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The Dilaridae of the Balkan Peninsula and of Anatolia (Insecta, Neuropterida, Neuroptera)

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Abstract

Basing upon all available information on type material of *Dilar turcicus* Hagen, 1858, *Dilar syriacus* Navás, 1909, and *Dilar lineolatus* Navás, 1909, together with a large number of dilarid specimens, the pleasing lacewings of Anatolia and Southeast Europe are revised. The current taxonomic concept of *D. turcicus* is confirmed, and a lectotype is designated. *Dilar turcicus* is widely distributed in the southeast of Europe (being the only representative of Dilaridae in this region), in Anatolia, and, most probably, in the Caucasus region. *Dilar syriacus* and *D. lineolatus* remain nomina dubia. *Dilar syriacus* might occur in Anatolia, while *D. lineolatus* is a species occurring in western Central Asia. Two new species, *Dilar anatolicus* **sp. n.** and *Dilar fuscus* **sp. n.** are described from Anatolia. Wings and genital segments of the three species occurring in Anatolia are illustrated, and a map documenting the known distribution of these species is provided.

Key Words

Dilar
lectotype designation
new species
nomina dubia
Europe
Asia minor

Introduction

The Dilaridae is a small family of the order Neuroptera comprising about 100 described valid species worldwide. Most species – all assigned to the genus *Dilar* Rambur, 1838 – have been recorded in the Northern Hemisphere, and particularly in Central, East and Southeast Asia (Aspöck et al. 2001, Oswald and Schiff 2001, New 2003, Zhang et al. 2014a, b, c, 2015), but a few species representing other genera, i.e. *Nallachius* Navás, 1909, *Neonallachius* Nakahara, 1963, and *Berothella* Banks, 1934, have been found in North and South America as well as in South and Southeast Asia, respectively (New 1989, 2003, Oswald 1998), and one species has been described from South Africa (Minter 1986).

In the Western Palaearctic most species of *Dilar* have been found in the southwest of Europe in the Iberian Peninsula (Aspöck et al. 2001, Monserrat and Triviño 2013, Monserrat 2014). Only one species – *Dilar turcicus* Hagen, 1858 – has so far been known to occur in the Balkan Peninsula (Aspöck et al. 1980, 2001). This species has also been recorded from various parts of Anatolia. Until now no proven records of other species of Dilaridae in Turkey have been published.

For many years we have, however, been aware of the existence of at least two further *Dilar* species which had been collected by two of us (H.A., U.A.) in Anatolia. However, the fact that the type material of *D. turcicus* had never been examined and the possibility of the occurrence of other described but not identifiable species (nomina dubia) prevented us from describing our unidentified species.

In the course of recent studies on Dilaridae of Asia, we have again examined the situation and have tried to

clarify all open questions as far as possible, so that we can now present a summarising overview on the Dilaridae of Anatolia and of Southeast Europe.

Material and methods

Specimens (partly pinned and dried, partly preserved in alcohol) on which this study is based are deposited in the following collections: Collection of Horst & Ulrike Aspöck, Vienna, Austria (HUAC); Collection of Hubert & Renate Rausch, Scheibbs, Austria (HRRC); Natural History Museum Vienna, Austria (NHMW); Museum für Naturkunde der Humboldt-Universität zu Berlin, Germany (MFN); Muséum National d'Histoire Naturelle, Paris, France (MNHN); Muséum d'Histoire Naturelle, Genève, Switzerland (MHN); Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, U.S.A. (MCZ).

Genitalic preparations were made by clearing the apex of the abdomen in a cold, saturated KOH solution for 3-4 h. After rinsing the KOH with acetic acid and water, the apex of the abdomen was transferred to glycerine for further dissection and examination. Habitus photos were taken by using Nikon D60 and D800 digital camera with Nikon MICRO NIKKOR 105 mm lens, and the genitalic figures of the new species were made by hand drawing under Leica M165C stereo microscope. The genitalia of the lectotype of *D. turcicus* were photographed with a Leica DFC camera attached to a Leica MZ16 binocular microscope and processed with the help of Leica Application Suite. They were then stacked with ZereneStacker 64-bit and processed with Adobe Photoshop Elements 8. The terminology of the genitalia generally follows U. Aspöck and H. Aspöck (2008).

Distribution map: Localities were taken from original literature (Suppl. material 1) and, together with the specimens examined by us, listed continuously with a number for each locality in MS Excel 2010 (Suppl. material 2); geographic coordinates introduced by us are in italics.

Taxonomy

Genus *Dilar* Rambur

Dilar Rambur, 1838: 9. Type species: *Dilar nevadensis* Rambur, 1838: pl. 9 (monotypy).
Cladocera Hagen, 1860: 56. Nomen nudum.
Lidar Navás, 1909: 153. Type species: *Dilar meridionalis* Hagen, 1866: 295, original designation.
Fuentenus Navás, 1909: 154. Type species: *Dilar campestris* Navás, 1903: 380, original designation.
Nepal Navás, 1909: 661. Type species: *Nepal harmandi* Navás, 1909: 661, original designation.
Rexavius Navás, 1909: 664. Type species: *Dilar nietneri* Hagen, 1858: 482, subsequent designation by Navás, 1914: 10.

Note. A description of the genus has been given on several occasions in recent publications (Zhang et al. 2014a, b, c, 2015). *Dilar* occurs in the southern parts of Europe (Spain, Portugal, France including Corsica, Italy including Sardinia, Croatia, Bosnia-Herzegovina, Montenegro, Macedonia, Bulgaria, Kosovo, Albania, Greece including several western and eastern islands, Ukraine, Russia); Northern Africa (Algeria, Tunisia); Asia (Turkey, Lebanon, Iran, Afghanistan, Turkmenistan, Kyrgyzstan, Tajikistan, Nepal, Pakistan, India, Sri Lanka, China, Korea, Japan, Thailand, Vietnam, Malaysia).

