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Annotated type catalogue of land snails collected from Taiwan (Formosa) in the Natural History Museum, London

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Abstract

The present catalogue lists the type specimens of land snail species, collected from Taiwan and deposited in the Natural History Museum, London. Thirty-seven nominal species described by Pfeiffer, Adams, Nevill, Moellendorff, Godwin-Austen and Gude were traced. I present here information on type status, collection data obtained from the registers and labels of each collection, and annotations on the current taxonomic affiliation. Lectotypes of 28 nominal (sub)species were newly designated. One holotype was fixed originally and two holotypes newly fixed by monotypy. Syntypes of two species and paralectotypes of three species were also discovered in the Museum. No specimen of the species *Pupina adamsi* Sowerby, 1878, which was supposed to be deposited in the NHM, was found. Pictures of the name-bearing types are provided for further research on biodiversity of the island.

Keywords

Type specimen, taxonomy, Taiwan, Gastropoda, land snail

Introduction

Taxonomic research on historic collections is essential for the modern study of taxonomy and biodiversity. Current taxonomic studies using morphological or molecular methods, e.g., Barcode of Life (Hebert et al. 2003), are among the important issues of organismal, as well as ecological and genetic diversity. However, these attempts will not achieve practical results without a correct identification of species. The most common challenge in current studies of land snail biodiversity in Taiwan is that the sampled specimens cannot be identified correctly and confidently, especially within microsnail taxa such as the diplommatinids. Researchers face similar problems concerning large snail groups such as the clausiliids (Hwang 2005). This situation is mainly due to a lack of type specimens for comparisons since most of the historic types are deposited abroad. The oversimplified descriptions and imprecise illustrations in the original publications from the 19th and early 20th centuries are not practical for modern research. Before complete systematic revisions of each group are possible, concise and updated reports on these types are urgently needed for biodiversity studies in Taiwan. Most of the types collected from Taiwan and deposited in the Naturmuseum Senckenberg, Frankfurt am Main have been reported and photographed in a series of publications by Zilch (e.g., 1953, 1966a, 1966b, 1968). Types described in the 1940s and deposited in the Nishinomiya Shell Museum, Japan, have been catalogued and photographed by Habe and Inaba (1996), Ohara and Otani (2002) and Hwang et al. (2008). Determinations of Taiwanese holotypes and lectotypes deposited in the Academy of Natural Sciences of Philadelphia, U.S.A., were accomplished by Baker (1963, 1964).

The Natural History Museum of London contains many specimens collected in Taiwan (Formosa). A major portion of these are housed in the type series which were previously in the collection of H. Cuming and H. Adams (Adams 1866; Pfeiffer 1866; Gray 1868). Most of these collections from the island were assembled by R. Swinhoe, a British consul and a pioneer of the study of the natural history in Taiwan (Swinhoe 1864, 1865; Fraser 1865, 1866). Pfeiffer (1866) described 13 species of land snails from Cuming's collection; H. Adams (1866, 1867, 1870, 1872) described 16 species from the collections of the Natural History Museum of London and his own. Some of the types described by other researchers such as Sowerby (1878), Godwin-Austen (1907) and Gude (1907), who worked in or with the NHM, are also deposited in the NHM. These type lots have not been re-examined and catalogued since their original publication. The present report provides the first catalogue and photographs of these type specimens.

Methods

In preparing this catalogue, type specimens were recognized and verified by comparing information on the specimen labels, the original descriptions, NHM registers and curatorial records of the Mollusca Section, Natural History Museum, London.

The type specimens are listed using modern classifications (Vaught 1989; Bouchet and Rocroi 2005; Hsieh et al. 2013). The collection data obtained from the registers and labels of each collection is provided. The publication dates of those names described in the Proceedings of the Zoological Society of London are corrected according to Duncan (1937). Taxonomic annotations are made when required. Photographs of the types are provided when they have not previously been presented. Type localities are cited as in original descriptions. The modern locality names in Hanyu Pinyin Romanisation are provided in brackets. Dimensions of shells are given as: shell height × shell width. An updated and detailed description of these type materials will be presented elsewhere in systematic studies of their respective groups.

Institutional abbreviations

NHM, Natural History Museum, London, U.K. (NHM registered specimens are cited as NHMUK); ANSP, Academy of Natural Sciences of Philadelphia, U.S.A.; SMF, Naturmuseum Senckenberg, Frankfurt am Main, Germany.

Results

I was able to find type specimens of 37 species in the NHM, including all 13 species identified by Pfeiffer (1866) and all 16 by Adams (1866, 1867, 1870, 1872). These specimens are listed in a current taxonomic assignment of nine families including the Cyclophoridae, Diplommatinidae, Pupinidae, Clausiliidae, Streptaxidae, Trochomorphidae, Ariophantidae, Bradybaenidae and Camaenidae. Specimens of *Pupina adamsi* Sowerby, 1878, which are supposedly deposited in the NHM, were not found. Types of eight additional species described by Nevill (1881, two species), Moellendorff (1884, one species), Godwin-Austen (1907, two species), Gude (1907, one species) and Rolle (1911, two species) from various collections were found. Lectotypes of 28 species were newly designated. Paralectotypes of three species, the lectotype of each having already been designated, were found. A holotype of one species was fixed by original designation and holotypes of two species have been fixed by monotypy in the present catalogue. Syntypes of two species were discovered, but no lectotypes were designated as more suitable material for lectotype designation may be kept in the museum where the respective author worked.

Specimens from the collections of shell dealers B. Schmacker (Shanghai, China) and Y. Hirase (Kyoto, Japan) were also found. These species were described by Schmacker and Boettger (1891), Pilsbry (1905) and Pilsbry and Hirase (1905–1906, 1909). Boettger and Pilsbry were the major contributors for description and publication. Due to a lack of evidence, e.g. original labels, of proof of examination of these specimens by Boettger and Pilsbry, these materials were excluded from the type series until further evidence can be found.

I noted the following features in the collection. (1) All specimens are cased in boxes having an originally handwritten label glued onto the bottom. The register information, if any, was also written on the bottoms of the cases. A concise locality, usually "Formosa" only, with or without a collector, was provided. (2) Some specimen lots are labelled "TYPE" using ink and handwriting different from the original labels. Such conditions are supposed to be determined as types and written by a curator or later researchers rather than by the original authors. (3) Ten species described by Adams (1866, 1867, 1870, 1872) were deposited in two batches in the NHM. One batch consists of the specimens that Swinhoe presented to the NHM in 1866, being subsequently examined and named by Adams. The other batch is Adams' own collection purchased by the NHM in 1878 after his death. Since all specimens were examined by Adams, both are considered as being from the type series.

Catalogue

Family CYCLOPHORIDAE
Genus *Cyclotus* Swainson, 1840

Cyclotus taivanus H. Adams, 1870

http://www.taibif.tw/en/catalogue_of_life/page/4e53-43b4-ed74-0962-a6da-f113-5fbb-174b-namecode-405332
Figure 1A

Cyclotus taivanus H. Adams, 1870: 378–379, pl. 27 figs. 11, 11a.

Type locality. Taiwan, Formosa [Taiwan Fu = Tainan City and northern Kaohsiung City] (Swinhoe).

Material examined. *Lectotype.* Formosa, coll. Swinhoe (NHMUK 1871.1.20.9/1), new designation, 10.1 × 16.5 mm, whorls 4.5.

Paralectotypes. Formosa, coll. Swinhoe (NHMUK 1871.1.20.9/2–8, 7 shells). Taiwan, Formosa, from collection of H. Adams (NHMUK 1878.1.28.22, 3 shells).

Remarks. The lot NHMUK 1871.1.20.9 was registered and labelled as "Cyclotus formosensis", but was later published as *C. taivanus*. Nine specimens were registered, but only eight were found. The specimen corresponding well in size with the measurement of Adams (1870) is designated as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

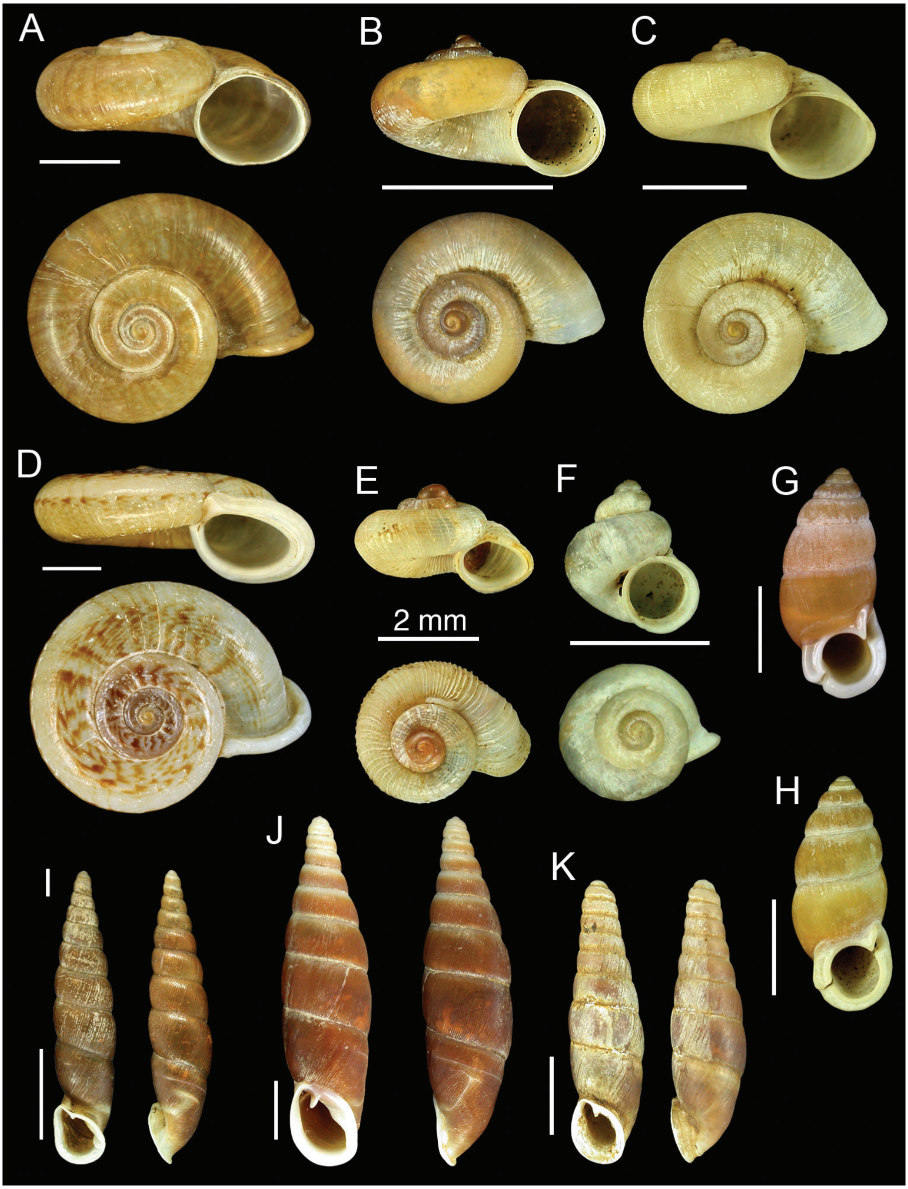

Figure 1. A *Cyclotus taivanus* H. Adams, 1870, lectotype NHMUK 1871.1.20.9/1 **B** *Platyrhaphe minutus* (H. Adams, 1866), lectotype NHMUK 1866.5.9.6/1 **C** *Platyrhaphe swinhoei* (H. Adams, 1866), lectotype NHMUK 1866.5.9.7/10 **D** *Ptychopoma wilsoni* (Pfeiffer, 1866), lectotype NHMUK 20040584/1 **E** *Chamalycaeus hungerfordianus* (Nevill, 1881), possible syntype NHMUK 1891.3.17.790 **F** *Dioryx swinhoei* (H. Adams, 1866), lectotype NHMUK 1866.5.9.8/1 **G** *Pupinella swinhoei* (H. Adams, 1866), lectotype NHMUK 1866.5.9.15/1 **H** *Pupinella swinhoei* syn. *Pupinopsis morrisonia* H. Adams, 1872, lectotype NHMUK 1871.1.20.16/1 **I** *Euphaedusa sheridani* (Pfeiffer, 1866), lectotype NHMUK 20040589/1 **J** *Hemiphaedusa exilis* (H. Adams, 1866), lectotype NHMUK 1866.5.9.4/1 **K** *Hemiphaedusa similaris* (H. Adams, 1867), lectotype NHMUK 1878.1.28.10/1. Scale bars = 5 mm, unless otherwise specified above the bar.

Genus *Platyrhaphe* Moellendorff, 1890

Platyrhaphe minutus (H. Adams, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/1451-61f0-132b-71f5-e030-a36b-75a3-1ab7-namecode-315206
Figure 1B

Cyclotus minutus H. Adams, 1866: 318, pl. 33 fig. 10.
Platyrhaphe minutus, Kobelt and Moellendorff 1897: 115.

Type locality. Takow, Formosa [northern Qi-Jin, Kaohsiung City] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe (NHMUK 1866.5.9.6/1), new designation, 4.4 × 6.9 mm, whorls 4.

Paralectotypes. Formosa, coll. Swinhoe (NHMUK 1866.5.9.6/2–3, 2 shells). Formosa, from collection of H. Adams (NHMUK 1878.1.28.73, 3 shells).

Remarks. Adams (1866) described the locality as Takow, Formosa, but the original label has only "Formosa". The specimen corresponding well in size with the measurement of Adams (1866) and having sculptures in good condition is designated as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Platyrhaphe swinhoei (H. Adams, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/4f5b-8cf6-7311-1585-f526-3427-7340-e0db-namecode-315208
Figure 1C

Cyclotus swinhoei H. Adams, 1866: 318, pl. 33 fig. 9.
Platyrhaphe swinhoei, Kobelt and Moellendorff 1897: 116.

Type locality. Takow, Formosa [northern Qi-Jin, Kaohsiung City] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe (NHMUK 1866.5.9.7/1, new designation, 6.8 × 11.6 mm, whorls 4.5.

Paralectotype. Formosa, coll. Swinhoe (NHMUK 1866.5.9.7/2, 1 shell). Formosa, from collection of H. Adams (NHMUK 1878.1.28.231, 1 shells)

Remarks. Adams (1866) described the locality as Takow, Formosa. However, this species was not actually collected there. I think Swinhoe and Adams used Takow to designate the area presently known as Kaohsiung City (Wu et al. 2008; also see remarks for *Oospira formosensis* (Adams, 1866)). The largest specimen corresponds well in size with the measurements of Adams (1866). It is here selected as the lectotype.

Genus *Ptychopoma* Moellendorff, 1885

Ptychopoma wilsoni **(Pfeiffer, 1866)**

http://www.taibif.tw/en/catalogue_of_life/page/a1f3-b693-4cad-94cc-160c-98ae-38b4-97d0-namecode-405367
Figure 1D

Pterocyclos wilsoni Pfeiffer, 1866: 831, pl. 46 fig. 12. [1865] (Apr. 1866).
Ptychopoma wilsoni, Kobelt and Moellendorff 1897: 88.

Type locality. Formosa [Taiwan] (Swinhoe).

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040584/1). new designation, 9.4 × 22.5 mm, whorls 5.

Paralectotypes. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040584/2-3, 2 shells).

Remarks. No specimen corresponds in size with the measurements of Pfeiffer (1866). The largest specimen mostly similar to the illustration in Pfeiffer (1866) is designated as the lectotype.

Genus *Chamalycaeus* Kobelt & Moellendorff, 1897

Chamalycaeus hungerfordianus **(Nevill, 1881)**

http://www.taibif.tw/en/catalogue_of_life/page/a6ad-a451-ead1-6549-84d1-38b3-4b28-fed5-namecode-315080
Figure 1E

Alycaeus hungerfordianus Nevill, 1881: 149–150.
Chamalycaeus hungerfordianus, Kuroda 1941: 81.

Type locality. Tamsui, Formosa [Danshui, New Taipei City] (Hungerford).

Material examined. *Possible syntypes*: Tamsui, Formosa, from collection of Hungerford (NHMUK 1891.3.17.790–791, 2 shells), 2.2–2.5 × 3.6–3.8 mm, whorls 3.75. Also in SMF (Zilch 1957).

Remarks. It is possible that further syntypes may be housed in the Indian Museum, Kolkata (Calcutta), India, where Nevill worked. Due to the lack of definitive evidence that the two specimens in the NHM were actually examined by Nevill, no lectotype designation has been made in the present article.

Genus *Dioryx* Benson, 1859

Dioryx swinhoei (H. Adams, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/e2c6-32a9-1653-e068-3819-bac2-23e3-3913-namecode-315083
Figure 1F

Alycaeus (*Dioryx*) *swinhoei* H. Adams, 1866: 318, pl. 33 fig. 11.
Dioryx swinhoei, Kobelt and Moellendorff 1897: 149.

Type locality. Takow, Formosa [northern Qi-Jin, Kaohsiung City] (Swinhoe).

Material examined. *Lectotype.* Formosa, coll. Swinhoe (NHMUK 1866.5.9.8/1), new designation, 6.0 × 5.5 mm, whorls 4.

Paralectotype. Formosa, coll. Swinhoe (NHMUK 1866.5.9.8/2, 1 shell).

Remarks. Adams (1866) described the locality as Takow, Formosa, but the original label has only "Formosa". Also see remarks for *Oospira formosensis* (Adams, 1866). The specimen with intact shell is designated as the lectotype.

Family DIPLOMMATINIDAE

Genus *Diplommatina* Benson, 1849

Diplommatina hungerfordiana Nevill, 1881

http://www.taibif.tw/en/catalogue_of_life/page/ca4a-ac7e-eeb0-ddb1-72a0-a26f-0975-efa5-namecode-315295

Diplommatina hungerfordiana Nevill, 1881: 150.

Type locality. Kulung, Formosa [should be Keelung, Northern Taiwan] (Hungerford).

Material examined. *Possible syntypes*: Formosa, coll. Hungerford (NHMUK 1891.3.17.724–726, 3 shells), 2.76–3.29 × 1.66–1.76 mm, whorls 5.5–6.5. Also in SMF (Zilch 1953, Figure 186).

Remarks. A photograph of a syntype was provided by Zilch (1953). Also see remarks for *Chamalycaeus hungerfordianus* (Nevill, 1881).

Family PUPINIDAE

Genus *Pupinella* Gray, 1850

Pupinella swinhoei H. Adams, 1866

http://www.taibif.tw/en/catalogue_of_life/page/4a7f-dfe1-59ea-ba46-f071-e4d1-7286-f51d-namecode-315419
Figure 1G

Pupinella (*Pupinopsis*) *swinhoei* H. Admas, 1866: 318, pl. 32 figs. 12, 12a.

Type locality. Tamsui, Formosa [Danshui, New Taipei City] (Swinhoe).

Material examined. *Lectotype* of *Pupinella swinhoei*. Formosa, coll. Swinhoe (NHMUK 1866.5.9.15/1), new designation, 13 × 5.5 mm, whorls 7. (Figure 1G).

Paralectotypes of *Pupinella swinhoei*. Formosa, coll. Swinhoe (NHMUK 1866.5.9.15/2-3, 2 shells). Formosa, from collection of H. Adams (NHMUK 1878.1.28.58, 3 shells)

Remarks. Adams (1866) described the locality of *P. swinhoei* as Tamsui, Formosa, but the original label has only "Formosa". The largest specimen corresponds well in size with the measurements of Adams (1866). It is here selected as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Pupinella swinhoei H. Adams, 1866

Syn. *Pupinopsis morrisonia* H. Adams, 1872

Figure 1H

Pupinopsis morrisonia H. Adams, 1872: 13, pl. 3 fig. 21.

Type locality. Mount Morrison, Formosa [Mt. Yushan] (Swinhoe).

Material examined. *Lectotype* of *Pupinopsis morrisonia*. South Formosa, coll. Swinhoe (NHMUK 1871.1.20.16/1), new designation, 12.5 × 5.3 mm, whorls 6.5. (Figure 1H).

Paralectotypes of *Pupinopsis morrisonia.* South Formosa, coll. Swinhoe (NHMUK1871.1.20.16/2, 1 shell). Mt. Morrison, South Formosa, from collection of H. Adams (NHMUK 1878.1.28.50, 3 shells).

Remarks. No specimen corresponds in size with the measurements and illustration of Adams (1872). The specimen similar to the measurements and in the best condition is designated as the lectotype.

Pupinella swinhoei H. Adams, 1866

Syn. *Pupina adamsi* Sowerby, 1878

Pupina adamsi Sowerby, 1878: sp. 33, pl. 4 fig. 33.

Type locality. Isl. Formosa [Taiwan] (ex. Mus. Brit.)

Remarks. The type specimen of *P. adamsi*, which was collected from Formosa and has been stated as being deposited in the NHM (Sowerby 1878), was not found.

Family CLAUSILIIDAE
Genus *Euphaedusa* Boettger, 1877

Euphaedusa sheridani (Pfeiffer, 1866)
http://www.taibif.tw/en/catalogue_of_life/page/c4cf-3a16-c980-f269-6ba0-090e-dccb-2c8d-namecode-316614
Figure 1I

Clausilia sheridani Pfeiffer, 1866: 830–831. [1865] (Apr. 1866).
Euphaedusa sheridani, Yen 1939: 107, pl. 10, fig. 54.

Type locality. Formosa [Taiwan] (Swinhoe).

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming NHMUK 20040589/1), new designation, 16.0 × 3.5 mm, whorls 10.

Paralectotypes. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040589/2–4, 3 shells; NHMUK 20040589/5, 1 shell, non *sheridani*).

Remarks. Pfeiffer (1866) described a variety with a projecting peristome inside, a narrowed aperture and an inconspicuous inferior lamella. Among the five specimens found, two shells are typical *sheridani* and two shells are of variety. The variations observed in the variety are caused by the thickened callus in the aperture of the fully matured shells. The original description gives a range of shell dimensions.

The largest specimen corresponds well in size with the measurements of Pfeiffer (1866). It is here selected as the lectotype for the stabilization of the name (ICZN 1999: Art. 74). The specimen NHMUK 20040589/5 has similar shell dimensions, but it differs from the other four in having a thin and brownish corneous exterior, a shinier surface, finer striation, a less expanded peristome, a non-protruding aperture and a superior lamella not connected to the spiral lamella. This specimen is closely resembles *E. aculus* (Benson, 1842) allies but is not a true *E. sheridani*. Because this specimen was examined by Pfeiffer, it should be included in the type series (ICZN 1999: Art. 72.4, 73.2). This specimen is still designated as a paralectotype.

Genus *Hemiphaedusa* Boettger, 1877

Hemiphaedusa exilis (H. Adams, 1866)
http://www.taibif.tw/en/catalogue_of_life/page/4ac5-7dd6-1c05-dee6-b6a0-6f0e-a9a7-710b-namecode-316633
Figure 1J

Clausilia (*Laciniaria*) *exilis* H. Adams, 1866: 317, pl. 33 fig. 6.
Hemiphaedusa exilis, Kuroda 1941: 140.

Type locality. Tamsui, Formosa [Danshui, New Taipei City] (Swinhoe).

Material examined. *Lectotype.* Formosa, coll. Swinhoe (NHMUK 1866.5.9.4/1), new designation, 27.0 × 7.1 mm, whorls 10.

Paralectotypes. Formosa, coll. Swinhoe (NHMUK 1866.5.9.4/2–3, 2 shells). Formosa, from collection of H. Adams (NHMUK 1878.1.28.207, 2 shells).

Remarks. Adams (1866) described the locality as Tamsui, Formosa, but the original label has only "Formosa". The specimen corresponding well in size with the measurements of H. Adams (1866) is designated as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Hemiphaedusa similaris **(H. Adams, 1867)**

http://www.taibif.tw/en/catalogue_of_life/page/8800-40ed-d9b1-5696-861a-c399-1104-4dc5-namecode-316647
Figure 1K

Clausilia (?) *similaris* H. Adams, 1867: 446, pl. 38 fig. 10. [1866] (Apr. 1867).
Hemiphaedusa similaris, Kuroda 1941: 140.

Type locality. Formosa [Taiwan] (Swinhoe).

Material examined. *Lectotype.* Formosa, from collection of H. Adams (NHMUK 1878.1.28.10/1), new designation, 17.3 × 4.8 mm, whorls 10.

Paralectotypes. Formosa, from collection of H. Adams (NHMUK 1878.1.28.10/2, 1 shell). Formosa, coll. Swinhoe (NHMUK 1866.5.9.3, 3 shells).

Remarks. None of these type series exactly match with the illustration and measurements in Adams (1867). The specimen in the best condition is here designated as the lectotype.

Genus *Oospira* Blanford, 1872

Oospira formosensis **(H. Adams, 1866)**

http://www.taibif.tw/en/catalogue_of_life/page/6230-62a2-52e0-7159-5ddc-51e0-783b-d62f-namecode-402850
Figure 2A

Clausilia (*Phaedusa*) *formosensis* H. Adams, 1866: 317, pl. 33 fig. 7.
Oospira (*Formosana*) *formosensis*, Nordsieck 1997: 11.

Type locality. Takow, Formosa [northern Qi-Jin, Kaohsiung City] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe (NHMUK 1866.5.9.5/1), new designation, 26.1 × 7.0 mm, whorls 10.

Paralectotypes. Formosa, coll. Swinhoe (NHMUK 1866.5.9.5/2–3, 2 shells). Formosa, from collection of H. Adams (NHMUK 1878.1.28.245, 1 shell).

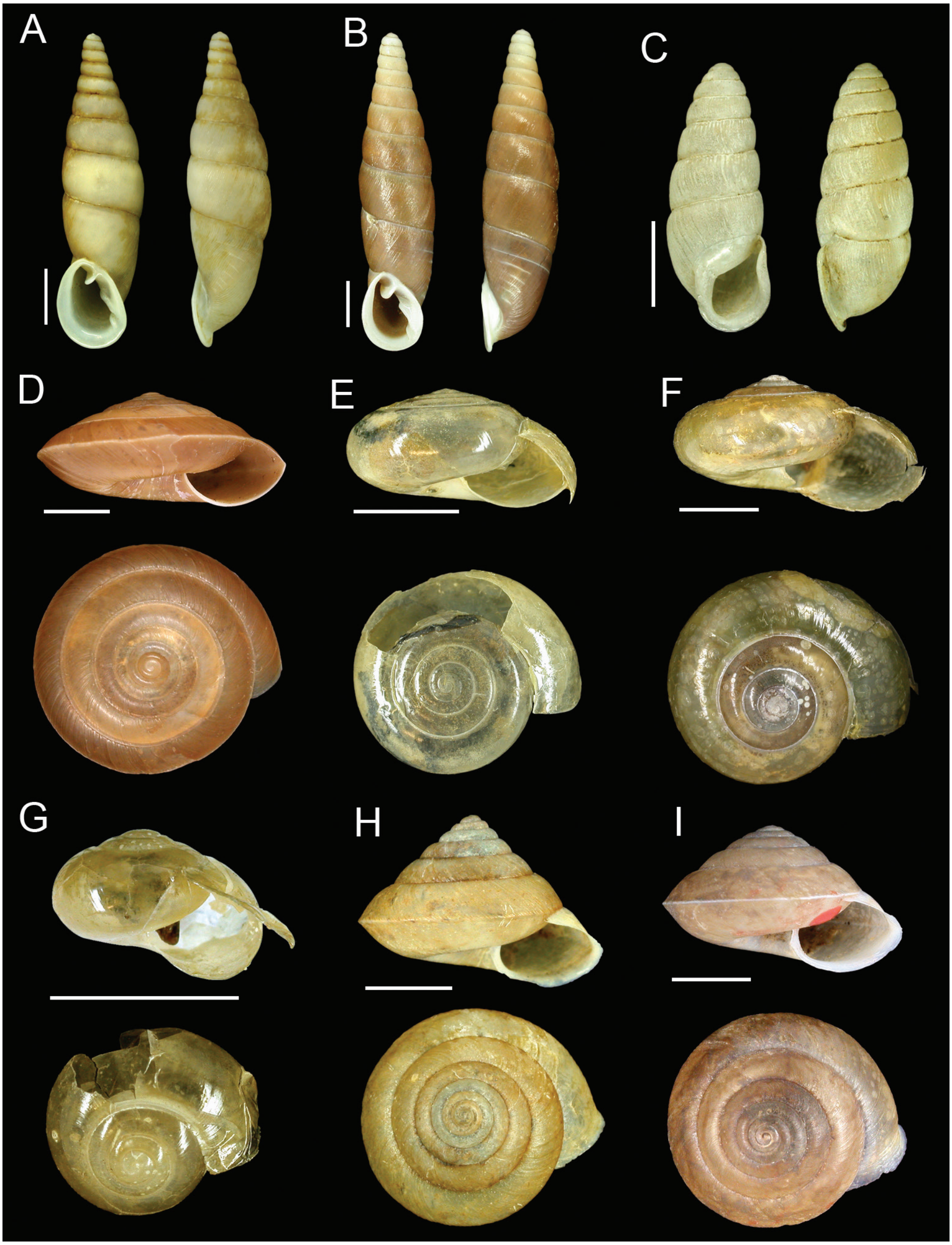

Figure 2. A *Oospira formosensis* (H. Adams, 1866), lectotype NHMUK 1866.5.9.5/1 **B** *Oospira swinhoei* (Pfeiffer, 1866), lectotype NHMUK 20040583/1 **C** *Elma swinhoei* (H. Adams, 1866), lectotype NHMUK 1866.5.9.14/1 **D** *Videnoida shermani* (Pfeiffer, 1866), lectotype NHMUK 20040584/1 **E** *Petalochlamys formosanus* (Schmacker & Boettger, 1891) syn. *Petalochlamys hypograpta* Godwin-Austen, 1907, holotype NHMUK 1903.7.1.1713 **F** *Petalochlamys vesta* (Pfeiffer, 1866), lectotype NHMUK 20040580 **G** *Ovachlamys fulgens* (Gude, 1900) syn. *Lamprocystis fulgida* Godwin-Austen, 1907, holotype NHMUK 1903.7.1.1714 **H** *Aegista fulvicans* (H. Adams, 1866), lectotype NHMUK 1866.5.9.10/1 **I** *Aegista granti* (Pfeiffer, 1866), lectotype NHMUK 20040579. Scale bars = 5 mm.

Remarks. The specimen corresponding well in size with the measurements of Adams (1866) is designated as the lectotype for the stabilization of the name (ICZN 1999: Art. 74). Adams (1866) described the locality as Takow, Formosa. This species has recently been recorded by Hsieh et al. (2013) in the Liu-gui and Mei-nong areas in eastern Kaohsiung City, which were visited by Swinhoe during his collection trip through southern Taiwan. This species was unlikely to have been collected in Takow (coastal areas of Kaohsiung City in 1866). Apparently, Swinhoe or Adams used Takow to represent an area approximating present-day Kaohsiung City. The same situation was also observed for the type locality of *Platryhaphe swinhoi* and *Dioryx swinhoei*.

***Oospira swinhoei* (Pfeiffer, 1866)**

http://www.taibif.tw/en/catalogue_of_life/page/f228-43fd-a0a7-32f2-aaea-1ba6-e70c-854d-namecode-402851
Figure 2B

Clausilia swinhoei Pfeiffer, 1866: 830, pl. 46 fig. 11. [1865] (Apr. 1866).
Oospira (*Formosana*) *swinhoei*, Nordsieck 1997: 11.

Type locality. Formosa [Taiwan] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040583/1), new designation, 35.0 × 8.1 mm, whorls 10.

Paralectotypes. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040583/2–3, 2 shells).

Remarks. The original description gives a range of shell dimensions. The largest specimen is designated as the lectotype.

Family STREPTAXIDAE
Genus *Elma* H. Adams, 1866

***Elma swinhoei* (H. Adams, 1866)**

http://www.taibif.tw/en/catalogue_of_life/page/45f2-e28e-c620-b0cb-2306-5af5-f514-0395-namecode-402881
Figure 2C

Ennea (*Elma*) *swinhoei* H. Adams, 1866: 317–318, pl. 33 fig. 8.
Elma swinhoei, Kuroda 1941: 148.

Type locality. Tamsui, Formosa [Danshui, New Taipei City] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe (NHMUK 1866.5.9.14/1), new designation, 15.7 × 6.1 mm, whorls 9.

Paralectotypes. Formosa, coll. Swinhoe (NHMUK 1866.5.9.14/2–3, 2 shells). Tamsui, Formosa, coll. Swinhoe, from collection of H. Adams (NHMUK 1878.1.28.30, 3 shells).

Remarks. The largest specimen corresponds well in size with the measurements of Adams (1866). It is here selected as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Family TROCHOMORPHIDAE

Genus *Videnoida* Habe, 1955

Videnoida shermani (Pfeiffer, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/af4c-5a14-6587-4495-c500-e4ba-0b5f-8a08-namecode-316729
Figure 2D

Helix shermani Pfeiffer, 1866: 828, pl. 46 fig. 5. [1865] (Apr. 1866).
Videnoida shermani, Chang 1994: 17.

Type locality. Formosa [Taiwan] (Swinhoe).

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040584/1), new designation, 8.7 × 19.3 mm, whorls 7.

Paralectotypes. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040584/2–3, 2 shells).

Remarks. The largest specimen mostly similar to the illustration in Pfeiffer (1866) is designated as the lectotype.

Family ARIOPHANTIDAE

Genus *Petalochlamys* Godwin-Austen, 1907

Petalochlamys formosanus (Schmacker & Boettger, 1891)

Syn. *Petalochlamys hypograpta* Godwin-Austen, 1907

http://www.taibif.tw/en/catalogue_of_life/page/7b11-e296-0f06-7c00-8eef-6282-8085-ec60-namecode-316691
Figure 2E

Macrochlamys (*Petalochlamys*) *formosana* var. *hypograpta* Godwin-Austen, 1907: 206, 212–214, pl. 115 figs. 2, 2b, pl. 116 figs. 5, 5b. (Apr. 1907).

Type locality. South Formosa [southern Taiwan] (Hirase)

Material examined. *Holotype.* Southern Formosa, from collection of Hirase (NHMUK 1903.7.1.1713), designated by monotypy, 11.0 × 6.3 mm, whorls 5.5. (Figure 2E).

Remarks. This name was first recommended by Pilsbry for specimens from Hirase's collection (Hirase 1908). However, Godwin-Austen (1907) received a specimen from Hirase, reported on its reproductive system and assigned it as the type species of the genus *Petalochlamys*. Hirase (1908: 16, published on 20 Jan. 1908) described his own specimens as a new variety of the same name in Japanese, on the basis of specimens collected from Hotawa; however, he also cited Godwin-Austen's study in a Japanese translation. Therefore, Godwin-Austen's 1907 publication unintentionally took precedence over Hirase's work, thereby claiming the authorship of this name. Being the type species of the genus, the name was thus elevated to the rank of species (ICZN 1999: Art. 61.4).

Petalochlamys vesta (Pfeiffer, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/206a-098e-58ca-00df-95c8-1038-5142-b787-namecode-316694
Figure 2F

Helix vesta Pfeiffer, 1866: 828, pl. 46 fig. 9. [1865] (Apr. 1866).
Petalochlamys vesta, Matsuda 1924: 49.

Type locality. Formosa [Taiwan] (Swinhoe)

Material examined. *Lectotype*. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040580), new designation, 8.5 × 16 mm, whorls 5.5.

Remarks. Although only one specimen is found in the NHM, it should be designated as lectotype under ICZN (1999: Rec. 73F).

Genus *Ovachlamys* Habe, 1946

Ovachlamys fulgens (Gude, 1900)

Syn. *Lamprocystis fulgida* Godwin-Austen, 1907

http://www.taibif.tw/en/catalogue_of_life/page/6f48-0a31-58ff-26e8-8637-e924-fbe9-9a3a-namecode-316684
Figure 2G

Macrochlamys fulgens Gude, 1900: 75, pl. 8 figs. 24–26.
Lamprocystis ? *fulgida* Godwin-Austen, 1907: 214, pl. 115 figs. 3–3f, pl. 116 figs. 6–6a.

Type locality. South Formosa [southern Taiwan] (Hirase)

Material examined. *Holotype* of *Lamprocystis fulgida*. South Formosa, from collection of Hirase (NHMUK 1903.7.1.1714), designated by monotypy, 4 × 7.3 mm, whorls 4.5.

Remarks. Godwin-Austen (1907) described the specimen as being 9.75 mm in shell width. By comparing his measurement with mine, I concluded that his was probably an inadvertent error.

Family BRADYBAENIDAE
Genus *Aegista* Albers, 1850

Aegista fulvicans (H. Adams, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/7c64-c58c-12eb-ac55-a7cd-a096-5667-5d70-namecode-404845
Figure 2H

Helix (*Plectotropis*) *fulvicans* H. Adams, 1866: 316, pl. 33 fig. 2.
Aegista (*Plectotropis*) *fulvicans*, Kuroda 1941: 147.

Type locality. Tamsui, Formosa [Danshui, New Taipei City] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe (NHMUK 1866.5.9.10/1), new designation, 9.9 × 14 mm, whorls 7.

Paralectotypes. Formosa, coll. Swinhoe (NHMUK 1866.5.9.10/2–3, 2 shells). Formosa, from collection of H. Adams (NHMUK 1878.1.23.204, 2 shells).

Remarks. Adams (1866) described the locality as Tamsui, Formosa, but the original label has only "Formosa". The largest specimen mostly similar to the illustration in Adams (1866) is designated as the lectotype.

Aegista granti (Pfeiffer, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/7c64-c58c-12eb-ac55-a7cd-a096-5667-5d70-namecode-404845
Figure 2I

Helix granti Pfeiffer, 1866: 828–829, pl. 46 fig. 10. [1865] (Apr. 1866).
Aegista (*Plectotropis*) *granti*, Kuroda 1941: 147.

Type locality. Formosa [Taiwan] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040579), new designation, 8.9 × 14.4 mm, whorls 6.5.

Remarks. Although only one specimen is found in the NHM, it should be designated as lectotype under ICZN (1999 Rec. 73F).

Genus *Pseudobuliminus* Gredler, 1887

Pseudobuliminus incertus (Pfeiffer, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/ded5-2c76-8885-2134-814e-8b5e-d842-c8e9-namecode-404771
Figure 3A

Bulimus incertus Pfeiffer, 1866: 830, pl. 46 fig. 1. [1865] (Apr. 1866).
Pseudobuliminus incertus, Schmacker and Boettger 1891: 163.

Type locality. Formosa [Taiwan] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040582/1), new designation, ca. 10 × 4.5 mm, whorls 9.5 (peristome damaged).

Paralectotypes. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040582/2–4, 3 shells).

