircular as in the present male adults. *Ascarops africana* was first distinguished from the other congeners by having a pair of large papillae just posterior to the cloacal aperture (Sandground, 1933). However, *Ascarops* species have a common caudal papillae pattern of so-called ‘Spirurid type’ (Chabaud & Petter, 1961). Sood & Kalia (1975) did not give a discrimination argument for *A. psittaculai* from other nominal congeners, but it resembled closely *A. strongylina*.

The presence of *Ascarops* in accidental hosts has been reported. Sandground (1933) found *A. africana* in a snake, *Boaeden lineatus*, and surmised that it acquired the worms by ingesting true host murid. Prod’hon (1967) also reported *A. africana* from a mongoose, *Herpestes ichneumon*, and considered that this accidental host had eaten the infected rodent, though his worms had only transverse, not spiral, thickenings of the pharynx wall. Besides those cases acquired by ingestion of infected definitive hosts, the third-stage larva has been known to develop to adult stage in accidental hosts. By experimental infection, the third-stage larvae of *A. strongylina* successfully developed to adult worms in rabbits (Ono, 1933; Alicata & McIntosh, 1933; Gupta, 1969). Surprisingly, *Ascarops* adults have been recorded from avian hosts: Jairajpuri & Siddiqi (1971) found one adult male of *Ascarops* sp. under the gizzard lining of a carnivorous bird, *Accipiter badius*, in India; Sood & Kalia (1975) found 11 adults of *A. psittaculai* from the intestine of a parakeet, *Psittacula krameria*, of India; Webster & Speckman (1977) also demonstrated many adult worms of *A. strongylina* from the proventriculus and gizzard of a cockatoo, *Cacatua galerita galerita*, in Canada. The authors suggested that species of *Ascarops* are not strictly host-specific and can establish in hosts belonging to different groups of vertebrates.

Besides *A. africana*, some records have been made on adult *Ascarops* from murids. Hasegawa et al. (1994) identified the worms from *R. rattus* of Lan Yu, Taiwan, as *A. strongylina*. Ganzorig et al. (1999) also recorded *A. strongylina* from a cricetid, *Myospalax psilurus*, in Mongolia, but this identification was doubtful because their males had much longer right spicule than the left one. Unidentified *Ascarops* adults were also collected from a cricetid, *Neotoma micropus*, of Texas (Charles et al., 2012). We surmise that the present worms, both larvae and adults, belong to one species, possibly *A. strongylina.* Presumably, the definitive host is the bearded pig, *Sus barbatus*, that is widely distributed in Borneo/ Kalimantan (Luskin & Ke, 2017). *Maxomys whiteheadi* plays a role as paratenic host, but the third-stage larvae may occasionally develop to adult stage in it. The absence of gravid females suggests that this rat is not a suitable final host.

As shown above, *Ascarops* species have wide host ranges and the morphology has not been fully understood yet. Some of them are surmised to be synonymous with each other. DNA sequence analysis may be especially helpful for strict identification of the species, and for elucidation of relationship of larva with adult stages found in a host. Unfortunately, no DNA sequence data are registered in the GenBank at the present time.

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