Dilar turcicus Hagen, 1858

Figs 1–10; 31

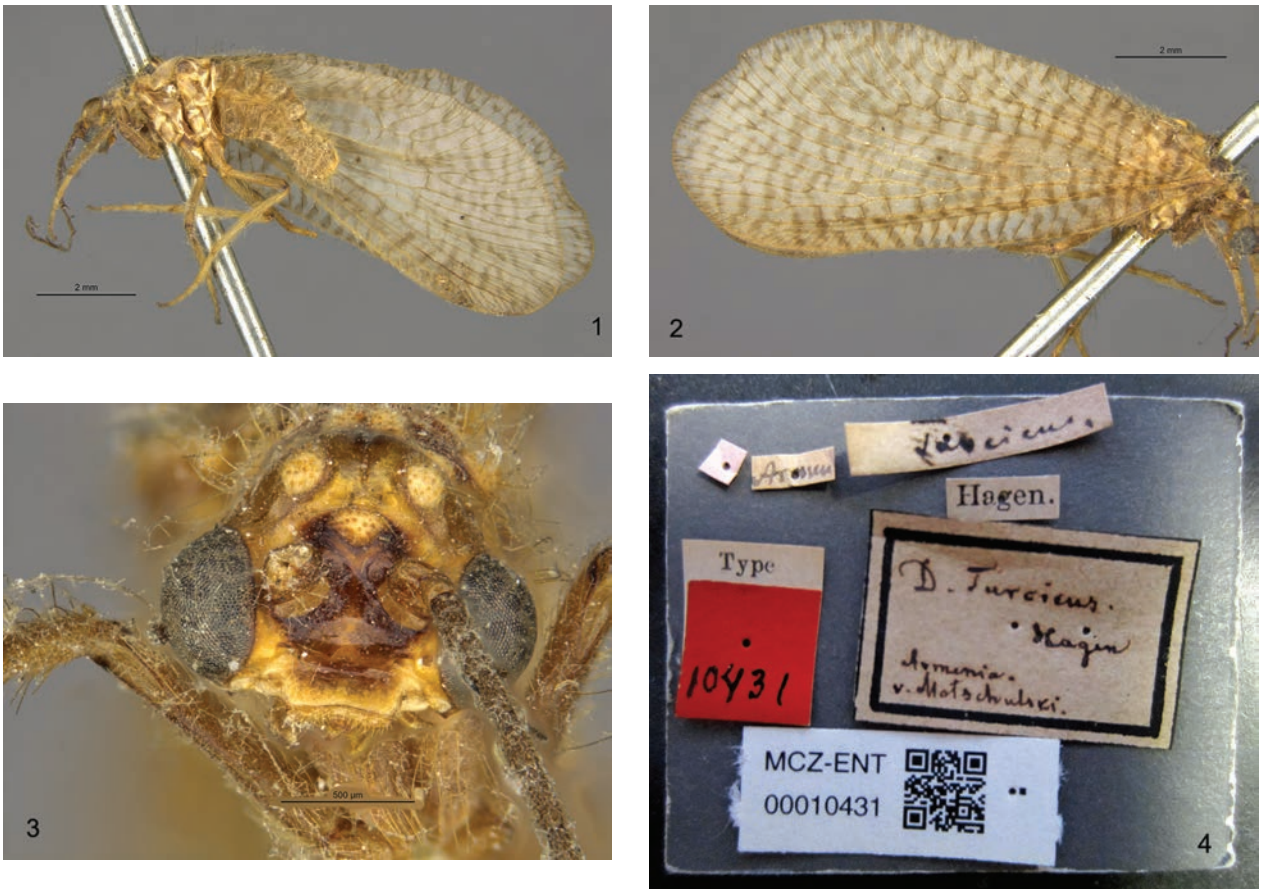
Dilar turcicus Hagen, 1858: Navás 1909, Aspöck et al. 1980, Aspöck et al. 2001.
Dilar corcyraeus Navás, 1909: Aspöck et al. 1980.

Remarks. After the original description by Hagen (1858) based upon two specimens, one from Turkey and one from Armenia, the species was redescribed, characterised and/or illustrated on several occasions (e.g. Navás 1909, 1914, Aspöck et al. 1980), but none of the two syntypes has ever been examined. When we realized that Anatolia harbours at least one further species of *Dilar* which could not be differentiated eidonomically from *D. turcicus*, an examination of the types became necessary. Both syntypes still exist. The syntype from Turkey ("Türkei", Smyrna [=Izmir] written on the original collecting label) is preserved in MFN in Berlin. Unfortunately, this specimen consists only of fragments of the wings (Fig. 8), which do not allow a definite identification. Therefore, we tried to examine the other syntype, which is from Armenia ("Armenien", without further details on the locality). This syntype is deposited in the MCZ[1] of the Harvard University in Cambridge and was kindly sent to us for examination. The specimen is a male in a fairly good condition (Figs 1–7), although it lacks the left fore- and hindwings. In particular, the abdomen is present so that we could study the genital segments. They agree perfectly with the genital segments of that species which has been regarded as *D. turcicus* Hagen until now (see Fig. 439 in Aspöck et al. 1980). We herewith designate the syntype from "Armenia" as the lectotype of *Dilar turcicus* Hagen, 1858.

D. turcicus shows a considerable variation in size and coloration of wings. Lengths of forewings vary from 7.5 to 13.5 mm. A reliable identification seems – at least presently – only possible on the basis of the male genital segments.

Distribution. As far as we know the southeast of Europe does not harbour any other species besides *D. turcicus*. We have examined more than 200 specimens from various localities on the Balkan Peninsula and have not

[1] Hermann August Hagen (1817–1893) moved from Germany to Cambridge, Mass., USA in 1867, where he became the first professor of entomology in the USA. He took (at least parts of) his collection with him to the Museum of Comparative Zoology, where it is still preserved.



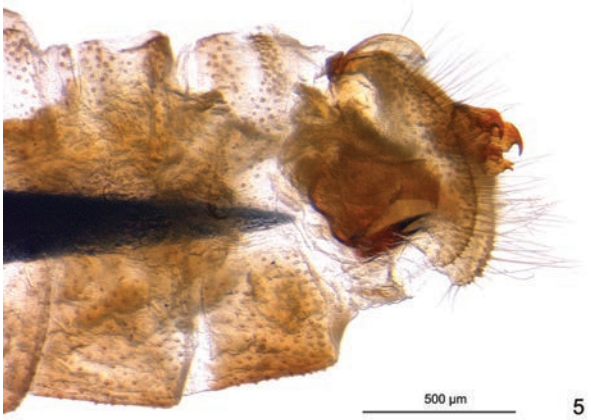
Figures 1–4. *Dilar turcicus* Hagen, lectotype, male (MCZ, Cambridge). **1.** Habitus, lateral view from left; **2.** Habitus, lateral view from right; **3.** Head, frontal view; **4.** Labels.

found any hint for the occurrence of a second *Dilar* species. Thus, it is a reasonable assumption that all published records of *D. turcicus* from localities situated in Europe really refer to this species. We have therefore included all published European records of *D. turcicus* in the map (Fig. 31). All records outside Europe (mainland) are based upon specimens examined by us. The documented distribution (Suppl. materials 1 and 2) comprises: Croatia, Bosnia-Herzegovina, Montenegro, Kosovo, Macedonia, Albania, Greece including several islands (Corfu, Chios, Skopelos, Samothraki, Thasos, Lesbos), Bulgaria, Ukraine, Russia, Turkey (Aspöck et al. 1980, 2001; Devetak 1991, 1992a, b; Devetak et al. 2015; Ghilarov 1962; Pongrácz 1913; Popov 1964, 1993, 2001, 2002, 2004, 2007; Zakharenko 1982, 1988; Zakharenko and Krivokhatsky 1993; specimens examined in the course of this study are listed in Suppl. material 2).