Remarks. The largest specimen corresponds well in size with the measurements of Pfeiffer (1866). It is here selected as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Genus *Acusta* Albers, 1860

Acusta assimilis (H. Adams, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/f063-8247-3258-a7f9-1230-23a1-7f12-e537-namecode-316552
Figure 3B

Nanina (*Acusta*) *assimilis* H. Adams, 1866: 316, pl. 33 fig. 1.
Acusta assimilis, Chang 1984: 18.

Type locality. Takow, Formosa [northern Qi-Jin, Kaohsiung City] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe (NHMUK 1866.5.9.11/1), new designation, 13.7 × 19.4 mm, whorls 5.75.

Paralectotypes. Formosa, coll. Swinhoe (NHMUK 1866.5.9.11/2–3, 2 shells).

Remarks. Adams (1866) described the locality as Takow, Formosa, but the original label has only "Formosa". The lot NHMUK 1866.5.9.11 was first registered and labelled as “Nanina propinqua”, then later published as *N. assimilis*. None of these shells exactly match with the measurements of Adams (1866). The specimen in the best condition is designated as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Acusta toyenmongaiensis Rolle, 1911

Acusta toyenmongaiensis Rolle, 1911: 32.

Type locality. Toyenmongai, Formosa [Dong-yuan-men-jie, Tainan = central area of modern-day Tainan City] (Rolle?)

Material examined. *Lectotype.* Toyenmongai, Formosa (SMF 7405), designated by Zilch (1968, pl. 7, fig. 27).

Paralectotypes. Formosa (NHMUK 1912.8.16.131–133, 3 shells, “original specimen”) , 11.3–12.3 × 13.3–14.2 mm, whorls 5.25–5.5. Also in SMF.

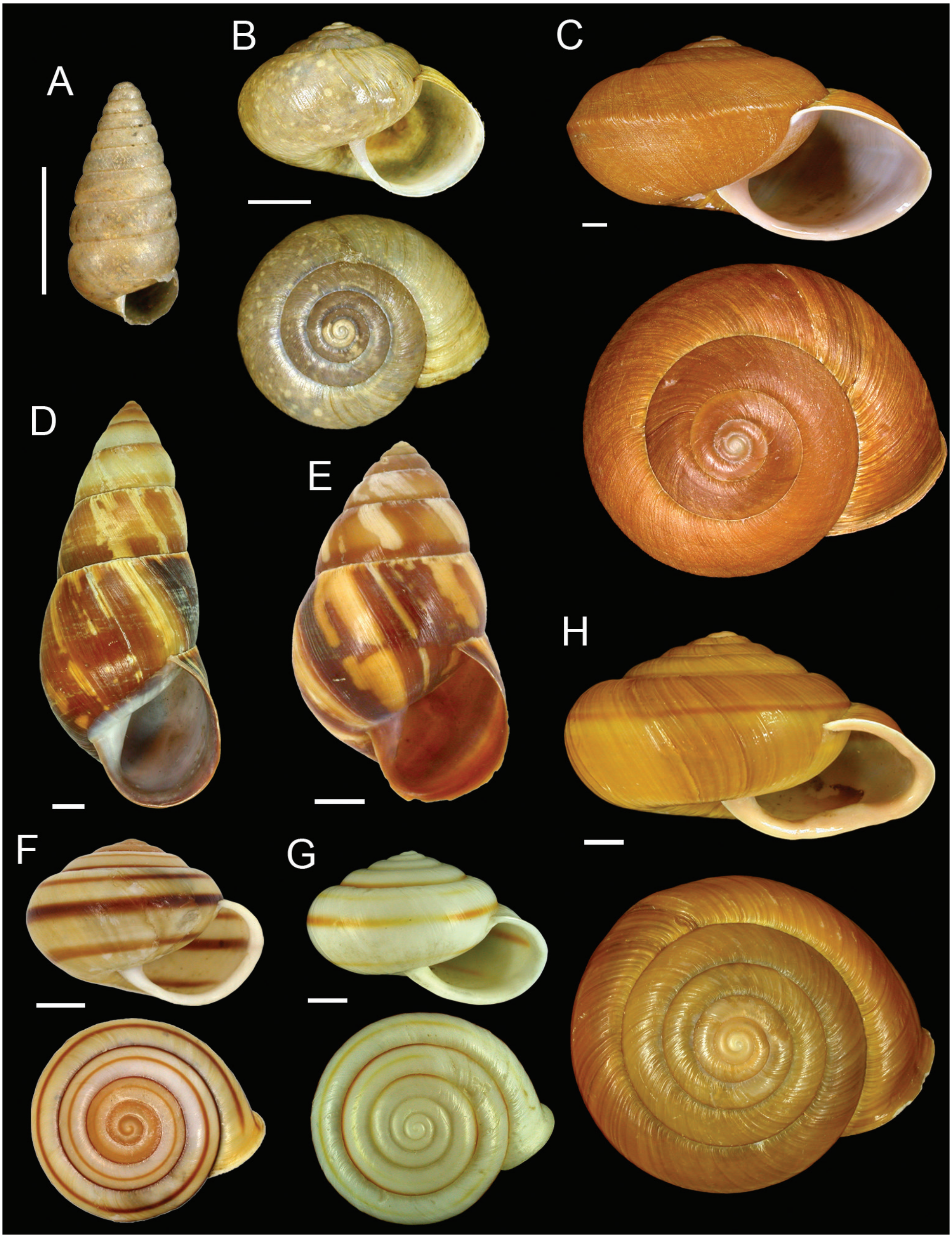

Figure 3. **A** *Pseudobuliminus incertus* (Pfeiffer, 1866), lectotype NHMUK 20040582/1 **B** *Acusta assimilis* (H. Adams, 1866), lectotype NHMUK 1866.5.9.11/1 **C** *Nesiohelix swinhoei* (Pfeiffer, 1866), lectotype NHMUK 20040585/1 **D** *Dolicheulota formosensis* (H. Adams, 1866), lectotype NHMUK 1866.5.9.1/1 **E** *Dolicheulota swinhoei* (Pfeiffer, 1866), lectotype NHMUK 20040586/1 **F** *Satsuma bacca* (Pfeiffer, 1866), lectotype NHMUK 20040577/1 **G** *Satsuma bacca* (Pfeiffer, 1866) syn. *Eulota warburgi* Gude, 1907, holotype NHMUK 1922.8.29.66 **H** *Satsuma bairdi* (H. Adams, 1866), lectotype NHMUK 20040587/1. Scale bars = 5 mm.

Genus *Nesiohelix* Kuroda & Emura, 1943

Nesiohelix swinhoei (Pfeiffer, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/6229-bc2d-cbaa-81c2-e0f7-c761-0936-09a5-namecode-316578
Figure 3C

Helix swinhoei Pfeiffer, 1866: 829, pl. 46 fig. 6. [1865] (Apr. 1866).
Nesiohelix swinhoei, Kuroda 1941: 148.

Type locality. Formosa [Taiwan] (Swinhoe).

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040585/1, large form), new designation, 42.7 × 75.3 mm, whorls 5.5.

Paralectotypes. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040585/2, 1 shell, large form, 50.9 × 68.1 mm, whorls 5.25; NHMUK 20040585/3–4, 2 shells, small form, 32.4–32.5 × 50.8–54.5 mm, whorls 4.75–5.0).

Remarks. The shell sizes of these four specimens do not agree with Pfeiffer's original measurements of 27–28 × 52–58 mm for the typical form and 25 × 46 mm for the minor form. I consider Pfeiffer's measurements to be incorrect. The largest specimen is designated as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Genus *Dolicheulota* Pilsbry, 1901

Dolicheulota formosensis (H. Adams, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/d4d5-9c75-7cde-9aa3-c80d-6ae0-ec2b-eda7-namecode-316574
Figure 3D

Bulimus (*Amphidromus*) *formosensis* H. Adams, 1866: 317, pl. 33 fig. 5.
Dolicheulota formosensis, Pilsbry and Hirase 1906: 735.

Type locality. Tamsui Mountains, Formosa [Danshui, New Taipei City] (Swinhoe).

Material examined. *Lectotype.* Formosa, coll. Swinhoe (NHMUK 1866.5.9.1/1), new designation, 55.4 × 24 mm, whorls 8.

Paralectotypes. Formosa, coll. Swinhoe (NHMUK 1866.5.9.1/2–3, 2 shells).

Remarks. Adams (1866) described the locality as Tamsui Mountains, Formosa, but the original label has only "Formosa". The largest specimen corresponding well in size with the measurements of H. Adams (1866) is designated as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Dolicheulota swinhoei (Pfeiffer, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/291f-4ce7-4fad-078f-d5bb-38ba-7785-3f53-namecode-316575
Figure 3E

Bulimus swinhoei Pfeiffer, 1866: 830, pl. 46 figs. 2, 2a. [1865] (Apr. 1866).
Dolicheulota swinhoei Pilsbry & Hirase, 1906: 735.

Type locality. Formosa [Taiwan] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040586/1), new designation, 37.1 × 21.4 mm, whorls 7.

Paralectotypes. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040586/2–3, 2 shells, one bleached and the other immature).

Remarks. The specimen in the best condition is designated as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Family CAMAENIDAE

Genus *Satsuma* A. Adams, 1868

Satsuma albida (H. Adams, 1870)

http://www.taibif.tw/en/catalogue_of_life/page/80bb-3054-2d71-db66-01fb-6288-7ba3-1741-namecode-402896

Helix (*Satsuma*) *albida* H. Adams, 1870: 378, pl. 27 fig. 9.
Satsuma albida, Minato, 1976: 84.

Type locality. Taiwan, Formosa [Taiwan Fu = Tainan City and northern Kaohsiung City] (Swinhoe).

Material examined. *Lectotype.* Takow, Formosa, from collection of H. Adams (NHMUK 1878.1.28.229), designated and photographed by Wu et al. (2008), 15 × 14 mm, whorls 5.8.

Remarks. Adams (1870) described the locality as Taiwan, Formosa, but it is " Takow, Formosa" on the label. See Wu et al. (2008) for a discussion of the type locality.

Satsuma bacca (Pfeiffer, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/3b47-78d4-0970-b4b4-ae3c-e171-67c8-d0cc-namecode-316610
Figure 3F

Helix bacca Pfeiffer, 1866: 829, pl. 46 fig. 8. [1865] (Apr. 1866).
Satsuma bacca, Richardson 1985: 268.

Type locality. Formosa [Taiwan] (Swinhoe).

Material examined. *Lectotype* of *Helix bacca*. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040577/1), new designation, 16.6 × 24.5 mm, whorls 5.5. (Figure 3F)

Paralectotype of *Helix bacca*. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040577/2, 1 shell, immature).

Remarks. This species was usually considered as a member of *Pancala* Kuroda & Habe, 1949. Hwang (2011) transferred it to the current genus because of genital and conchological similarities. Besides, *Pancala* is preoccupied by a dipteran genus (Enderlein 1936). The only mature specimen is designated as lectotype.

Satsuma bacca (Pfeiffer, 1866)

Syn. *Eulota* (*Euhadra*) *warburgi* Gude, 1907

Figure 3G

Eulota (*Euhadra*) *warburgi* Gude, 1907: 164–165, figs. 1, 2.

Type locality. Dunes at Long-Krau, South Formosa [coastal area of Northwest Hengchung Peninsula] (Warburg)

Material examined. *Holotype* of *Eulota* (*Euhadra*) *warburgi*. Dunes at Long-Krau, Southern Formosa, coll. Warburg, Feb. 1888, from collection of Naturhistorisches Museum, Hamburg (NHMUK 1922.8.29.66), original designation, 19.2 × 30.5 mm, whorls 5.75. (Figure 3G)

Satsuma bairdi (H. Adams, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/6293-3ac5-ce65-683e-ef8c-6101-7142-a9e1-namecode-402916

Figure 3H

Helix (*Camaena*) *bairdi* H. Adams, 1866: 316, pl. 33 fig. 3.
Satsuma bairdi, Richardson 1985: 268.

Type locality. Tamsui, Formosa [Danshui, New Taipei City] (Swinhoe)

Material examined. *Lectotype*. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040587/1), new designation, 22.7 × 40.0 mm, whorls 6.25.

Paralectotypes. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040587/2–3, 2 shells).

Remarks. Adams (1866) described the locality as Tamsui, Formosa, but the original label has only "Formosa". None of these shells exactly match with the measurements of Adams (1866). The specimen in the best condition is designated as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Satsuma formosensis (Pfeiffer, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/8f82-28a2-5e55-911c-d11c-a5ce-1537-af29-namecode-402919
Figure 4A

Helix formosensis Pfeiffer, 1866: 829, pl. 46 fig. 7. [1865] (Apr. 1866).
Satsuma formosensis, Richardson 1985: 270.

Type locality. Formosa [Taiwan] (Swinhoe).

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040578), new designation, 17 × 26 mm, whorls 6.

Remarks. Pfeiffer (1866) mentioned that the shell height is 12–13 mm, but only one specimen is found in the NHM. More than one specimen was probably examined by Pfeiffer. Therefore, this is designated as a lectotype instead of a holotype.

Satsuma mellea (Pfeiffer, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/8cbf-f9d6-70dd-b1d2-abbf-2f09-2c6e-8166-namecode-402922
Figure 4B

Helix mellea Pfeiffer, 1866: 829–830, pl. 46 fig. 4. [1865] (Apr. 1866).
Satsuma melleum (sic.), Lai 1990: 50.

Type locality. Formosa [Taiwan] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040576/1), new designation, 11 × 23.2 mm, whorls 5.

Paralectotypes. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040576/2–3, 2 shells).

Remarks. The largest specimen mostly similar to the illustration in Pfeiffer (1866) is designated as the lectotype.

Satsuma sphaeroconus (Pfeiffer, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/676b-ddd0-aa05-0ce7-2977-e3c7-8bb4-25e3-namecode-402928
Figure 4D

Bulimus sphaeroconus Pfeiffer, 1866: 830, pl. 46 fig. 3. [1865] (Apr. 1866).
Satsuma (*Coniglobus*) *sphaeroconus*, Kuroda and Habe 1949: 59.

Type locality. Formosa [Taiwan] (Swinhoe)

Material examined. *Lectotype.* Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040575/1), new designation, 23.1 × 18.5 mm, whorls 6.

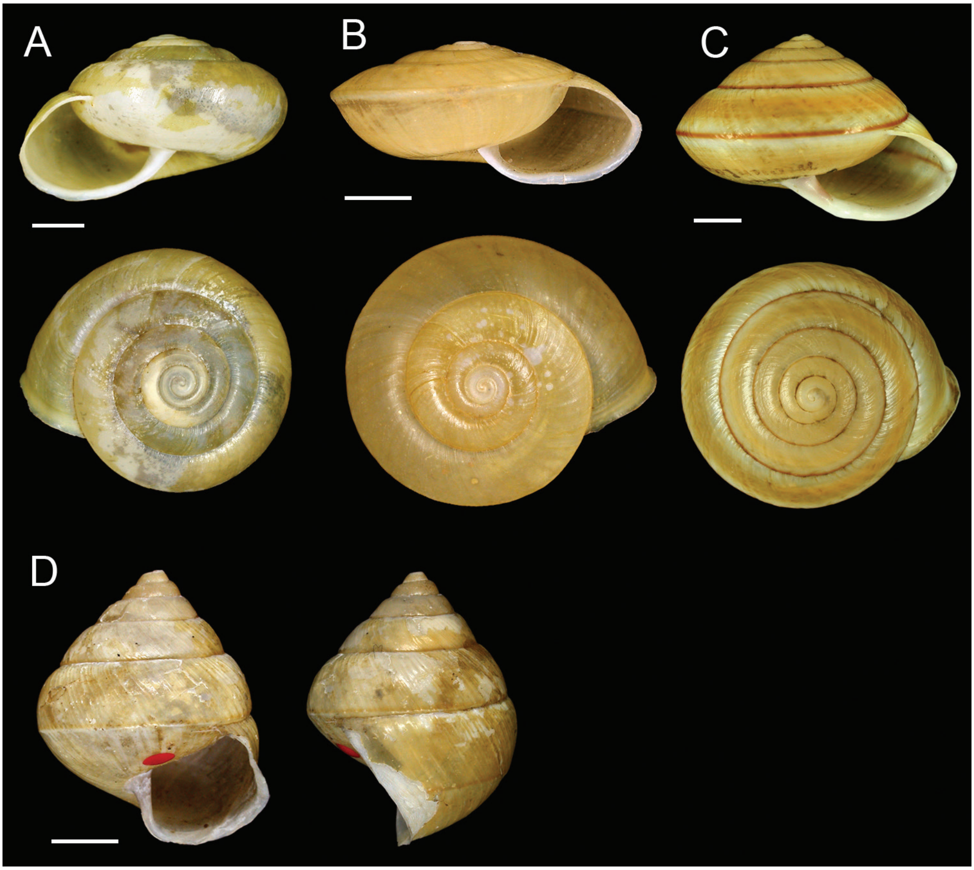

Figure 4. A *Satsuma formosensis* (Pfeiffer, 1866), lectotype NHMUK 20040578 **B** *Satsuma mellea* (Pfeiffer, 1866), lectotype NHMUK 20040576/1 **C** *Satsuma succincta* (H. Adams, 1866), lectotype NHMUK 1866.5.9.9/1 **D** *Satsuma sphaeroconus* (Pfeiffer, 1866), lectotype NHMUK 20040575/1. Scale bars = 5 mm.

Paralectotype. Formosa, coll. Swinhoe, from collection of H. Cuming (NHMUK 20040575/2, 1 shell, immature).

Remarks. The only mature shell with a red spot is designated as the lectotype.

Satsuma succincta (H. Adams, 1866)

http://www.taibif.tw/en/catalogue_of_life/page/4aa0-b629-2eb1-14c9-054a-7754-f168-a2e8-namecode-402929
Figure 4C

Helix (*Camaena*) *succincta* H. Adams, 1866: 316–317, pl. 33 figs. 4, 4a.
Satsuma succincta, Richardson 1985: 273.

Type locality. Takow, Formosa [northern Qi-Jin, Kaohsiung City] (Swinhoe).

Material examined. *Lectotype.* Takow Mountain, Formosa, coll. Swinhoe (NHMUK 1866.5.9.9/1), new designation, 22.8 × 31.2 mm, whorls 6.5.

Paralectotypes. Takow Mountain, Formosa, coll. Swinhoe (NHMUK 1866.5.9.9/2–6, 5 shells; NHMUK 1866.5.9.9/7, 1 shell, non *succincta*, immature shell of *Aegista lautsi branchylasis* (Schmacker & Boettger, 1891)).

Remarks. One of the specimens is labelled "Takow mountains" on base of shell. It is here selected as the lectotype for the stabilization of the name (ICZN 1999: Art. 74).

Genus *Yakuchloritis* Habe, 1955

Yakuchloritis hungerfordianus (Moellendorff, 1884)

http://www.taibif.tw/en/catalogue_of_life/page/ac86-40bf-dd43-3659-1e45-9174-49a8-8ff4-namecode-316613

Helix hungerfordiana Moellendorff, 1884: 336–337, pl. 7 fig. 7.
Yakuchloritis hungerfordianus, Chang 1990: 36.

Type locality. insulae Hongkong [Hongkong Islands] (Moellendorff)

Material examined. *Lectotype.* Hong Kong (SMF 45429), designated by Zilch (1966b, fig. 42).

Paralectotypes. Hong Kong and Guangdung, China (SMF, 11 shells) (Zilch 1966b).

Possible paralectotypes. Keelung, Formosa, coll. Hungerford (NHMUK 1891.3.17.5–6, 2 shells), 9.6 × 18.1 mm, whorls 5.5; 9.7 × 16.5, whorls 5.5.

Remarks. This species was named by Nevill, in a letter to Hungerford, on the basis of the samples that Hungerford collected from Formosa; however, the species was not published until 1884 by Moellendorff. Having examined Moellendorff's collection from Hong Kong and Guangdung (Moellendorff 1884), I cannot find evidence of whether the lot in the NHM was actually seen by Moellendorff. Since he listed Formosa as one of the localities, I consider the specimens in the NHM to be possible paralectotypes.

Genus *Moellendorffia* Ancey, 1887

Moellendorffia hiraseana Pilsbry, 1905

Syn. *Stegodera* (*Trihelix*) *helleri* Rolle, 1911

http://www.taibif.tw/en/catalogue_of_life/page/1c56-7520-15b7-106a-322e-2f3c-77bb-032c-namecode-316609

Moellendorffia (*Trihelix*) *hiraseana* Pilsbry, 1905: 66–67, pl. 2 fig. 4–6.
Stegodera (*Trihelix*) *helleri* Rolle, 1911: 31–32.

Type locality. Toyenmongai auf Formosa [Dong-yuan-men-jie, Tainan = central area of modern-day Tainan City] (Rolle?)

Material examined. *Lectotype* of *Stegodera helleri*. Toyenmongai, Formosa, coll. Rolle, 1910 (SMF 7404), designated as holotype by Zilch (1966a, fig. 57), see remarks below.

Paralectotypes of *Stegodera helleri*. (SMF, 4 shells) (Zilch 1966a).

Possible paralectotypes of *Stegodera helleri*. Toyenmongai, Formosa, coll. Rolle, "1/2/11", from collection of V.W. MacAndrew, no. 1563 (NHMUK 20040594, 4 shells), 6.4–6.9 × 15.9–17.4mm, whorls 4.75.

Remarks. No holotype was originally fixed by Rolle (1911). Zilch (1966a) considered a specimen in SMF as the holotype, which here is accepted as a subsequent lectotype designation, and thus all other specimens from Rolle's original lot receive the status of paralectotypes under Art. 74.6, ICZN (1999).

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A new species of the cleptoparasitic bee genus *Thyreus* from northern Yemen and southwestern Saudi Arabia (Hymenoptera, Apidae)

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Abstract

A new species of cleptoparasitic bee of the genus *Thyreus* Panzer (Apinae: Melectini) is described and figured from northern Yemen and southwestern Saudi Arabia. *Thyreus shebicus* Engel, **sp. n.** is a relatively small species superficially similar to the widespread and polytypic species *T. ramosus* (Lepeletier de Saint Fargeau) and *T. ramosellus* (Cockerell) but more closely allied to various African forms on the basis of the male genitalia. The species is distinguished from its congeners on the basis of coloration pattern, male hind leg structure, and particularly male terminalia.

Keywords

Apoidea, Anthophila, Melectini, Arabian Peninsula, taxonomy, cleptoparasitism

Introduction

The cleptoparasitic bee genus *Thyreus* Panzer is one of the more remarkable of Old World lineages. The genus consists of 108 described species (Lieftinck 1962, 1968; Rozen 1969; Eardley 1991; Schwarz 1993; Straka and Engel 2012), and, where known, are cleptoparasitic on species of *Amegilla* Friese (e.g., Bischoff 1927; Popov 1967; Lieftinck 1968 and references therein) and possibly on *Anthophora* Latreille and *Eucera* Scopoli (Stoeckhert 1954; Rozen 1969; Wafa and Mohamed 1970). Species are frequently variable and sometimes even cryptically similar to regionally close taxa, making the group a bane of melittologists. Indeed, although a comprehensive monograph of the group is available (Lieftinck 1962, 1968), it remains a serious challenge to confidently identify several species, particularly those numerous taxa superficially similar to presumably widespread species such as *Thyreus ramosus* (Lepeletier de Saint Fargeau) (e.g., Straka and Engel 2012). Nonetheless, species of *Thyreus* are not infrequently encountered and there is a great potential for detailed biological studies at nesting aggregations of *Amegilla*.

During ongoing survey work in the Kingdom of Saudi Arabia (e.g., Alqarni et al. 2011, 2012a, 2012b, 2013, 2014a, 2014b, in press; Hannan et al. 2012; Engel et al. 2012, 2013, 2014), a new species of *Thyreus* was discovered in the mountainous areas south from Makkah and this proved conspecific with additional material already known from northwestern Yemen (Figs 1–2). Recognizing the value of descriptive science (Grimaldi and Engel 2007), the species is described herein and compared with its close congeners as an effort to improve the concepts and circumscription of cleptoparasitic bees in the Arabian Peninsula (Engel 2011; Gonzalez et al. 2013), and to encourage melittologists in the region to seek further material along with its host.

Material and methods

Material is deposited in the King Saud University Museum of Arthropods, Plant Protection Department, College of Food and Agriculture Sciences, King Saud University, Riyadh, Kingdom of Saudi Arabia (**KSMA**) and Division of Entomology (Snow Entomological Collections), University of Kansas Natural History Museum, Lawrence, Kansas, USA (**SEMC**). Morphological terminology is based on that of Engel (2001) and Michener (2007), with the addition of those annotations developed by Lieftinck (1962, 1968: *vide etiam* Straka and Engel 2012) for patches of plumose white setae on the mesosoma. As was done by Straka and Engel (2012), we have supplemented the setal patch annontations with their full names inserted in parentheses to ease use while simultaneously maintaining continuity with Lieftinck's seminal works. The format for the descriptions follows that of Rightmyer and Engel (2003), Straka and Engel (2012), and Engel and Michener (2012). Photomicrographs were prepared with a Canon EOS 7D digital camera attached to an Infinity K-2 long-distance microscope lens and employing a Xenon flash. Measurements were taken with an ocular micrometer on an Olympus SZX12 stereomicroscope.

Systematics

Genus *Thyreus* Panzer

Thyreus shebicus Engel, sp. n.

http://zoobank.org/DEE104F7-E84B-41F8-8355-9CC55C154A23
Figs 1–11

Holotype. ♂, N. Yemen, high plateau, 14-4-82 [14 April 1982], I.L. Hamer (SEMC). This is the exact label data from the holotype male and is unfortunately not very precise but likely refers to the mountainous area north of Sana'a and bordering Jazan, Saudi Arabia.

Paratypes. 1♀, Saudi Arabia, Asir, Abha, Sawdah [Sodah] (near ropeway), 2670 m, 18°17'37.19"N, 42°21'31.49"E, 22-v-2012 [22 May 2012], M.A. Hannan (KSMA); 1♀, Saudi Arabia: Asir, Abha, Sodah, nr. dam, 2500 m, 18°14'11.64"N, 42°24'49.96"E, 22-v-2012 [22 May 2012], M.S. Engel (SEMC); 1♀, Saudi Arabia, Abha, 6.vi.1972 [6 June 1972], 18.13°42.30°E, A.W. Harvey (SEMC).

Diagnosis. The new species is superficially similar to *T. ramosus* and *T. ramosellus* (Cockerell) but can be distinguished most readily in the form of the male terminalia [*cf.* Figs 5–9 with those in Lieftinck (1968)], particularly in the unique structure of the seventh metasomal sternum and even more extensively with the latter species. In addition, the ventral longitudinal carina of the male metafemur is incomplete (as in *T. ramosellus*, complete in *T. ramosus*) but the apex of the metatibia lacks a comb of dense, long, fine, plumose setae (present in *T. ramosellus*, absent in *T. ramosus*). Females of *T. shebicus* differ from *T. ramosus* and *T. ramosellus* in that *plsa* (anterior posterolateral mesoscutal) does not meet *pls* (posterolateral mesoscutal) and is well differentiated from the latter, and *pls* (posterolateral mesoscutal) is generally smaller in the new species, separated by more than the diameter of an individual *pls* (posterolateral mesoscutal) [distance equal to or frequently less than the diameter of *pls* (posterolateral mesoscutal) in *T. ramosus* and *T. ramosellus*]. The new species may be distinguished from the widespread *T. histrionicus* (Illiger), another superficially similar species, by the more deeply sinuate mesoscutellar posterior margin, the incomplete ventral longitudinal carina of the male metafemur (complete in *T. histrionicus*), the outer surface of the metabasitarsus not concave (concave in *T. histrionicus*), the presence of spots on the male sixth tergum (absent in *T. histrionicus*), and the form of the hidden sterna and genitalia [*cf.* Figs 5–9 to Lieftinck's (1968) figure 20].

Description. ♂: Total body length 10.0 mm; forewing length 7.5 mm. Head wider than long (length 2.3 mm, width 2.9 mm); upper interorbital distance 1.8 mm; lower interorbital distance 1.3 mm. Intertegular distance 2.2 mm; mesoscutellar posterior margin with median emargination, weakly sinuate (Fig 3), apicolateral angle only weakly produced. Ventral longitudinal carina of metafemur incomplete, carinate only in apical two-thirds, basad carina becomes a defined acarinate angled ridge (in this regard somewhat similar to *T. ramosellus*); inner anterior angle of metatibia not swollen or projecting into prominence or point between metatibial spurs but inner

Figures 1–2. Lateral habitus of *Thyreus shebicus* Engel, sp. n. **1** Male (holotype) **2** Female (paratype).

apical border bearing spurs produced gradually outward and posteriorly bordered by apical depressed area with more elongate black setae; apex of metatibia without comb of dense, long, fine, plumose setae; outer surface of metabasitarsus not concave. Apex of seventh metasomal tergum with apicolateral prominences distinct, acutely pointed, length of individual prominence less than one-half of distance between them, truncate margin between prominences straight, without medial emargination or swelling; male terminalia as in Figs 5–9.

Labrum with coarse punctures separated by less than a puncture width except medially and basally separated by a puncture width or slightly less and small, circular, basolateral impunctate areas, integument between punctures smooth, basomedially with shallow, short V-shaped furrow with smaller closer punctures therein; clypeus with small nearly contiguous punctures, integument between smooth; supraclypeal area as on clypeus except punctures sparse medially; lower face as on clypeus except

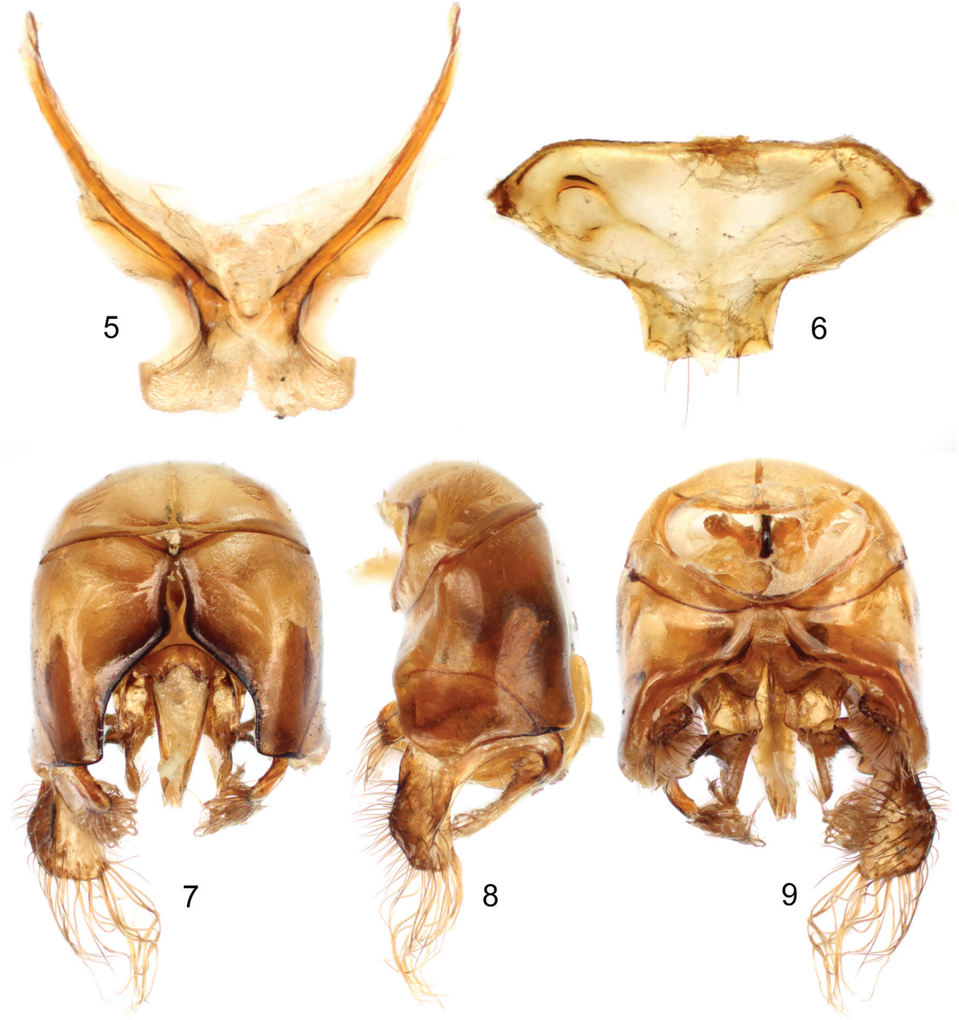
Figures 3–4. Male (holotype) of *Thyreus shebicus* Engel, sp. n. **3** Mesosomal dorsum **4** Metasomal dorsum.

punctures more well defined, becoming progressively larger toward upper frons; punctures become smaller and sparser in ocellocular area, integument between punctures smooth; punctures weaker and shallower on vertex, separated by less than a puncture width immediately posterior to ocelli and bordering preoccipital carina, otherwise rather sparse on vertex; punctures of gena coarse, shallow, and progressively more dense from above to nearly contiguous by midlength; postgena finely imbricate and impunctate. Pronotum with coarse, shallow punctures separated by a puncture width or less, integument between smooth to faintly imbricate; mesoscutum with well-defined, coarse, contiguous punctures laterally (Fig 3), punctures slightly more widely spaced medially such that punctures separated by about 0.25–0.5 times a puncture width, integument between punctures smooth; axilla with punctures contiguous; mesoscutellum with punctures as on mesoscutum except separated by 0.25–0.75 times a puncture width, more closely spaced laterally; pleura with coarse, nearly contiguous punctures, integument between punctures (where evident) finely and faintly imbricate, punctures of mesopleuron ventrally becoming more elongate and widely spaced, punctures of preëpisternal area and metapleuron smaller than those of mesopleuron and contiguous; hypoepimeral area large, coarse, nearly contiguous punctures; propodeal lateral and posterior surfaces with coarse, shallow, ill-defined, nearly contiguous punctures. Metasoma with small punctures separated by a puncture width or more often less (Fig 4), punctures more coarse, larger, and somewhat more poorly defined on discs of more apical terga, integument between faintly and finely imbricate, apical margins narrowly impunctate and finely imbricate; sterna with similar punctation except those on discs of more basal sterna more widely spaced and becoming more poorly defined on more apical sterna.

Integument black except dark brown on labrum, mouthparts, legs, and apically on mesoscutellum, seventh metasomal tergum, and on apical sterna. Wing membranes hyaline and slightly infumate except with whitish along apical border of 2rs-m and 2m-cu (Figs 1–2), veins dark brown to black.

Pubescence generally fuscous to black over entire body except in the presence of long plumose white setae over most of face (Fig 10), posterior on vertex, ventral margin of mandible, entire gena, postgena, outer surface of protibia and probasitarsus (although white setae appressed and short on this surface), outer surface of mesotibia and mesotarsus (appressed on these surfaces), apical ventro-posterior border of mesofemur, outer posterior angles of meso- and metacoxae, outer surface of metatibia and metarasus (appressed on these surfaces), and on mesosoma (using the annotation system of Lieftinck 1962, 1968) as follows: *deps* (dorsal mesepisternal) and *lpn* (lateral pronotal) present; *als* (anterolateral mesoscutal) present but diffuse and faint; *ms* (median mesoscutal) present but diffuse and faint; *mls* (mediolateral mesoscutal) present albeit very diffuse; *plsa* (anterior posterolateral mesoscutal) present along border with tegula, not meeting *pls* (posterolateral mesoscutal) posteriorly; *t* (tegular) present and prominent posteriorly on tegula; *pls* (posterolateral mesoscutal) present, not extending laterally to meet *plsa* (anterior posterolateral mesoscutal); *ps* (parascutellar) and *s* (mesoscutellar) absent; *deps* (dorsal mesepisternal), *hypm* (hypoepimeral area), and *lp* (lateral propodeal) present, *veps* (ventral mesepisternal) present albeit diffuse (Figs 1, 3) (much of these white patches are diffuse in the male and partially rubbed off as preserved, most patches more well defined in female). Mesoscutellum with patch of long, plumose, white setae extending posteriorly from undersurface of mesoscutellum medially, patch wide but not reaching to apicolateral corners. Metasomal terga with prominent patches of appressed, plumose white setae as follows: first metasomal tergum with large, L-shaped patches laterally; second metasomal tergum with lateral patch L-shaped although transverse section more well developed; third through sixth metasomal terga with transverse lateral patches, those of sixth tergum more rounded (Fig 4).

♀: As described for male except in usual gender differences and as follows: Total body length 8.1–9.9 mm; forewing length 7.1–8.1 mm. Head wider than long (length 2.3–2.6 mm, width 2.9–3.4 mm); upper interorbital distance 1.8–1.9 mm; lower in-



Figures 5–9. Male terminalia of holotype of *Thyreus shebicus* Engel, sp. n. **5** Seventh metasomal sternum **6** Eighth metasomal sternum **7** Genital capsule, dorsal view **8** Genital capsule, lateral view **9** Genital capsule, ventral view. Note: One gonostylus is missing.

terorbital distance 1.3–1.5 mm. Intertegular distance 2.3–2.7 mm; mesoscutellar posterior margin as in male but sometimes sinuate margin weaker and posterior angles more prominent. Pygidial plate relatively narrow, lateral margins largely straight and converging apically, apex broad and truncate, surface imbricate and impunctate, apically with weak medial carina.

Mesoscutal punctures slightly more spaced than in male; metasomal terga with punctures generally separated by less than a puncture width, apical margins narrowly impunctate and imbricate except apical margin of fifth tergum broadly impunctate and imbricate, covering approximately apical half.

Figures 10–11. Faces of *Thyreus shebicus* Engel, sp. n. **10** Male (holotype) **11** Female (paratype).

Integument and pubescence as in male except reddish brown on pygidial plate; white mesoscutal setal patches generally more well defined and not as diffuse as in male; second through fifth metasomal terga with transverse lateral patches (Fig 2).

Etymology. The specific epithet refers to the ancient kingdom of Sheba, realm of the Queen of Sheba and the people of Tubba', and likely consanguineous with the Sabaeans who occupied several of those areas in the southwest of the Arabian Peninsula in which the species here has been taken.