The exact type locality of *D. turcicus* remains unknown. In the middle of the 19th century the name Armenia was used also for regions in the east of Anatolia. Whether *D. turcicus* occurs in Armenia of present time is not sure. However, Ghilarov (1962) described the larva of *D. turcicus* from the Caucasus region, not far away from the proven record of *D. turcicus* in the Crimean peninsula. Thus, one can hardly doubt that *D. turcicus* occurs in present day Armenia. There are also several published records of *D. turcicus* in Anatolia (Kiyak and Özdikmen 1993, Canbulat and Kiyak 2005, O.B. Kovanci and B. Kovanci 2015, Canbulat 2007). However, these records could not be checked by us and have therefore been included in the distribution map as *Dilar* sp.

Dilar corcyraeus has already been synonymised 35 years ago (Aspöck et al. 1980). It was described on the basis of a single female, which is deposited in the NHMW, Vienna. The type locality is the Greek island of Corfu, from where also *D. turcicus* has been recorded (Aspöck et al. 1980). Navás (1909) himself had already considered that it might be a variety of *D. turcicus*. Here we provide a photograph of the type of *D. corcyraeus* (Fig. 9).

Biology. The biology of *D. turcicus* is poorly known, with only a few scattered observation records (Ghilarov 1962; Aspöck et al. 1980; New 1986). Adults are usually found on shady places with rich low vegetation, bushes and trees, frequently near stone walls with numerous crevices where the larvae may pupate after their development in the soil. The number of larval instars is unknown, but up to 12 moults have been observed under experimental conditions (New 1986). However, there is no indication that the number surmounts the three instars known from Neuroptera under natural conditions. Duration of development from egg to adult is probably at least one year. Adults are mainly active after sunset and are attracted by artificial light. *Dilar turcicus* has a considerably



Figures 5–7. *Dilar turcicus* Hagen, lectotype, male (MCZ, Cambridge). **5.** Genital segments, lateral view; **6.** Genital segments, dorsal view; **7.** Genital segments, ventral view.

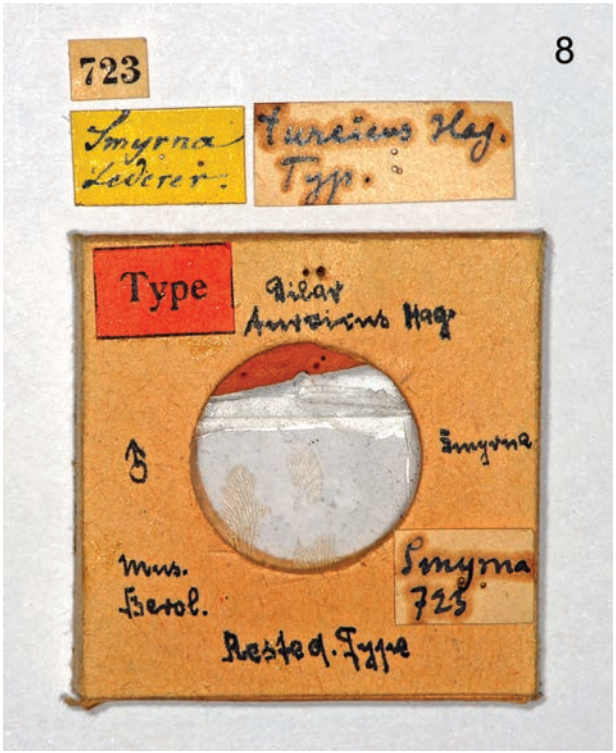


Figure 8. *Dilar turcicus* Hagen, syntype [now paralectotype] male (MFN, Berlin). Fragments of wings and labels.

Figures 9–10. *Dilar turcicus* Hagen, holotype female of *Dilar corcyraeus* Navás (NHMW, Vienna). **9.** Habitus (The abdomen is preserved in a vial in glycerine), dorsal view; **10.** Labels.

large vertical distribution, with records ranging from few meters up to 2100 m above sea level.

Dilar syriacus Navás, 1909

Dilar syriacus Navás, 1909: Navás 1913, 1914, 1925, Monserrat 1988, Legrand and Lachaise 1994, Oswald 1998.

Remarks. This species has been described based on a single male specimen without abdomen deposited in the MNHN, Paris. According to the description of Navás (1909), the specimen resembles *D. turcicus*. As the type lacks the abdomen, it cannot be identified reliably. Therefore, Monserrat (1988) has declared *Dilar syriacus* as a nomen dubium, which was confirmed by Legrand and Lachaise (1994). The type was collected most probably near Beirut. Perhaps it will be possible to clarify the species as soon as one can collect there and find out which species occur in the surroundings of Beirut.

Dilar lineolatus Navás, 1909

Figs 11–13

Dilar lineolatus Navás, 1909: Navás 1914, Monserrat 1988, Oswald 1998.

Remarks. This species was described on the basis of a specimen from "Turkmenien (Tekke)". Turkmenien is the old German word for that part of western Central Asia which is largely identical with the present Turkmenistan. In his description of the species Navás (1909) translated "Turkmenien" as "Turcomania". Later "Turcomania" was erroneously interpreted as Turkey by Oswald (1998). "Tekke" is a frequent geographic name also in Anatolia, and thus Oswald (1998) decided to choose a locality named "Tekke" situated in Turkey as the type locality of *D. lineolatus*. He even gave the geographic coordinates: 40°09'N/29°41'E, which is certainly wrong. Possibly, Oswald's (1998) interpretation gave rise to the subsequent records in Anatolia (Canbulat and Kiyak 2005). We do not think that *D. lineolatus* really occurs in Turkey. The type locality of *D. lineolatus* should be somewhere far more in the east.

The holotype of *D. lineolatus* (Figs 11–13) is in poor condition. It is a female, but it lacks the abdomen. Only one forewing and the hindwings are present. We (H.A. & U.A.) examined this specimen already in 1967 (H. Aspöck and U. Aspöck 1968) and our opinion on this species of that time can now be confirmed: *D. lineolatus* is a valid and distinct species and cannot be assigned to any of the species recorded from Western and/or Central Asia. The coloration of the wings and of the wing venation is rather dark and characteristic so that it may be possible to clarify the species. However, at present *D. lineolatus* has to be regarded as a nomen dubium, because due to the lack of the genitalia a clarification of the taxonomic status of this species is not possible.

Figures 11–13. *Dilar lineolatus* Navás, holotype, female (MFN, Berlin). **11.** Left forewing; **12.** Right hindwing; **13.** Labels.

Dilar anatolicus sp. n.

http://zoobank.org/9A9EC5E2-270A-43FC-ADE3-6459233F89A9
Figs 14–25; 31

Diagnosis. This species is characterized by the forewings with numerous pale brown spots and by the male gonocoxite complex 9, 10 and 11 with short, feebly sclerotized ninth gonocoxite and elongate, blade-like tenth gonocoxite.

Description. Male. Length of forewing 11.0–12.2 mm, of hindwing 9.5–10.3 mm.

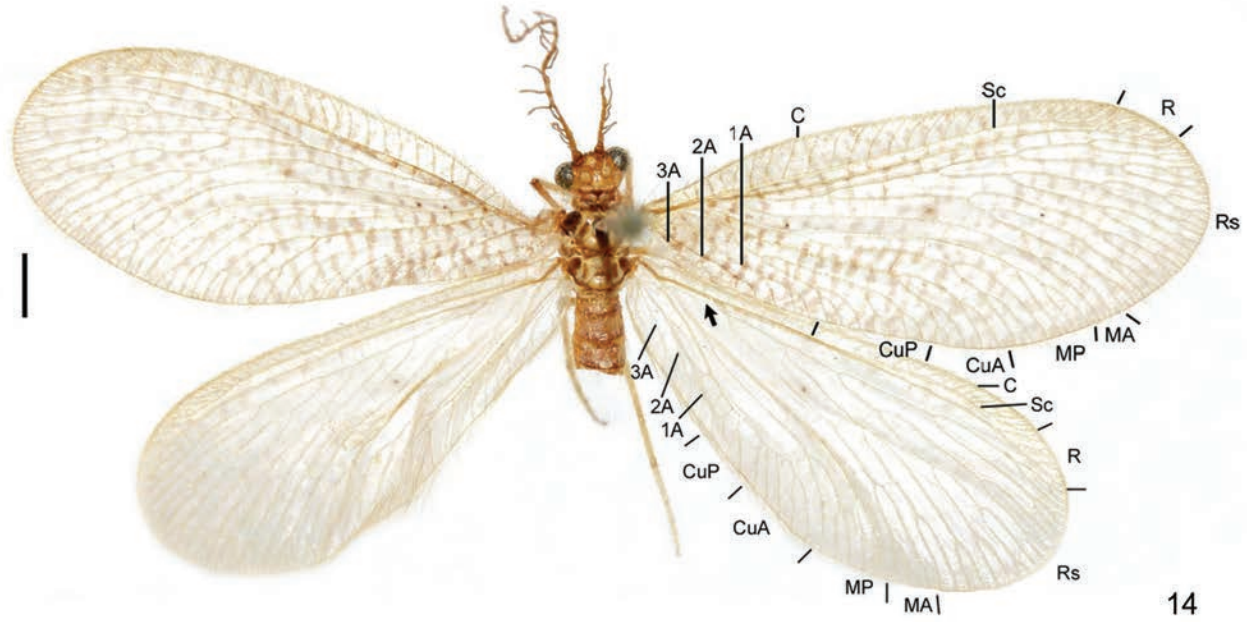


Figure 14. *Dilar anatolicus* sp. n., holotype, male (HUAC, Vienna), habitus. Arrow indicates base of hindwing MA vein. Scale bar = 1.0 mm.

Figure 15. *Dilar anatolicus* sp. n., paratype, female, habitus (HUAC, Vienna). Scale bar = 1.0 mm.

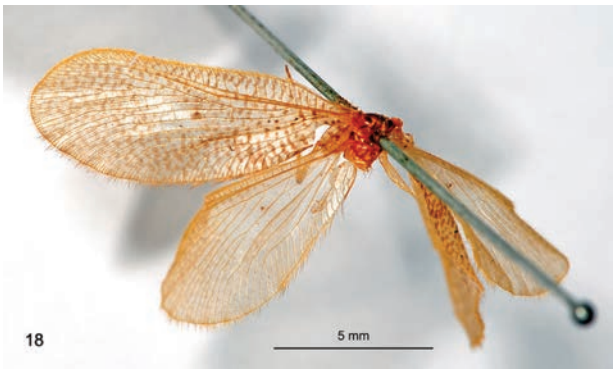
Head pale yellowish brown, with pale yellow setose tubercles. Compound eyes blackish brown. Antenna with ca. 29 segments, pale yellow, with scape and pedicel pale brown, flagellum unipectinate on most flagellomeres, medial branches much longer than those on both ends, longest branch nearly 3.0 times as long as the corresponding flagellomere, but branch of 1st flagellomere short and dentate, distal eight flagellomeres simple.

Prothorax pale yellowish brown, pronotum dark brown with several hairy yellowish tubercles; meso- and metathorax yellow, each notum laterally with a pair of broad, brown markings and a pair of pale brown narrow stripes; mesonotum medially with a pair of additional brown markings near anterior margin. Legs pale yellow, with femora blackish brown at tip. Wings hyaline, slightly yellowish brown, with numerous pale brown spots. Forewing ~2.5 times as long as wide, densely spotted, with markings slightly darkened toward anal region; a few markings on posteroproximal area connected with each other, forming short transverse stripes; an immaculate area present distal to median nygma; two nygmata present on proximal portion, both slightly smaller than

Figures 16–17. *Dilar anatolicus* sp. n., paratype, male (MFN, Berlin). **16.** Habitus, lateral view from left; **17.** Labels.

median nygma. Hindwing ~2.1 times as long as wide, slightly paler than forewing, with dark markings largely reduced; one nygma present at middle. Veins pale yellowish brown; Rs with four main branches on both fore- and hindwings.

Abdomen pale yellowish brown, pregenital segments dorsally brown. Ninth tergite in dorsal view with nearly truncate anterior margin and a deeply V-shaped posterior incision, leaving a narrow median portion and a pair of subtriangular hemitergites, which are obtuse and slightly incurved distally; in lateral view broad, with straight ventral margin and arcuate posterior margin. Ninth sternite obviously shorter than ninth tergite, with nearly truncate posterior margin. Ectoproct in dorsal view with a pair of digitiform projections, posteroventrally with a pair of subsemicircular and flattened lobes, a pair of bifid unguiform projections and a pair of short, feebly