Discussion

At first glance the new species could easily be confused with the widespread *T. ramosus* and, despite some of the difficulties with Lieftinck's (1968) key, will generally run to that taxon if the ventral longitudinal carina of the male metafemur is ignored. Otherwise, based on this feature, *T. shebicus* would run to *T. ramosellus*. Nonetheless, there are profound differences in the structure of the male terminalia between *T. shebicus* and *T. ramosus* and *T. ramosellus* [*cf.* Figs. 5–9 with Lieftinck's (1968) figures 32–33, 37–38]. Moreover, the form of the mesoscutellum and male seventh metasomal tergum in *T. shebicus* do not match those of either of the aforementioned species. In fact, many forms identifiable as *T. ramosus* or *T. ramosellus* sensu Lieftinck (1968) may represent distinct, perhaps even cryptic species, and there is a general need for a revised circumscription of the taxa within this complex and perhaps across the entire genus, as is necessary for many bee genera where concepts of species have not been tested in a generation or more (Gonzalez et al. 2013). Among African species there are those that closer approximate *T. shebicus* in the structure of the hidden sterna, such as *T. abyssinicus* (Radoszkowski) and *T. brachyaspis* (Cockerell), but the terminalia and genital capsules among all three remain specifically distinct and the patterns of coloration and other structural features (e.g., form of the seventh metasomal tergum) are further different (*vide* Eardley 1991). Nonetheless, this general similarity between African and western Arabian taxa is a general pattern observed across several insect groups and also matches with the geological history of the region (e.g., El-Hawagry et al. 2013; Engel et al. 2014). Notwithstanding the apparent patterns mentioned, a comprehensive phylogeny of *Thyreus* is necessary to tests these hypotheses and reveal the complicated biogeographic history of the clade.

Admittedly, *Thyreus* is not only a large and diverse group, encompassing a vast distribution throughout the Old World, but the distinctions between natural units have been challenging to discern. Lieftinck's herculean effort was certainly a massive leap forward and some of his hypotheses for widespread and rather polytypic species require further testing, ideally in combination with genetic data. In addition to the aforementioned *T. ramosus* and *T. ramosellus*, another such suspicious species is *T. nitidulus* (Fabricius) (*vide* Lieftinck 1959). Such work is not only pertinent for the proper characterization of species within the genus, but will permit eventually a comprehensive phylogenetic and biogeographic study across the clade, and, should sufficiently-large numbers of host nests be discovered to provide a ready supply of developmental stages of species of *Thyreus*, then perhaps the unique mesoscutellar shield of *Thyreus* could be explored from an evolutionary developmental perspective. Differential gene expression comparisons between developing *Thyreomelecta* Rightmyer and Engel and basal members of *Thyreus* would be revealing as to the underlying genetic architecture of morphogenesis in these bees.

Several suitable species of *Amegilla* were found flying in the same locality as *T. shebicus*. Any or multiples of these may serve as the host for this species and only through discovery of the nests of the *Amegilla* will it be possible to ascertain the specific association of the cleptoparasite. Continued intensive sampling and hunting for nests of bees in southwestern Saudi Arabia and particularly in the area around Abha is needed. Presently documented species of *Thyreus* from the Arabian Peninsula include the regionally widespread *T. elegans* (Morawitz) and *T. ramosus*, *T. ramosellus* in the northern parts, *T. parthenope* Lieftinck in largely the west and south of the peninsula (western Saudi Arabia and Yemen), and *T. fallibilis* (Kohl) in the southwest [originally described from 'South Arabia', a former name for the Republic of Yemen and some parts of Jazan, Asir, and Najran (*N.B.*: 'S. Arabia' on many pre-1968 labels refers to 'South Arabia', of the Federation of South Arabia or the Protectorate of South Arabia, and not Saudi Arabia)].

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RESEARCH ARTICLE

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Description of adult and third instar larva of *Trichostetha curlei* sp. n. (Coleoptera, Scarabaeidae, Cetoniinae) from the Cape region of South Africa

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Abstract

A new high altitude montane species of *Trichostetha* Burmeister, 1842 is described from the Elandsberg range of the Western Cape interior. This represents the 14th species of the genus and the first to be reported with a description of its larva. It is a significant addition to the growing number of species that exhibit no adult feeding behaviour and a short period of activity restricted to the onset of summer. Larvae dwell in rock crevices, feeding on decomposing plant matter. The genus *Trichostetha* is heterogeneous and the complex variability observed in some species, especially *T. capensis* (Linnaeus, 1767), requires the re-instatement of taxa that were recently synonymised. Thus, *T. bicolor* Péringuey, 1907 is here re-proposed as a separate species and *T. capensis hottentotta* (Gory & Percheron, 1833) as a separate subspecies. Conversely, *T. alutacea* Allard, 1994 is recognised as a dark variety of *T. signata* (Fabricius, 1775) and is, consequently, synonymised with this species.

Keywords

Scarabaeidae, Cetoniinae, genus *Trichostetha*, new species, revised status, third instar larva, Cape Floral Region, South Africa

Introduction

The genus *Trichostetha* Burmeister, 1842 is endemic to southern Africa and currently consists of 13 species and four subspecies (Holm and Marais 1992; Holm and Stobbia 1995; Sakai and Nagai 1998; Holm and Perissinotto 2004). With the exception of *T. fascicularis* (Linnaeus, 1767), which is subdivided into a number of subspecies and is widespread throughout South Africa and in the southern part of Botswana (Holm and Perissinotto 2011), all the other species are fairly stable and restricted to small distributional ranges (Holm and Marais 1992). Most of them occur in the Cape Floral Region and generally, but not exclusively, in mountainous terrain. Adults have traditionally been reported as feeding on the flowers of a variety of *Protea*, *Berkheya* and *Berzelia* (Péringuey 1907; Holm and Marais 1988; Holm and Stobbia 1995; Holm and Perissinotto 2004) as well as *Leucospermum* and *Brunia* species (JB Ball, pers. observ.). However, it is now clear that some species are actually associated with different plant species (e.g. *T. coetzeri* Holm & Marais, 1988 and *T. fascicularis maraisi* Stobbia, 1995), while others do not seem to feed at all in their adult stage (i.e. *T. dukei* Holm & Marais, 1988, *T. hawequas* Holm & Perissinotto, 2004 , *T. curlei* sp. n. and *T. calciventris* Stobbia, 1995).

Several species in this genus have only been described recently, from poorly sampled areas or from isolated mountain peaks (Holm and Perissinotto 2004). Observations in these areas have escalated during the past few years and as a result another undescribed species has now been discovered in the Cape region. The larval stages of a few species have been collected and successfully reared in the recent past (Holm and Stobbia 1995, R. Perissinotto pers. observ., A.P. Marais pers. comm.), but to date they have not been described for any of the known species. The new species reported here was collected both in the adult and third instar larval stage. This provides an opportunity to describe for the first time the larva of a representative of this genus.

The objective of this work is, therefore, to present a complete description of adult, larva and ecology of this new species and to relate this to the complex ecological and taxonomic issues that characterize the genus *Trichostetha*.

Materials and methods

The first records of this new species were reported from December 2009 and November 2011 by HC Ficq, who observed a few specimens in flight or perched on leaves and flowers of typical fynbos vegetation on the southern slope of the Elandsberg range of the Western Cape interior. After it became clear that an undescribed species was involved, a dedicated survey was undertaken to the area in November 2013. All specimens were collected in the mid morning to early afternoon hours using a standard net or direct hand picking. Larvae were obtained by excavating 10–20 cm underground in rock crevices, using standard garden tools. Specimens were preserved in 10% formalin and 99% ethanol for laboratory analyses.

The description of morphological characters follows the terminology used by Krikken (1984) and Holm and Marais (1992). Specimen length was measured from the anterior margin of the clypeus to the apex of the pygidium. Specimen width represents the maximum width of the elytra. Photos of male and female types were taken with a Ricoh CX1 camera with macro setting. Where necessary, the background was removed from the photos using Adobe Photoshop, in order to increase clarity of resolution. In situ photos were taken with a Nikon D800, fitted with 105 mm Nikon macro-lens.

The terminology for larval morphology follows Hayes (1929), Böving (1936) and Ritcher (1966). In order to give the most accurate information on chaetotaxy, the hair-like setae of the cranium and other structures were classified according to their relative sizes into two groups, medium to long (80–300 µm) and minute or small setae (5–40 µm). Refer to Šípek et al. (2008) for a detailed schematic figure. Morphological analysis and measurements were carried out using Olympus SZX9 and Olympus BX 40 light microscopes, both equipped with digital camera Olympus Camedia 5060. Mouthparts were dissected and if necessary mounted on slides in Liquide de Swan (e.g. Švácha and Danilevsky 1986). Photographs were taken using a Canon 550D digital camera equipped with Canon MP-E 65/2,8 MACRO lens with 5:1 optical magnification. Final images were composed from multiple layer-focussed pictures using Helicon Focus software (Helicon Soft Ltd.). All pictures were digitally enhanced using Adobe Photoshop CS4 (Adobe Inc.).

Collections are abbreviated as follows: ISAM – Iziko South African Museum, Cape Town, South Africa; PCBM – Private Collection JB Ball & AP Marais, Cape Town, South Africa; PCRP – Private Collection R Perissinotto & L Clennell, Port Elizabeth, South Africa; PCAC – Private Collection AI Curle, Johannesburg, South Africa; TMSA – Ditsong National Museum of Natural History (ex Transvaal Museum), Pretoria, South Africa. Geographical abbreviations are as follows: WC – Western Cape Province; EC – Eastern Cape Province; NC – Northern Cape Province; FS – Free State Province; KZN – KwaZulu-Natal Province; NW – North-West Province; MP – Mpumalanga Province; LP – Limpopo Province; BO – Republic of Botswana.

Species description

Trichostetha curlei sp. n.

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Type series. Holotype ♂: South Africa, WC, Elandsberg 33°19'49"S, 21°18'13"E, 1478 m asl, 13 Nov 2013, JB Ball & R Perissinotto (ISAM). Paratypes, 16♂ 2♀: same data as above (ISAM, PCBM, PCRP); 5♂ 1♀, same locality, but 16 Nov 2009, HC Ficq (PCAC); 2♂ 2♀, same locality, but 14 Nov 2011, HC Ficq (PCAC).

Etymology. The species is named after the South African lepidopterist AI Curle, who brought to our attention the existence of this undescribed Cetoniinae from the Elandsberg range.

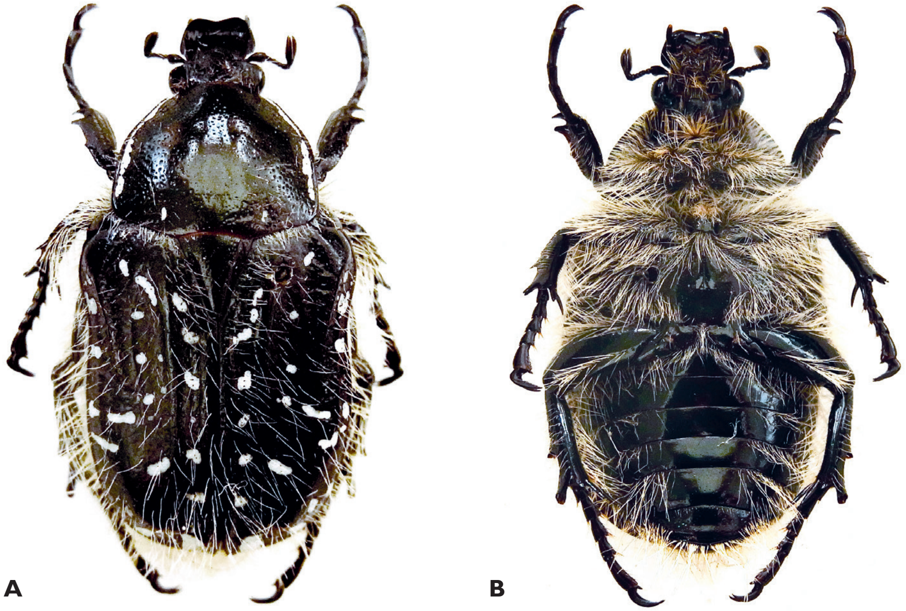

Figure 1. *Trichostetha curlei* sp. n.: Male dorsal (**A**) and ventral (**B**) habitus (length 18 mm) (Photos: L Clennell).

Description of adult (Figures 1–4). ***Male, holotype.*** Size: length 18.0 mm; width 9.2 mm.

Body (Figure 1A). Dark green to black; long white setae and white tomentose marks widespread, particularly on elytral surface.

Head. Black with scattered whitish, long setae and dense round punctures; clypeus sharply upturned, with broad anterior margin rounded, depressed at centre, forming two lateral lobes, which together with marked lateral ridges form concavity with raised frons at middle; antennal club, pedicel and flagellum black; antennal club short, pedicel and flagellum with long, erected white setae.

Pronotum. Dark green to black, shiny; disc without setae and with only few small, shallow punctures; scattered round punctures becoming larger and denser towards lateral margins; short setae restricted to lateral declivity; white tomentum restricted to stripe on lateral margins and two basal spots near posterior margin in shallow depression anteriad of scutellar basal corners; postero-lateral angle slightly rounded, posterior margin mildly sinuate anteriad of scutellum; anterior margin straight and as wide as eyes.

Scutellum. Dark green, shiny with sharply pointed apex and deep lateral grooves; few, scattered small punctures bearing short setae mainly around basolateral corners.

Elytron. Dark green to black; with sparse but very long white setae; humeral and third costa sharply raised and very marked; umbone wider than pronotum; small sparse white maculae, denser on second and fourth elytral striae where they form dotted lines, larger maculae present on lateral and apical declivity; crescent to horseshoe punctures

Figure 2. *Trichostetha curlei* sp. n.: Dorsal (**A**) and lateral (**B**) view of aedeagus (length 6.8 mm) (Photos: L Clennell).

distributed throughout surface, becoming more irregular in shape and scattered on umbone, costae, lateral and apical declivities.

Pygidium. Black with long white setae; with extensive white markings in basal two thirds, on each side of midline.

Legs. Protibia with few short setae, tridentate, with proximal denticle drastically reduced; distal teeth very pointed; anterior arolium bisetose; mesotibia with many long setae and two median external denticles, proximal extremely reduced, distal furcate and pointed outwardly; mesotibial claws sharply bent to form hook-like structure; metatibia covered in long setae, with median outer ridge not very pronounced, posterior arolium bisetose; all femora covered in dense, long white setae.

Underside (Figure 1B). Dark green, shiny, with dense setation and scattered punctures covering entire surface, except parts of mesometasternal process, medial half of abdominal sternites and ventral surface of metafemora; mesosternal lobe simple and flat, not protruding; sternites 3-6 with deep medial concavity.

Aedaegus (Figure 2). Parameres tapering gradually into sharply pointed apical end, gently curved downwards at apical half; without setae.

Female, paratype (Figure 3). Size: length 17.3 mm; width 8.9 mm . General shape and colour patterns similar to male, but white marks substantially reduced throughout body surface; white setation drastically reduced both on dorsal and ventral surfaces; tarsal segments shorter and protibial denticles wider and rounded; wing surface approximately one fifth smaller than in male; sternites 3-6 with slight medial convexity.

Variability. Males range from 12.9 to 18.0 mm in length and from 7.0 to 9.0 mm in width (n = 24), while females vary between 15.5 and 17.3 mm in length and between 8.2 and 8.5 mm in width (n = 2). All specimens exhibit a dark green to black dorsal colour, but there are brown areas on elytral disc in some cases. The extent of white maculation throughout the surface can also change substantially among specimens. The male pronotum occasionally exhibits second and/or third smaller discal spots in shallow depressions towards the lateral declivity, at middle or near the anterior margin.

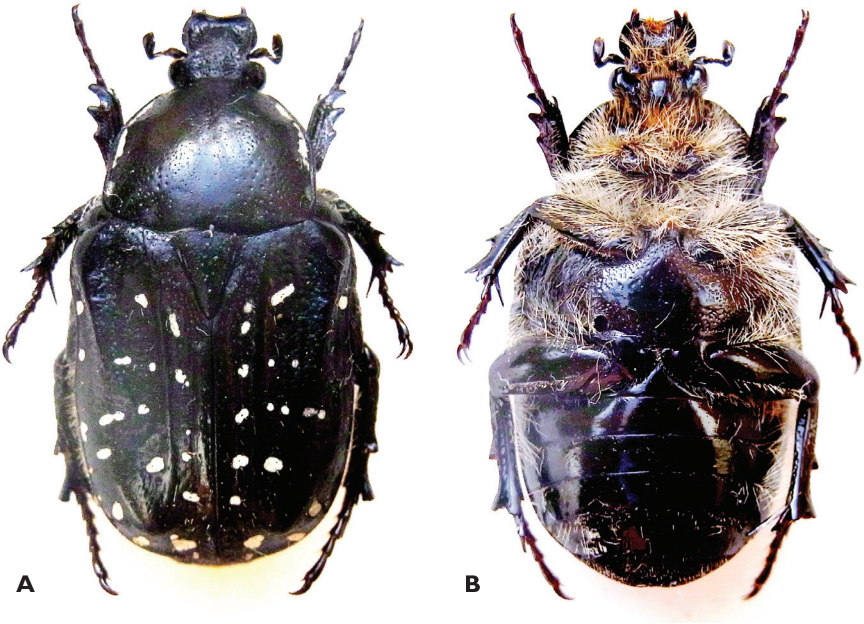

Figure 3. *Trichostetha curlei* sp. n.: Female dorsal (**A**) and ventral (**B**) habitus (length 17.3 mm) (Photo: L Clennell).

Figure 4. *Trichostetha curlei* sp. n.: Male specimen in its natural habitat on the Elandsberg summit, November 2013 (Photo: JB Ball).

Diagnosis. *Trichostetha curlei* sp. n. is most closely related to the smaller species of the genus, *T. dukei* and *T. hawequas*. It differs from both in having extremely well developed white pilosity in the male, sharp elytral costae, dark green background colour and extensive white maculation on the pygidium (Figures 1, 3, 4).

Remarks. It appears that, despite being seen on numerous flowers in different plant families, the univoltine adults are unable to feed and are active for a relatively short period of time at the onset of summer, from mid November to mid December. Their observed behavior is unexpected for a member of the genus *Trichostetha*, in that they show very little flying activity, preferring rather to perch on leaves and flowers of a variety of shrub species (Figure 4), which may serve as mating platform. Adults were noted on a number of plants, including *Leucadendron rubrum* (both male and female flower heads), *Protea eximia*, *Passerina truncata*, *Elegia filacea* (both male and female flowers) and *Cullumia bisulca*.

Description of third instar larva (Figures 5–6). ***Material examined.*** Two third instar larvae with the following data: South Africa, Western Cape Province; Elandsberg, 13 Nov 2013, JB Ball & R. Perissinotto legit.

Body (Figure 5A). Larva scarabaeiform, of typical Cetoniinae habitus, maximal length 38–41 mm; cranium brown to dark-brown, body densely setose, creamy-white or greyish, setae yellowish to orange-brown; abdominal segments IX and X fused dorsally, ventrally separated by an incomplete groove.

Head capsule (Figure 5B). Maximum width between 3.3 and 3.6 mm; cranium glabrous with linear microsculpture, brown; antennifer, postclypeus and labrum darker, frontoclypeal suture and apices of mandibles black; frontal sutures shallowly bisinuated; epicranial insertions of antennal muscles feebly developed (visible only as small depressions near the midline of frontal sutures); epicranial suture extending anteriorly into frons; cranial chaetotaxy summarized in Table 1; posterior epicranial setae with a single long and several minute setae; anterior frontal setae absent, exterior frontal setae minute; clypeus almost rectangular, membranous anteclypeal part covering about 1/3 of entire clypeal area; postclypeus strongly sclerotized with one anterior and a pair of exterior clypeal setae (one shorter than the other); frontoclypeal suture distinct; stemmata rudimental.

Antennae (Figures 5G, H). Four-jointed (an I–IV), relative length of antennomeres: an I > an IV > an II > an III; an III with ventral, apical projection exhibiting a single sensory spot; roud (apical) sensorial field of ultimate antennomera shifted slightly laterally; two dorsal and two ventral sensorial spots present.

Table 1. Cranial chaetotaxy of *Trichostetha curlei* sp. n. third instar larva.

	Epicranium				Frons				Clypeus		Labrum				
Group of setae	DES	PES	AES	EES	PFS	EFS	AFS	AAS	ACS	ECS	PLS	PMS	ELS	LLS	SMLL
Long + medium	1+1	1+0	1	1-3+8-12	1	0	0	1	1	1+1	0-1+1-3	1	2+1-2	7-8	8
Minute	4–9	2–4		3–4	0	1	0	0	0	0	0	0	0	0	0

Abbreviations: AAS = setae on anterior frontal angle; ACS = anterior clypeal setae; AES = anterior epicranial setae; AFS = anterior frontal setae; DES = dorso-epicranial setae; ECS = exterior clypeal setae; EES= exterior epicranial setae; EFS = exterior frontal setae; ELS = exterior labral setae; LLS = setae on lateral labral lobe; PES = posterior epicranial setae; PFS = posterior frontal setae; PLS = posterior labral setae; PMS = paramedial labral setae. SMLL = seate on the medial labral lobe. For explanation of length categories of setae see 'Materials and methods'.

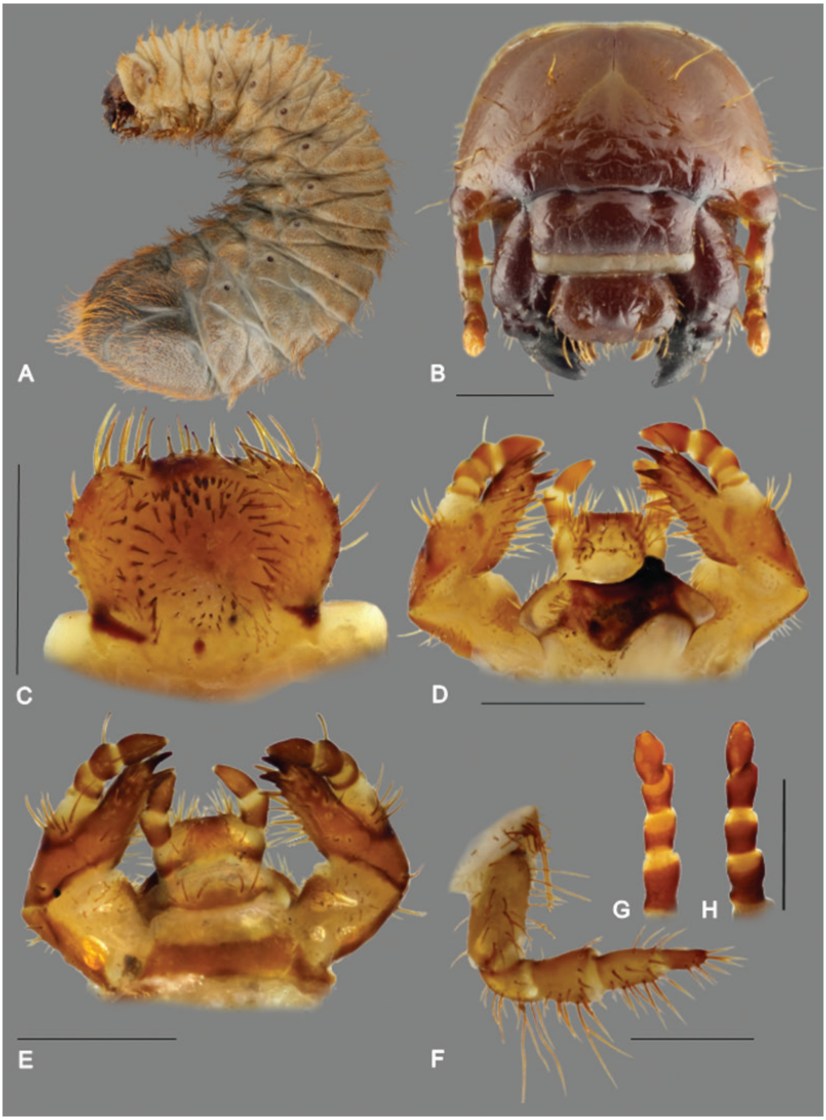

Figure 5. *Trichostetha curlei* sp. n., third instar larva. **A** Habitus of fully grown larva (length 41 mm) **B** cranium **C** epipharynx **D** Labio-maxillar complex and hypopharynx, dorsal aspect **E** labio-maxillar complex and hypopharynx, ventral aspect **F** metathoracic leg, lateral aspect **H** antenna (**G** dorsal aspect **H** ventral aspect). Scale bars: 1 mm (Photos: P Šípek).

Labrum. Symmetrical, anterior margin trilobed with numerous setae; clithra present; dorsal labral surface with two transverse rows of setae.

Epipharynx (Figure 5C). Haptomerum with zygum convex, with a transverse row of 12-15 spiny setae, eight to ten similar setae at posterior base of haptomerum; sensilla of zygum grouped below apex of haptomerum; haptomeral process and proplegmata absent; acroparia with external margin of lateral labral lobes with six long setae on

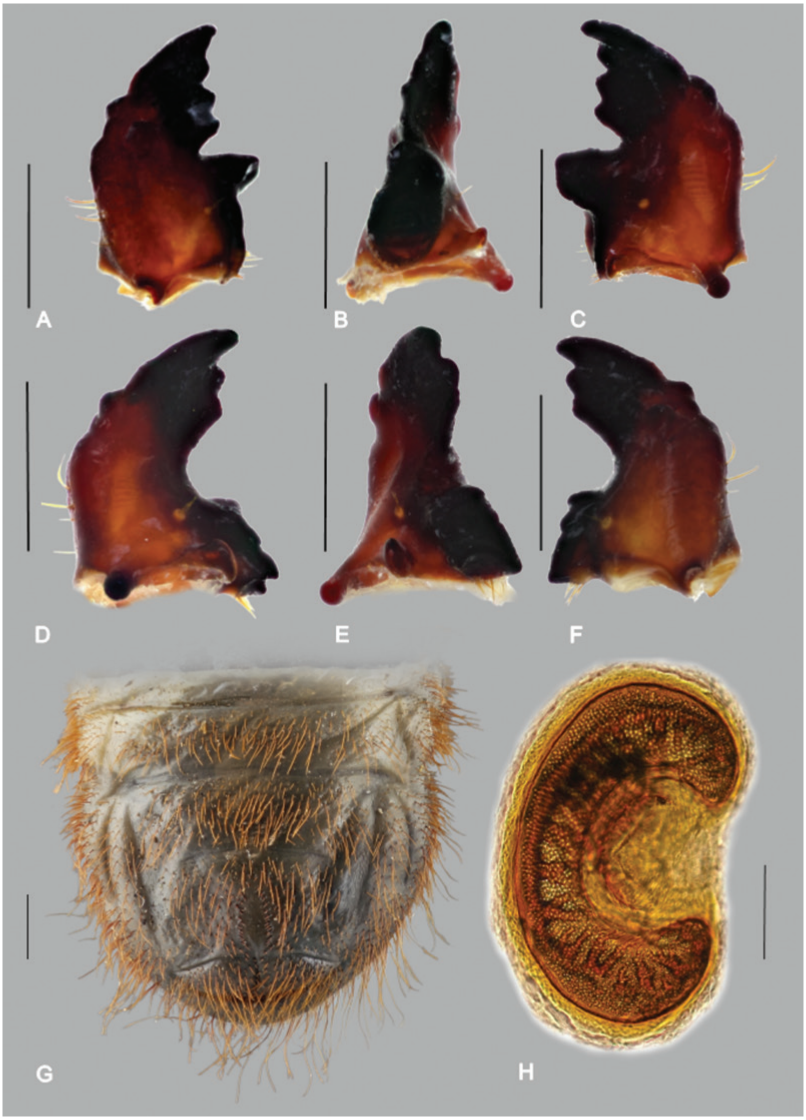

Figure 6. *Trichostetha curlei* sp. n.,third instar larva. **A, B, C** Left mandible (**A** dorsal aspect **B** medial aspect **C** ventral aspect) **D, E, F** right mandible (**D** ventral aspect **E** medial aspect **F** dorsal aspect) **G** last abdominal segments, ventral aspect **H** thoracic spiracle. Scale bars: A–G – 1 mm, H – 0.1 mm (Photos: P Šípek).

ventral and four setae on dorsal side; medial labral lobe with two rows of four setae; acanthoparia bearing five to seven setae with distinctly swollen base (projecting out of epipharyngeal margin); lateral margin of epipharynx serrate; subapical seta of acanthoparia slightly longer than posterior setae, apical seta about three times longer than subapical seta; plegmata absent; chaetoparia with about 60 setae arranged in three to four irregular rows, medial rows with stout, spine-like setae; dexiotorma robust, straight;

right pternotorma present; laeotorma short, left pternotorma triangular, large; haptolachus with sense cone (left nesium) low and obtuse, sclerotised plate (right nesium) absent; plate-shaped sclerite feebly developed; anterior part of haptolachus (distad to sense cone) with short spine-like setae; postero-lateral part with group of two pore-like setae on each side; phoba and crepis absent.

Mandibles (Figure 6A–F). Asymmetrical, scrobis with four to six setae; longitudinal furrow absent; anterolateral portion of dorsal mandibular surface with two setae (often broken); interior seta more or less distinct, exterior seta short, indistinct; patches of two to four dorsomolar and ventromolar setae concealed in single rim on both mandibles (however, dorsomolar setae were absent on one of two left mandibles examined); stridulatory area with seven to ten transversal ridges; left mandible with four and right mandible with three prominent scissorial teeth; apical third of external mandibular margin with prominent obtuse or slightly pointed tubercle; molar lobes of both mandibles with sharp projections; posterior margin of right madibular calyx bilobed (in medial aspect), dorsal lobe about twice as large as ventral; calyx of left mandible flattened with convex posterior margin; brustiae with 5–7 and 10–13 setae on right and left mandible, respectively.

Maxilla (Figures 5D, E). Dorsal surface of cardo and labacoparia with 10–14 and 12–13 setae, respectively; ventral surface of cardo with 2–3 and 21–28 setae, respectively; stipes with around 21–31 slender hair-like setae dorsally and 2–3 long stout setae at external margin; stridulatory area composed of 6–8 well sclerotised spine-like stridulatory teeth organized in oblique raw; truncate process (blunt tubercle) present; ventral face of stipes with single prominent seta at proximal margin and transverse, prominent group of seven setae at base of maxillary palpi; galea and lacinia entirely fused forming mala, galeo-lacinial suture indistinct, entirely absent on ventral surface; galear portion of mala with single falcate uncus and 9–11 long hair-like setae in longitudinal rows; lacinial part of mala with one large and one small uncus and a minute conical seta at base of larger uncus; dorso-medial side with 16–20 very long hair-like setae; setae proximal to galear and lacinial unci generally shorter and stouter than other setae; ventral surface of mala with two longitudinal rows of 3–5 stout setae and basal transverse group of 3–4 hair-like setae; maxillary palps four–jointed, penultimate joint with two setae.

Hypopharyngeal scleroma (Figure 5D). Asymmetrical with strong protruding and pointed truncate process; tufts of tegumentary expansions (= phoba, *sensu* Böving 1936) present on left lateral lobe, but absent on central portion of hypopharyngeal scleroma (at base of truncate process); two additional tegumentary expansions below medio-lateral margin of hypopharyngeal scleroma; lateral lobes only feebly sclerotized, anterior margin of left lobe with 12 setae, anterior margin of right lobe with 6–9 setae.

Ligula (Figure 5D). Dorsal surface with group of approximately 15–20 long hair-like setae on each lateral margin; paramedial longitudinal row of 3–4 stout setae and proximal transverse row of 12–14 campaniform sensilla interrupted by central pair of conical setae; labial palpi two–jointed.

Thorax (Figures 5A, F; 6H). First thoracic sublobe densely setose, with approximately 12 transverse rows of setae; posterior margin of prothoracic sclerite with about 10

Figure 7. *Trichostetha curlei* sp. n.: Typical habitat on the southern slope of the Elandsberg range (Photo: R Perissinotto).

setae on dorsal and four setae on ventral surface; each sublobe of meso- and metathoracic segments with 3–6 rows of dorsal setae, anterior row(s) generally with shorter setae than posterior rows; respiratory plate of mesothoracic spiracle "C"-shaped, 0.4 × 0.25 mm (height × width) (Figure 7H); distance between lobes almost equal to maximal diameter of respiratory plate; respiratory plate with 15–20 holes across diameter; all pairs of legs subequal (Figure 5A, F); pretarsi cylindrical with 7–8 setae and minute pointed tip.

Abdomen (Figures 5A, 6G). Nine-segmented, densely setose; dorsi of abdominal segments I–VI with three sublobes, VII and VIII with only two; each sublobe bearing six to ten rows of setae; like in thorax, setae in anterior rows shorter than in posterior rows; abdominal spiracles more concealed than mesothoracic spiracle, distance between lobes of respiratory plate equal or shorter than half maximal diameter of respiratory plate; all spiracles subequal in size; abdominal spiracles on segment VI–VIII more circular than preceding ones; dorsum of last abdominal segment entirely covered with medium to long hair-like setae; hammate setae absent.

Raster (Figure 6G). Palidium monostichous (however few irregular pali scattered around main row and on ventral anal lobe), composed of two rows of approximately 15-19 short, spine-like pali; septula posteriorly open, about three times longer than wide; tegilla not separated from other groups of setae, entire venter of last abdominal segment covered with hair-like setae interspersed with few spine-like setae; ventral and dorsal anal lobes with numerous medium to long setae, transverse anal row of dense setae absent.

Discussion

Trichostetha curlei sp. n. represents the latest discovery within a group of montane relict species that have been described recently from the Cape region of South Africa. The high altitude habitat of the Elandsberg range (about 1500 m asl), where the species occurs, is characterized by quartzite fynbos, which comprises about 10% of the Fynbos Biome and is confined to the more arid areas of the Capensis Region (Figure 7). The vegetation unit is specifically Matjiesfontein Quarzite Fynbos (type FFq 3 of Mucina and Rutherford 2006) and includes mainly medium dense and tall shrubs with asteraceous, ericaceous, proteoid and restioid fynbos plants, but also some elements of the Succulent Karoo Biome (Figure 7) (Mucina and Rutherford 2006).

The species most closely related to *T. curlei* sp. n. are *T. dukei* and *T. hawequas*. *Trichostetha curlei* sp. n. differs from the first mainly by its sharply upturned anterior clypeal margin and from the second by its dark green background body colouration and the presence of extensive white markings on the pygidium. The two species also occupy habitats that are remarkably different to that of *T. curlei*, with *T. dukei* restricted to South Hex Sandstone Fynbos (FFs 8 of Mucina and Rutherford 2006) and *T. hawequas* found in Hawequas Sandstone Fynbos (FFs 10 of Mucina and Rutherford 2006) vegetation types. The three are, however, sufficiently different in terms of external morphology (e.g. small body size, variable extent of female brachyptery) and habitat/ecology (e.g. non-feeding adult) from the other *Trichostetha* species to possibly warrant inclusion into a distinct species group. A full revision is required in this regard, including molecular genetic analyses.

The genus *Trichostetha* is complex and includes a number of species and subspecies with as yet unresolved taxonomic status. The largest uncertainties regard the phylogenetic relationships and taxonomic position of the members currently constituting the *T. capensis* group. Holm and Marais (1988, 1992) synonymized a number of species and subspecies previously described in this group as junior or invalid names of *T. capensis*. Subsequent observations have shown however that at least two species and two subspecies warrant re-instatement. Antoine (2006) has already argued convincingly for the recognition of *T. fuscorubra* (Voët, 1779) as a separate species. A review of existing collections and new material gathered during the last 20 years has shown that *T. bicolor* Péringuey, 1907 should also be regarded as separate from *T. capensis*. The two species not only differ significantly in phenotypic characteristics, as described by Péringuey (1907), but also occupy different habitats and exhibit different ecological dynamics. Contrary to what was suggested by Holm and Marais (1988), the two neither occur sympatrically nor exhibit intermediate forms. *Trichostetha capensis capensis* is found in the Cape Peninsula area, and possibly further inland to the north, in typical Peninsula Sandstone Fynbos vegetation (type FFs 9 of Mucina and Rutherford 2006), where adults feed mainly on flowers of *Protea*, *Berzelia* and *Leucospermum* species. On the other hand, *T. bicolor* is restricted to a narrow coastal band between Saldanha and St Helena Bay, where vegetation is very short, of the Saldanha Granite Strandveld type (FS 2 of Mucina and Rutherford 2006). Here, adults feed predominantly on flowers of *Agathosma capensis* (Figure 8).

Figure 8. *Trichostetha bicolor* feeding on flowers of *Agathosma capensis* (Rutaceae) at Saldanha Bay, September 2004 (Photo: L Clennell).

At the extreme north of its distribution range, in the Cederberg, Piketberg and the Bokkeveldberge, *T. capensis capensis* is replaced by a distinct subspecies, *T. c. oweni*, as described by Allard (1992). The populations located to the east of the Cape Peninsula extend as far as the Kouga mountains of the Eastern Cape and exhibit characteristics broadly matching the description of *T. hottentotta* of Gory and Percheron (1833), with drastically reduced white maculation and lighter brick-red ground colouration. There are, however, complex variations over this typical form that require molecular analysis, in order to resolve the full taxonomy and phylogeny of the group. It is thus proposed here that a provisional solution may consist of recognizing the subspecies status of *T. c. hottentotta*, as suggested earlier by Allard (1992).

Trichostetha signata also exhibits some variability, with its southern populations often regarded as a separate subspecies or even distinct species. Recent work undertaken throughout its distribution range has now showed that indeed the population situated in the extreme south-western Cape, especially the Cape Peninsula, represents a valid subspecies with the characteristics originally described by Burmeister (1842) and here re-designated as *T. signata tibialis*. On the other hand, there is virtual certainty now that *T. alutacea*, earlier described by Allard (1992) as a proper species, separate from *T. signata*, is actually a darker, “oiled” variety of the latter. Extensive investigations within the type locality undertaken during the last decade have only revealed the existence of *T. capensis hottentotta*, *T. fascicularis fascicularis* and *T. signata* in the broader area of the Franschhoek Pass. Specimens of *T. signata* are often darkened by diffusion of lipids to the surface after death, particularly visible when fresh adults are pinned.

It is most likely that new undescribed species occur in the least explored mountain ranges, particularly of the Western Cape, as this seems to be the epicenter of the genus, from where radiation presumably occurred in the past. For instance, the specimen represented in Fig. 1175 (Plate 105) of Sakai and Nagai (1998) is certainly not *T. calciventris*, as erroneously reported in this book. The locality mentioned for the specimen is "Keeromberg", which is situated in the extreme western portion of the Langeberg mountain range of the WC. Although a recent search has failed to retrieve further specimens for analysis, it is possible that this may represent a species yet unknown to science, although very closely related to *T. dukei*.