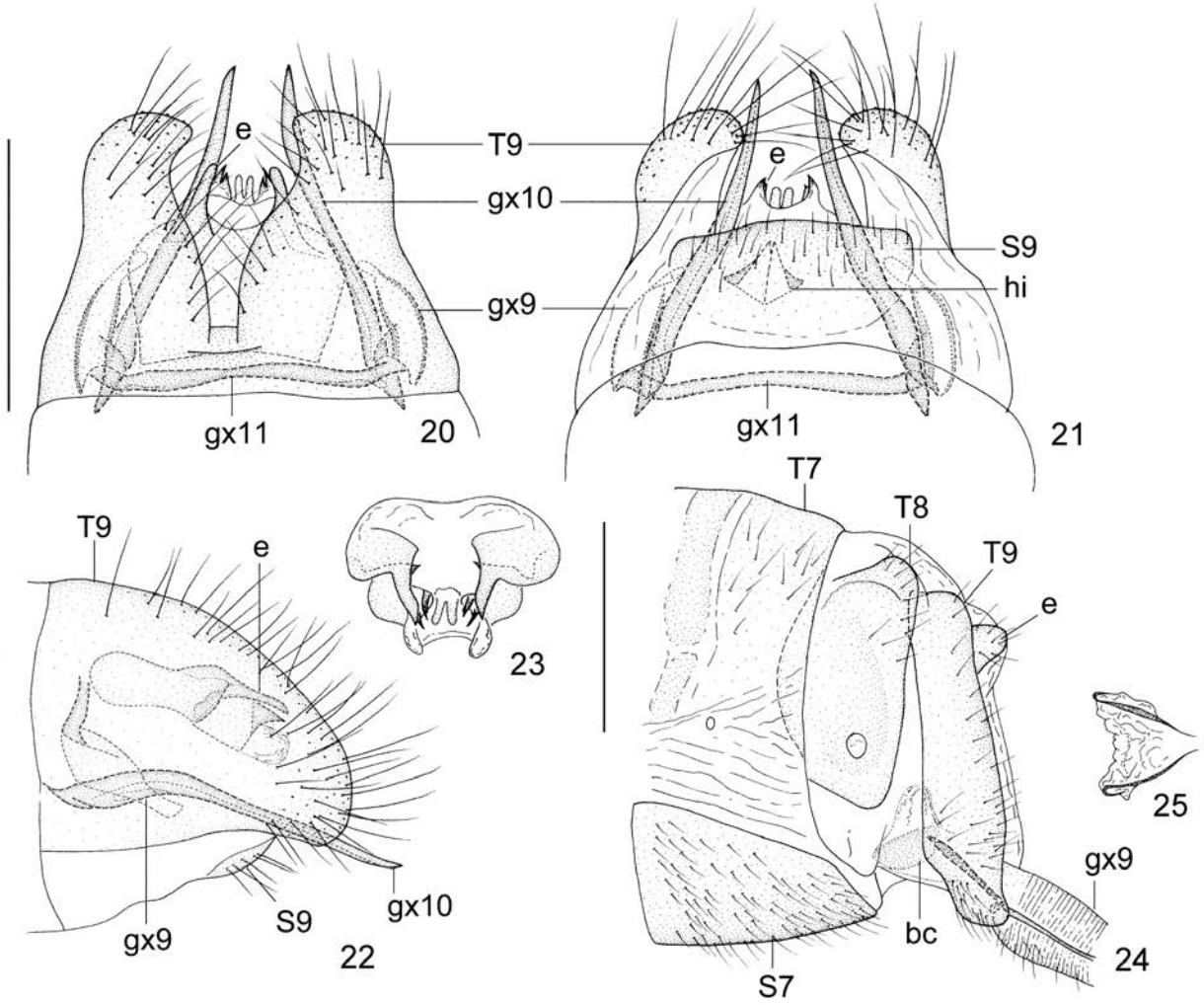
Figures 18–19. *Dilar anatolicus* sp. n., paratype, male (MHN, Genéve). **18.** Habitus; **19.** Labels.

sclerotized, digitiform projections. Ninth gonocoxite short, shield-like, mostly membranous and transparent, with sclerotized lateral margin and with a strongly narrowed, obtuse apex; tenth gonocoxite slenderly elongate, blade-like, nearly 2.5 times as long as ninth gonocoxite, straightly directed posteriorly with median portion feebly curved; fused eleventh gonocoxites (= gonarcus) beam-shaped, laterally connectedto base of ninth gonocoxites. Hypandrium internum subtriangular, with lateral margins slightly arcuate.

Female. Length of forewing 10.9 mm, of hindwing 10.0 mm.

Seventh sternite in lateral view subtrapezoidal. Eighth abdominal segment without subgenitale. Basal part of bursa copulatrix sac-like, nearly rhomboid in ventral view, proximally membranous and strongly rugose, distally sclerotized into a pair of lateral sclerites and a median ridge. Ectoproct rather small, ovoid.

Type material. Holotype ♂, "Asia minor, Kizilçahamam [a district of Ankara Prov., 40°28′N, 32°38′E], 1200 m, 7. 70 / G. Friedel leg." (HUAC). Paratypes: 1♀, same data as holotype (HUAC); 1♂, "ANATOLIEN, Icel, Kilik. Taurus, Namrun [a town of Toroslar Dist., Mersin



Figures 20–25. *Dilar anatolicus* sp. n. **20.** Male genitalia, dorsal view; **21.** Male genitalia, ventral view; **22.** Male genitalia, lateral view; **23.** Male ectoproct, caudal view; **24.** Female genitalia, lateral view; **25.** Bursa copulatrix, ventral view. bc: bursa copulatrix; e: ectoproct; gx9–11: ninth to eleventh gonocoxites; hi: hypandrium internum; S7–9: seventh to ninth sternite; T7–9: seventh to ninth tergite. Scale bars = 0.5 mm.

Prov.], 37.03N, 34.46E, 1400-1800 m, 18.VI. / TÜRKEI, ANATOLIEN 1979, C. Holzschuh & F. Ressl" (HUAC); 1♂, "ANATOLIEN, Bursa, Uludağ, 700 m, 40.12N, 29.04E, 6.VII. / BULGARIEN-TÜRKEI-GRIECHENLAND-EXP. 1978, H. & U. ASPÖCK, H. & R. RAUSCH, P. RESSL" (HUAC); 3♂1♀, "As[ia]. Min[or]. Kizilcahamam 18-24.VII.[19]72. Pinker" (HRRC); 1♂, "ANATOLIEN, Icel, Kilik. Tauris, Namrun, 37.03N/34.46E, 1400-1800 m, 29.V.-3.VII.[19]79, TÜRKEI, ANATOLIEN 1979 C. Holzschuh, F. Ressl" (HRRC); 1♂, "Dilar syriacus ♂ Nav[ás], 620 Taurus, 48. Asie. Min[or]. Coll. Pictet" (MHN); 1♂, "Syrien, Ehrenberg/Lidar turcicus Hag/388/Type" [The word Type on the old label is wrong] (MFN).

Distribution. Turkey: Western, central, and southern parts of Anatolia (Fig. 31); supposedly reaching Syria or Lebanon to the south.

Etymology. Adjective, masculine, nominative, singular; an attribute to the genus name. From lat. *anatolicus* 3 = referring or belonging to Anatolia, the Asian part of Turkey.

Remarks. *Dilar anatolicus* sp. n. can be distinguished from all other western Palaearctic species of *Dilar* based on the slenderly elongate male ninth gonocoxites and the short, largely membranous male tenth gonocoxites. In appearance, *D. anatolicus* sp. n. looks similar to its co-existing Turkish species *D. turcicus,* but it can be easily distinguished from the latter by the male ninth tergite without median projection and by the different shape of sclerotization of the female bursa copulatrix. Interestingly, *D. anatolicus* sp. n. appears to be closely related to *D. sinicus* Nakahara, 1957, which is distributed in northern China (Zhang et al. 2014a), by having the similar male gonocoxites 9, 10 and 11 with short, shield-like ninth gonocoxite and slenderly elongate tenth gonocoxite. However, in *D. anatolicus* sp. n. the male ninth gonocoxite is largely membranous and transparent with obtuse apex, while in *D. sinicus* the male ninth gonocoxite is entirely sclerotized with acutely pointed apex. Possibly *D. anatolicus* sp. n. occurs sympatrically with *D. syriacus* (see under *D. syriacus*).