Updated list and distribution of *Trichostetha* species and subspecies

T. albopicta Gory & Percheron, 1833; WC, EC
T. barbertonensis Holm & Marais, 1988; MP
T. bicolor Péringuey, 1907; WC
T. calciventris Stobbia, 1995; WC
T. capensis capensis (Linnaeus, 1767); WC, NC, EC
T. capensis hottentotta (Gory & Percheron, 1833); WC, EC
T. capensis oweni Allard, 1992; WC, NC
T. coetzeri Holm & Marais, 1988; NC
T. curlei Perissinotto, Šípek & Ball, sp. n.; WC
T. dukei Holm & Marais, 1988; WC
T. fascicularis fascicularis (Linnaeus, 1767); WC, NC, EC
T. fascicularis maraisi Stobbia, 1995; NC
T. fascicularis natalis Burmeister, 1842; EC
T. fascicularis prunipennis Burmeister, 1842; EC, FS, KZN, MP, LP, NW, BO
T. fuscorubra (Voët, 1779); WC, EC
T. hawequas Holm & Perissinotto, 2004; WC
T. mimetica Devecis, 1997; WC
T. potbergensis Holm & Perissinotto, 2004; WC
T. signata signata (Fabricius, 1775) (= *T. alutacea* Allard, 1991); WC, EC, NC
T. signata tibialis Burmeister, 1842; WC

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Diversity of *Manota* Williston (Diptera, Mycetophilidae) in Ulu Temburong National Park, Brunei

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Abstract

A total of 15 species of *Manota* Williston, 1896 are recorded from Brunei, based on the investigations in 2013-2014. Thirteen species are recorded from Ulu Temburong National Park and three species from the Universiti Brunei Darussalam Campus in Tungku. Six species are described as new to science: *Manota belalongensis* **sp. n.**, *M. kaspraki* **sp. n.**, *M. macrothrix* **sp. n.**, *M. megachaeta* **sp. n.** and *M. pileata* **sp. n.** from Ulu Temburong, and *M. ricina* **sp. n.** from Tungku. New records of the following species are given: *Manota bifida* Hippa & Papp, *M. bruneiensis* Hippa & Ševčík, *M. hyboloma* Hippa & Ševčík, *M. oligochaeta* Hippa, *M. pappi* Hippa, *M. perangulata* Hippa & Ševčík, *M. pollex* Hippa, *M. procera* Hippa and *M. simplex* Hippa.

Keywords

Insecta, Sciaroidea, Manotinae, fungus gnats, taxonomy, new species, Borneo, Belalong, Tungku, Oriental region

Introduction

Fungus gnats (Diptera: Sciaroidea) represent one of the most abundant and diverse groups of insects in forest habitats, in both temperate and tropical regions. Within Sciaroidea, the family Mycetophilidae belongs to the most species rich groups, with some 4500 described species worldwide and possibly the same number of species still awaiting description. The predominantly tropical subfamily Manotinae form a rather uniform and well-defined group that has been proved to be monophyletic in studies based on both morphological (Hippa et al. 2005) and molecular characters (Ševčík et al. 2013). Of the 4 genera included, only *Manota* Williston, 1896 is distributed worldwide with more than 200 described species (cf. Hippa and Kurina 2012, 2013; Hippa and Ševčík 2013) and the number of undescribed species is difficult to estimate because *Manota* is considered as an open-ended taxon (see Bickel 2009). The species inventory of *Manota* in the Oriental Region during the past 10 years has raised the number of species from one (Senior-White 1922) to 89 (for a review of investigations see Hippa and Ševčík 2010, 2013).

The specimens of *Manota* can be easily identifiable among other mycetophilids in collections due to their small size and characteristically reduced wing venation (Fig. 1). On the other hand, the species identification is rather difficult because it is based on the study of male terminalia under a relatively high magnification.

The mycetophilid fauna of Borneo, as well as of the entire Indomalayan Archipelago is still poorly known. Concerning Brunei, only several named species of Mycetophilidae (see Hippa and Ševčík 2010; Papp and Ševčík 2011; Ševčík and Hippa 2010) and four species from the closely related families Diadocidiidae and Keroplatidae (Papp and Ševčík 2005; Ševčík and Papp 2009; Ševčík 2012) have been reported up to the present.

In 2013, collaboration between Universiti Brunei Darussalam and the University of Ostrava was established, resulting in two field trips to Ulu Temburong National Park (February 2013 and January 2014). This contribution is the first from a series of ecological and taxonomic papers devoted to the study of this well preserved and highly diverse lowland rainforest in Brunei. Its aim is to describe 5 new species of *Manota* from Ulu Temburong National Park, to record 9 additional species and discuss the potential species richness in this area. The opportunity is also taken to describe a new species from the university campus near the capital of Brunei, Bandar Seri Begawan, outside the Temburong District.

Material and methods

Most of the material examined was collected with Malaise traps. A total of six Malaise traps (Fig. 2) were operated in the area in 5–17.ii.2013 and 7–18.i.2014. Additional samples were obtained by sweeping the undergrowth of the rainforest with an entomological net.

The material was collected into and preserved in ethanol. The abdomen or only the apical part of the abdomen was detached from the specimen and macerated in warm concentrated potassium hydroxide (KOH). We also detached the hypopygium beyond segment 8. After washing in water and dehydration in stages of increasing concentrations of alcohol we mounted them in 'Euparal' between two pieces of cover slip, which allows the specimen to be studied from both sides under a compound microscope. These preparations are now attached to normal microscope slides by two strips of adhesive tape across their edges and are easily detached when needed. Other parts of the body were not macerated, but after dehydration we mounted the whole flies as they were in 'Euparal', lying on their side. The descriptions of the hypopygium should only be taken as rough guidelines to interpret the drawings. The morphological terminology follows our earlier papers (Hippa and Ševčík 2010, 2013). The terminology is also indicated in Figs 3–4. Illustrations were made with the aid of a drawing tube attached to a Leitz Diaplan compound microscope. Wing length is given measured from wing base (and from humeral cross vein) to wing tip.

The material is deposited in the following collections: Universiti Brunei Darussalam, Brunei (UBDC), University of Ostrava, Czech Republic (UOSC), and Natural History Museum, London, Great Britain (BMNH).

Study area

The study area is located at the Kuala Belalong Field Studies Centre (KBFSC), a research field station of the Universiti Brunei Darussalam. It is situated in the Ulu Temburong National Park; geographic coordinates are 4°33'N and 115°10'E, elevations in the KBFSC surroundings range from 60 (the station) to ca 300 m asl. The topography is very rugged, with narrow ridges and steep slopes. The site represents pristine lowland mixed dipterocarp forest, only slightly touched by human activities (Cranbrook and Edwards 1994; Hédl et al. 2009). The climate is equatorial with average temperatures around 30 °C. There is no dry season and precipitation reaches 4 000 mm. Relative air humidity in the forest exceeds 95% (Dykes 2000). For a review of biological investigations carried out at the station see Cranbrook and Edwards (1994).

Results

Descriptions of the new species

Manota belalongensis **sp. n.**
http://zoobank.org/8BB86E68-1183-41AD-8BFA-3F9BB23437DB
Fig. 3

Description. Male. Colour. Head dark brown, face and clypeus paler brown. Antenna brown, scapus and pedicellus paler brown. Mouthparts yellowish. Thorax brown, preepisternum 2 ventrally and episternum 3 paler yellowish. Legs yellowish, apex of coxa 2 and 3, trochanter 3 and basal third of femur 3 infuscated. Wing brownish, halter pale brown with blackish knob. Abdomen brown, sternites paler than tergites. All setosity pale, yellowish or brownish. **Head.** Antennal flagellomere 4, Fig. 3A. Palpomere 3 of maxillary palpus with apico-mesial thumb-like extension, with 4 apically expanded and curved sensilla; palpomere 4 with parasegment; palpomere 5 is 1.5 times as long as palpomere 4. Number of strong postocular setae 10. **Thorax.** Anepisternum setose, with 56 setae; anterior basalare setose, with 8 setae; preepisternum 2 non-setose; laterotergite setose, with 37 setae; episternum 3 setose, with 6 setae. **Legs.** Mid and hind tibial organs absent. **Wing.** R_1 meeting C well on the basal half of the costal margin; the sclerotized part of M_2 extending near to the level of the tip of R_1; wing length 1.4 (1.5) mm. **Hypopygium.** Fig. 3B–E: Sternite 9 laterally fused with gonocoxa, posterior margin extending well over the middle of gonocoxa, near to the base of gonostylus, anterior margin incised, the setae similar to ventral setae of the gonocoxa. Ventral mesial margin of gonocoxa short, simple, the ventral setae of gonocoxa unmodified. Parastylar lobe subtriangular, with 2 setae at postero-mesial margin. Paraapodemal lobe not identifiable. Dorsal mesial margin of gonocoxa simple, posteriorly slightly sigmoid in shape, without megasetae or other stronger setae. Gonocoxa without a postero-lateral lobe. The dorsal setae of gonocoxa unmodified, similar to those on the ventral side. One juxtagonostylar seta present; it is a curved acute megaseta arising from oval basal body which is ca. one third of the length of the seta. Anteriorly from the juxtagonostylar megaseta there is a plate-like lobe bearing a row of 7 blunted rather thin megasetae. Gonostylus small, elongate, apically bilobed, the ventral side setose, dorsal side non-setose, the apical lobes with a few long setae which are not much stronger than the other gonostylar setae. Aedeagus elongate subtriangular, with weak lateral shoulders, the apex curved ventrad. Hypoproct large, extending posteriorly to the apices of gonostyli, number of its ventral setae (sternite 10) ca. 30 on each half, these setae widely distributed over the ventral surface. Cerci mesially separate.

Female unknown.

Discussion. *Manota belalongensis* belongs to a large group, world-wide in distribution, in which male sternite 9 is long and laterally fused with the gonocoxa. In the key to Oriental and Palaearctic *Manota* (Hippa 2011) the species runs to *M. heptacantha* Hippa, 2006 from Peninsular Malaysia and Thailand and is also in most respect very similar to it (cf. Hippa 2006: Fig. 6E, F). It differs by having the gonostylus apically bilobed (simple in *M. heptacantha*), by having only two setae on the parastylar lobe (several in *M. heptacantha*) and by having the postero-mesial angle (apex) of the parastylar lobe abruptly narrowed (evenly narrowing in *M. heptacantha*).

Etymology. The species is named after the river Belalong at which the type locality is situated.

Types. *Holotype*. Male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 4°32'50"N, 115°09'28"E, 8–18.i.2014, primary lowland rainforest, Malaise trap 4, J. Ševčík & D. Kaspřák leg. (in UBDC).

***Manota kaspraki* sp. n.**
http://zoobank.org/E0F48B63-4F4D-4A59-A0F0-05EAB6CF8286
Figs 1, 4

Description. Male. Colour. Head pale brown, face and clypeus pale yellowish. Antenna brown, scapus and pedicellus paler. Mouthparts yellowish. Thorax pale brown, preepisternum 2 pale yellowish. Legs yellowish. Wing brownish, halter brownish with blackish knob. Abdomen pale brown, sternites paler than tergites. All setosity pale, yellowish or brownish. **Head.** Antennal flagellomere 4, Fig. 4A. Palpomere 3 of maxillary palpus with apicomesial thumb-like extension, with 3 apically expanded and curved sensilla; palpomere 4 with parasegment; palpomere 5 ca. 1.4 times longer than palpomere 4. Number of strong postocular setae 10–11. **Thorax.** Anepisternum setose, with 14–31 setae; anterior basalare setose, with 6–10 setae; preepisternum 2 setose, with 8–11 setae, laterotergite non-setose; episternum 3 setose, with 2–3 setae. **Legs.** Mid and hind tibial organs absent. **Wing.** R_1 meeting C well on the basal half of the costal margin; the sclerotized part of M_2 extending near to the level of the tip of R_1; wing length 1.3–1.5 (1.1–1.4) mm. **Hypopygium.** Fig. 4B–E: Sternite 9 about one third of ventral length of gonocoxa, with sharply delimited convex sides, posterior margin transverse with a wide submembranous notch, anterior margin shallowly incised, the setae similar to adjacent ventral setae of gonocoxa. Ventral mesial margin of gonocoxa simple, sigmoid. Parastylar lobe large, almost semicircular, with 5–7 setae scattered on the ventral surface. Paraapodemal lobe oval, at least partly covered by gonocoxa and parastylar lobe. The dorsal mesial margin of gonocoxa simple, convex, contiguous with the simple oblique posterior margin; posteriorly at the dorsal mesial margin there is a finger-like lobe apically bearing a stronger and a weaker seta; this lobe is very similar to the juxtagonostylar setae in appearance. Two juxtagonostylar setae, one an unmodified acute megaseta, the other a usual seta, both arising from a common basal body which is about one half of the length of the setae. Gonostylus elongate, slightly angled, with sub-basal lateral rounded lobe, the setosity confined to the lateral lobe and the apical part, some of the setae shorter but strong (spine-like megasetae). Aedeagus short, with strong lateral shoulders, the apex straight, not curved ventrad; on the ventral side of aedeagus (Fig. 4C–E) there is a membranous lobe, which may belong to aedeagus. Hypoproct posteriorly extending near to the apex of gonostylus, unusually narrow; ventrally with one seta on each side (sternite 10), postero-dorsally with two strong setae on each side, the microtrichia unusually long. Cerci mesially fused.

Female unknown.

Discussion. *Manota kaspraki* is not especially similar to any other described *Manota*. In the key to Oriental and Palaearctic *Manota* it runs to couplet 38 by the following characters: anepisternum setose, preepisternum 2 setose, laterotergite non-setose, anterior basalare setose, gonostylus unilobed and straight (not geniculate). Couplet 38 leads to a large number of species (18). The acute spine-like megasetae apically on the curiously hump-sided gonostylus and the narrow long microtrichose hypoproct distinguish *M. kaspraki* from any hitherto described *Manota*. The inflated paraapodemal

Figure 1. Habitus of *Manota kaspraki* sp. n. (Photo by D. Kasprák).

Figure 2. Malaise trap in the rainforest around Kuala Belalong Field Studies Centre (Photo by J. Ševčík).

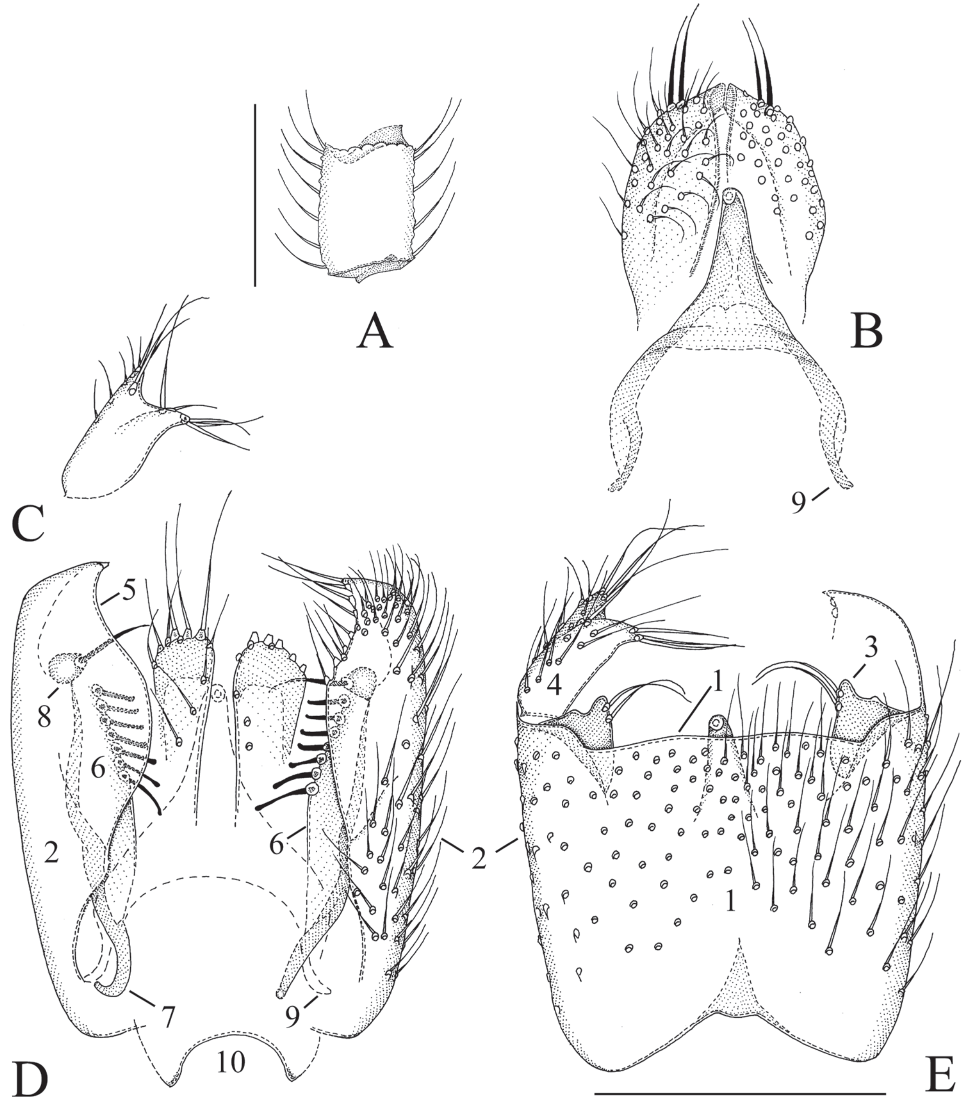

Figure 3. *Manota belalongensis* sp. n. (holotype). **A** Antennal flagellomere 4, lateral view **B** Aedeagus and hypoproct. ventral view **C** Gonostylus, dorsal view **D** Hypopygium, dorsal view **E** Hypopygium, ventral view. Scale 0.1 mm. 1 = sternite 9, 2 = gonocoxa, 3 = parastylar lobe, 4 = gonostylus, 5 = dorsal mesial margin of gonocoxa, 6 = plate-like lobe ventrally from the dorsal mesial margin of gonocoxa, 7 = gonocoxal apodeme, 8 = juxtagonostylar seta, 9 = aedeagal apodeme, 10 = tergite 9.

lobe is reminiscent of e.g. *Manota vesicaria* Hippa, 2009 from Thailand, but otherwise the species are not much similar.

Etymology. The species is named after Mr. David Kasprák, a PhD student at the University of Ostrava, who participated in both the expeditions to Brunei, helped with the installation of Malaise traps and with other field activities.

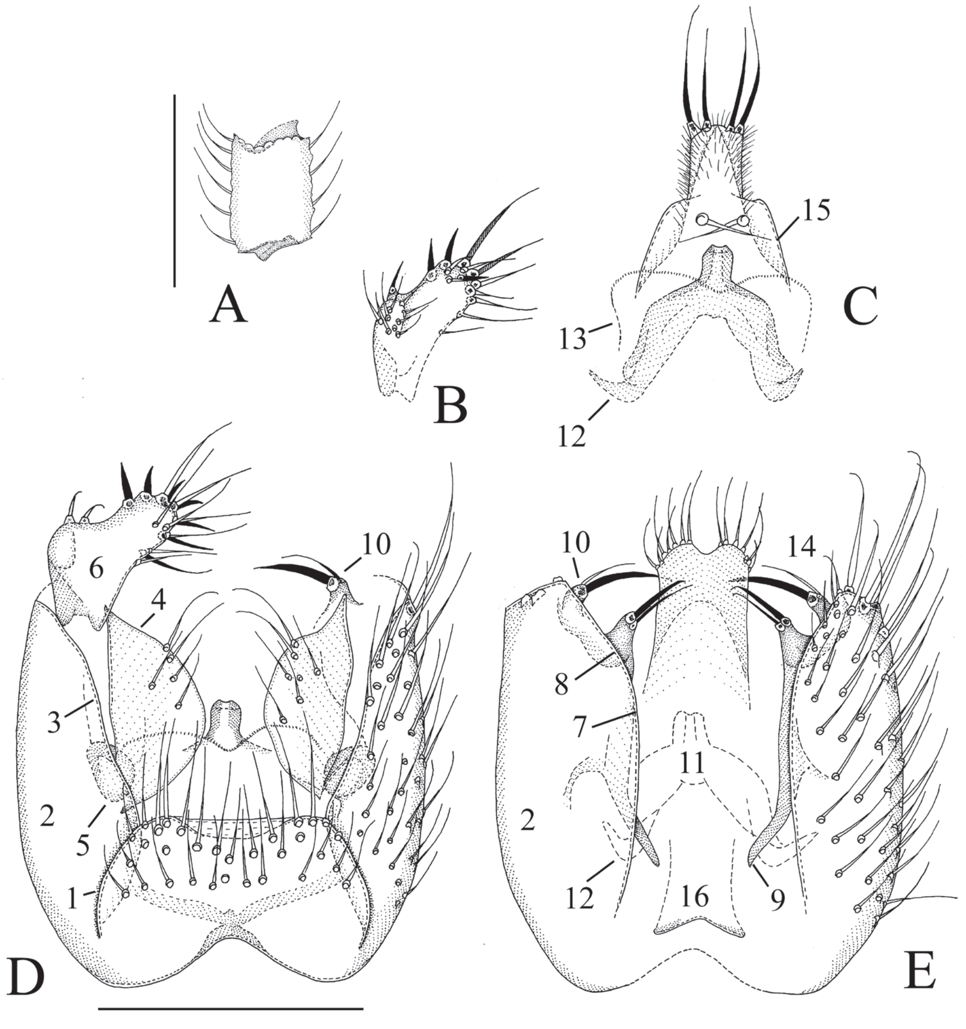

Figure 4. *Manota kaspraki* sp. n. (holotype). **A** Antennal flagellomere 4, lateral view **B** Gonostylus, dorsal view **C** Aedeagus and hypoproct, ventral view **D** Hypopygium, ventral view **E** Hypopygium, dorsal view. Scale 0.1 mm. 1 = sternite 9, 2 = gonocoxa, 3 = ventral mesial margin of gonocoxa, 4 = parastylar lobe, 5 = paraapodemal lobe, 6 = gonostylus, 7 = dorsal mesial margin of gonocoxa, 8 = lobe at dorsal mesial/apical margin of gonocoxa, 9 = gonocoxal apodeme, 10 = juxtagonostylar setae, 11 = aedeagus, 12 = aedeagal apodeme, 13 = membranous lobe, 14 = cerci, 15 = ventral seta of hypoproct (sternite 10), 16 = tergite 9.

Types. *Holotype*. Male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 4°32'50"N 115°09'28"E, 7–18.i.2014, primary lowland rainforest, Malaise trap 1 (night), D. Kaspřák & J. Ševčík leg. (in UBDC).

Paratypes. 2 males with same data as holotype except Malaise trap 1 (ODP) (in UBDC and UOSC); 2 males, the same data except sweeping February 2013 (in BMNH).

Manota macrothrix **sp. n.**

http://zoobank.org/A5341B31-FF64-44FA-B173-29FD0A157C2B

Fig. 5

Description. Male. Colour. Head brown, face and clypeus paler brown. Antenna brown. Mouthparts yellowish. Thorax pale brown, preepisternum 2 ventrally pale yellowish. Legs yellowish, femur 3 with a very slight indication of infuscation. Wing brownish, halter pale brown with blackish knob. Abdomen pale brown, sternites paler than tergites. All setosity pale, yellowish or brownish. **Head.** Antennal flagellomere 4, Fig. 5A. Palpomere 3 of maxillary palpus with apico-mesial thumb-like extension, with 5 apically expanded and curved sensilla; palpomere 4 with parasegment; palpomere 5 is 1.3 times as long as palpomere 4. Number of strong postocular setae 10–11. **Thorax.** Anepisternum setose, with 34–55 setae; anterior basalare non-setose; preepisternum 2 setose, with 15 setae, laterotergite non-setose; episternum 3 setose, with ca. 9 setae. **Legs.** Mid and hind tibial organs absent. **Wing.** R_1 meeting C well on the basal half of the costal margin; the sclerotized part of M_2 extending near to the level of the tip of R_1; wing length 1.4–1.6 (1.5–1.7) mm. **Hypopygium.** Fig. 5B–E: Sternite 9 about one half of ventral length of gonocoxa, with sharply delimited convex sides, posterior margin not well seen in the holotype because the dorsal membranous area extruded, anterior margin deeply incised, the setae similar to adjacent ventral setae of gonocoxa. Ventral mesial margin of gonocoxa simple, sigmoid. Parastylar lobe oblique, subtriangular, with 3 setae antero-mesially (at apex). Paraapodemal lobe well exposed in ventral view. The dorsal mesial margin of gonocoxa simple, convex, posteriorly with a group of tightly placed setae. Gonocoxa posterolaterally with an apically setose apophysis/lobe. Two juxtagonostylar setae, both long apically curved megasetae, both arising from a common basal body, about one third of the length of megasetae. Gonostylus elongate and slightly curved, with moderately long setosity ventrally and dorsally, without megasetae or other setae deviating from the general setosity. Aedeagus short subtriangular, with distinct lateral shoulders, the apex curved ventrad. Hypoproct posteriorly extending to level of middle of gonostylus, the ventral part divided into two elongate oval lobes (sternite 10) covered by ca 30 very long setae on each half, postero-dorsally with a few both fine and strong setae. Cerci mesially separate.

Female unknown.

Discussion. *Manota macrothrix* belongs to a large group of species, common in the Oriental region, all of which have a well-developed apico-mesial thumb-like extension on palpomere 3, a setose anepisternum and preepisternum 2, a non-setose anterior basalare and laterotergite, a short vein R_1, laterally free tergite 9, an oblique sickle-shaped or subtriangular parastylar lobe, well developed paraapodemal lobe, an apically setose apophysis at the apico-dorsal margin of the gonocoxa, two juxtagonostylar megasetae arising from a common basal body and a rather unmodified elongate gonostylus. Within this group *M. macrothrix* is similar to *M. dolichothrix* Hippa & Ševčík, 2010 from Sabah by having extremely long setae ventrally on the hypoproct (on sternite 10) but differs in having these setae widely scattered on each half of the

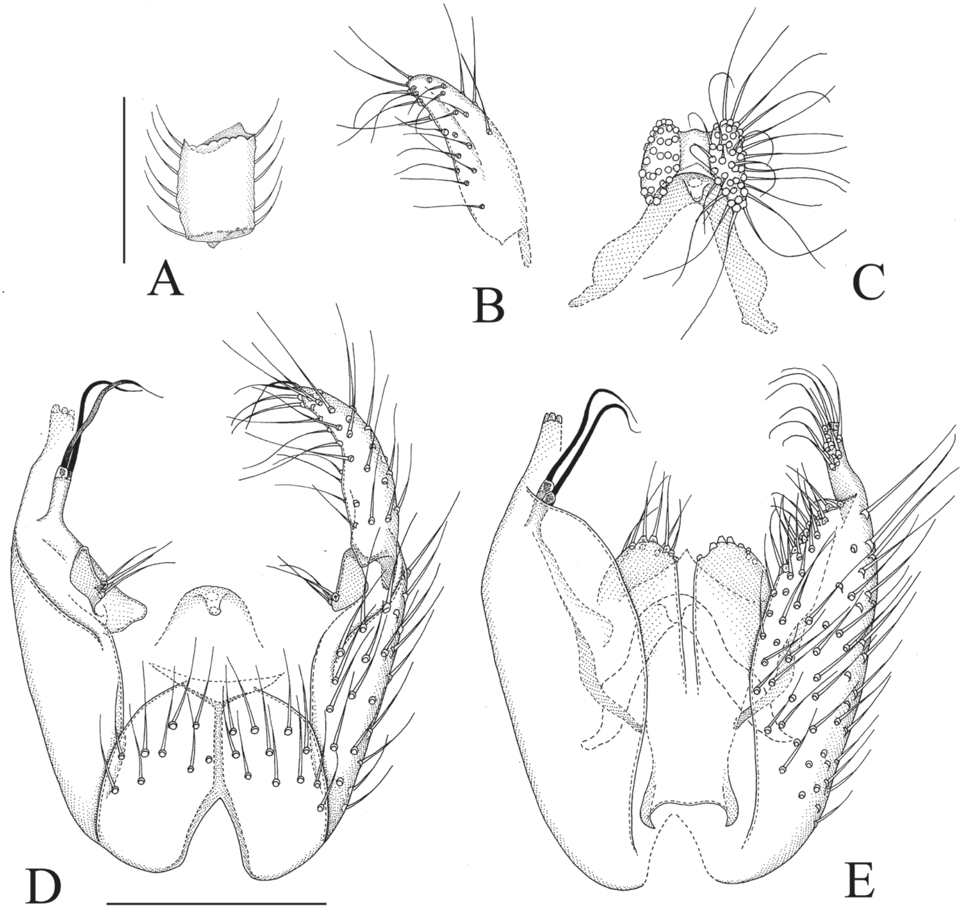

Figure 5. *Manota macrothrix* sp. n. (holotype). **A** Antennal flagellomere 4, lateral view **B** Gonostylus, dorsal view **C** Aedeagus and hypoproct, ventral view **D** Hypopygium, ventral view **E** Hypopygium, dorsal view. Scale 0.1 mm.

hypoproct, while they are in a single row on each half in *M. dolichothrix*. Further, in *M. macrothrix* the subapical setae of gonostylus are shorter, less than twice longer than the medial width of gonostylus, while in *M. dolichothrix* they are almost three times as long as the width of gonostylus. There are many minor differences between the two species (Fig. 5B–E, Hippa and Ševčík 2010: Fig. 6B–C).

Etymology. The name is a Latinized Greek noun, *macrothrix*, long-hair, referring to the very long setae on the hypoproct.

Types. *Holotype*. Male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 4°32'50"N 115°09'28"E, 7–17.i.2014, primary lowland rainforest, Malaise trap 2, J. Ševčík & D. Kaspřák leg. (in UBDC).

Paratype. 1 male, Brunei, Ulu Temburong, 14.ii – 9.iii 1982, Malaise trap, M. C. Day leg. (in BMNH).

***Manota megachaeta* sp. n.**

http://zoobank.org/661EA393-5728-4952-84BC-BCBCB50061CB
Fig. 6

Description. Male. Colour. Head brown, face and clypeus paler brown. Antenna brown, scapus and pedicellus paler brown. Mouthparts yellowish. Thorax pale brown, preepisternum 2 ventrally paler yellowish. Legs yellowish. Wing yellowish brown, halter pale brown with blackish knob. Abdomen pale brown, sternites paler than tergites. All setosity pale, yellowish or brownish. **Head.** Antennal flagellomere 4, Fig. 6A. Palpomere 3 of maxillary palpus with apicomesial thumb-like extension, with 5 apically expanded and curved sensilla; palpomere 4 with parasegment; palpomere 5 is 1.3 times as long as palpomere 4. Number of strong postocular setae ca 9. **Thorax.** Anepisternum setose, with 33 setae; anterior basalare non-setose; preepisternum 2 setose, with 14 setae, laterotergite non-setose; episternum 3 setose, with ca. 11 setae. **Legs.** Mid and hind tibial organs absent. **Wing.** R_1 meeting C well on the basal half of the costal margin; the sclerotized part of M_2 extending near to the level of the tip of R_1; wing length 1.4 (1.5) mm. **Hypopygium.** Fig. 6B–E: Sternite 9 about one half of ventral length of gonocoxa, with sharply delimited convex sides, posterior margin convex, anterior margin deeply incised, the setae posteriorly stronger than anteriorly. Ventral mesial margin of gonocoxa simple, concave. Parastylar lobe oblique, subtriangular, with 3 setae anteriorly (at apex). Paraapodemal lobe well exposed in ventral view. The dorsal mesial margin of gonocoxa simple, convex, postero-mesially with a weak setose lobe; posterior margin simple, at posterior margin on a more ventral level with a finger-like lobe bearing two apical and one sub-basal acute curved megasetae. Generally the dorsal setae of gonocoxa similar to the ventral ones. Two juxtagonostylar setae, both long curved acute megasetae arising from a common low inconspicuous basal body. Gonostylus oval, with moderately long setosity ventrally, the dorsal side non-setose except for a transverse row of megasetae on apical half, the megasetae acute and increasing in length towards the mesial margin. Aedeagus short subtriangular, with distinct lateral shoulders, the apex curved ventrad; in Fig. 6C the medially visible part is vas deferens. Hypoproct posteriorly extending to level of base of gonostylus, the ventral part divided into two elongate lobes (sternite 10) with 4 setae each, postero-dorsally with a few both fine and strong setae. Cerci mesially separate.

Female unknown.

Discussion. By the following characters *Manota megachaeta* runs to couplet 65 in the key to Oriental and Palaearctic *Manota* (Hippa 2011): anepisternum setose, preepisternum 2 setose, laterotergite non-setose, anterior basalare non-setose, juxtagonostylar setae/megasetae simple and not greatly expanded, the dorsal posterior margin of gonocoxa with a cylindrical, not flat, setigerous lobe. This couplet leads to *M. anceps* Hippa & Ševčík, 2010, *M. duplex* Hippa, 2006, *M. perpusilla* Hippa, 2006, *M. vesicaria* Hippa, 2009, *M. pellii* Hippa, 2008 and *M. hexacatha* Hippa & Ševčík, 2010. However, *M. megachaeta* is not especially similar to any of them and is easily distinguished by the subapical transverse row of unusually strong megasetae dorsally on the gonostylus.

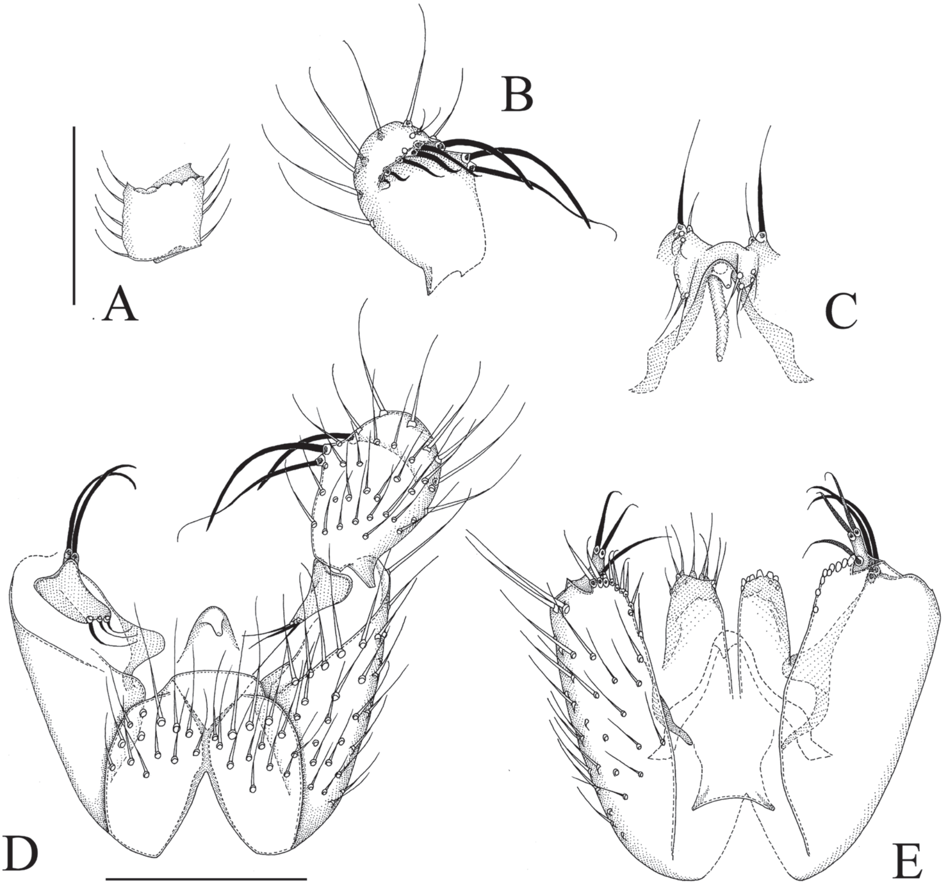

Figure 6. *Manota megachaeta* sp. n. (holotype). **A** Antennal flagellomere 4, lateral view **B** Gonostylus, dorsal view **C** Aedeagus and hypoproct, ventral view **D** Hypopygium, ventral view **E** Hypopygium, dorsal view. Scale 0.1 mm.

Etymology. The name is a Latinized Greek noun, *megachaeta*, large seta, referring to the unusually long megasetae on the gonostylus.

Types. *Holotype*. Male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 4°32'50"N, 115°09'28"E, 7–18.i.2014, primary lowland rainforest, Malaise trap 1 (DOP), J. Ševčík leg. (in UBDC).

Manota pileata sp. n.

http://zoobank.org/B00859B6-7712-4083-9297-E617CBABA8F7
Fig. 7

Description. Male. Colour. Head brown, face and clypeus paler brown. Antenna brown. Mouthparts yellowish. Thorax brown, preepisternum 2 and episternum 3 ventrally paler yellowish. Legs yellowish, apical fourth of femur 3 infuscated. Wing brownish, halter pale brownish with blackish knob. Abdomen brown, sternites paler than tergites. All setosity pale, yellowish or brownish. **Head.** Antennal flagellomere 4, Fig. 7A. Palpomere 3 of maxillary palpus with apico-mesial thumb-like extension, with 4 apically expanded and curved sensilla; palpomere 4 with parasegment; palpomere 5 is 1.7 times as long as palpomere 4. Number of strong postocular setae 11. **Thorax.** Anepisternum setose, with 33 setae; anterior basalare setose, with 12 setae; preepisternum 2 setose, with ca. 17 setae, laterotergite non-setose; episternum 3 setose, with ca. 12 setae. **Legs.** Mid tibial organ absent; hind tibial organ present. **Wing.** R_1 meeting C well on the basal half of the costal margin; the sclerotized part of M_2 extending near to the level of the tip of R_1; wing length 1.5 (1.6) mm. **Hypopygium.** Fig. 7B–D: Sternite 9 about one half of ventral length of gonocoxa, with sharply delimited convex sides, posterior margin with narrow deep cleft, anterior margin deeply incised, the setae similar to adjacent ventral setae of gonocoxa. Ventral mesial margin of gonocoxa angled. Parastylar lobe large, elongate oval, oblique, with 4 setae at mesial margin. Paraapodemal lobe not identified; at the place where a paraapodemal lobe is usually visible there is a plate-like lobe with three megasetae. The dorsal mesial margin of gonocoxa simple, convex, posteriorly forming a weak lobe with marginal and ventral setae; posterior margin of gonocoxa transverse, simple. The dorsal setae of gonocoxa similar to ventral ones. Two juxtagonostylar setae, both long curved megasetae, the dorsal one stronger than the ventral one, both arising from a common basal body, about one half of the length of the stronger megaseta. Gonostylus elongate oval, with moderately long setosity ventrally and dorsally, fewer and partly weaker setae ventrally, the apico-mesial setae longer than the others, at the middle of mesial margin a few setae which are thick, rather short and which differ from the other setosity. Aedeagus short subtriangular, with distinct lateral shoulders, the apex curved ventrad. Hypoproct posteriorly extending to level of middle of gonostylus, the ventral part (sternite 10) posteriorly with non-setose lobe which have a pair of small oval processes anteriorly bearing three setae each. These processes partly surrounding the apex of aedeagus. Postero-dorsal part of hypoproct with a few both fine and strong setae. Cerci mesially separate.