Figure 26. *Dilar fuscus* sp. n., holotype, female (HUAC, Vienna), habitus. Scale bar = 1.0 mm.

Dilar fuscus sp. n.

http://zoobank.org/58C2459C-4D54-493A-8A60-DFD0C8F34B49
Figs 26–30

Diagnosis. This species is characterized by the entirely brown wings without distinct markings (at least in the female).

Description. Female. Length of forewing 10.9–12.2 mm, of hindwing 9.9–11.2 mm.

Head brown, with three pale yellow setose tubercles; vertex medially with a blackish brown vittae. Compound eyes blackish brown. Antenna with ca. 25 segments, pale brown.

Prothorax blackish brown, pronotum with pale yellow anterior margin and several yellowish tubercles clothed with brownish hairs; mesothorax and metathorax blackish brown, dorsally yellow at middle. Legs yellowish brown, with each segment blackish brown at tip. Wings entirely brown, without distinct markings. Forewing ~2.5 times as long as wide, with distal half slightly paler; proximally with two or three nygmata, medially with one nygma, which is slightly larger than proximal ones. Hindwing slightly paler than forewing; one nygma present at middle. Veins brown; Rs with six main branches on both fore- and hindwings.

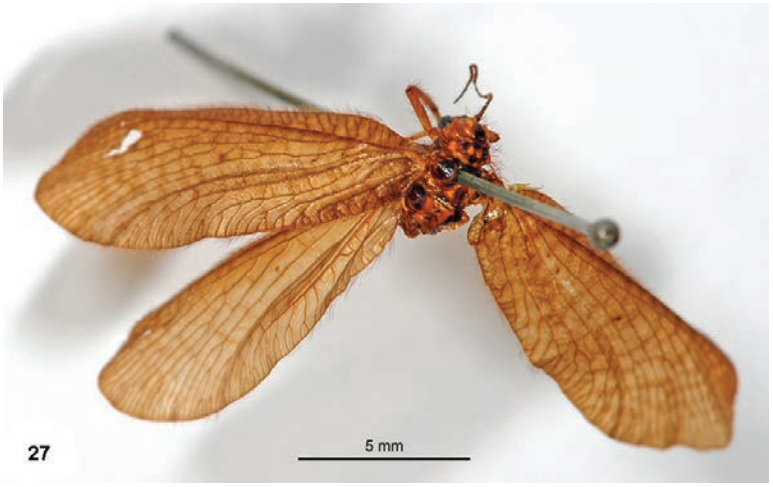
Abdomen pale brown. Ovipositor pale yellowish brown. Seventh sternite in lateral view subtriangular. Eighth abdominal segment without subgenitale. Basal part of bursa copulatrix sac-like, subtriangular in ventral view, most parts membranous and strongly rugose, with ventrolateral portions slightly sclerotized anteroposteriad. Ectoproct rather small, ovoid.

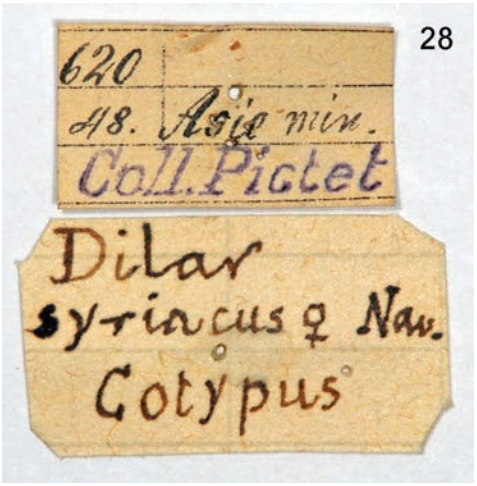
Male. Unknown.

Type material. Holotype ♀, "Prov. AYDIN, Str., Nazilli-Beydağ, 38.01N/28.18E, 650 m, 24.V./SUD-WEST-ANATOLIEN-EXP, 1981, H. et U. et Ch. ASPÖCK, H. et R. RAUSCH, F. RESSL" (HUAC). Paratypes: 1♀, same data as holotype (HUAC); 1♀, "Prov. AYDIN, Str. Nazilli – Beydag, 38.01N/28.18E, 650 m, 24.V., SÜDWEST-ANATOLIEN-EXP. 1981, H. et U. et Ch. ASPÖCK, H. et R. RAUSCH, F. RESSL, 81/25" (HRRC); 1♀, "Dilar syriacus ♀ Nav[ás]. Cotypus, 620/48. Asie min[or]. Coll. Pictet" (MHN).

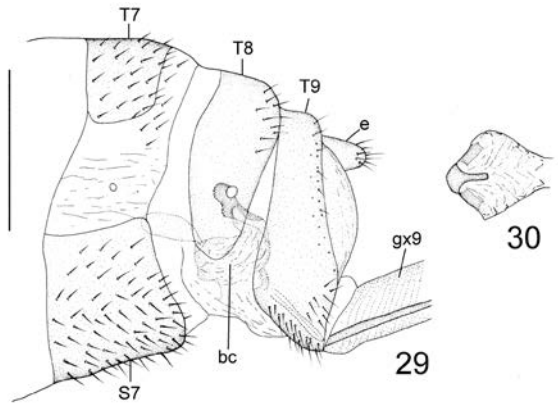
Distribution. The only reliable record of *D. fuscus* sp. n. is from the type locality in western Anatolia (Fig. 31).

Etymology. Adjective, masculine, nominative, singular; an attribute to the genus name. From lat. *fuscus* 3 = dark. The name refers to the dark coloration of the wings.





Figures 27–28. *Dilar fuscus* sp. n., paratype, female (MHN, Genéve). **27.** Habitus; **28.** Labels. [The label "Dilar syriacus Nav. ♀, Cotypus" is wrong].



Figures 29–30. *Dilar fuscus* sp. n. **29.** Female genitalia, lateral view; **30.** Bursa copulatrix, ventral view. Scale bar = 0.5 mm.

Remarks. Despite the unknown male, *D. fuscus* sp. n. is a spectacular new species and can be easily distinguished from all other species of *Dilar* based on the entirely brown wings without distinct markings. The female genitalia of *D. fuscus* sp. n. are principally similar to the co-existing species *D. turcicus* based on the basal part of bursa copulatrix with lateral portions slightly sclerotized. It can, of course, not be excluded that the hitherto unknown male has a different coloration of the wing membrane or even a patterned wing membrane. Such kind of sexual dimorphism has been known from other Dilaridae (Zhang et al. 2015).