Female unknown.

Discussion. In the key to Oriental and Palaearctic *Manota*, *M. pileata* runs through couplet 45 to couplet 50 including the Eastern-Palaearctic *M. indahae* Hippa & Kjaerandsen, 2010 by the following characters: anepisternum setose, preepisternum 2 setose, laterotergite non-setose, gonostylus one-lobed, parastylar lobe present and cerci medially separate, gonostylus without blunt-ended megasetae on apical half, gonostylus without comb-like row of five setae subbasally at the ventral mesial margin, aedeagus apically narrow, without ear-like apico-lateral lobes, parastylar lobe in anterior–posterior direction short, at most twice as long as broad, aedeagus apically symmetrical, the setae medio-dorsally on gonostylus fine, not deviating from the other gonostylar setosity and the dorsal mesial margin of gonocoxa without a thumb-like lobe posteriorly. The two species are not very similar: *M. pileata* is distinguished from *M. indahae* e.g. by the following characters: parastylar lobe has only 4 setae (numerous in *M. indahae*), dorsally

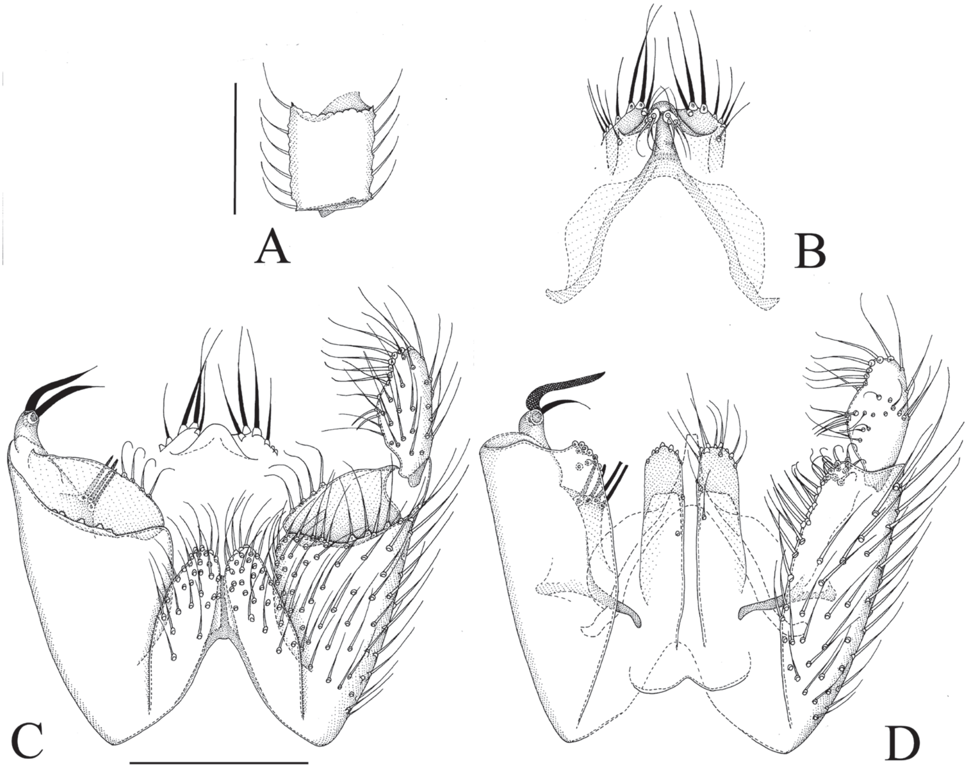

Figure 7. *Manota pileata* sp. n. **A** Antennal flagellomere 4, lateral view **B** Aedeagus and hypoproct, ventral view **C** Hypopygium, ventral view **D** Hypopygium, dorsal view. Scale 0.1 mm.

from the parastylar lobe there is a plate-like lobe bearing three megasetae (no such lobe), medio-ventrally on the hypoproct there is a rounded lobe (no lobe), and posterior margin of sternite 9 with a cleft (without). Even if the outline of the posterior part of aedeagus is symmetrical it is seen that there is some asymmetry inside (Fig. 7B).

Etymology. The name is a Latin adjective, *pileatus*, *-a*, *-um*, capped, referring to the cap- or hood-like lobes enclosing the apex of aedeagus.

Types. *Holotype*. Male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 4°32'50"N, 115°09'28"E, 7–17.i.2014, primary lowland rainforest, Malaise trap 2, Ševčík & Kaspřák leg. (in UBDC).

Manota ricina sp. n.

http://zoobank.org/D4232D67-2085-47D1-895B-E25C95CCB2EB
Fig. 8

Description. Male. Colour. Head brown, face and clypeus paler brown. Antenna brown. Mouthparts yellowish. Thorax brown, preepisternum 2 pale yellowish. Legs yellowish. Wing brownish, halter brownish with blackish knob. Abdomen brown, sternites paler than tergites. All setosity pale, yellowish or brownish. **Head.** Antennal flagellomere 4, Fig. 8A. Palpomere 3 of maxillary palpus with apico-mesial thumb-like extension, with 5 apically expanded and curved sensilla; palpomere 4 with parasegment; palpomere 5 is 1.4 times as long as palpomere 4. Number of strong postocular setae 9. **Thorax.** Anepisternum setose, with 50 setae; anterior basalare non-setose; preepisternum 2 setose, with 30 setae, laterotergite non-setose; episternum 3 setose, with ca. 18 setae. **Legs.** Mid and hind tibial organs absent. **Wing.** R_1 meeting C well on the basal half of the costal margin; the sclerotized part of M_2 extending near to the level of the tip of R_1; wing length 1.5 (1.6) mm. **Hypopygium.** Fig. 8B–E: Sternite 9 about half of ventral length of gonocoxa, with sharply delimited convex sides which are contiguous with the convex posterior margin, anterior margin deeply incised, the setae at posterior margin very long and strong, on other parts similar to adjacent ventral setae of gonocoxa. Ventral mesial margin of gonocoxa simple, concave. Parastylar lobe oblique, subtriangular, with 3 setae antero-mesially (at apex). Paraapodemal lobe well exposed in ventral view. The dorsal mesial margin of gonocoxa simple, sigmoid, posteriorly with a row of prominent closely placed setae which become broader and flattened towards the posterior end of the row; posteriorly from the row of setae there is a short finger-like lobe with one apical seta. The general dorsal setosity of gonocoxa similar to the ventral one. Two juxtagonostylar setae present, both long curved megasetae arising from a short common basal body, about one fifth of the length of megasetae. Gonostylus elongate subquadrangular, with moderately long setosity ventrally, dorsally non-setose except for a few very strong setae at apical margin on a slightly tuberculate area. Aedeagus subtriangular, with small lateral shoulders, the apex curved ventrad. Hypoproct posteriorly extending to level of basal third of gonostylus, the ventral part with a pair of elongate lobes (sternite 10) bearing ca. 15 scattered setae each, the posterodorsal part with one strong and a couple of weaker setae on each half. Cerci mesially separate.

Female unknown.

Discussion. *Manota ricina* resembles *M. curvata* Hippa, 2006 from Peninsular Malaysia and Sumatra in many respects and follows it in the key to Oriental and Palaearctic *Manota* to couplet 70 by the following characters: anepisternum setose, preepisternum 2 setose, laterotergite non-setose, juxtagonostylar megasetae simple, not expanded, gonocoxa with a conspicuous apicodorsal lobe which is fully exposed, this lobe is flattened, not cylindrical. *M. ricina* is similar to *M. curvata* by having the posteriormost setae at the margin of the above-mentioned lobe flat, blade-like, but the shape of the gonostylus is different: in *M. ricina* it is about twice longer than broad, rather straight, in *M. curvata* it is more than 4 times longer than broad and curved. We suspect that the small finger-like lobe posteriormost in the row of setae at the mesial margin of the gonocoxa is actually the lobe mentioned above and is not flattened and in this respect the key possibly needs to be revised. *M. ricina* also differs from *M. curvata* by the chaetotaxy of the gonostylus, the strong apicodorsal setae being lacking in the latter.

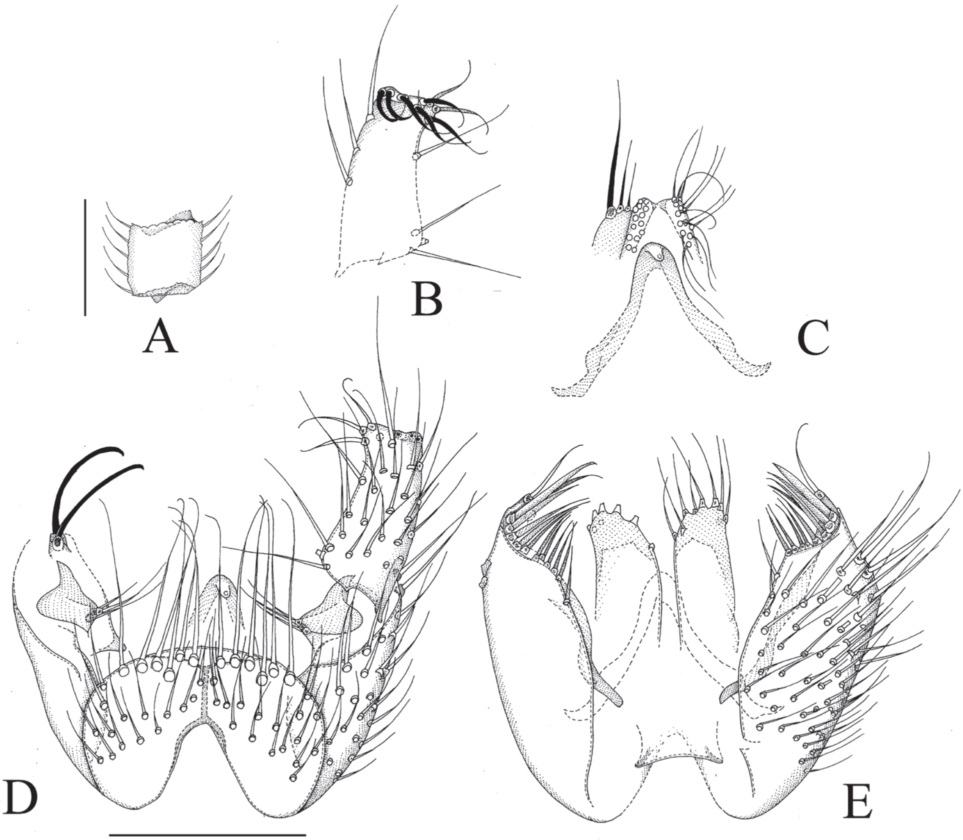

Figure 8. *Manota ricina* sp. n. (holotype). **A** Antennal flagellomere 4, lateral view. **B** Gonostylus, dorsal view **C** Aedeagus and hypoproct, ventral view **D** Hypopygium, ventral view **E** Hypopygium, dorsal view. Scale 0.1 mm.

Etymology. The name is a Latin adjective, *ricinus, -a, -um*, veiled, referring to the veil-like fringe of setae posteriorly on the sternite 9.

Types. *Holotype*. Male, Brunei, Tungku, UBD Campus, nr KBFSC Headquarters, 4°58'35"N, 114°53'26"E, 19–22.i.2014, secondary forest, Malaise trap, J. Ševčík & D. Kaspřák leg. (in UBDC).

Records of other *Manota* species from Brunei

Manota bifida Hippa & Papp, 2007

Material studied. 10 males, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 5–17.ii.2013, primary lowland rainforest, Malaise trap 3b, J. Ševčík leg. (5 in UBDC, 5 in UOSC); 5 males with the same data except 7–17.i.2014, Malaise trap

2, J. Ševčík & D. Kaspřák leg. (3 in UBDC, 2 in UOSC); 1 male with the same data except 7–18.i.2014, Malaise traps in gaps, I. H. Tuf leg. (in UOSC).

Remarks. The species was earlier known from Thailand (Hippa and Papp 2007) and Brunei (Hippa and Ševčík 2010).

Manota bruneiensis Hippa & Ševčík, 2010

Material studied. 1 male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 5–17.ii.2013, primary lowland rainforest, Malaise trap 1, J. Ševčík leg. (in UBDC); 1 male with the same data except 7–17.i.2014, Malaise trap 2, J. Ševčík & D. Kaspřák leg. (in UOSC).

Remarks. The species was earlier known only by the type material from Brunei (Hippa and Ševčík 2010).

Manota hyboloma Hippa & Ševčík, 2010

Material studied. 1 male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, primary lowland rainforest, sweeping, February 2013, J. Ševčík leg. (in UBDC).

Remarks. The species was earlier known only by the type material from Brunei (Hippa and Ševčík 2010).

Manota oligochaeta Hippa, 2006

Material studied. 1 male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 7–17.i.2014, primary lowland rainforest, Malaise trap 2, J. Ševčík & D. Kaspřák leg. (in UOSC); 1 male, Brunei, Tungku, UBD Campus, nr KBFSC Headquarters, 19–22.i.2014, secondary forest, Malaise trap, J. Ševčík & D. Kaspřák leg. (in UBDC).

Remarks. The species was earlier known from Peninsular Malaysia (Hippa 2006, 2008) and Thailand (Hippa 2009, 2011; Hippa and Papp 2007).

Manota pappi Hippa, 2006

Material studied. 1 male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 7–17.i.2014, primary lowland rainforest, Malaise trap 3, J. Ševčík & D. Kaspřák leg. (in UBDC); 1 male with the same data except 8–18.i.2014, Malaise trap 4 (in UOSC); 1 male with the same data except 15.ii.2013, sweeping (in UOSC).

Remarks. The species was earlier known from Peninsular Malaysia (Hippa 2006, 2008), Brunei and Malaysia, Sabah (Hippa and Ševčík 2010).

Manota perangulata Hippa & Ševčík, 2010

Material studied. 1 male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 7–18.i.2014, primary lowland rainforest, Malaise trap 1 (night), J. Ševčík leg. (in UBDC); 1 male with the same data except 8–18.i.2014, Malaise trap 4, J. Ševčík & D. Kaspřák leg. (in UOSC).

Remarks. The species was earlier known from Brunei (Hippa and Ševčík 2010) and Thailand (Hippa 2011).

Manota pollex Hippa, 2006

Material studied. 1 male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, 5–17.ii.2013, primary lowland rainforest, Malaise trap 3b, J. Ševčík leg. (in UBDC).

Remarks. The species was earlier known from Peninsular Malaysia (Hippa 2006, 2008) and Thailand (Hippa 2011).

Manota procera Hippa, 2006

Material studied. 1 male, Brunei, Bandar Seri Begawan, UBD Campus, nr KBFSC Headquarters, 19–22.i.2014, secondary forest, Malaise trap, J. Ševčík & D. Kaspřák leg. (in UBDC).

Remarks. The species was earlier known from Peninsular Malaysia (Hippa 2006, 2008) and Thailand (Hippa 2009; Hippa and Papp 2007).

Manota simplex Hippa, 2006

Material studied. 1 male, Brunei, Ulu Temburong N. P., Kuala Belalong Field Studies Centre, primary lowland rainforest, sweeping, January 2013, J. Ševčík leg. (in UBDC); 1 male with the same data except 7–17.i.2014, Malaise trap 2, J. Ševčík & D. Kaspřák leg. (in UOSC); 1 male with the same data except Malaise trap 2 (in UBDC).

Remarks. The species was earlier known from Peninsular Malaysia (Hippa 2006, 2008), Thailand (Hippa 2008, 2009, 2011) and Malaysia, Sabah (Hippa and Ševčík 2010).

Discussion

Species richness of *Manota* in Brunei

A total of 13 species of *Manota* is reported here from the relatively small area in Ulu Temburong National Park. Two additional species are known from the coastal area of the Universiti Brunei Darussalam campus in Tungku. One species (*Manota oligochaeta*) is common to both these areas. Out of the total of 15 species, 6 were already reported from Brunei by Hippa and Ševčík (2010). These numbers are based on a relatively limited sampling during two field trips to the area and they will definitely be increasing with future studies. Additional four species of *Manota*, not collected in 2013 and 2014, were reported from Ulu Temburong by Hippa and Ševčík (2010), so the total number of *Manota* species known from Ulu Temburong National Park is 17 and that for the entire Brunei is 19.

If we use the Chao 1 formula (Chao 1984; Colwell and Coddington 1994) to calculate the estimated true species diversity of *Manota* in Ulu Temburong National Park, the resulting number would be 29. For comparison, in a rainforest in Peninsular Malaysia (Ulu Gombak Field Study Centre), a total of 27 sympatric species were recorded (Hippa 2006) and the potential species richness could be estimated as 35.

Altogether, more than 50 species of Mycetophilidae and 16 species of Keroplatidae have so far been collected in Ulu Temburong National Park. The patterns of diversity of these taxocoenoses will be treated in a separate paper (Ševčík et al., in prep.).

Notes on diurnal activity

One trap was emptied 3 times a day (at 7 am, 1 pm and 7 pm), so that it was possible to acquire also data on diurnal and night activity of several species. This will be subject of a separate paper (Kaspřák et al., in prep.) but concerning *Manota*, *M. kaspraki* and *M. perangulata* were collected during the night, *M. bruneiensis* and *M. megachaeta* in the morning, and *M. bruneiensis* in the afternoon, indicating a day-long activity of *Manota* species in the tropics. These are the first records of diurnal activity of *Manota* species.

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RESEARCH ARTICLE

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New records of the genus *Iporhogas* Granger (Hymenoptera, Braconidae, Rogadinae) from Vietnam, with description of four new species

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Abstract

The genus *Iporhogas* Granger, 1949 (Braconidae: Rogadinae) is recorded for the first time for Vietnam. Four new species of the genus *Iporhogas*, viz. *Iporhogas albilateralis* **sp. n.**, *I. contrastus* **sp. n.**, *I. simulatus* **sp. n.** and *I. tricoloratus* **sp. n.**, from Vietnam are described and illustrated, and additionally, one species, *Iporhogas guangxiensis* Chen & He, 1997, is newly recorded for Vietnam's fauna of the family Braconidae. A key to the five Vietnamese species of the genus *Iporhogas* and a checklist with distributions of the ten species are provided.

Keywords

Braconidae, Rogadinae, *Iporhogas*, new record, new species, Vietnam

Introduction

The Rogadinae is one of the largest subfamilies of Braconidae, as far as known species of this subfamily consists of koinobiont endoparasitoids of lepidopteran larvae in which the host caterpillar is mummified (van Achterberg 1991; Townsend and Shaw 2009). Little is known of the subfamily Rogadinae from Vietnam, and since 2007, some papers on Vietnamese Rogadinae with description of 17 new species have been published (Long and van Achterberg 2007, 2008a, 2008b). To date only seven genera and 25 species of Vietnamese Rogadinae have been reported in papers scattered in the literature (Long and Belokobylskij 2003; Long and van Achterberg 2008a, 2008b; Butcher et al. 2012).

The genus *Iporhogas* proposed by Granger (1949) is a small genus of the rogadine braconids, this genus comprises six species, of which five occur in the Oriental region (Chen and He 1997) and one in the Afrotropical region (Granger 1949). Six *Iporhogas* species were keyed by Chen and He (1997) with five species described and illustrated as new from China, but without any information on their hosts.

For several years the author has been collecting Braconidae from all over Vietnam to gain an understanding of the braconid fauna of Vietnam. In this paper four new and aberrant species of *Iporhogas* from Vietnam present in the Braconidae Collection of Vietnam National Museum of Nature (VNMN) are described and illustrated. A checklist and the distribution of ten species of the genus *Iporhogas* are given, in addition one species is recorded for the first time from Vietnam, together they represent the first record of the genus *Iporhogas* for Vietnam.

Material and methods

Specimens studied are deposited in the Collection of the Institute of Ecology & Biological Resources (IEBR) and Vietnam National Museum of Nature (VNMN) at Ha-Noi, assembled by the author during numerous expeditions in Vietnam. The specimens of *Iporhogas* were mainly collected by using sweep nets or malaise traps set in open habitats as secondary or impoverished forests.

All the types are kept in Vietnam National Museum of Nature (VNMN) (Ha-Noi, Vietnam), but two females designated as paratypes of *Iporhogas albilateralis* sp. n. ('Rog.282') and *Iporhogas contrastus* sp. n. ('Rog.367'), and one male designated as paratype of *Iporhogas tricoloratus* sp. n. ('Rog.363') are donated to Naturalis Biodiversity Center (RMNH), Leiden, The Netherlands.

Terminology used in this paper follows van Achterberg (1993), sculpture terms are based on Harris (1979), and vein terminology follows the modified Comstock-Needham system (van Achterberg 1993). For diagnosis of the Rogadinae see van Achterberg (1991); for identification and subdivision of the subfamily, see van Achterberg (1993); for a key to the genera of the subfamily Rogadinae, see Chen and He (1997); for additional references and data, see Yu et al. (2013). The photographs were taken with a Canon G15 camera attached to an Olympus SZ61 binocular microscope at IEBR. Abbreviations used in this paper are as follows: POL = postocellar line; OOL = ocular-ocellar line; Od = diameter of posterior ocellus; MT: Malaise trap; 'Rog. + number': code number indexing for specimens of the Rogadinae in the collection; N: North, S: South, NC: North Central, NE: Northeast, NW: Northwest; NP: National Park; NR: Nature Reserve.

Results

Checklist and distribution of *Iporhogas* species

Iporhogas albilateralis sp. n., from Vietnam
Iporhogas contrastus sp. n., from Vietnam
Iporhogas chinensis Chen & He, 1997, from China
Iporhogas flavistigma Chen & He, 1997, from China
Iporhogas guangxiensis Chen & He, 1997, from China, Vietnam
Iporhogas infuscatipennis Granger, 1949 from Madagascar
Iporhogas rugivertex Chen & He, 1997, from China
Iporhogas simulatus sp. n., from Vietnam
Iporhogas tricoloratus sp. n., from Vietnam
Iporhogas unicolor Chen & He, 1997, from China

Systematics

Iporhogas Granger, 1949

Figs 1–34

Iporhogas Granger, 1949: 167. Type-species (by monotypy): *Iporhogas infuscatipennis* Granger, 1949.

Diagnosis. Antennal segments 47–54 (female), 36–43 (male), apical segment with spine; maxillary and labial palpi of female normal; hypostomal carina joining occipital carina ventrally (Fig. 13); occipital carina complete and concave (Figs 5, 11, 17, 24, 32); vertex rugose or transversely rugose; frons rugose; malar suture shallow; eyes emarginate (Fig. 18); precoxal sulcus shallow and narrow, absent anteriorly and posteriorly; mesopleuron smooth or finely and sparsely punctate; notauli rather wide and crenulate; vein 1-SR of fore wing medium-sized, continuous with vein 1-M (Figs 10, 29); vein m-cu of fore wing antefurcal, curved, gradually merging into vein 2-CU1, and converging to vein 1-M posteriorly; vein 3-SR of fore wing longer than 2-SR (Figs 10, 29); vein 1-CU1 short; vein 1-SR+M of fore wing sinuate; vein cu-a of fore wing nearly vertical; vein M+CU1 of fore wing nearly straight; vein 1-M of hind wing straight; vein 1r-m of hind wing comparatively short and oblique (Figs 23, 34); vein m-cu of hind wing absent; tarsal claws single or with large rounded lobe; hind tibial spurs curved, glabrous or setose basally; apex of hind tibia with distinct comb of specialized setae at inner side; propodeum areolate because of (partly) developed submedial carinae (Figs 6, 12, 20, 25, 33); propodeal tubercles absent; first metasomal tergite with large dorsope (Figs 14, 21, 27), its dorsal carinae united behind level of spiracles and without basal flanges; second tergite with comparatively large mediobasal triangular area, connected to a medio-longitudinal carina (Figs 8, 14, 21, 27); fourth-fifth tergites with sharp lateral crease (Fig. 9); hypopygium of female medium-sized to large; ovipositor sheath rather slender (Fig. 9).

Key to species of the genus *Iporhogas* from Vietnam

1 Tarsal claws simple, without lobe (Fig. 31).......................................**2**

– Tarsal claws with large acute lobe (Fig. 16).......................................**3**

2 Occipital carina in dorsal view angularly concave (Fig. 17); propodeum with small triangular areola and without basal carina (Fig. 20); vein 1-SC+R of hind wing almost straight apically (Fig. 23); vein 2-SC+R of hind wing quadrate (Fig. 23) ....***I. simulatus* sp. n.**

– Occipital carina in dorsal view roundly concave (Fig. 32); propodeum without areola and with basal carina; vein 1-SC+R of hind wing distinctly curved apically (Fig. 34); vein 2-SC+R of hind wing subquadrate, swollen apically (Fig. 34).. ***I. guangxiensis* Chen & He**

3 Occipital carina in dorsal view slightly concave (Fig. 5); vein 1-CU1 of fore wing nearly quadrate (Fig. 10); two basal metasomal tergites black medially (Fig. 8)...***I. albilateralis* sp. n.**

– Occipital carina in dorsal view deeply concave (Figs 11, 24); vein 1-CU1 of fore wing transverse (Fig. 29); first metasomal tergite white or black basally; second tergite black apically (Figs 14, 27) **4**

4 Propodeum reddish yellow (Fig. 25); precoxal sulcus narrow and punctate (Fig. 28); ocelli rather large, distance between anterior and posterior ocelli 0.4 times as long as diameter of ocellus (Fig. 24).................***I. tricoloratus* sp. n.**

– Propodeum black (Figs 12, 15); precoxal sulcus wide and distinctly crenulate (Fig. 15); ocelli smaller, distance between anterior and posterior ocelli equal to diameter of ocellus (Fig. 11) ....***I. contrastus* sp. n.**

Descriptions

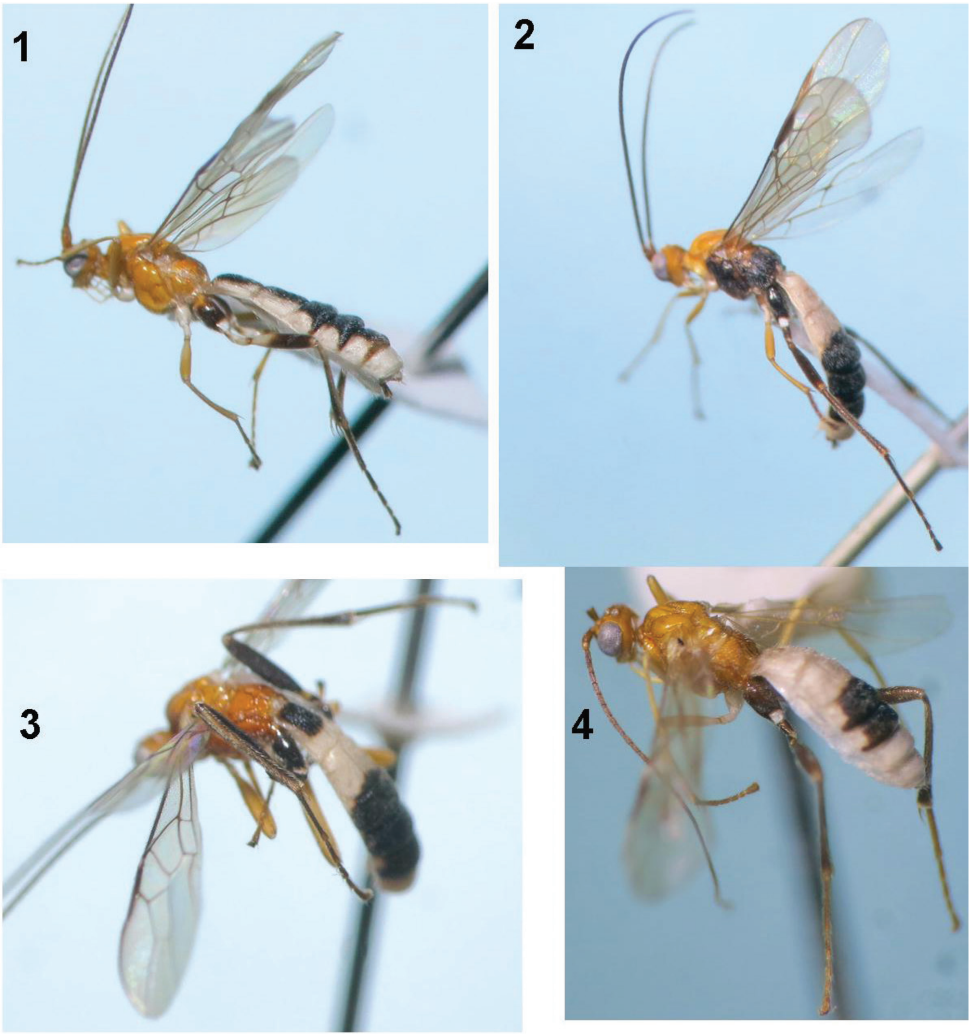
Iporhogas albilateralis sp. n.

http://zoobank.org/3D5BE644-6BBA-4884-B392-BC0433A51531

Figs 1, 5–10

Material. Holotype, female (VNMN), 'Rog.608', "[NE Vietnam:] Vinh Phuc, Tam Dao NP, 110m, bushes, 06.x.2008, KD Long". Paratypes; 1 female (VNMN), 'Rog.224', "[S Vietnam:] Kien Giang, Phu Quoc island, garden, 21.vii.2002, KD Long"; 1 female (RMNH), 'Rog.282', " [NW Vietnam:] Hoa Binh, Yen Thuy, fruit orchard, MT, 01-10.ix.2002, KD Long".

Description. Holotype, female, body length 6.1 mm, fore wing length 4.6 mm (Fig. 1).



Figures 1–4. 1 *Iporhogas albilateralis* sp. n., female habitus **2** *Iporhogas contrastus* sp. n., female habitus **3** *Iporhogas tricoloratus* sp. n., female habitus **4** *Iporhogas tricoloratus* sp. n., male habitus.

Head. Antenna broken, with 35 segments remaining; middle segments 3.0 times longer than wide (6:2); third antennal segment 1.1 times fourth segment (9:8); width of face equal to length of face and clypeus combined; malar space 1.2 times as long as mandible width (6:5); mandible width 0.7 times as long as hypoclypeal depression (5:7); in dorsal view height of eye 3.2 times as long as temple (16:5); occipital carina weakly concave (Fig. 5); in lateral view, width of eye 3.0 times as long as temple (15:5); ocelli large, POL:Od:OOL=2:5:4; distance between anterior and posterior ocelli 0.75 times as long as OOL (3:4) (Fig. 5); face rugose-punctate with circular fine striae around antennal socket; frons shiny, finely rugose; temple smooth; vertex shiny with fine curved striae (Fig. 5).

Mesosoma. Length of mesosoma 1.45 times as long as high (70:48); propleuron wide and deep, crenulated anteriorly (Fig. 7); mesoscutum shiny with sparse fine punctures; notauli deep, crenulated anteriorly, smooth posteriorly; scutellar sulcus 0.4 times as long as scutellum (5:12) with one medial carina; scutellum shiny, smooth; precoxal sulcus shallow, punctate; mesopleuron shiny, largely smooth medially (Fig. 7), anterior area of mesopleuron and mesosternum with sparse fine punctures; metapleuron punctate; propodeum areolate medially, punctate basally, rugose apically (Fig. 6).

Wings. Fore wing: pterostigma 3.8 times as long as wide (38:10); r:2-SR:3-SR:SR1=7:13:20:34; vein r arising from middle of pterostigma; vein 1-SR+M distinctly S-shaped; vein cu-a vertical, postfurcal; vein 1-CU1 near subquadrate (Fig. 10), 1-CU1:cu-a:2-CU1 =2:7:23; basal length of second submarginal 2.5 times as long as its apical width (32:13). Hind wing: vein M+CU 1.2 times as long as vein 1-M; M+CU:1-M: 1r-m=28:24:13; vein 2-SC+R transverse.

Legs. Hind coxa shiny, with oblique fine striae dorso-apically; length of hind femur, tibia and basitarsus 4.8, 9.0 and 9.0 times as long as their width, respectively; inner hind tibial spur 0.4 times as long as basitarsus (14:36); hind tarsal claw with large lobe.

Metasoma. First tergite 1.1 times as long as its apical width (33:31) (Fig. 8); medially second tergite 1.5 times longer than third tergite (30:20); second suture wide, crenulate; first and second tergites with medial longitudinal carina; third-fifth tergites with dense parallel striae on whole surface; ovipositor sheath 0.75 times as long as hind basitarsus (9:12); ovipositor sheath straight (Fig. 9).

Colour. Body bicoloured; scapus yellow; antennal segments brownish yellow; palpi pale yellow; fore and middle legs yellow; hind coxa black, yellow basally; hind trochanter and trochantellus white; hind femur black, white basally; hind tibia yellowish brown basally, darkish apically; hind tarsus brown; pterostigma and vein yellowish brown; propodeum brownish yellow; first-second metasomal tergites black medially, white laterally; third-fifth tergites largely black medially, white baso-laterally; sixth tergite white entirely; sternites ivory.

Variation. Paratypes with 54 antennal segments; first tergite 1.1–1.25 times as long as apical width; medial length of metasomal second tergite 1.5 times as long as third tergite medially; body length 6.2–6.5 mm; fore wing length 4.7–4.8 mm.

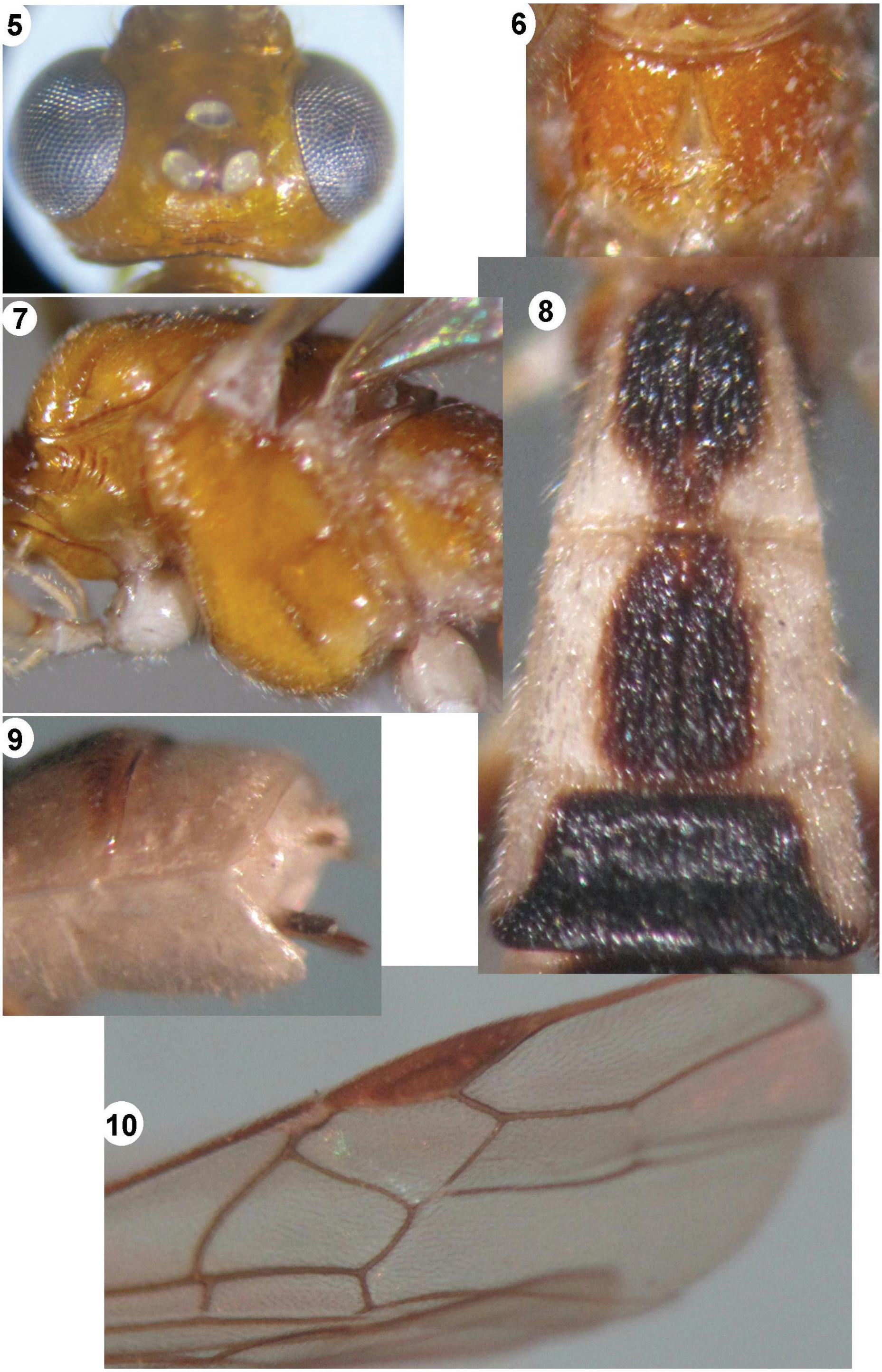
Male. Unknown.

Distribution. NE Vietnam: Vinh Phuc; NW Vietnam: Hoa Binh; S Vietnam: Phu Quoc Island.

Biology. Unknown.

Etymology. From “albus” (Latin for “white”) and “lateralis” (Latin for “of the side”), because of the white lateral side of the metasoma.

Notes. *Iporhogas albilateralis* sp. n. can be distinguished from other species by having the hind coxa with oblique striae dorso-apically. The new species differs from *I. chinensis* Chen & He, 1997, from China by having the precoxal sulcus shallow, punctate; mesopleuron finely and sparsely punctate; metapleuron punctate and vein cu-a of fore wing distinctly postfurcal. The new species also differs from *I. flavistigma*



Figures 5–10. *Iporhogas albilateralis* sp. n., female. **5** head dorsal **6** propodeum dorsal **7** mesosoma lateral **8** metasomal tergites 1-3 dorsal **9** apex of metasoma lateral **10** fore wing.

Chen & He, 1997, from China by having the occipital carina in dorsal view roundly concave; precoxal sulcus shallow, sparsely punctate; metapleuron largely punctate and vein M+CU of hind wing slightly longer vein 1-M.

Iporhogas contrastus sp. n.

http://zoobank.org/F166F73A-585D-4931-9152-BE14743ACC6C

Figs 2, 11–16

Material. Holotype, female (VNMN), 'Rog.713', "[NW Vietnam:] Hoa Binh, Mai Chau, Tan Son, orchard, MT, N20°43'10.3", E104°59'47.0", 650m, 1–5.v.2010, KD Long". Paratypes: 1 female (RMNH), 'Rog.367', "[NW Vietnam:] Lai Chau, Tam Duong, Lai Nhi Thang, forest, 09.x.2004, KD Long"; 1 female (VNMN), 'Rog.047', "[NC Vietnam:] Ha Tinh, Huong Son, Rao An, forest, 200m, 22.v.1998, KD Long".