Discussion

Three species of the genus *Dilar*, i.e. *D. turcicus*, *D. anatolicus* sp. n. and *D. fuscus* sp. n., are now known from the Balkan Peninsula and Anatolia, with clear specific identities. In the southeast of Europe only *D. turcicus* occurs, while in Anatolia all these three species are present. *Dilar fuscus* sp. n. is known in the female only, which can easily be identified by the unusual dark coloration of the wings (see Figs 26–27). The other two species – *D. turcicus* and *D. anatolicus* sp. n. – can easily be differentiated on the basis of morphological characters of the male genitalia, usually even in dried specimens. *Dilar turcicus* is equipped with a conspicuous median dorsal processus on male ninth tergite, whereas *D. anatolicus* sp. n. lacks this processus. A reliable differentiation of these two species on the basis of coloration and wing marking patterns is – at least presently – not possible.

D. turcicus is a Pontomediterranean faunal element with a distribution comprising large parts of Southeast Europe, probably all major parts of Anatolia, and most probably parts of the Caucasus region. To the best of our knowledge *D. turcicus* is the only representative of the family Dilaridae in the Balkan Peninsula and in the southern parts of East Europe. The northernmost records of this species in Europe are in Croatia, Bulgaria, Ukraine, and Russian north of Caucasus. Most probably the species had survived during the last glacial period in various refugial areas in the southeast of Europe and in Anatolia respectively.

In Anatolia *D. anatolicus* sp. n. and *D. fuscus* sp. n. have been known to us for long, but with respect to the unsolved questions concerning the described species they remained undescribed until now. After examination, re-examination and re-consideration of the three pertinent species – *Dilar turcicus* Hagen, *Dilar syriacus* Navás, and *Dilar lineolatus* Navás respectively – the situation has largely been clarified (concerning *D. syriacus* and *D. lineolatus* as far as possible at present). *Dilar syriacus* (type locality: probably surroundings of Beirut) remains a nomen dubium, it cannot be excluded that it will turn out to be identical either with *D. turcicus* (then it would be a junior synonym) or with *D. anatolicus* sp. n. (then it would become a senior synonym). However, it may also be a species different from both.

D. lineolatus has erroneously been associated with Anatolia. The species has been described from the region of Tekke in Turkmenia (probably today in Turkmenistan)

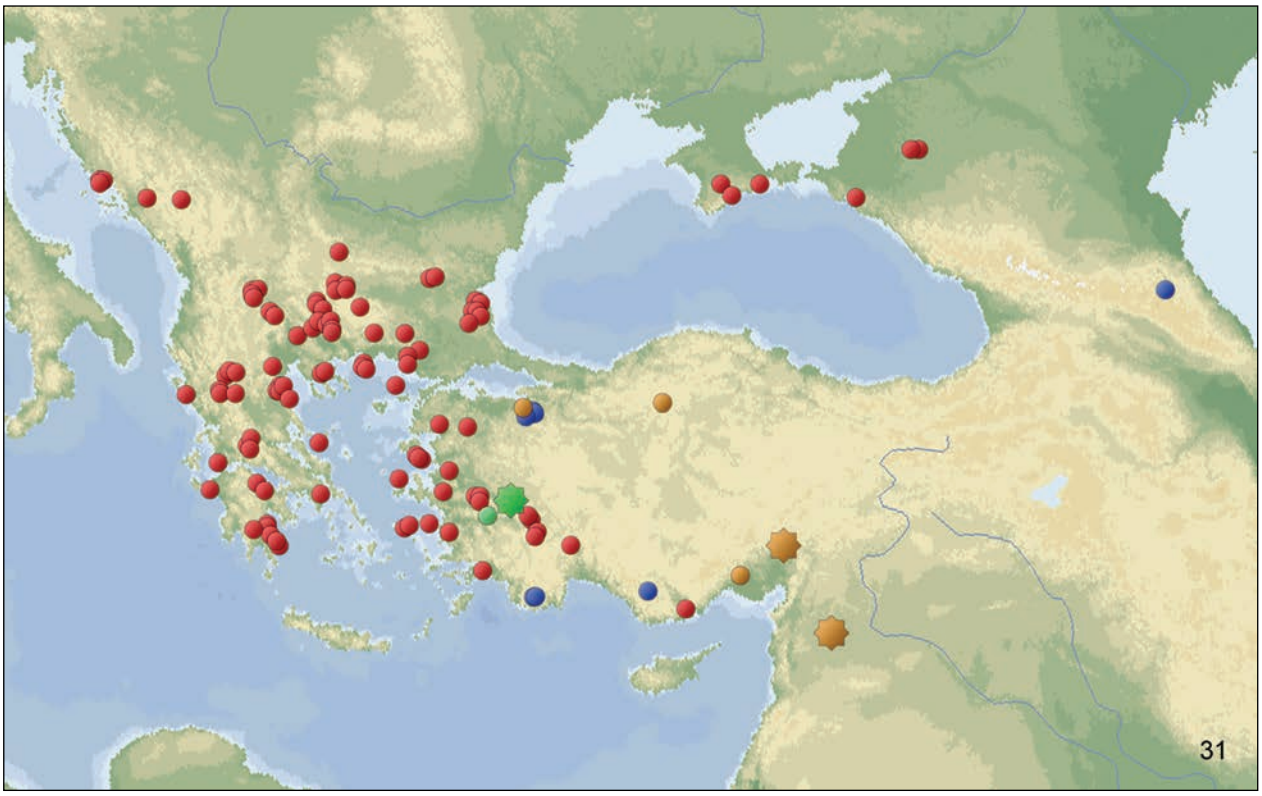


Figure 31. Distribution of Dilaridae in Southeast Europe and Anatolia (see geographical coordination and references of distribution records in Suppl. materials 1–2). Red = *D. turcicus*; brown = *D. anatolicus* sp. n.; green = *D. fuscus* sp. n.; star = identified specimens without exact locality; blue = *Dilar* sp.

and does presumably not occur in Anatolia. The existing remains of the damaged holotype cannot be assigned to any of the known species of *Dilar*.

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We want to express our grateful thanks to a number of colleagues who have helped substantially in this study: Philip D. Perkins and Rachel Hawkins (MCZ) organized, promoted and speeded the sending of photographs and finally the syntype of D. turcicus from Armenia which became the lectotype and thus the precondition for the taxonomy in this paper. Michael Ohl and Lukas Kirschey (MFN) have sent photographs of the other syntype of D. turcicus and of the type of D. lineolatus and a further specimen which turned out to represent *D. anatolicus* sp. n. Peter J. Schwendinger (MHN) provided specimens from the Pictet collection. Hubert and Renate Rausch (Scheibbs) entrusted their enormous Dilaridae collection to us for this study. Antoine Mantilleri (MNHN) helped us committedly to get into contact with the persons curating the Neuropterida collection. Several specimens of *D. anatolicus* sp. n. and of *D. turcicus* respectively in the HUAC were collected by the following entomologists: Ernst Arenberger, Georg Friedel †, Carolus Holzschuh, Friedrich Kasy †, Josef Klimesch †, Hans Malicky, Franz Ressl †, Alfred Radda and Josef Thurner †. Harald Bruckner (NHMW) deserves our special gratitude for providing the database of all the records, for producing the distribution map and finally for photographs, especially for the focus stacking images of the genital sclerites of the lectotypus of *D. turcicus*. We gratefully acknowledge the valuable input of the reviewers. This research was supported by the National Natural Science Foundation of China (Nos. 31322051 and 31320103902).