Description. Holotype, female, body length 6.1 mm, fore wing length 5.0 mm (Fig. 2).

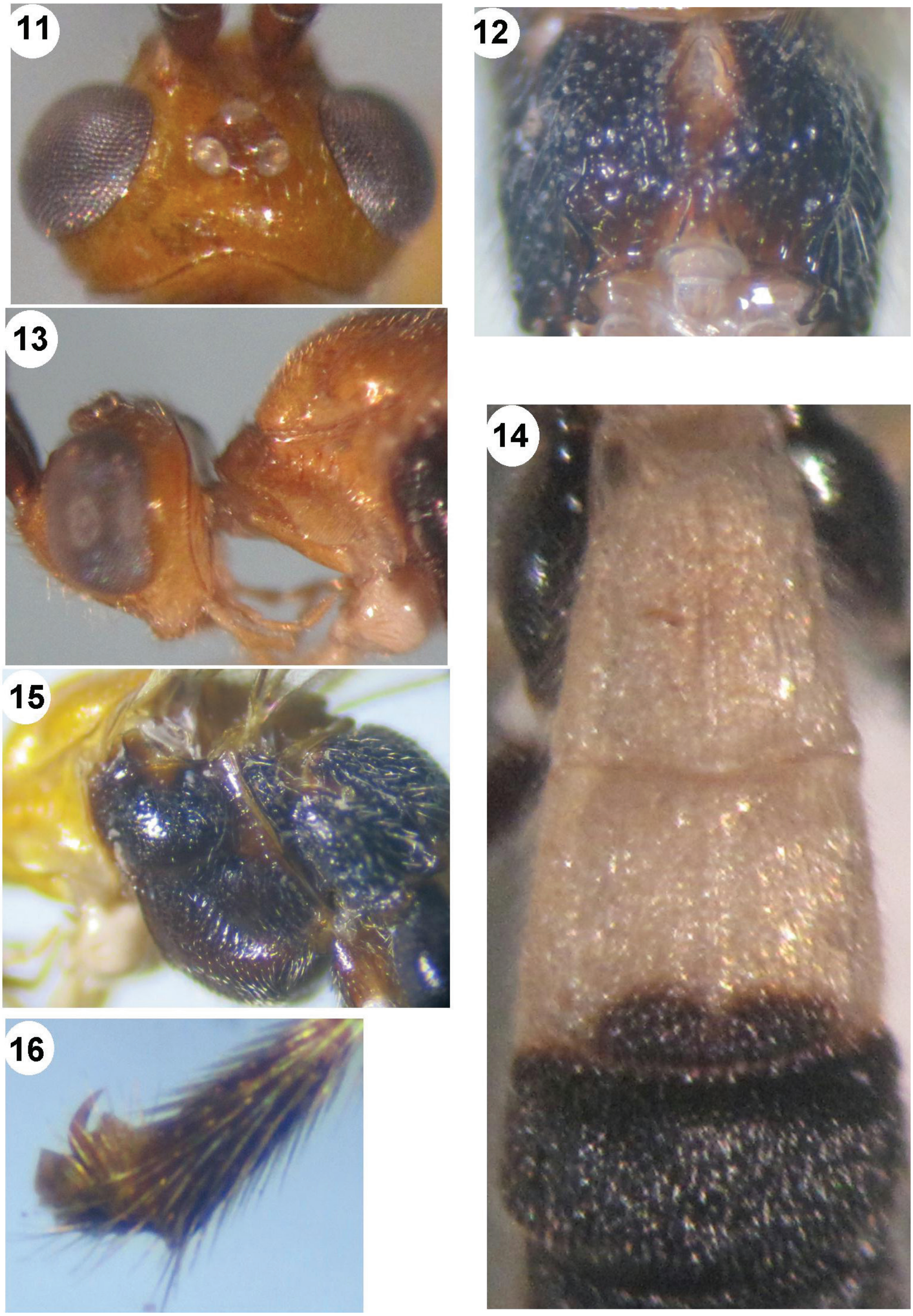
Head. Antenna broken, with 51 segments remaining; middle segments twice longer than wide (6:3); third antennal segment 1.3 times fourth segment (9:7); width of face 1.1 times length of face and clypeus combined (19:17); malar space 0.85 times as long as mandible width (6:7); mandible width 0.9 times as long as hypoclypeal depression (7:8); in dorsal view height of eye 2.8 times as long as temple (17:6); occipital carina deeply concave (Fig. 11); in lateral view width of eye 3.0 times as long as temple (15:5); POL:Od:OOL=3:4:4; distance between anterior and posterior ocelli equal to OOL (Fig. 11); face with short median carina, rugose medially, lateral area with fine transverse striae; frons with fine transverse striae; vertex and temple smooth.

Mesosoma. Length of mesosoma 1.6 times as long as high (72:45); propleuron wide, crenulated (Fig. 13); notauli deep, crenulate; mesonotum with sparse fine punctures; scutellar sulcus 0.5 times as long as scutellum (6:12) with one medial carina; scutellum sparsely punctate; mesopleuron shiny and smooth medially, sparsely and finely punctate anteriorly and posteriorly; precoxal sulcus wide, crenulate (Fig. 15); mesosternum sparsely punctate; metapleuron rugose-punctate; propodeum areolate medially, rugose-punctate anteriorly, rugose latero-posteriorly (Fig. 12).

Wings. Fore wing: pterostigma 4.4 times as long as wide (44:10); r:2-SR:3-SR:SR1=10:13:26:42; vein r arising before middle of pterostigma; vein 1-SR+M nearly straight; vein cu-a distinctly postfurcal; 1-CU1:cu-a:2-CU1=3:6:28; basal length of second submarginal 2.5 times as long as its apical width (35:14). Hind wing: vein M+CU 1.3 times vein; M+CU:1-M:1r-m=32:24:12; vein 2-SC+R transverse.

Legs. Hind coxa sparsely punctate dorsally; length of hind femur, tibia and basitarsus 5.7, 8.75 and 9.0 times as long as their width, respectively; inner hind tibial spur 0.33 times as long as basitarsus (12:36); hind tarsal claw with large acute lobe (Fig. 16).

Metasoma. First tergite 1.2 times as long as its apical width (40:33) (Fig. 14); first-second tergites sparsely striate; medial length of second tergite 1.5 times third tergite



Figures 11–16. *Iporhogas contrastus* sp. n., female. **11** head dorsal **12** propodeum dorsal **13** head lateral and propleuron **14** metasomal tergites 1-3 dorsal **15** mesosoma lateral **16** hind tarsal claw lateral.

(30:20); first-second metasomal tergites with medial longitudinal carina, sparsely striate (Fig. 14); third tergite without medial carina; third-fifth tergites densely striate; ovipositor sheath as long as hind inner spur; ovipositor slender.

Colour. Scapus and antennal segments brown; palpi yellow; stemmaticum black; pronotum and mesonotum yellow; mesopleuron, metapleuron and propodeum black; fore coxa ivory; fore femur, tibia and tarsus yellow, except telotarsus brownish yellow; middle coxa brown, fore femur, tibia and tarsus yellow, except telotarsus brownish yellow; hind coxa black, hind femur, tibia and tarsus blackish brown; fore wing yellowish brown; pterostigma yellow with brown border; veins yellowish brown; first and second tergites white, except black spot at apex of second tergite; third-fifth tergites black; tergite 6 white; hypopygium ivory with long sparse setae; ovipositor sheath brown.

Variation. Paratypes: antenna with 49 segments; first tergite 1.2 times as long as its apical width; medial length of metasomal second tergite 1.3–1.5 times third tergite medially; body length 6.1–7.8 mm; fore wing length 5.5–6.6 mm; stemmaticum brown; lateral lobes of mesoscutum dark brown; first metasomal tergite with brown spot at base.

Male. Unknown.

Distribution. NW Vietnam: Hoa Binh (Mai Chau), Lai Chau (Tam Duong); NC Vietnam: Ha Tinh (Huong Son).

Biology. Unknown.

Etymology. From “contra” (Latin for “opposite”), because of the contrasting orange and black of its body colour.

Notes. *Iporhogas contrastus* sp. n. differs from *I. chinensis* Chen & He, 1997, from China by having: the metapleuron rugose-punctate; precoxal sulcus wide, crenulate; hind tarsal claw with large lobe; vein cu-a of fore wing distinctly postfurcal; vein M+CU of hind wing 1.3 times as long as vein 1-M and hind leg entirely black. The new species differs from *I. flavistigma* Chen & He, 1997, from China by having: the occipital carina in dorsal view deeply concave; precoxal sulcus wide, crenulate; metapleuron largely punctate; vein 2-SC+R of hind wing transverse and hind leg entirely black.

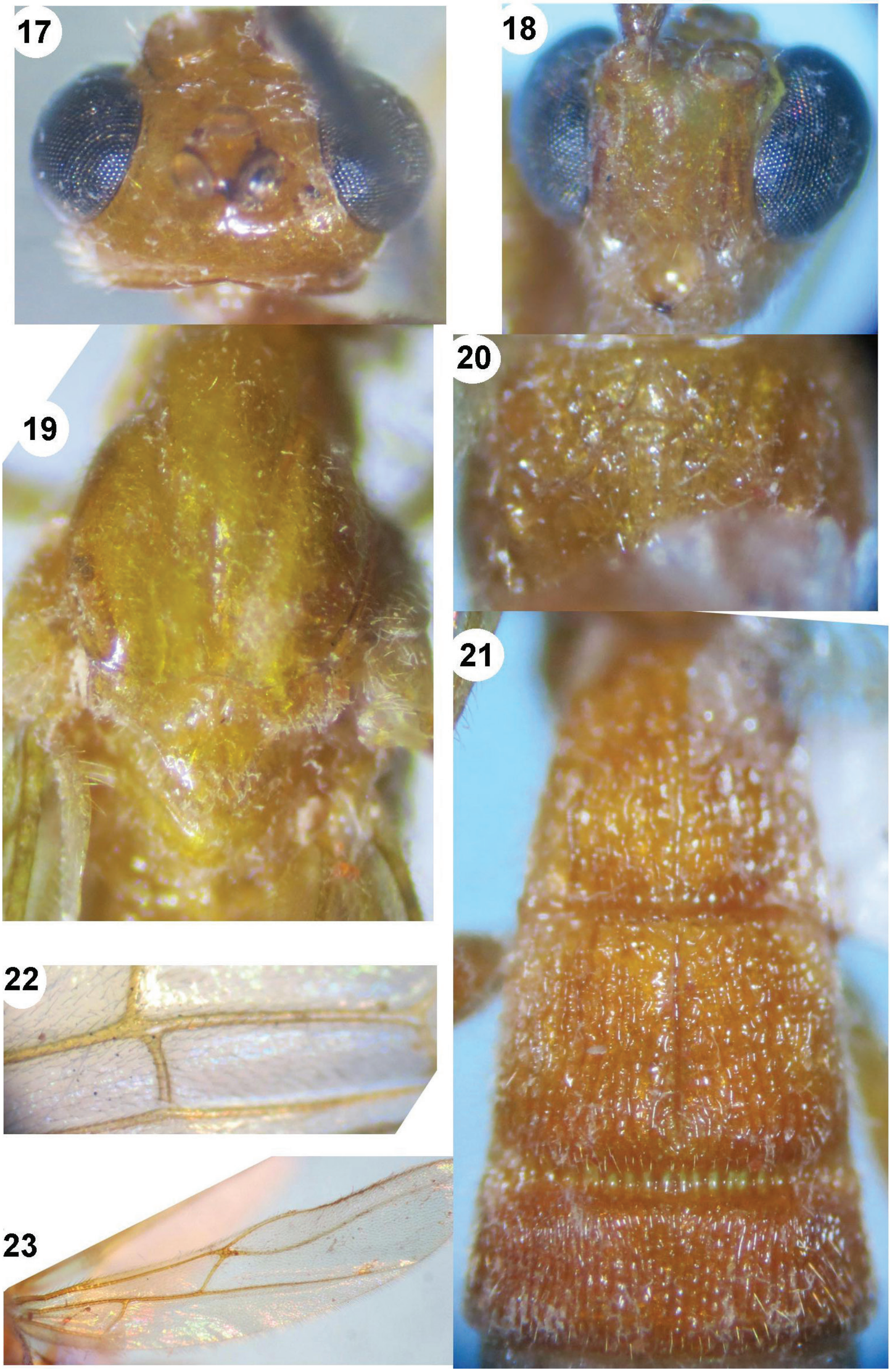
Iporhogas simulatus sp. n.

http://zoobank.org/EB11CDBE-E11A-4B2F-9A05-AD0B1DFC2DA7
Figs 17–23

Material. Holotype, female (VNMN), ‘Rog.798’, “[C Vietnam:] Thua Thien-Hue, A Luoi, A Roang, forest, 700m, 28.v.2006, HV Tru”.

Description. Holotype, female, body length 7.5 mm, fore wing length 5.8 mm.

Head. Antenna broken, with 19 segments remaining; middle segments 1.75 times longer than wide (7:4); third antennal segment 1.4 times fourth (10:7); width of face 1.1 times length of face and clypeus combined (22:20); malar space 0.8 times as long as mandible width (7:9); mandible rugose, mandible width 0.9 times as long as hypoclypeal depression (9:10); malar suture present; in dorsal view height of eye 2.85



Figures 17–23. *Iporhogas simulatus* sp. n., female. **17** head dorsal **18** head frontal **19** mesonotum **20** propodeum dorsal **21** metasomal tergites 1–3 dorsal **22** veins 1-CU1 and cu-a of fore wing **23** hind wing.

times as long as temple (20:7), occipital carina in dorsal view angularly concave (Fig. 17); in lateral view width of eye 2.25 times as long as temple (18:8); ocelli large, POL:Od:OOL=3:7:5; distance between anterior and posterior ocelli 0.8 as long as OOL (4:5) (Fig. 17); face transversely rugose (Fig. 18); frons transversely rugose; vertex and temple smooth.

Mesosoma. Length of mesosoma 1.5 times as long as high (98:66); propleuron wide and deep, crenulate; mesoscutum almost smooth, with sparse fine punctures; notauli deep and crenulate anteriorly, flat posteriorly; mesoscutum with deep smooth medial depression between notauli (Fig. 19); scutellar sulcus 0.5 times as long as scutellum (8:15); scutellum with sparse fine punctures; precoxal sulcus wide and shallow, sparsely rugose-punctate; mesopleuron and mesosternum smooth; metapleuron sparsely rugose; propodeum with small triangular areola and without basal carina, sparsely rugose laterally (Fig. 20).

Wings. Fore wing: pterostigma 4.1 times as long as wide (53:13); r:2-SR:3-SR:SR1=12:20:31:58; vein r arising from middle of pterostigma; vein 1-SR+M slightly curved; vein cu-a slightly postfurcal; vein 1-CU1 very short and nearly quadrate (Fig. 22); cu-a:2-CU1=9:31; basal length of second submarginal 3.6 times as long as its apical width (47:13). Hind wing: vein M+CU 1.3 times as long as vein 1-M (39:29); M+CU:1-M: 1r-m=39:29:16; vein 2-SC+R quadrate (Fig. 23).

Legs. Hind coxa largely smooth dorsally, sparsely and finely punctate ventrally; length of hind femur, tibia and basitarsus 5.3, 8.8 and 9.0 times as long as their width, respectively; inner hind tibial spur 0.3 times as long as basitarsus (14:45); hind tarsal claw simple.

Metasoma. First tergite 1.1 times as long as its apical width (47:44) (Fig. 21); medial length of second tergite 1.9 times third tergite (36:24); first-second tergites with medial longitudinal carina; ovipositor sheath 0.6 times as long as hind basitarsus (9:14).

Colour. Yellow; scapus and pedicel yellow; eyes and antennal segments brown; palpi yellow; first-third metasomal tergites yellow, fourth-sixth tergites pale yellow; wing vein yellow; pterostigma yellow, brownish apically.

Male. Unknown.

Distribution. NC Vietnam: Thua Thien-Hue (A Luoi, A Roang).

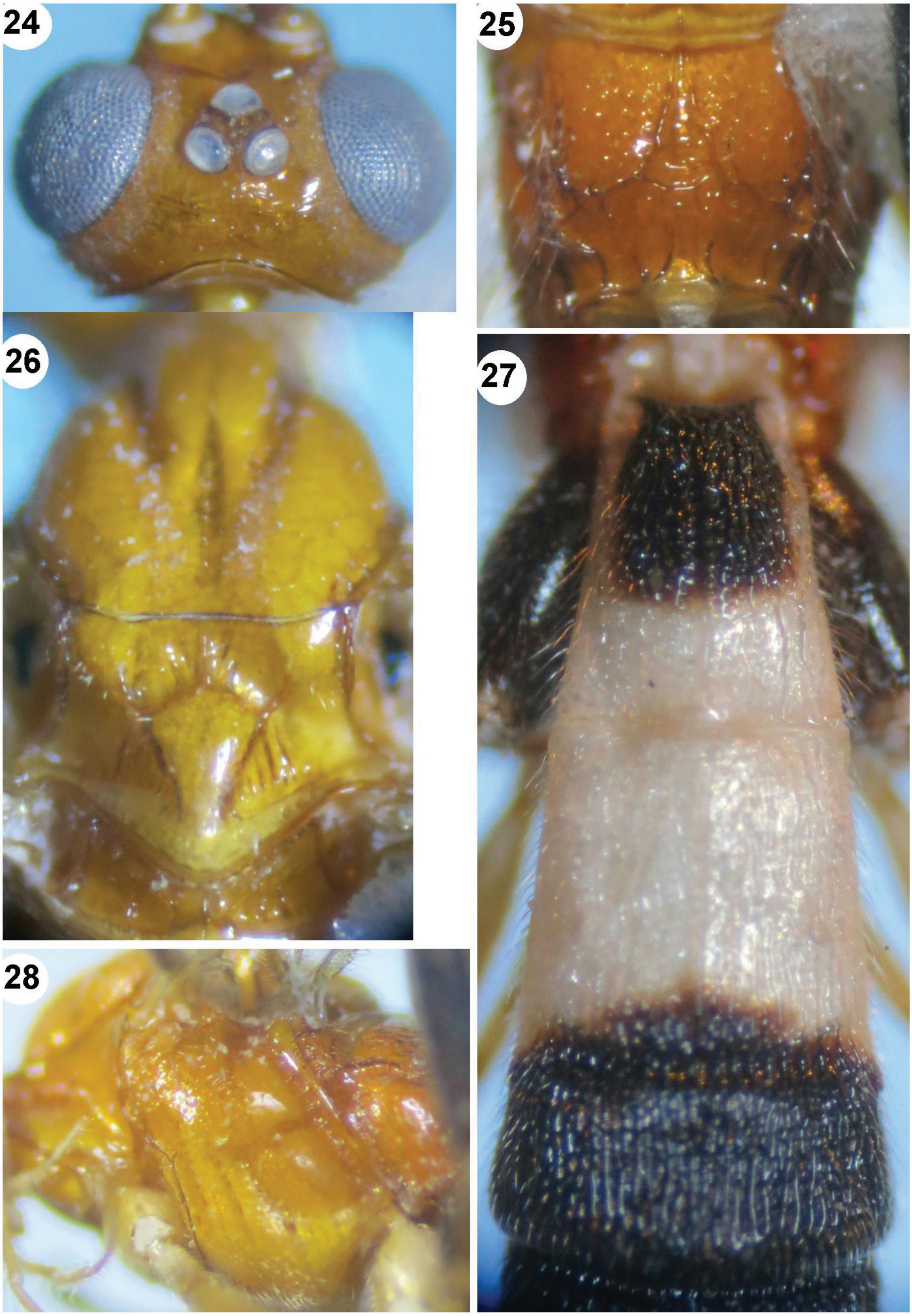
Biology. Unknown.

Etymology. Named from “simulo” (Latin for “imitate, copy”), because this species is similar to *Iporhogas guangxiensis* Chen & He, 1997.

Iporhogas tricoloratus sp. n.

http://zoobank.org/FA89EC6F-FD71-4530-AFF0-3CF4DCBE1591
Figs 3, 4, 24–30

Material. Holotype, female (VNMN), ‘Rog.629’, “[NC Vietnam:] Quang Binh, Xuan Trach, Phong Nha-Ke Bang NP, forest, sweeping net, 18.iv.2010, KD Long”.



Figures 24–28. *Iporhogas tricoloratus* sp. n., female. **24** head dorsal **25** propodeum dorsal **26** mesonotum **27** metasomal tergites 1–3 dorsal **28** mesosoma.

Paratypes: 10 males, ‘Rog.053’ (VNMN), “[NW Vietnam:] Hoa Binh, Yen Thuy, forest, 20°28'12N 105°34'40E 80m, 4.v.2002”; ‘Rog.259’ (VNMN), “[NW Vietnam:] Hoa Binh, Yen Thuy, forest, MT 20°23'06N, 105°34'11E 300m, 10–20.vii.2002; KD Long”; ‘Rog.360, Rog.361, Rog.362’ (VNMN), ‘Rog.363’ (RMNH), “[NW Vietnam:] Son La, Moc Chau, Xuan Nha NR, forest, 11.x.2004, KD Long”; ‘Rog.495’ (VNMN), “[NE Vietnam:] Ha Giang, Vi Xuyen, Cao Bo, forest, 300m, 11.v.2007, KD Long”; ‘Rog.555’ (VNMN), “[NE Vietnam:] Ha Giang, Vi Xuyen, Ngoc Duong, bushes, 18.x.2006, KD Long”; ‘Rog.598’ (VNMN), “[NE Vietnam:] Vinh Phuc, Tam Dao NP, 200m, 05.ix.2008, KD Long”; ‘Rog.633’ (VNMN), “[NW Vietnam:] Phu Tho, Xuan Son, MT N21°14', E104°57' 140m, 1–5.x.2009, KD Long, NH Thao”.

Description. Holotype, female, body length 6.3 mm, fore wing length 5.0 mm (Fig. 3).

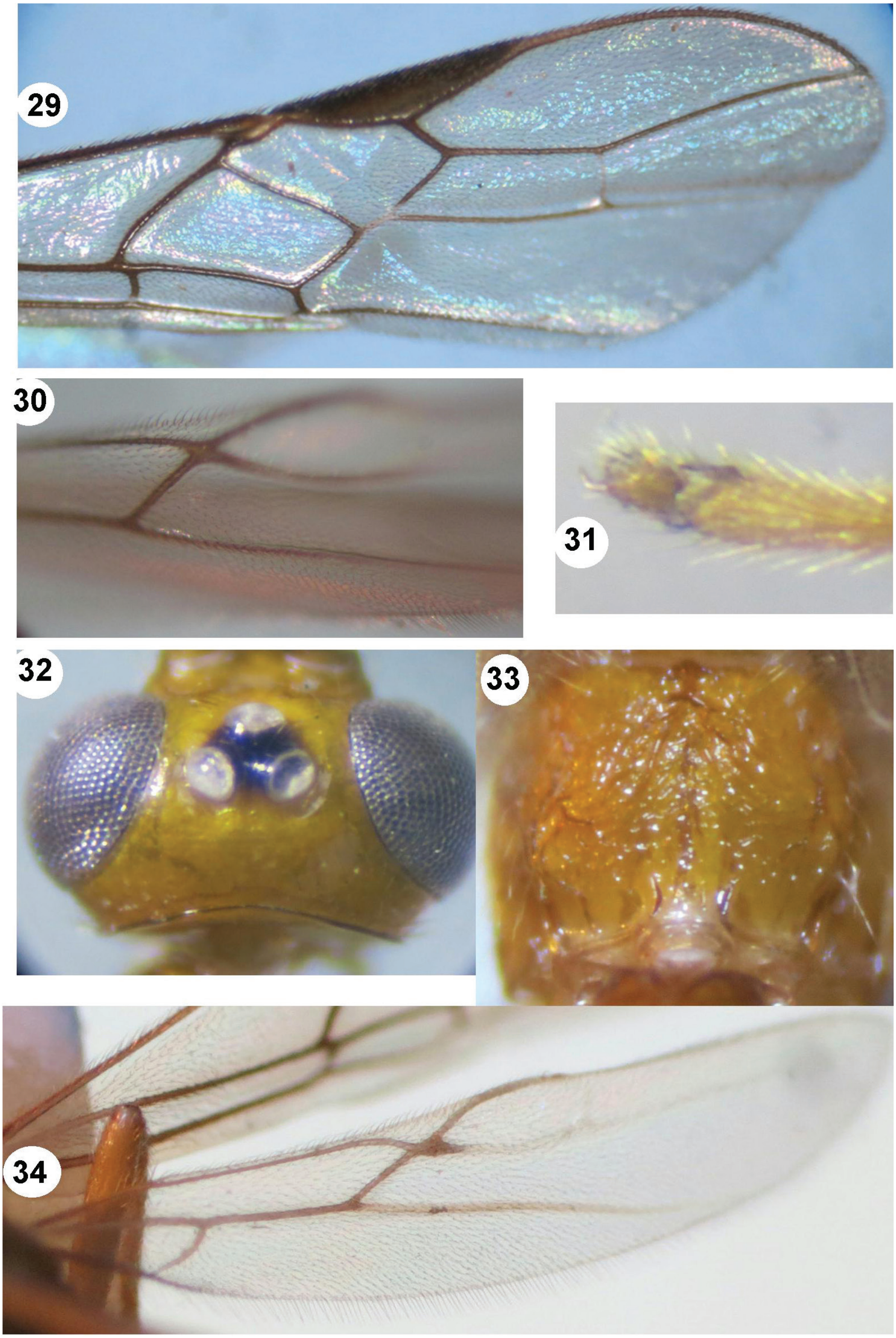
Head. Antenna with 47 segments; middle segments 2.8 times longer than wide (7.0:2.5); third segment 1.1 times fourth (8:7); width of face as long as length of face and clypeus combined; malar space 0.7 times as long as mandible width (5:7); mandible width 0.9 times as long as hypoclypeal depression (7:8); malar suture present; in dorsal view, height of eye 3.4 times as long as temple (17:5), occipital carina roundly concave (Fig. 24); in lateral view, width of eye 4.2 times as long as temple (25:6); POL:Od:OOL=2:5:3.5; distance between anterior and posterior ocelli 0.6 times as long as OOL (2:3.5) (Fig. 24); face rugose medially, transversely striate laterally; frons smooth with divergent striae close to antennal sockets; vertex with fine transverse striae; temple smooth.

Mesosoma. Length of mesosoma 1.5 times as long as high (73:50); propleuron deep and crenulate anteriorly, shallower posteriorly and finely crenulate; mesoscutum shiny with deep groove medially (Fig. 26), finely sparsely punctate; notauli narrow, deep and crenulate anteriorly, flat and smooth posteriorly; scutellar sulcus 0.6 times as long as scutellum (6:10), with 3 carinae (Fig. 26); scutellum almost smooth; precoxal sulcus short and shallow, crenulate (Fig. 28); mesopleuron sparsely and finely punctate anteriorly, smooth posteriorly; mesosternum sparsely punctate; metapleuron finely punctate; propodeum areolate medially, depressed posteriorly, sparsely punctate anteriorly, almost smooth posteriorly (Fig. 25).

Wings. Fore wing: pterostigma 4.6 times as long as wide (32:7); r:2-SR:3-SR:SR1=7:11:18:45; vein r arising near middle of pterostigma; vein 1-SR+M weakly S-shaped; vein cu-a distinctly postfurcal (Fig. 29), 1-CU1:cu-a:2-CU1:3-CU1=2:4:21:4; basal length of second submarginal 3.2 times as long as its apical width (35:11). Hind wing: vein M+CU 1.4 times as long as 1-M; M+CU:1-M:1r-m=35:25:13; vein 2-SC+R subquadrate (Fig. 30).

Legs. Upper side of hind coxa shiny and with sparse fine punctures; length of hind femur, tibia and basitarsus 4.8, 8.4 and 9.0 times as long as their width, respectively; inner hind tibial spur 0.4 times as long as basitarsus (11:30); hind tarsal claw with large lobe.

Metasoma. First tergite 1.3 times as long as its apical width (37:28) (Fig. 27); first-second tergites with medial carinae and sparse longitudinal striae, third-fifth ter-



Figures 29–34. 29–30 *Iporhogas tricoloratus* sp. n., female. **28** mesosoma lateral **29** fore wing **30** hind wing (in part) **31–34** *Iporhogas guangxiensis* Chen & He, 1997, female. **31** hind tarsal claw lateral **32** head dorsal **33** propodeum dorsal **34** hind wing.

gites without medial carina and densely striate, sixth tergite sparsely striate; medial length of second tergite 1.6 times than third (33:21); second suture wide, crenulate; hypopygium with long rather dense setae; ovipositor sheath as long as hind basitarsus.

Colour. Tricoloured body; scapus and pedicellus yellowish brown; antennal segments brown; palpi pale yellow; eyes brown; mesosoma yellow; fore and middle legs yellow; hind leg black, except coxa, trochanters and trochantellus black; hind tibia and tarsus brown; pterostigma and wing veins yellowish brown; first metasomal tergite black medio-basally, white apically and baso-laterally; second tergite white, except black apex; third-fifth tergites black entirely; sixth tergite entirely white; hypopygium white; ovipositor sheath 0.7 times as long as hind inner spur (8:11).

Variation. Paratypes (males; Fig. 4), antenna with 36–43 segments; first tergite 1.1–1.3 times as long as its apical width; medially second metasomal tergite 1.3–1.5 times as long as third tergite medially; body length 4.5–5.2 mm; fore wing length 3.6–4.4 mm.

Mesopleuron of males sometimes with fine transverse crenulae anteriorly; mesopleuron rugose-punctate anteriorly; fore and middle legs pale yellow; hind coxa and femur brown; hind tibia and tarsus yellowish brown; pterostigma and wing veins of males yellow or yellowish brown; first and second metasomal tergites white or ivory, except black spot at base of first and at apex of second tergite; third-fourth tergites black, except white basal corners; fifth and sixth tergites entirely white.

Distribution. NW Vietnam: Lai Chau (Tam Duong), Hoa Binh (Yen Thuy), Phu Tho (Xuan Son); NE Vietnam: Ha Giang (Vi Xuyen), Vinh Phuc (Tam Dao NP); NC Vietnam: Quang Binh (Phong Nha-Ke Bang NP).

Biology. Unknown.

Etymology. From “tri” (Latin for “three”), and “coloris” (Latin for “hue, tint”), because of the tricoloured body.

Notes. *Iporhogas tricoloratus* sp. n. differs from *I. chinensis* Chen & He, 1997, from China by having: the ocelli large; metapleuron finely punctate and vein M+CU of hind wing comparatively long, 1.4 times as long as vein 1-M. The new species differs from *I. flavistigma* Chen & He, 1997, from China by having the occipital carina in dorsal view roundly concave; metapleuron finely punctate and hind coxa finely punctate.

Iporhogas guangxiensis Chen & He, 1997

Figs 31–34

Material. 1 female (VNMN), ‘Rog.246’, “[NW Vietnam:] Hoa Binh, Yen Thuy, fruit orchard, MT 20–30.x.2002, KD Long”; 1 female (VNMN), ‘Rog.567’, 1 male (VNMN), ‘Rog.569’, “[NE Vietnam:] Ha Giang, Vi Xuyen, Dao Duc, secondary forest, sweeping 20.x.2007, KD Long”.

Notes. Female: body length 5.0-5.1 mm, length of fore wing 4.2 mm, antenna 6.3 mm; male: body length 4.0 mm, length of fore wing 3.5 mm, antenna 4.5 mm; in dorsal view occipital carina weakly concave (Fig. 32); basal length of second submarginal cell of fore wing 1.6 times as long as its apical width (16:10); vein M+CU of hind wing 1.3-1.6 times as long as vein 1-M (Fig. 34); vein 1-SC+R curved apically; vein 2-SC+R of hind wing subquadrate, swollen apically (Fig. 34); hind tarsal claw simple (Fig. 31); propodeum areolate medially (Fig. 33); ovipositor sheath 1.55 times as long as hind inner spur (14:9).

Distribution. China; NW Vietnam: Hoa Binh (Yen Thuy), NE Vietnam: Ha Giang (Vi Xuyen).

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A set of multi-entry identification keys to African frugivorous flies (Diptera, Tephritidae)

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Keywords
Tephritidae, Africa, identification key

Introduction

Tephritid fruit flies, or "true" fruit flies (Diptera, Tephritidae) include approximately 500 genera and 4800 valid species (Norrbom 2004), whose vast majority (95%) is represented by phytophagous species (reviewed in Aluja and Norrbom 1999). Among them, frugivorous flies represent approximately 25–30% of all tephritid species, occur in tropical and temperate regions of all continents except the Antarctic and are predominantly distributed in five main genera (*Anastrepha* Schiner, *Rhagoletis* Loew, *Ceratitis* MacLeay, *Dacus* Fabricius and *Bactrocera* Macquart). Frugivorous tephritids attack healthy fruit still on the tree. The larvae develop inside the fruit, feed on the plant tissues, and complete their developmental cycle in the soil. A relatively limited number (approximately 100) of frugivorous species are phytophagous pests whose larvae attack pulp and/or seeds of cultivated fruits and crops of agricultural importance. In Africa, damage on commercial fruits and crops is caused mainly by polyphagous species belonging to the genera *Ceratitis*, *Dacus* and *Bactrocera* (De Meyer et al. 2008;

White 2006). Other African and closely related genera with fewer taxa are *Capparimyia* Bezzi, *Carpophthoromyia* Austen, *Neoceratitis* Hendel, *Perilampsis* Bezzi and *Trirhithrum* Bezzi, which also include some species of economic significance.

Currently, identification of tephritid flies is a specialized task largely performed by a restricted pool of experienced taxonomists, a group that is constantly becoming smaller due to the well-known problems related to the general loss of taxonomical expertise on insects as well as on most taxonomic groups (Carvalho et al. 2007; Wilson 2000). In the last few decades, globalisation of fruit trade and transport (Aluja and Mangan 2008; Malacrida et al. 2007) has made the need for swift, reliable and accurate identification methods for frugivorous flies even more urgent. For example, in 1995, the erroneous identification of *B. zonata* as *B. pallidus* in Egypt produced a three-year delay on implementation of phytosanitary measures and resulted in serious damage to the agricultural productivity of the whole Alexandria region.

The morphological identification of African tephritids largely depends on the use of classical single-entry (dichotomous) keys. These keys are available for most African genera (e.g., White 2006), with the important exception of the genus *Ceratitis*, whose species can only be identified through separate subgeneric keys (De Meyer 1996, 1998, 2000; De Meyer and Freidberg 2006). The main disadvantage of single-entry keys is that species identification inevitably fails whenever the user is not able to select any of the dichotomous character states listed in the key (e.g., due to his inadequate taxonomic expertise, lack of clarity of the key, damaged specimen, etc.). Additionally, the specific terminology used in published keys represents a serious obstacle for non-specialist users who are not particularly acquainted with insect morphology and taxonomy. For these reasons, obtaining the taxonomical expertise that is necessary to identify tephritids using the above mentioned tools has never been an easy task, particularly for African scientists who can only rely on a limited number of comprehensive reference collections in the continent (as, for example, the South African National Collection of Insects, Pretoria - South Africa, the National Museums of Kenya, Nairobi - Kenya, or the International Institute of Tropical Agriculture (IITA), Cotonou - Benin). Molecular techniques represent a partial solution to counteract loss of taxonomical expertise on tephritid flies. DNA barcoding has been proposed as a relatively rapid and effective tool for the identification of fruit flies (Armstrong and Ball 2005). Yet, despite the availability of relatively large reference libraries of DNA barcodes for tephritid fruit flies, this method is still not routinely used for identification mainly due to shortcomings such as the difficulty of resolving important species complexes (Smit et al. 2013; Virgilio et al. 2010) and the incompleteness of reference libraries (Virgilio et al. 2012).

To try and reduce the effects of some of the aforementioned issues, we developed a set of freely available multi-entry identification keys for African fruit flies. The keys provide a professional identification tool that is also accessible to non-specialised morphologists (*i.e.*, people that might be interested in fruit fly identification such as students, technicians, agronomists, quarantine officers, ecologists, farmers, molecular biologists, etc.). Matrixes containing scores for 340 characters from 400 African species belonging to the genera *Bactrocera*, *Capparimyia*, *Carpophthoromyia*, *Ceratitis*, *Dacus*, *Neoceratitis*, *Perilampsis* and *Trirhithrum* were compiled from data sets that were used within the framework of previous taxonomic revisions (De Meyer 1996, 1998, 2000, 2006, 2009; De Meyer and Freidberg 2005, 2006, 2012; White et al. 2003; White 2006; White and Goodger 2009). Scores were transferred into seven separate data sets, imported into LUCID 3.5 (www.lucidcentral.org) and used as the main data sources for the multi-entry identification keys. Species lists and morphological characters were then revised and optimised in order to include only (a) species with valid names under the International Code of Zoological Nomenclature and (b) characters including at least two character states in congeneric species. This generated 7 matrixes with a total of 68352 entries. Additionally, a "pre-key" for genus designation was built *ex novo* by selecting a set of 23 characters that were deemed to be informative for generic separation. A total of 390 taxa were included in seven identification keys for species identification within genus or genus group (*Bactrocera* + *Dacus*, *Capparimyia*, *Carpophthoromyia*, *Ceratitis*, *Neoceratitis*, *Perilampsis*, *Trirhithrum*). For each genus, species of economic importance were assigned to a separate subset (see below).

Different character sets were considered for each genus (range 11-90 characters and 22–204 character states). The complete lists of species, characters, character states and dependencies considered for each key are provided as supplementary files (SF1, SF2). Each character state was scored in LUCID as either "present and common" or "absent" (other options such as "present but rare", "common and misinterpreted" etc. were not implemented). The "not scoped" option was used to generate unfolding keys, *i.e.* keys with characters that are initially not shown but appear only when a pre-defined subset of species remains to be identified. We built unfolding keys whenever character scores were only available for subsets of a maximum of 5 congeneric taxa. Dependencies between characters were also generated. Positive dependencies were defined whenever a character was only meaningful in relation to a previously defined character state (*e.g.* in the *Ceratitis* key, the character "number of frontal setae" is positively dependent from the character state "frontal setae: yes"). Conversely, negative dependencies were generated to discard characters that were not meaningful after a previous character state was selected (*e.g.* in the *Ceratitis* key, the character "females, aculeus tip with small notch" is negatively dependent on the character state "sex: male"). To facilitate identification, characters were grouped into head, thorax, wings, legs and abdomen character sets. The character "sex" was always placed first, in order to reduce the character list by discarding all negative dependencies controlled by the character states "male" and "female".

We considered that the number of morphological characters used in the largest identification keys (*i.e.* keys to *Bactrocera*/*Dacus*, *Ceratitis*, *Trirhithrum*) might also represent an obstacle to non-specialists. Hence, we arbitrarily defined three subsets of characters for these keys including (1) only characters of very straightforward use (included in the subset "step1: use only the most straightforward characters to get a short list of candidate species"), (2) all characters except the ones of most difficult use (subset "step 2: try identification by excluding only the most difficult characters") and (3) all characters, including "easy", "average", and "difficult" ones (subset "step 3: use also difficult characters if step 2 does not bring to species identification"). The user has the possibility of following a three steps identification procedure that considers characters of straightforward use at first, followed by characters of more and more difficult interpretation. This procedure should facilitate identification and reduce the risk of misidentification (particularly if a species can be identified only through step 1 or through step 1 and 2). We also defined a subset for species of economical importance. The use of this subset should speed up the identification of the more commonly trapped / intercepted taxa. When using this subset, identification should be carefully verified *a posteriori* (through the hyperlink to species description, see below) as all the less common species not included in this subset might be erroneously identified as species of economical importance (false positives). Of course, character and species subsets can all be ignored and the user can either arbitrarily score any of the characters available from the full list or use the "best" option provided by the LUCID software which should allow choosing characters with the highest discrimination power (the "best" option can be repeatedly used after eliminating redundant characters through the "prune" option). In any case, being a multi-entry key, the user can always decide either to skip characters, to choose multiple answers whenever he is uncertain about the correct score and/or to restrict the identification only to the most common species.

We tried to make the technical terminology used in the single-entry keys more accessible to non-specialists by adopting a consistent framework of character names and indicating in parentheses alternative names of the same character in the published scientific literature (as it happens for example with the *Ceratitis* subapical / cubital / preapical wing band). We then embedded images that clearly illustrate name and position of each character on the insect body as well as images showing how the same character state looks in different species. An initial set of 2300 images was assembled from the databases of the Royal Museum for Central Africa (RMCA) and of the London Natural History Museum (NHM). Images were grouped according to species name and body part (head, thorax dorsal, thorax lateral, abdomen, wings, legs), divided in groups and, when possible, assigned to each combination of character state and species name. This generated a database of approximately 28000 repeated images (for example, the same thorax image of a particular species was repeatedly used to illustrate postpronotal lobe, scutum and scutellum characters for that species). The large set of embedded images aims at clearly illustrating the morphological variability of the same character state across species. In fact, we consider that many terms used to describe morphological variation (such as "small / large, darker / paler, thicker / thinner etc.") while being straightforward for a tephritid taxonomist (who can rely on the experience accumulated after the examination of large numbers of specimens) are not always clear to non-specialised users. Therefore, we dedicated particular attention to provide multiple images to show, for example, how "narrow" a wing discal band should be, before being considered as "broad" or how "small" a postpronotal spot can be before being scored as "occupying most of postpronotum".

Once a tentative identification is obtained (or when the list of candidate species is reduced to a few taxa), the keys give the possibility of verifying the correspondence between the examined voucher and (1) the species description as it appears in the published scientific literature and (2) images from the RMCA and NHM tephritid collections. Discrepancies between the examined voucher and available images (as it might result from the occurrence of multiple character states for a species) can then be verified through hyperlinks to either the species description or to all character states considered for that species in the LUCID input matrix. Information regarding the taxonomic status, geographic distribution and collection specimens of each taxon is also available through hyperlinks to Encyclopedia of Life (EOL) and to the Belgian Biodiversity Platform (BeBIF, a section of GBIF, the Global Biodiversity Information Facility). Links to the Barcoding of Life Database website (BOLD) allow verifying the availability and geographical coverage of DNA barcodes for each species. In some cases, the available character list will not always allow the unambiguous identification of a taxon (as it happens, for example, with females of the subgenus *Ceratitis* (*Pterandrus*)). Under these circumstances, the direct comparison of species descriptions and distributions is the best strategy to try and resolve the short list of candidate taxa.

The keys can be accessed online (http://keys.lucidcentral.org/keys/v3/fruitflies/) or freely downloaded and used from a computer hard drive (supplementary files SF3-10). The first option is only recommended for a preliminary overview of the key structure, while downloading and running the keys (e.g. from a memory stick used as a removable device) should allow a faster and more effective use of the software. A quick start guide providing basic information about the key functioning is associated to the downloadable version.

Acknowledgments

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Supplementary material 1

List of species, characters and character states considered in each identification key

Authors: Massimiliano Virgilio, Ian White, Marc de Meyer

Data type: multimedia

Link: doi: 10.3897/zookeys.428.7366.app1

Supplementary material 2

List of positive and negative character dependencies in each identification key

Authors: Massimiliano Virgilio, Ian White, Marc de Meyer

Data type: multimedia

Link: doi: 10.3897/zookeys.428.7366.app2

Supplementary material 3

Key to genera

Authors: Massimiliano Virgilio, Ian White, Marc de Meyer

Data type: multimedia

Explanation note: A set of multi-entry identification keys to African frugivorous flies (Diptera, Tephritidae): key to genera.

Link: doi: 10.3897/zookeys.428.7366.app3

Supplementary material 4

Key to *Capparimyia*

Authors: Massimiliano Virgilio, Ian White, Marc de Meyer

Data type: multimedia

Explanation note: A set of multi-entry identification keys to African frugivorous flies (Diptera, Tephritidae): key to *Capparimyia.*

Link: doi: 10.3897/zookeys.428.7366.app4

Supplementary material 5

Key to *Carpophthoromyia*

Authors: Massimiliano Virgilio, Ian White, Marc de Meyer

Data type: multimedia

Explanation note: A set of multi-entry identification keys to African frugivorous flies (Diptera, Tephritidae): key to *Carpophthoromyia*.

Link: doi: 10.3897/zookeys.428.7366.app5

Supplementary material 6

Key to *Ceratitis*

Authors: Massimiliano Virgilio, Ian White, Marc de Meyer

Data type: multimedia

Explanation note: A set of multi-entry identification keys to African frugivorous flies (Diptera, Tephritidae): key to *Ceratitis.*

Link: doi: 10.3897/zookeys.428.7366.app6

Supplementary material 7

Key to *Dacus* and *Bactrocera*

Authors: Massimiliano Virgilio, Ian White, Marc de Meyer

Data type: multimedia

Explanation note: A set of multi-entry identification keys to African frugivorous flies (Diptera, Tephritidae): key to *Dacus* and *Bactrocera*.

Link: doi: 10.3897/zookeys.428.7366.app7

Supplementary material 8

Key to *Neoceratitis*

Authors: Massimiliano Virgilio, Ian White, Marc de Meyer

Data type: multimedia

Explanation note: A set of multi-entry identification keys to African frugivorous flies (Diptera, Tephritidae): key to *Dacus* and *Neoceratitis*.

Link: doi: 10.3897/zookeys.428.7366.app8

Supplementary material 9

Key to *Perilampsis*

Authors: Massimiliano Virgilio, Ian White, Marc de Meyer

Data type: multimedia

Explanation note: A set of multi-entry identification keys to African frugivorous flies (Diptera, Tephritidae): key to *Dacus* and *Perilampsis*.

Link: doi: 10.3897/zookeys.428.7366.app9

Supplementary material 10

Key to *Trirhithrum*

Authors: Massimiliano Virgilio, Ian White, Marc de Meyer

Data type: multimedia

Explanation note: A set of multi-entry identification keys to African frugivorous flies (Diptera, Tephritidae): key to *Dacus* and *Trirhithrum*

Link: doi: 10.3897/zookeys.428.7366.app10

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RESEARCH ARTICLE

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A new species of *Chiasmocleis* (Microhylidae, Gastrophryninae) from the Atlantic Forest of Espírito Santo State, Brazil

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Abstract

Among Neotropical microhylids, the genus *Chiasmocleis* is exceptionally diverse. Most species of *Chiasmocleis* were described in recent years based on external morphology, but recent studies using molecular data did not support the monophyly of the species groups clustered based on feet webbing. Furthermore, a phylogeographic study of *C. lacrimae* estimated high genetic divergence and low gene flow among populations across small geographic ranges. Increasing the molecular and geographic sampling, and incorporating morphological data, we identified new cryptic species. Herein, we used novel genetic and morphological data to describe a new species of *Chiasmocleis*.

Keywords

Amphibians, *Chiasmocleis quilombola* sp. n., cryptic species, phylogenetics, systematics

Introduction

The diversity of evolutionary lineages with little phenotypic differences (i.e., cryptic species) might be better understood in the light of genetic delimitation of evolutionary units (Thomé et al. 2012, Hambäck et al. 2013). Recent molecular phylogenies of anuran, including work on species from the Brazilian Atlantic Forest, did not recovered as monophyletic the species groups clustered based mostly on morphology (Amaro et al. 2009, Canedo and Haddad 2012, Fouquet et al. 2012, Thomé et al. 2012).

Species are segments of population level evolutionary lineages and do not necessarily need to be phenetically distinguishable, diagnosable, monophyletic, intrinsically reproductively isolated, ecologically divergent, or anything else to be considered species, but they only have to be evolving separately from other lineages (de Queiroz 1998, de Queiroz 2007).

A recent molecular phylogeny (de Sá et al. 2012) recovered a polyphyletic *Chiasmocleis* and, to render the genus monophyletic, transferred one species to *Elachistocleis* and three species to *Syncope*. Recently, Peloso et al. (2014) placed *Syncope* in the synonymy of *Chiasmocleis*. *Chiasmocleis* is the most diverse genus of Neotropical microhylids, with 29 species distributed throughout Amazonia, Atlantic Forest, and open areas in South America, such as the Brazilian Cerrado and the Chaco of Bolivia and Paraguay (Cruz et al. 1997, de Sá et al. 2012, Peloso et al. 2014).

Tonini et al. (2013) in a phylogeographic analysis estimated high genetic divergence and low gene flow among populations of *Chiasmocleis lacrimae* (described as *C. carvalhoi* Cruz et al. 1997) in the Brazilian Atlantic Forest. Samples of two potential new species and of "*C. capixaba*" with less feet webbing were included as populations of *C. lacrimae*. Moreover, the study suggested that populations isolated-by-distance could represent recently diversified species, estimated to Miocene and Pliocene. Increasing the sampling along the distribution of *C. lacrimae* and *C. capixaba* and using additional molecular and morphological data, we were able to differentiate the phylogenetic structure and morphological differences associate to intraspecific and interspecific variation. We found that *C. lacrimae* and *C. capixaba* were not recovered as monophyletic, in fact populations corresponding to undescribed distinct evolutionary lineages. Although these undescribed lineages have similar body size and shape, and low nuclear divergence, they are exceptionally divergence in mitochondrial markers and are geographically structured.

Herein, we describe a new species of *Chiasmocleis* from the Atlantic Forest of southeastern Brazil and present a phylogenetic hypothesis for the species group.

Material and methods

Specimens and tissues used herein and comparative material are deposited in the following collections: 1) CFBH: Coleção de Anfíbios Célio Fernando Baptista Haddad, Departamento de Zoologia, Universidade Estadual Paulista Rio Claro, Rio Claro, São Paulo State, Brazil; 2) MNRJ: Museu Nacional do Rio de Janeiro, Rio de Janeiro, Rio de Janeiro State, Brazil; 3) Museu de Zoologia, Universidade de São Paulo, São Paulo, São Paulo State, Brazil; 4) MBML: Museu de Biologia Mello Leitão, Santa Teresa, Espírito Santo State, Brazil; 5) CTA: Coleção de Tecidos e DNA da Universidade Federal do Espírito Santo (UFES) and LGA: Laboratório de Genética Animal, Vitória, Espírito Santo State, Brazil; 6) RN and CTRN: Universidade Federal Rural do Rio de

Janeiro, Seropédica, Rio de Janeiro State, Brazil. Field numbers correspond to M. T. Rodrigues (MTR), Universidade de São Paulo, São Paulo, São Paulo State, Brazil; P. Rocha (PEU), Universidade Federal da Bahia, Salvador, Bahia State, Brazil; and J. F. R. Tonini (JFRT), vouchers are at UFES. Specimens examined and tissues samples are listed in Appendix 1 and 2, respectively, and sample localities are shown in Figure 1.

The following measurements were adapted from Duellman (2001) and Peloso and Sturaro (2008); measurements were taken for 56 individuals with a digital caliper under a stereomicroscope to the nearest 0.1 mm: SVL (snout-vent length); HDL (hand length; from the base of the thenar tubercle to the tip of the third finger); HDL4 (hand length from the base of the thenar tubercle to the tip of the fourth finger); HL (head length; from snout to angle of the jaw); HW (head width; between the angle of jaws); ED (eye diameter; between anterior and posterior corner of the eye); IOD (inter-orbital distance; distance between anterior corner of the eyes); IND (inter-nostril distance); END (eye-nostril distance; from the anterior corner of the eye to the posterior margin of nostril); THL (thigh length; from the center of the cloaca opening to the outer edge of the flexed knee); TBL (tibia length; from the outer edge of the flexed knee to the heel); FAL (forearm length); FL (foot length; from tibia-tarsal articulation to tip of fourth toe); 3FD (diameter of third finger disk); 4TD (diameter of fourth toe disk). Fingers and toes are numbered and abbreviated as follows: Fingers I–IV = FI–IV, Toes I–V = TI–V.

Molecular Analyses: Total genomic DNA was extracted from ethanol-preserved liver or muscle tissues using Qiagen DNeasy kit (Valencia, California, USA). We used four molecular markers (mtDNA: 12S, 16S, and NADH dehydrogenase subunit 2 [ND2]; nucDNA: brain-derived neurotrophic factor [BDNF]), amplified using previously published primer sets and PCR profiles (de Sá et al. 2012, Tonini et al. 2013). We performed a multiple loci alignment using an iterative procedure to compute a series of alignment/tree pairs in SATé-II (Liu et al. 2012), using default settings. GenBank accession numbers are given in Appendix 2.

The following outgroup were chosen based on published phylogenies including species of *Chiasmocleis* (de Sá et al. 2012): *C. leucosticta*, *C. mantiqueira*, *C. crucis*, *C. schubarti,* and *C. cordeiroi*. We selected a total of 100 samples (ingroup includes 69 samples) for a data set consisting of 2,473 base pairs. The best partition schemes and substitution models (Table 1) were chosen using PARTITION FINDER v1.1.1 (Lanfear et al. 2012) and used in phylogenetic analysis downstream.

We applied two approaches of phylogenetic estimation: 1) Maximum Likelihood (ML) and 2) Bayesian inference (BI) using the dataset containing the markers 12S, 16S, ND2, and BDNF. Maximum Likelihood in RAXML v7.2.8 (Stamatakis 2006) used a rapid-bootstrap with 1000 replications. Bayesian Inference in BEAST v1.7.4 (Drummond et al. 2012) used birth-death process as tree prior, linked tree models across partition, relaxed clock model with linked mitochondrial markers, but not the nuclear gene. The BI analysis ran for 50 million generations and the parameters were sampled every 5,000 generations producing a total of 10,000 trees. We discarded the first 1,000 trees as burnin in TREEANOTATOR. The output file was checked using TRACER v1.5

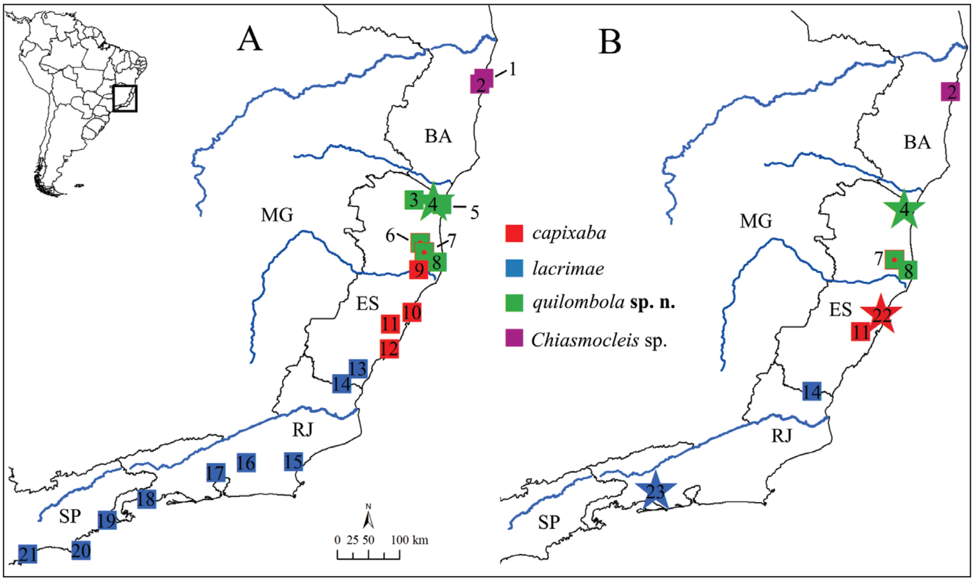

Figure 1. Sample localities of **A** tissues and **B** specimens included in the present study. Sites with more than one color indicates syntopy. List of localities: **1** Porto Seguro, **2** Trancoso, **3** ReBio Córrego Veado, **4** FloNa do Rio Preto (type locality of *C. quilombola* sp. n.), **5** Parque Estadual de Itaúnas, **6** ReBio Sooretama, **7** Reserva Natural Vale, **8** Povoação, **9** FloNa dos Goytacazes, **10** Costa Bela, **11** ReBio Duas Bocas, **12** Guarapari, **13** Mata da Usina Paineiras, **14** Mimoso do Sul, **15** ReBio União, **16** Cachoeiras de Macacu, **17** Duque de Caxias, **18** Angra dos Reis, **19** Picinguaba, **20** Ilha de São Sebastião, **21** Bertioga, **22** Aracruz (type locality of *C. capixaba*), **23** Horto Florestal (type locality of *C. lacrimae*). Blue lines represent major coastal rivers, from North to South: Jequitinhonha, Mucuri, Doce, and Paraíba do Sul. BA = Bahia State, ES = Espírito Santo State, RJ = Rio de Janeiro State, SP = São Paulo State, and MG = Minas Gerais State.

Table 1. Best partition scheme and substitution models selected using Partition Finder.

Subset	Best Model	Subset partitions	Subset sites
1	HKY+I+G	12S	1–700
2	HKY+G	16S, ND2_1	701–1044, 1661–2473\3
3	K80+I	BDNF	1045–1660
4	HKY+G	ND2_2	1662–2473\3
5	GTR+G	ND2_3	1663–2473\3

and values of Effective Sample Size >200 were considered suitable. Nodes having bootstrap values >70 in ML and posterior probabilities >0.95 in BI were considered as well supported. Analyses were performed through Cipres (Miller et al. 2010) and trees were visualized and edited using FIGTREE. Data available from the Dryad Digital Repository: http:// 10.5061/dryad.gm41t. Genetic distance (p-uncorrected) was calculated in MEGA5.0 (Tamura et al. 2011). A second species awaits description (Forlani et al. *submitted*) and it is referred throughout this manuscript as *Chiasmocleis* sp.

Results

The phylogenetic hypotheses generated through ML (Figure 2) and the BI (Figure 3) resulted in similar topology. The ML tree (Figure 2) supported two new species as sister group of *C. capixaba*, *C. lacrimae* correspond to a basal node; whereas in the BI tree (Figure 3) *C. capixaba* was estimated as sister to *C. lacrimae*, but the posterior probability of this node was lower than 0.95. Both the ML and BI trees showed clades of *C. leucosticta*, *C. mantiqueira*, *C. crucis*, *C. schubarti*, and *C. cordeiroi*, but not *C. lacrimae* and *C. capixaba* (Figure 2, 3). Populations of *C. capixaba* and *C. lacrimae* from the north of the Espírito Santo State, as well as populations of *C. lacrimae* from southern areas of the Bahia State, would represent two new cryptic lineages closely related to *C. lacrimae* and *C. capixaba*. In the ML analysis populations from southern Espírito Santo formed a clade that makes *C. lacrimae* polyphyletic (Figure 2), whereas in the BI these populations formed a clade including also populations of *C. lacrimae* from the states of São Paulo and Rio de Janeiro (Figure 3). However, given the lack of support for this node in both analyses, basing taxonomic change on the presumed polyphyly is not warranted at present.

Therefore, our results show that the new species clusters within the genus *Chiasmocleis*.

Description of a new species

***Chiasmocleis quilombola* sp. n.**
http://zoobank.org/81CD38A6-72C6-4CAF-A4AC-45C011459A0E
Figure 4

Holotype. MZUSP147478, adult male, collected at the Floresta Nacional do Rio Preto (Figure 4A), Municipality of Conceição da Barra, Espírito Santo State, Brazil (18°21'19"S; 39°50'39"W), collected on December 8-16, 2009, by L. P. Costa, J. F. R. Tonini, J. Dalapicolla, R. Duda, and C. M. Mattedi.

Paratopotypes. Males: MZUSP147471–73, MZUSP147475–76, MZUSP147494; female: MZUSP147479 (Figure 4B), Municipality of Conceição da Barra, Espírito Santo State, Brazil (18°21'19"S; 39°50'39"W), collected on December 8-16, 2009, by L. P. Costa, J. F. R. Tonini, J. Dalapicolla, R. Duda, and C. M. Mattedi.

Diagnosis. A small-sized species of *Chiasmocleis* (males SVL mean= 14 ± 1.4 mm; female SVL = 17.1 mm), diagnosed by the following combination of characters: (1) body slender; (2) snout rounded in lateral and dorsal views; (3) all fingers slightly fringed, not webbed, in males and female; (4) all toes fringed and slightly webbed in males and female; (5) dermal spines on fingers and toes of males can be present or absent, absent in female; (6) dermal spines on dorsal surface of males can be present or absent, absent in female; (7) dermal spines absent on ventral surface in males and female; (8) dermal spines on chin and snout of males can be present or absent, absent in female; (9) dermal spines over outer surfaces of legs and cloaca in males can be present

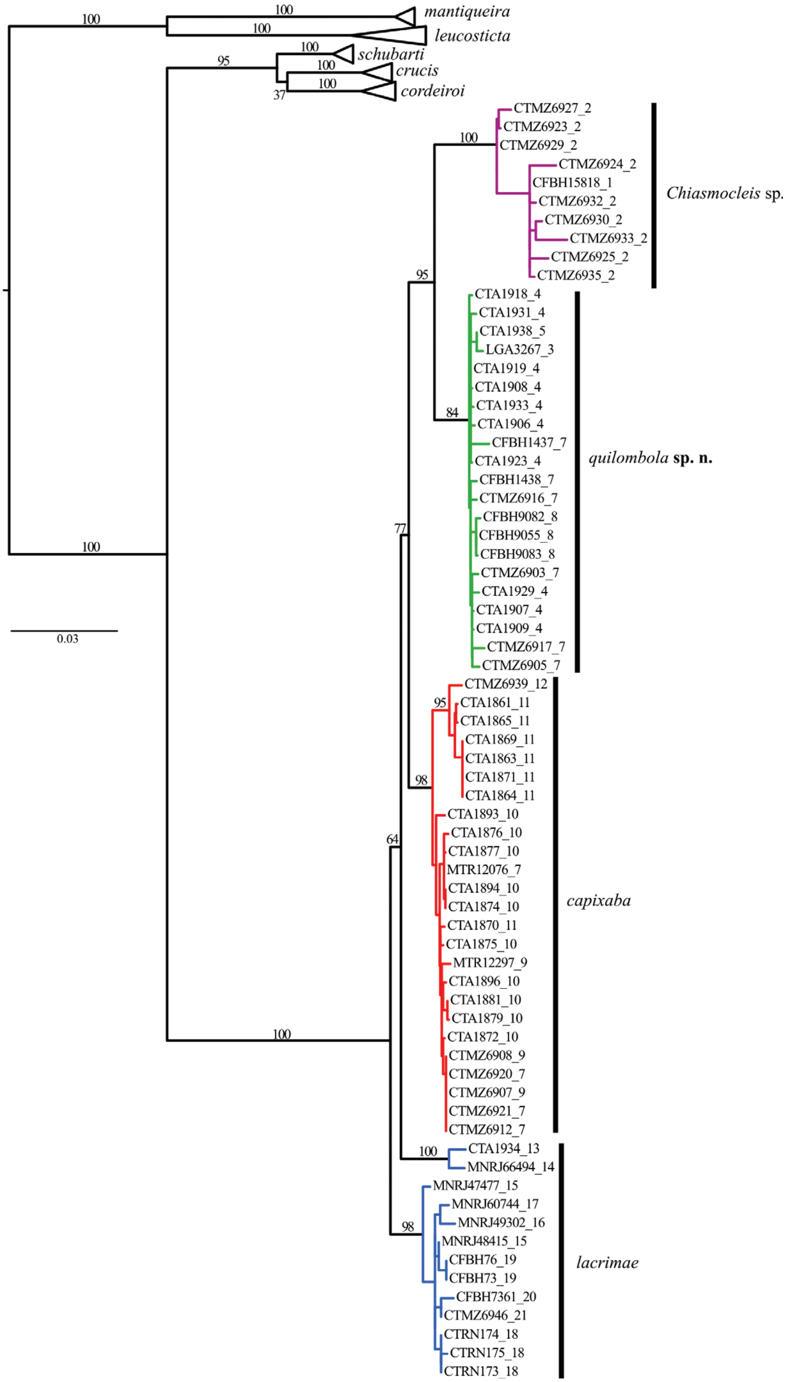

Figure 2. Maximum likelihood tree including 12S, 16S, ND2, and BDNF. Node numbers correspond to bootstrap, values >70 indicate good support. Although *C. lacrimae* may not represent a monophyletic species, bootstrap values are low to make further assumptions. Numbers after underscore symbol correspond to localities present in Figure 1. Scale bar represents number of substitutions/site.

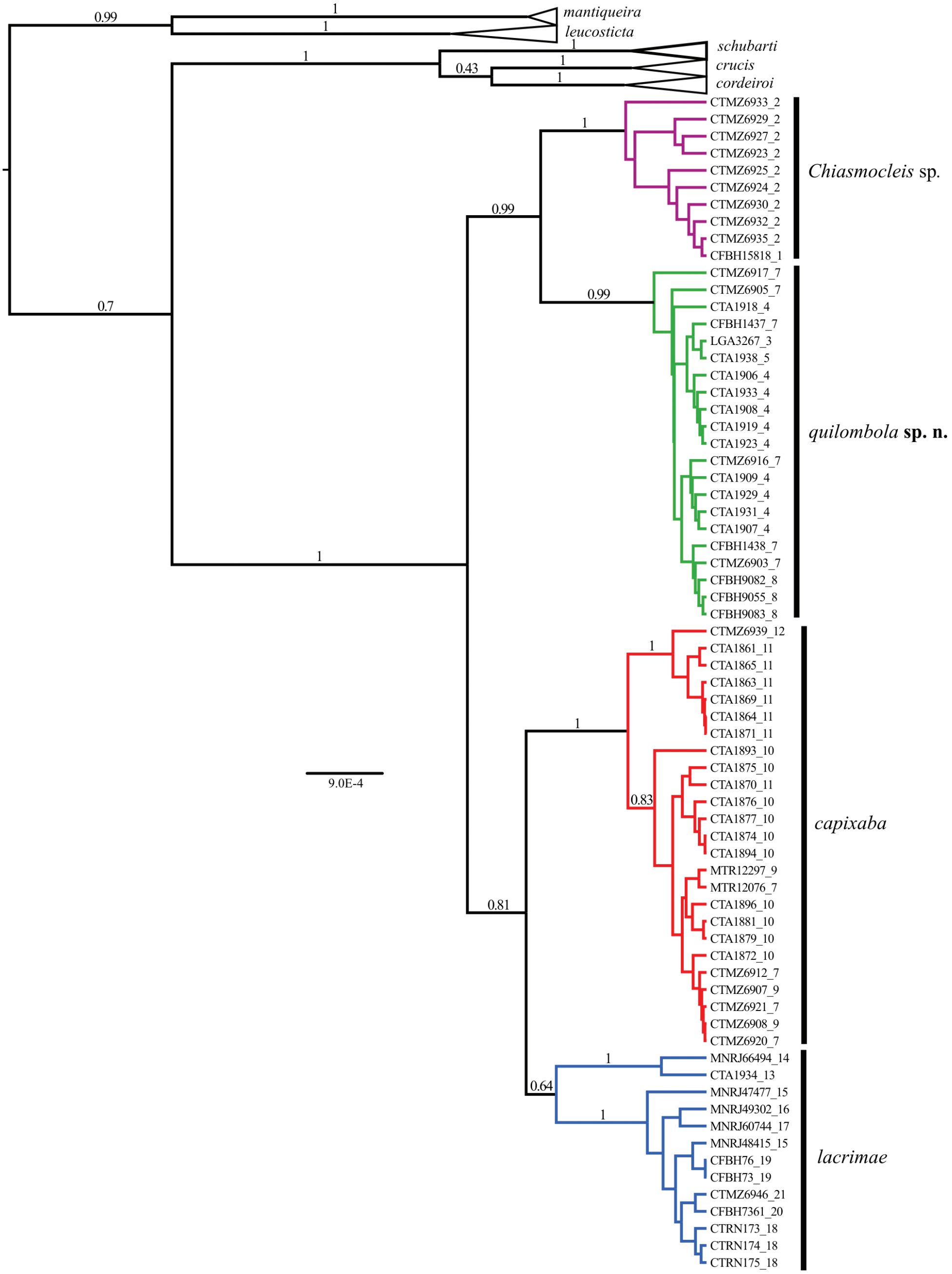

Figure 3. Phylogenetic hypothesis obtained through Bayesian Inference using 12S, 16S, ND2, and BDNF. Node numbers correspond to posterior probabilities, values >0.95 indicate good support. Numbers after underscore symbol correspond to localities present in Figure 1. Scale bar represents number of substitutions/site.

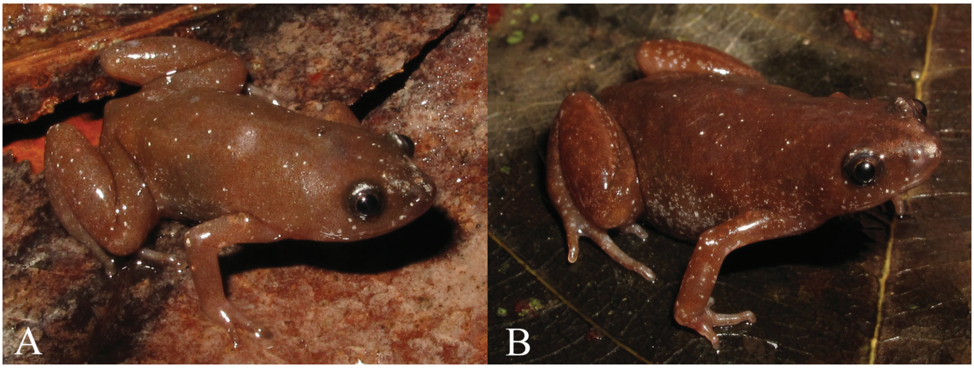

Figure 4. *Chiasmocleis quilombola* sp. n. *in vivo*. **A** male (holotype: MZUSP147478) and **B** female (MZUSP147479, paratopotype). Not in scale.

or absent, absent in female; (10) female has para-cloacal glands; (11) incomplete occipital fold; (12) vocal slits present in males; (13) dorsal coloration brown; (14) medial ventral body surface light cream colored, whereas ventrolateral surfaces have a light brown and cream marbled pattern; (15) ventral surfaces of fore and hind limbs with a homogeneously and finely dark pattern over a cream background; (16) dorsal surface of fore and hind limbs light brown with a few cream spots or blotches, more distinct on the fore limbs; (17) male throat infuscate; (18) mid-dorsal and/or line on posterior surface of thighs may be present; and (19) tympanum indistinct.

Description of holotype. Body small (SVL = 15.7 mm), slender, slightly ovoid (Figure 5); head triangular in shape, broader than long; snout short, tip of snout rounded (Figure 5A–B); nostrils located closer to the tip of snout than to eye, not protuberant, directed laterally (Figure 5C); inter-nostril distance smaller than eye–nostril distance and smaller than eye diameter; canthus rostralis slightly defined; loreal region slightly convex; lips not flared; eyes small, slightly protruding; inter-orbital area flat; incomplete occipital fold; tympanum indistinct; upper jaw projecting beyond lower one; tongue large, elongate, and laterally free; premaxillae, maxillae, and vomerine teeth absent; choanae small, rounded, widely separated, positioned anterolaterally to eye; vocal slit present.

Arms slender, lacking tubercles on forearm. Hands not webbed (Figure 5D); fingers tips rounded, not expanded, and slightly fringed; fingers lacking dermal spines; finger lengths I<II<IV<III; thumb without nuptial asperities; subarticular tubercles well developed and rounded, proximal subarticular tubercles larger than others; supernumerary tubercles absent; thenar tubercle well developed, ovoid, and at the base of finger I; two palmar tubercles, a rounded inner tubercle and an elongated outer one (Figure 5D). Legs short, moderately robust; knee and heel lacking tubercles; tibial and tarsal ridges absent. Foot slightly webbed (Figure 5A–B, E); toes slightly fringed; toe tip rounded lacking disks; subarticular tubercles well developed, ovoid; supernumerary tubercles absent; an oval inner, but no outer, metatarsal tubercle. Toe lengths I<II<V<III<IV; toes lacking dermal spines; tibia length slightly shorter than thigh

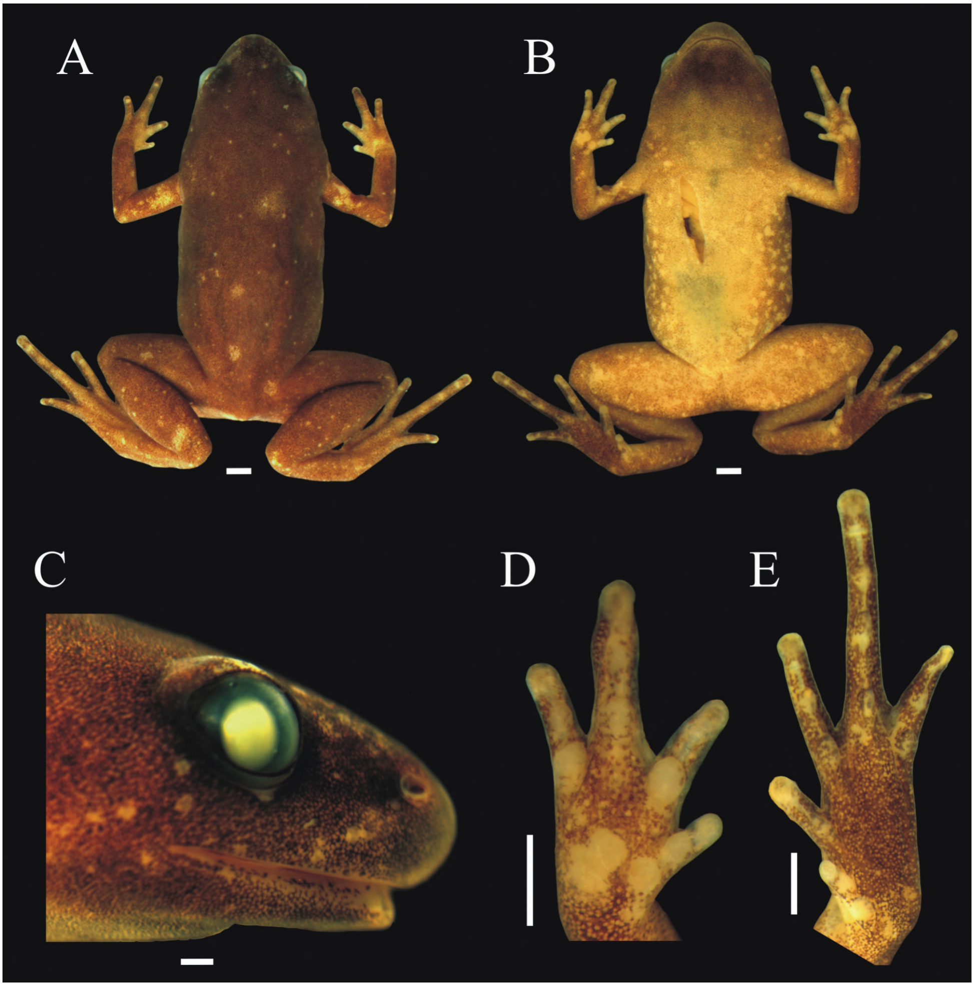

Figure 5. Holotype of *C. quilombola* sp. n. (MZUSP 147478). **A** Dorsal **B** ventral, and **C** lateral views **D** right hand and **E** right foot. White bars = 1 mm.

length; combined thigh and tibia lengths approximately 82.8% of snout-vent length; foot length approximately 43.9% of snout-vent length.

Skin smooth, dorsal surfaces of body lacking dermal spines. Throat black and few dermal spines found on chin and snout (Figure 5B). Cloaca lacks para-cloacal tubercles or glands.

Coloration in preservative. Dorsum dark brown with a few small cream spots and blotches; dorsal surface of limbs dark brown with cream blotches and small spots, particularly on the proximal forelimb; palm of hands marbled brown and pale cream, foot dark brown; belly surface cream, dorsolateral and ventral surfaces with a marbled pale brown and cream pattern; throat dark brown to black. Ventral surface of thighs light brown with a finely reticulated dark pattern over a cream background cream with

Table 2. Morphometric measurements (mm) of the type series of *C. quilombola* sp. n.

Specimen	Type	Sex	SVL	HL	HW	ED	IOD	IND	END	THL	TBL	FL	3FD	4TD	FAL	HDL	HDL4
MZUSP147471	Paratype	Male	14.4	2.8	3.8	1.0	2.6	1.1	1.5	6.1	6.3	6.2	0.3	0.3	3.0	2.8	1.8
MZUSP147472	Paratype	Male	15.3	2.8	4.1	1.3	2.7	1.2	1.3	7.1	6.6	6.6	0.3	0.4	3.2	3.4	2.2
MZUSP147473	Paratype	Male	16.1	3.2	3.9	1.1	2.2	1.1	1.3	6.0	6.0	6.4	0.2	0.2	3.2	3.3	2.1
MZUSP147475	Paratype	Male	14.5	2.8	4.6	1.3	2.6	1.3	1.3	6.6	6.4	6.7	0.4	0.4	3.3	3.5	2.2
MZUSP147476	Paratype	Male	16.1	2.7	4.4	1.2	2.7	1.3	1.4	6.7	6.3	6.1	0.3	0.5	3.0	3.3	1.8
MZUSP147478	Holotype	Male	15.7	2.8	4.5	1.3	2.8	1.1	1.3	6.6	6.5	6.9	0.4	0.4	3.2	3.5	2.3
MZUSP147494	Paratype	Male	16.6	3.1	4.6	1.4	2.6	1.2	1.4	7.0	6.9	7.6	0.3	0.4	3.3	3.8	2.4
MZUSP147479	Paratype	Female	17.2	2.9	4.6	1.3	2.9	1.3	1.4	6.7	6.6	6.8	0.3	0.4	3.3	3.5	2.3

Abbreviations: SVL = snout-vent length; HDL = hand length; HDL4 = hand length from the base of the thenar tubercle to the tip of the fourth finger; HL = head length; HW = head width; ED = eye diameter; IOD = inter-orbital distance; IND = inter-nostril distance; END = eye-nostril distance; THL = thigh length; TBL = tibia length; FAL = forearm length; FL = foot length; 3FD = diameter of third finger disk; 4TD = diameter of fourth toe disk. For tissues numbers see Appendix 2.

Figure 6. Larissa Gaigher and Dr. Yuri Leite inspecting pitfall traps installed at the type locality of *C. quilombola* sp. n., Floresta Nacional do Rio Preto, Municipality of Conceição da Barra, Espírito Santo State, Brazil.

a few cream spots more evident close to the edges; ventral surfaces of tibia and tarsus finely marbled in light brown with cream, lighter than the dorsal surface. Absence of distinct lines on the body and limbs.

Measurements of holotype (in mm)**.** SVL 15.7; HDL 3.4; HDL4 2.3; HL 2.7; HW 4.5; ED 1.3; IOD 2.8; IND 1.1; END 1.2; THL 6.5; TBL 6.4; FL 6.9, FAL 3.2; 3FD 0.3; 4TD 0.4.

Variation in the type series. Measurements data of the type series are given in Table 2 and information of the comparative material are provided in Appendix 1. Overall, the type series agrees with the holotype coloration; one specimen has a mid-dorsal line and a line on the posterior surface of the thighs and also more dermal spines (MZUSP147475). The incomplete occipital fold varied from indistinct to weakly visible laterally (= incomplete). The combined mean thigh and tibia length represents approximately 81% of mean snout-vent length in males, and 77.7% in females; foot length approximately 41.6% of snout-vent length in males and 39.7% in females.

Etymology. The specific epithet *quilombola* refers to people who inhabit quilombo communities. Historically, quilombos were communities constituted by and used as refuges for escaped slaves between 1530 and 1815 during colonial Portuguese rule in Brazil. Nowadays in the north of Espírito Santo Estate quilombola communities still remain and maintain alive their traditions, such as quilombola food and craftwork. This species' name is indeclinable.

Distribution. *Chiasmocleis quilombola* sp. n. is known from localities between the Doce River and the Mucuri River, e.g., Floresta Nacional do Rio Preto and Parque Estadual de Itaúnas, Municipality of Conceição da Barra; Reserva Biológica Córrego Veado, Municipality of Pinheiros; Reserva Natural, Reserva Biológica de Sooretama, and Cocoa plantations in Povoação, Municipality of Linhares (Appendix 2). The populations assigned to *C. lacrimae* and *C. capixaba* at northernmost of Espírito Santo State are allocated to the new taxon *C. quilombola* sp. n. (Figure 1).

Natural history. *Chiasmocleis quilombola* sp. n. was collected in pitfall traps after heavy rains at Floresta Nacional do Rio Preto (Figure 6). The lines of pitfalls were installed at the vicinity of a permanent lagoon and a temporary swamp. The Floresta Nacional do Rio Preto has 2,830 ha and an elevation between five to 50 m above the sea level. The soil is typical of coastal areas, mostly sand. The area consists of secondary forested areas and plantations with few remnants of primary Atlantic Forest.

Discussion

Chiasmocleis quilombola sp. n. has been misidentified as *C. lacrimae* and *C. capixaba* due to an overlap in feet webbing and body size (e.g., Tonini et al. 2013, see below). *Chiasmocleis quilombola* sp. n. corresponds to clade N2, *Chiasmocleis* sp. to clade N1, *C. capixaba* to central clade, and *C. lacrimae* to southern clades of Tonini et al. (2013). Our morphological observations and comparisons with other species combined with molecular information support *C. quilombola* sp. n. and *C.* sp. as separate evolutionary lineages (see below and Figure 1, 2). Low levels of genetic divergence in the BDNF (Table 3) between *C. quilombola* sp. n. and closely related species is consistent with recent cladogenetic events and supports a previous study that estimated initial speciation within this clade (i.e., *C. lacrimae*, *C. capixaba*, *C. quilombola* sp. n., and *Chiasmocleis* sp.) during the Miocene/Pliocene (Tonini et al. 2013). *Chiasmocleis quilombola* sp. n. and *Chiasmocleis* sp. corresponds to an earlier lineage split dated to approximately the Pliocene/Pleistocene (Tonini et al. 2013).

Chiasmocleis quilombola sp. n. is distinct from *C. schubarti* (species with which occurs in sympatry) in having smaller snout-vent length, feet slightly webbed, cream ventral surface, and marbled light brown and cream dorsolateral pattern instead of larger snout-vent length, absence of feet webbing and belly pattern roughly marbled in dark brown and light cream in *C. schubarti* (Cruz et al. 1997). *Chiasmocleis quilombola* sp. n. is most similar to *C. lacrimae* and *C. capixaba,* species with which it has been previously confused (e.g. Tonini et al. 2013). However, the new species is distinguished from closely relatives by the following set of characters: 1) a smaller body size, shorter head length, shorter thigh and tibia compared to *C. lacrimae*, *C. capixaba*, and *C.* sp. (Table 4), 2) smaller eye diameter, inter-orbital distance, inter-nostril distance, diameter of third finger disk, and diameter of fourth toe disk than *C. capixaba*, 3) smaller

Table 3. Genetic distance (p-uncorrected) in the BDNF (upper-right) and in the ND2 (lower-left) among *Chiasmocleis quilombola* sp. n. and sister species. Values at the diagonal correspond to the genetic distance within species in the ND2.

Species	*capixaba*	*lacrimae*	*cordeiroi*	*crucis*	*quilombola* sp. n.	*schubarti*	*Chiasmocleis* sp.
capixaba	**0.015**	0.001	0.008	0.008	0.001	0.007	0.003
lacrimae	0.064	**0.044**	0.008	0.008	0.001	0.007	0.003
cordeiroi	0.211	0.227	**0.013**	0.005	0.008	0.004	0.007
crucis	0.182	0.198	0.108	**0.015**	0.008	0.005	0.007
quilombola sp. n.	0.071	0.082	0.217	0.209	**0.006**	0.007	0.004
schubarti	0.206	0.204	0.107	0.103	0.22	**0.017**	0.007
Chiasmocleis sp.	0.098	0.104	0.253	0.237	0.083	0.236	**0.023**

eye-nostril distance, feet length, hand length, and hand length to the tip of the fourth finger than *C. lacrimae*. Moreover, males of *C. quilombola* sp. n. have less webbing on the foot (more extensive web on the foot in *C. capixaba*, absent in *Chiasmocleis* sp., and ranging from little to absent in *C. lacrimae*; Cruz et al. 1997, Peloso et al. 2014, Forlani et al. *submitted*). The new species has slender arms, legs, finger, and toes (robust arms and legs in *C. lacrimae*; thick fingers and toes in *C. capixaba*), as well as smaller and less abundant dermal spines in males (spines larger and abundant in *C. lacrimae*; abundant in *C. capixaba*). Males of *C. quilombola* sp. n. posses less amount of fringes between fingers II and III and a slender third finger than males *C. capixaba.*

Chiasmocleis quilombola sp. n. are distinguished from other *Chiasmocleis* species by: 1) four externally evident fingers and five toes distinguishes it from *C. antenori*, *C. carvalhoi*, and *C. tridactyla* (digit reduction; Walker 1973, Nelson 1975, Duellman and Mendelson 1995); 2) a shorter snout-vent length differentiate it from *C. alagoanus*, *C. albopunctata*, *C. anatipes*, *C. atlantica*, *C. avilapiresae*, *C. bassleri*, *C. centralis*, *C. cordeiroi*, *C. crucis*, *C. devriesi*, *C. hudsoni*, *C. leucosticta*, *C. magnova*, *C. mehelyi*, *C. papachibe*, *C. royi*, *C. sapiranga*, *C. shudikarensis*, *C. supercilialba*, and *C. ventrimaculata* (larger snout-vent length; Dunn 1949, Bokermann 1952, Walker and Duellman 1974, Caramaschi and Pimenta 2003, Cruz et al. 1997, Cruz et al. 1999, Caramaschi and Cruz 1997, Cruz et al. 2007a, Moravec and Köhler 2007, Peloso and Sturaro 2008, Funk and Cannatella 2009, Morales and McDiarmid 2009, Peloso et al. 2014); 3) small feet webbing of males and females distinguish the new species from *C. cordeiroi*, *C. leucosticta*, *C. mantiqueira*, and *C. sapiranga* (more extensive webbed feet in males and females; Cruz et al. 1997, Cruz et al. 2007a,b); 4) a light cream belly pattern without dark spots distinguished it from *C. alagoanus*, C. *atlantica*, *C. haddadi*, *C. leucosticta,* and *C. mantiqueira* (belly pattern roughly marbled in dark brown and pale cream, Cruz et al.1997, Cruz et al.1999, Cruz et al. 2007b, Peloso et al. 2014); and 5) snout rounded and belly light cream colored differentiate it from *C. gnoma* (snout truncate and belly boldly marbled in brown and pale cream; Canedo et al. 2004).

Chiasmocleis quilombola sp. n. occurs in sympatry with *C. schubarti* at the Floresta Nacional do Rio Preto, Municipality of Conceição da Barra, and at the Reserva Biológica Córrego Veado, Municipality of Pinheiros; it also occurs with *C. capixaba* and *C. schu-*

Table 4. Differences between *Chiasmocleis capixaba*, *C. lacrimae*, *C. quilombola* sp. n., and *Chiasmocleis* sp.

Species	***capixaba***	***lacrimae***	***quilombola* sp. n.**	***Chiasmocleis* sp.**
capixaba	SVL=15.1 (SD 0.6) HL=2.8 (SD 0.1) THL=6.2 (SD 0.3) TBL=6.1 (SD 0.3)	Feet webbing	head length; thickness of limbs, fingers, and toes; dermal spines	Feet webbing; thickness of limbs; dermal spines
lacrimae	mtDNA (ND2: 6.4%, 16S: 1.3%, 12S: 1.8%) nuDNA (BNDF: haplotype sharing)	SVL=16.1 (SD 0.9) HL=3.3 (SD 0.2) THL=6.6 (SD 0.4) TBL=6.5 (SD 0.3)	head and limb length; feet webbing; thickness of limbs; dermal spines	body size; thickness; dermal spines
quilombola sp. n.	mtDNA (ND2: 7.1%, 16S: 0.8%, 12S: 1.1%) nuDNA (BNDF: haplotype sharing)	mtDNA (ND2: 8.2%, 16S: 0.8%, 12S: 1.8%) nuDNA (BNDF: haplotype sharing)	SVL=14 (SD 1.4) HL=2.6 (SD 0.2) THL=5.8 (SD 0.7) TBL=5.6 (SD 0.6)	Feet webbing; thickness of limbs
Chiasmocleis sp.	mtDNA (ND2: 9.8%, 16S: 2.2%, 12S: 1.2%) nuDNA (BNDF: no haplotype sharing)	mtDNA (ND2: 10%, 16S: 2.3%, 12S: 2.1%) nuDNA (BNDF: no haplotype sharing)	mtDNA (ND2: 8.3%, 16S: 1.6%, 12S: 2.1%) nuDNA (BNDF: haplotype sharing)	SVL=15.3 (SD 0.7) HL=3.4 (SD 0.1) THL=6 (SD 0.3) TBL=6.2 (SD 0.3)

SVL snout-vent length; HL head length; THL tight length; TBL tibia length; SD standard deviation.

barti at the Reserva Natural Vale, Reserva Biológica de Sooretama, and at Cocoa plantations in Povoação, sites in the Municipality of Linhares. The new species is allopatric to *Chiasmocleis* sp. and *C. lacrimae* (Figure 1). We did not have access to tissues samples of *C. capixaba* from Nova Viçosa, Bahia State (Van Sluys 1998), to include in the genetic analysis, thus the phylogenetic relationship of this population remains unclear.

Cryptic species have challenged our ability to assess current levels of biodiversity. Anuran taxonomy has used various data sources to describe the species diversity, e.g., advertisement calls, external morphology, osteology, tadpoles, ecology, molecular data, karyotypes (Duellman and Trueb 1986, Haas 2003). However, *Chiasmocleis* systematics has been based on external morphology from adults and behavioral information (Wogel et al. 2004, Hartmann et al. 2002, Nascimento and Skuk 2006, Oliveira Filho and Giaretta 2006, Langone et al. 2007, Peloso and Sturaro 2008, Rodrigues et al. 2008, Santana et al. 2012, but see Peloso et al. 2014). Sexual dimorphism in size, amount of webbing, and color pattern have been useful characters to diagnose species (Cruz et al. 1997). Recent molecular studies 1) demonstrated the non-monophyly of traditionally recognized species groups (de Sá et al. 2012, Peloso et al. 2014) and 2) reported high genetic divergences and low gene flow along small geographical scales, suggesting that some populations could represent new species (Tonini et al. 2013). Given the current overall biodiversity crisis and specifically the worldwide threats to amphibian biodiversity, molecular studies should move beyond the identification of genetic clades and should make every effort to formally describe those evolutionary lineages. Herein, we have taken this approach and described a new species based on a combination of morphological characters in a clade of cryptic species with shown high genetic diversity and low gene flow.

The new species occupy coastal areas North of Espírito Santo State, a region that is under strong human pressure. Therefore, marine and coastal communities are susceptible to impacts of proposed modifications in the landscape for the exploitation of mineral resources. In this context, *C. quilombola* sp. n. may face imminent threat of habitat loss, as consequence of the deforestation and intensive occupation of the space by human activities.

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Appendix I

Examined material and measurements from males included in the morphological analyses.

Chiasmocleis	**Numbers**	**Locality**	**State**	**SVL**	**HL**	**HW**	**ED**	**IOD**	**IND**	**END**	**THL**	**TBL**	**FL**	**3FD**	**4TD**	**FAL**	**HDL**	**HDL4**
capixaba	MNRJ17514	Aracruz	ES	14.77	2.91	4.04	1.18	2.57	1.16	1.21	6.19	6.34	6.43	0.35	0.44	2.98	3.36	2.08
capixaba	MNRJ17515	Aracruz	ES	13.98	2.84	4.44	1.28	2.71	1.21	1.39	6.17	6.13	6.58	0.29	0.46	3.07	3.28	1.94
capixaba	MNRJ17516	Aracruz	ES	14.47	2.93	3.98	1.18	2.64	1.19	1.32	6.08	5.96	6.64	0.30	0.42	3.10	3.36	2.16
capixaba	MNRJ17517	Aracruz	ES	14.70	3.00	4.10	1.36	2.61	1.29	1.26	6.23	6.10	6.74	0.33	0.51	3.15	3.55	2.32
capixaba	MNRJ17518	Aracruz	ES	16.02	3.13	4.39	1.32	2.64	1.21	1.45	6.61	6.80	7.45	0.38	0.48	3.62	3.86	2.33
capixaba	MNRJ17519	Aracruz	ES	15.40	2.99	3.95	1.36	2.63	1.23	1.56	6.05	6.31	6.28	0.33	0.45	3.38	3.17	2.09
capixaba	MNRJ17520	Aracruz	ES	14.94	2.76	3.82	1.26	2.66	1.20	1.36	5.71	6.06	5.90	0.41	0.47	2.96	3.15	1.80
capixaba	MNRJ17535	Aracruz	ES	15.23	2.96	3.83	0.97	2.39	1.18	1.07	6.18	5.76	5.97	0.38	0.42	2.76	3.05	2.13
capixaba	MNRJ17536	Aracruz	ES	15.24	2.50	3.92	1.23	2.60	1.16	1.41	5.83	5.79	6.63	0.33	0.45	2.93	3.52	2.19
capixaba	MNRJ17895	Aracruz	ES	15.46	2.89	4.32	1.12	2.56	1.22	1.21	6.62	6.30	6.46	0.33	0.47	3.25	3.34	2.15
capixaba	MNRJ22962	Reserva Natural Vale	ES	14.83	3.02	4.44	1.26	2.67	1.18	1.38	6.29	6.08	6.37	0.36	0.44	3.12	3.34	2.08
capixaba	MNRJ22966	Reserva Natural Vale	ES	15.05	2.99	4.41	1.37	2.71	1.19	1.43	6.71	6.20	6.25	0.36	0.52	3.18	3.15	1.72
capixaba	MZUSP147468	ReBio Duas Bocas	ES	15.88	3.05	4.40	1.27	2.87	1.25	1.41	6.84	6.53	6.92	0.43	0.43	3.06	3.44	2.14
capixaba	MZUSP147469	ReBio Duas Bocas	ES	16.23	3.02	4.61	1.05	2.99	1.31	1.68	6.80	6.71	7.05	0.48	0.48	3.28	3.29	2.30
lacrimae	MNRJ17480	Horto Florestal	RJ	16.20	3.40	4.40	1.10	2.70	0.90	1.40	6.50	6.50	7.30	0.30	0.40	3.30	3.60	2.50
lacrimae	MNRJ17481	Horto Florestal	RJ	15.60	3.30	4.10	1.10	2.60	1.00	1.40	6.20	6.30	7.20	0.40	0.40	3.50	3.60	2.60
lacrimae	MNRJ17482	Horto Florestal	RJ	16.20	3.50	2.60	1.30	2.60	1.00	1.90	6.50	6.50	7.10	0.40	0.50	3.30	3.80	2.50
lacrimae	MNRJ17484	Horto Florestal	RJ	19.15	3.57	4.82	1.35	2.84	1.44	1.69	7.45	7.35	8.23	0.34	0.36	3.56	4.23	2.69
lacrimae	MNRJ17485	Horto Florestal	RJ	16.10	3.70	4.30	1.20	2.50	0.90	1.60	6.90	6.70	7.50	0.30	0.40	3.40	3.60	2.40
lacrimae	MNRJ17486	Horto Florestal	RJ	15.07	3.00	4.33	1.22	2.52	1.22	1.50	6.30	6.22	6.68	0.30	0.43	3.19	3.44	2.24
lacrimae	MNRJ17487	Horto Florestal	RJ	16.10	3.33	4.38	1.19	2.91	1.30	1.68	6.94	6.78	7.16	0.27	0.39	3.46	3.53	2.08
lacrimae	MNRJ17488	Horto Florestal	RJ	15.90	3.20	3.80	1.10	2.50	0.90	1.30	5.80	6.20	6.60	0.30	0.40	3.00	3.30	2.20
lacrimae	MNRJ17489	Horto Florestal	RJ	15.40	3.10	3.90	1.20	2.20	0.90	1.30	6.10	6.10	6.90	0.30	0.40	3.10	3.40	2.10
lacrimae	MNRJ17490	Horto Florestal	RJ	16.10	3.30	4.00	1.10	2.50	0.90	1.40	6.70	7.10	7.70	0.40	0.40	3.50	4.20	2.70
lacrimae	MNRJ17491	Horto Florestal	RJ	15.26	2.90	4.75	1.21	2.92	1.47	1.49	6.59	6.46	7.13	0.32	0.41	3.34	3.78	2.41
lacrimae	MNRJ17492	Horto Florestal	RJ	15.50	3.90	4.60	1.30	2.50	1.20	1.50	6.10	6.30	6.50	0.40	0.40	3.10	3.70	2.50
lacrimae	MNRJ17498	Horto Florestal	RJ	17.10	3.70	4.70	1.20	2.50	1.10	1.40	6.70	6.80	6.90	0.40	0.50	3.40	3.40	2.50

Chiasmocleis	**Numbers**	**Locality**	**State**	**SVL**	**HL**	**HW**	**ED**	**IOD**	**IND**	**END**	**THL**	**TBL**	**FL**	**3FD**	**4TD**	**FAL**	**HDL**	**HDL4**
lacrimae	MNRJ17505	Horto Florestal	RJ	16.80	3.42	4.62	1.41	2.84	1.32	1.71	7.19	6.88	7.43	0.33	0.38	3.50	3.87	2.42
lacrimae	MNRJ17506	Horto Florestal	RJ	16.95	3.30	4.84	1.36	3.00	1.35	1.62	7.19	6.80	7.32	0.41	0.43	3.60	4.09	2.63
lacrimae	MNRJ17507	Horto Florestal	RJ	15.16	3.14	4.43	1.29	2.71	1.24	1.45	6.06	6.13	6.28	0.34	0.41	3.12	3.51	2.22
lacrimae	MNRJ17565	Horto Florestal	RJ	16.66	2.97	4.42	1.36	2.79	1.30	1.47	7.05	6.69	7.14	0.49	0.43	3.23	3.97	2.63
lacrimae	MNRJ66497	Mimoso do Sul	ES	16.60	3.14	4.77	1.40	2.89	1.31	1.48	6.69	6.49	6.90	0.39	0.43	3.55	3.80	2.32
quilombola sp. n.	MNRJ29057	Povoação	ES	12.72	2.70	3.89	1.05	2.42	1.08	1.20	5.35	5.05	5.24	0.30	0.39	2.65	2.79	1.79
quilombola sp. n.	MNRJ29058	Povoação	ES	13.23	2.68	3.90	1.12	2.47	1.10	1.12	5.28	4.91	5.17	0.34	0.42	2.52	2.78	1.73
quilombola sp. n.	MNRJ29059	Povoação	ES	13.56	2.53	3.63	1.15	2.37	1.08	1.12	5.36	5.25	5.33	0.29	0.39	2.80	3.00	1.89
quilombola sp. n.	MNRJ29060	Povoação	ES	12.59	2.55	3.79	1.08	2.41	1.08	1.16	5.12	4.67	4.56	0.32	0.32	2.48	2.48	1.67
quilombola sp. n.	MNRJ29073	Povoação	ES	13.76	2.53	3.94	1.25	2.43	1.18	1.29	5.67	5.63	5.88	0.41	0.41	2.88	3.07	1.85
quilombola sp. n.	MNRJ29074	Povoação	ES	13.47	2.33	3.72	1.18	2.27	1.08	1.15	5.24	5.27	5.60	0.32	0.40	2.73	3.02	1.81
quilombola sp. n.	MBML2858	Povoação	ES	13.47	2.54	3.94	0.88	2.04	0.82	1.03	5.11	5.39	5.50	0.33	0.43	2.61	2.91	1.72
quilombola sp. n.	MBML2866	Povoação	ES	12.15	2.24	3.34	1.05	2.16	0.72	0.95	5.26	5.11	5.33	0.27	0.39	2.55	2.75	1.62
quilombola sp. n.	MBML2863	Povoação	ES	12.30	2.34	3.75	0.82	2.00	0.83	0.93	5.22	5.32	5.42	0.31	0.48	2.50	2.63	1.59
quilombola sp. n.	MZUSP147473	Flona Rio Preto	ES	16.07	3.18	3.87	1.09	2.18	1.09	1.33	6.01	6.00	6.41	0.24	0.23	3.15	3.30	2.07
quilombola sp. n.	MZUSP147478	Flona Rio Preto	ES	15.71	2.75	4.52	1.30	2.80	1.13	1.25	6.55	6.47	6.91	0.35	0.44	3.21	3.45	2.33
quilombola sp. n.	MZUSP147471	Flona Rio Preto	ES	14.43	2.75	3.83	1.03	2.57	1.11	1.51	6.07	6.27	6.23	0.25	0.26	2.99	2.84	1.83
quilombola sp. n.	MZUSP147475	Flona Rio Preto	ES	14.48	2.79	4.55	1.28	2.55	1.28	1.25	6.63	6.41	6.73	0.36	0.36	3.26	3.48	2.16
quilombola sp. n.	MZUSP147494	Flona Rio Preto	ES	16.55	3.14	4.63	1.36	2.55	1.24	1.36	7.02	6.89	7.59	0.25	0.37	3.33	3.80	2.40
quilombola sp. n.	MZUSP147476	Flona Rio Preto	ES	16.09	2.70	4.36	1.24	2.65	1.31	1.36	6.73	6.26	6.11	0.32	0.47	2.95	3.33	1.83
quilombola sp. n.	MZUSP147472	Flona Rio Preto	ES	15.28	2.80	4.08	1.33	2.67	1.24	1.33	7.08	6.55	6.60	0.34	0.41	3.20	3.40	2.22
sp.	MTR13495	Trancoso	BA	15.92	3.39	4.07	1.06	2.65	0.94	1.43	6.37	6.16	6.77	0.27	0.42	3.60	3.45	2.06
sp .	MTR13547	Trancoso	BA	13.80	3.53	4.09	0.97	2.36	1.00	1.35	5.59	5.68	5.72	0.27	0.35	2.95	3.18	2.27
sp .	MTR13545	Trancoso	BA	15.07	3.51	4.24	1.10	2.43	1.03	1.35	5.91	6.41	6.78	0.29	0.38	2.95	3.40	2.35
sp .	MTR13590	Trancoso	BA	15.48	3.48	3.99	1.17	2.51	0.80	1.32	6.01	6.22	6.69	0.30	0.45	3.11	3.73	2.41
sp .	MTR13565	Trancoso	BA	16.27	3.78	4.31	0.95	2.59	1.04	1.61	5.64	6.33	6.56	0.33	0.46	3.20	3.68	2.67
sp .	MTR13548	Trancoso	BA	15.36	3.34	4.57	1.06	2.52	1.12	1.09	6.44	6.62	6.72	0.30	0.40	3.19	3.64	2.36
sp .	MTR13546	Trancoso	BA	15.53	3.10	4.40	1.24	2.30	0.91	1.46	6.02	5.96	6.56	0.31	0.40	2.90	3.30	2.14
sp .	MTR13489	Trancoso	BA	15.34	3.53	4.05	1.16	2.35	1.00	1.36	6.67	6.54	6.73	0.27	0.44	3.40	3.46	2.40

Appendix 2

Samples included in the molecular analyses and genbank numbers. Numbers in bold were retrieved from previous studies.

Chiasmocleis	**Voucher**	**Tissue**	**Locality**	**State**	**12S**	**16S**	**ND2**	**BDNF**
capixaba	MZUSP147497	CTA1861	ReBio Duas Bocas	ES	KM111721	KM111817	**JQ410706**	KM111908
capixaba	MZUSP147498	CTA1863	ReBio Duas Bocas	ES	KM111722	KM111818	**JQ410707**	KM111909
capixaba	MZUSP147499	CTA1864	ReBio Duas Bocas	ES	KM111723	KM111819	**JQ410708**	KM111910
capixaba	MZUSP147468	CTA1865	ReBio Duas Bocas	ES	KM111724	KM111820	KM111992	KM111911
capixaba	MZUSP147482	CTA1869	ReBio Duas Bocas	ES	KM111725	KM111821	KM111993	KM111912
capixaba	MZUSP147469	CTA1870	ReBio Duas Bocas	ES	KM111726	KM111822	KM111994	KM111913
capixaba	MZUSP147500	CTA1871	ReBio Duas Bocas	ES	KM111727	KM111823	**JQ410709**	KM111914
capixaba	MZUSP147510	CTA1872	Serra	ES	KM111728	KM111824	**JQ410685**	KM111915
capixaba	MZUSP147512	CTA1874	Serra	ES	KM111729	KM111825	**JQ410690**	KM111916
capixaba	MZUSP147513	CTA1875	Serra	ES	KM111730	KM111826	**JQ410691**	KM111917
capixaba	JFT479	CTA1876	Serra	ES	KM111731	KM111827	**JQ410692**	KM111918
capixaba	MZUSP147514	CTA1877	Serra	ES	KM111732	KM111828	**JQ410693**	KM111919
capixaba	JFT483	CTA1879	Serra	ES	KM111733	KM111829	**JQ410694**	KM111920
capixaba	JFT499	CTA1881	Serra	ES	KM111734	KM111830	**JQ410695**	KM111921
capixaba	MZUSP147520	CTA1893	Serra	ES	KM111735	KM111831	**JQ410700**	KM111922
capixaba	MZUSP147521	CTA1894	Serra	ES	KM111736	KM111832	**JQ410701**	KM111923
capixaba	MZUSP147523	CTA1896	Serra	ES	KM111737	KM111833	**JQ410702**	KM111924
capixaba	MTR12276	CTMZ6907	FloNa dos Goytacazes	ES	KM111738	KM111834	-	KM111925
capixaba	MTR12296	CTMZ6908	FloNa dos Goytacazes	ES	KM111739	KM111835	**JQ410688**	KM111926
capixaba	MTR12407	CTMZ6912	Reserva Natural Vale	ES	KM111740	KM111836	-	-
capixaba	MTR12484	CTMZ6920	Reserva Natural Vale	ES	KM111741	KM111837	-	KM111927
capixaba	MTR12485	CTMZ6921	Reserva Natural Vale	ES	KM111742	KM111838	-	KM111928
capixaba	-	CTMZ6939	Guarapari	ES	KM111743	KM111839	-	KM111929
capixaba	MTR12076	MTR12076	Reserva Natural Vale	ES	KM111744	KM111840	**JQ410687**	KM111930
capixaba	MTR12297	MTR12297	FloNa dos Goytacazes	ES	KM111745	KM111841	**JQ410689**	KM111931
cordeiroi	CFBH32057	CFBH15784	Ilhéus	BA	KM111759	KM111852	KM111995	KM111939

Chiasmocleis	Voucher	Tissue	Locality	State	12S	16S	ND2	BDNF
cordeiroi	MZUSP147496	CTA1935	Ituberá	BA	KM111760	KM111853	KM111996	KM111940
cordeiroi	MTR22122	MTR22122	EE Wenceslau Guimarães	BA	KM111761	KM111854	KM111997	KM111941
cordeiroi	MTR22123	MTR22123	EE Wenceslau Guimarães	BA	KM111762	KM111855	KM111998	KM111942
cordeiroi	PEU137	PEU137	Jaguaripe	BA	KM111763	KM111856	KM111999	KM111943
cordeiroi	PEU146	PEU146	Jaguaripe	BA	KM111764	KM111857	KM112000	KM111944
crucis	MTR6001	CTMZ6898	Serra do Teimoso	BA	KM111765	KM111858	KM112001	KM111945
crucis	-	CTMZ6900	Ilhéus	BA	KM111766	KM111859	KM112002	KM111946
crucis	-	CTMZ6901	Ilhéus	BA	KM111767	KM111860	KM112003	KM111947
crucis	MTR16070	MTR16070	Serra Bonita	BA	KM111768	KM111861	KM112004	KM111948
lacrimae	-	CFBH73	Picinguaba	SP	KM111748	**KC180040**	**JQ410715**	**KC180202**
lacrimae	CFBH17495	CFBH7361	Ilha de São Sebastião	SP	KM111749	KM111844	-	
lacrimae	-	CFBH76	Picinguaba	SP	KM111750	**KC180063**	**JQ410714**	**KC180163**
lacrimae	JFT981	CTA1934	Matada Usina Paineiras	ES	KM111751	KM111845	**JQ410710**	KM111932
lacrimae	-	CTMZ6946	Bertioga	SP	KM111752	KM111846	-	KM111933
lacrimae	RN7003	CTRN173	Angra dos Reis	RJ	KM111753	KM111847	-	-
lacrimae	RN7004	CTRN174	Angra dos Reis	RJ	KM111754	KM111848	-	KM111934
lacrimae	RN7005	CTRN175	Angra dos Reis	RJ	KM111755	KM111849	-	KM111935
lacrimae	MNRJ47477	MNRJ47477	ReBio União	RJ	KM111746	KM111842	-	-
lacrimae	MNRJ48415	MNRJ48415	ReBio União	RJ	KM111747	KM111843	-	-
lacrimae	MNRJ49302	MNRJ49302	Cachoeiras de Macacu	ES	KM111756	KM111850	**JQ410712**	KM111936
lacrimae	MNRJ60744	MNRJ60744	Duque de Caxias	RJ	KM111757	-	**JQ410713**	KM111937
lacrimae	MNRJ66494	MNRJ66494	Mimoso do Sul	ES	KM111758	KM111851	**JQ410711**	KM111938
leucosticta	CFBH19029	CFBH8594	PE Ilha do Cardoso	SP	KM111769	KM111862	-	-
leucosticta	MZUSP136053	CTMZ2485	PE Carlos Botelho	SP	KM111770	KM111863	-	-
leucosticta	MZUSP136055	CTMZ2493	PE Carlos Botelho	SP	KM111771	-	-	KM111949
leucosticta	MZUSP136059	CTMZ2497	PE Carlos Botelho	SP	-	KM111864	-	KM111950
leucosticta	MTR7128	CTMZ6943	Fazenda Intervales	SP	-	-	KM112005	KM111951

Chiasmocleis	**Voucher**	**Tissue**	**Locality**	**State**	**12S**	**16S**	**ND2**	**BDNF**
leucosticta	-	CTMZ6944	Piedade	SP	KM111772	-	KM112006	-
mantiqueira	-	CTMZ6891	Serra do Brigadeiro	MG	KM111773	KM111865	-	KM111952
mantiqueira	UFMG-A9643	UFMG-T1802	Ouro Branco	MG	KM111774	KM111866	KM112007	-
mantiqueira	UFMG-A9659	UFMG-T1804	Ouro Branco	MG	KM111775	KM111867	-	KM111953
mantiqueira	UFMG-A9651	UFMG-T1810	Ouro Branco	MG	KM111776	KM111868	-	KM111954
mantiqueira	UFMG-A9656	UFMG-T1815	Ouro Branco	MG	KM111777	KM111869	-	KM111955
quilombola sp. n.	-	CFBH1437	ReBio Sooretama	ES	KM111778	**KC180044**	-	**KC180193**
quilombola sp. n.	-	CFBH1438	ReBio Sooretama	ES	KM111779	**KC179977**	-	**KC180168**
quilombola sp. n.	CFBH19471	CFBH9055	Povoação	ES	KM111780	KM111870	KM112008	KM111956
quilombola sp. n.	CFBH18076	CFBH9082	Povoação	ES	KM111781	KM111871	KM112009	KM111957
quilombola sp. n.	CFBH18077	CFBH9083	Povoação	ES	KM111782	KM111872	KM112010	KM111958
quilombola sp. n.	JFT831	CTA1906	FloNa do Rio Preto	ES	KM111783	KM111873	JQ410669	KM111959
quilombola sp. n.	MZUSP147471	CTA1907	FloNa do Rio Preto	ES	KM111784	KM111874	**JQ410670**	KM111960
quilombola sp. n.	MZUSP147472	CTA1908	FloNa do Rio Preto	ES	KM111785	KM111875	**JQ410671**	KM111961
quilombola sp. n.	MZUSP147473	CTA1909	FloNa do Rio Preto	ES	KM111786	KM111876	**JQ410672**	KM111962
quilombola sp. n.	MZUSP147474	CTA1918	FloNa do Rio Preto	ES	KM111787	KM111877	**JQ410673**	KM111963
quilombola sp. n.	MZUSP147475	CTA1919	FloNa do Rio Preto	ES	KM111788	KM111878	**JQ410674**	KM111964
quilombola sp. n.	MZUSP147494	CTA1923	FloNa do Rio Preto	ES	KM111789	KM111879	**JQ410677**	KM111965
quilombola sp. n.	MZUSP147479	CTA1929	FloNa do Rio Preto	ES	KM111790	KM111880	**JQ410679**	KM111966
quilombola sp. n.	MZUSP147480	CTA1931	FloNa do Rio Preto	ES	KM111791	KM111881	**JQ410680**	KM111967
quilombola sp. n.	MZUSP147493	CTA1933	FloNa do Rio Preto	ES	KM111792	KM111882	**JQ410681**	KM111968
quilombola sp. n.	JFT990	CTA1938	PE de Itaúnas	ES	-	KM111883	-	KM111969
quilombola sp. n.	MTR12017	CTMZ6903	Reserva Natural Vale	ES	KM111793	KM111884	-	KM111970
quilombola sp. n.	MTR12077	CTMZ6905	Reserva Natural Vale	ES	KM111794	KM111885	-	-
quilombola sp. n.	MTR12470	CTMZ6916	Reserva Natural Vale	ES	KM111795	KM111886	-	KM111971
quilombola sp. n.	MTR12471	CTMZ6917	Reserva Natural Vale	ES	KM111796	KM111887	-	KM111972
quilombola sp. n.	MTR21527	LGA3267	ReBio Córrego Veado	ES	KM111797	KM111888	**JQ410668**	KM111973
schubarti	CFBH9331	CFBH2078	ReBio Sooretama	ES	KM111798	**KC180071**	KM112011	**KC180122**
schubarti	CFBH18075	CFBH9060	Povoação	ES	KM111799	KM111889	KM112012	KM111974

Chiasmocleis	**Voucher**	**Tissue**	**Locality**	**State**	**12S**	**16S**	**ND2**	**BDNF**
schubarti	CFBH 22501	CTA1860	ReBio Duas Bocas	ES	KM111800	KM111890	KM112013	KM111975
schubarti	MZUSP147485	CTA1887	FloNa do Rio Preto	ES	KM111801	KM111891	KM112014	KM111976
schubarti	MZUSP147487	CTA1924	FloNa do Rio Preto	ES	KM111802	KM111892	KM112015	KM111977
schubarti	MTR12094	CTMZ6906	FloNa dos Goytacazes	ES	KM111803	KM111893	KM112016	KM111978
schubarti	LGA2630	LGA2630	ReBio Córrego Veado	ES	KM111804	KM111894	**JQ410661**	KM111979
schubarti	MTR12266	MTR12266	FloNa dos Goytacazes	ES	KM111805	KM111895	KM112017	KM111980
schubarti	MTR17524	MTR17524	PE do Rio Doce	MG	KM111806	KM111896	KM112018	KM111981
schubarti	MTR17571	MTR17571	PE do Rio Doce	MG	KM111807	KM111897	KM112019	KM111982
sp.	-	CFBH15818	Porto Seguro	BA	-	KM111898	-	KM111983
sp.	MTR13466	CTMZ6923	Trancoso	BA	KM111808	KM111899	**JQ410665**	KM111984
sp.	MTR13489	CTMZ6924	Trancoso	BA	KM111809	KM111900	**JQ410666**	KM111985
sp.	MTR13495	CTMZ6925	Trancoso	BA	KM111810	KM111901	-	KM111986
sp.	MTR13545	CTMZ6927	Trancoso	BA	KM111811	KM111902	-	KM111987
sp.	MTR13547	CTMZ6929	Trancoso	BA	KM111812	KM111903	-	KM111988
sp.	MTR13548	CTMZ6930	Trancoso	BA	KM111813	KM111904	-	KM111989
sp.	MTR13565	CTMZ6932	Trancoso	BA	KM111814	KM111905	-	KM111990
sp.	MTR13579	CTMZ6933	Trancoso	BA	KM111815	KM111906	-	KM111991
sp.	MTR13589	CTMZ6935	Trancoso	BA	KM111816	KM111907	KM112020	-