References

Aspöck H, Aspöck U (1968) Zwei weitere neue Spezies des Genus *Dilar* Rambur (Neuroptera, Planipennia) aus Asien (Vorläufige Mitteilung). Entomologisches Nachrichtenblatt, Wien 15: 3–6.

Aspöck H, Aspöck U, Hölzel H (1980) Die Neuropteren Europas. 2 vols. Goecke & Evers, Krefeld, 495 pp, 355 pp.

Aspöck H, Hölzel H, Aspöck U (2001) Kommentierter Katalog der Neuropterida (Insecta: Raphidioptera, Megaloptera, Neuroptera) der Westpaläarktis. Denisia 2: 1–606.

Aspöck U, Aspöck H (2008) Phylogenetic relevance of the genital sclerites of Neuropterida (Insecta: Holometabola). Systematic Entomology 33: 97–127. doi: 10.1111/j.1365-3113.2007.00396.x

Canbulat S (2007) A checklist of Turkish Neuroptera with annotating on provincial distributions. Zootaxa 1552: 35–52.

Canbulat S, Kiyak S (2005) Contribution to the Fauna of Neuroptera (Insecta) of South-Western Anatolia. Annals of the Upper Silesian Museum (Entomology) 13: 9–60.

Devetak D (1991) Neuropteroidea. Megaloptera, Raphidioptera, Planipennia (Insecta). Fauna Durmitora 4: 135–159.

Devetak D (1992a) Megaloptera, Raphidioptera and Planipennia (Neuropteroidea, Insecta) of Croatia. Znanstvena Revija 4: 89–114.

Devetak D (1992b) Present knowledge of the Megaloptera, Raphidioptera and Neuroptera of Yugoslavia (Insecta: Neuropteroidea). In: Canard M, Aspöck H, Mansell MW (Eds) Current Research in Neuropterology. Proceedings of the 4th International Symposium on Neuropterology. Bagnères-de-Luchon, France. Toulouse, 107–118.

Devetak D, Klokočovnik V, Rausch H, Janžekovič F (2015) Fauna of the Neuropterida (Raphidioptera, Neuroptera) of the Protected Area Jasen, Macedonia: a summer flash. Turkish Journal of Zoology 39: 15–27. doi: 10.3906/zoo-1305-43

Ghilarov MS (1962) The larva of *Dilar turcicus* Hag. and the position of the family Dilaridae in the order Planipennia. Entomologicheskoe Obozrenie 41: 402–416.

Hagen HA (1858) Russlands Neuropteren. Stettiner Entomologische Zeitung 19: 110–134.

Hagen HA (1860) Neuroptera Neapolitana von A. Costa, nebst Synopsis der Ascalaphen Europas. Stettiner Entomologische Zeitung 21: 38–56.

Hagen HA (1866) Die Neuropteren Spaniens nach Ed. Pictet's Synopsis des Neuroptères d'Espagne. Genève 1865. 8. tab. 14 col. und Dr. Staudingers Mittheilungen. Stettiner Entomologische Zeitung 27: 281–302.

Kiyak S, Özdikmen H (1993) Über einige neuropterenarten von Soguksu National park (Kizilcahamam, Ankara). Priamus 6: 156–160.

Kovanci OB, Kovanci B (2015) Contribution to the knowledge of Mantispoidea, Osmyloidea, and Myrmeleontidea with new records for the Neuroptera fauna of northwestern Turkey. Turkish Journal of Zoology 39: 110–118. doi: 10.3906/zoo-1401-45

Legrand J, Lachaise M (1994) Les Dilaridae de Navás conservés dans les collections nationales (MNHN, Paris) [Neuroptera]. Revue Française d'Entomologie (N.S.) 16: 87–92.

Minter LR (1986) The first record of Dilaridae (Neuroptera) from the Afrotropical Region. Journal of the Entomological Society of Southern Africa 49: 87–94.

Monserrat VJ (1988) Revisión de la obra de L. Navás, I: El genero *Dilar* Rambur, 1842 (Neuropteroidea, Planipennia: Dilaridae). Neuroptera International 5: 13–23.

Monserrat VJ (2014) Los diláridos de la Península Ibérica (Insecta: Neuropterida: Neuroptera: Dilaridae). Heteropterus Revista de Entomologia, 14: 187–214.

Monserrat VJ, Triviño V (2013) Atlas de los neurópteros de la Península Ibérica e Islas Baleares (Insecta, Neuroptera: Megaloptera, Raphidioptera, Planipennia). Monografias S.E.A., Sociedad Entomológica Aragonesa 13: 1–154.

Navás L (1903) Diláridos de España. Memorias de la Real Academia de Ciencias y Artes de Barcelona (3) 4: 373–381.

Navás L [1909] (1908–1909) Monografía de la familia de los Diláridos (Ins. Neur.). Memorias de la Real Academia de Ciencias y Artes de Barcelona (3) 7: 619–671.

Navás L (1913) Mis excursiones por el extranjero en el verano de 1912 (25 julio–16 septiembre). Memorias de la Real Academia de Ciencias y Artes de Barcelona (3) 10: 479–514.

Navás L (1914) Family Dilaridae. Neuroptera. Genera Insectorum 156: 1–14.

Navás L (1925) Les dilarides (Ins. Névroptères) du Muséum National de Paris. Bulletin du Muséum National d'Histoire Naturelle, Paris (1) 31: 188–189.

New TR (1986) A review of the biology of Neuroptera Planipennia. Neuroptera International, Supplemental Series 1: 1–57.

New TR (1989) Planipennia, Lacewings. Handbuch der Zoologie, Vol. 4 (Arthropoda: Insecta), Part 30. Walter de Gruyter, Berlin, 132 pp.

New TR (2003) The Neuroptera of Malesia. Fauna Malesiana vol. 4, Brill, Leiden, VIII + 204 pp.

Oswald JD (1998) Annotated catalogue of the Dilaridae (Insecta: Neuroptera) of the world. Tijdschrift voor Entomologie 141: 115–128. doi: 10.1163/22119434-99900008

Oswald JD, Schiff NM (2001) A new species of the genus *Dilar* Rambur (Neuroptera: Dilaridae) from Borneo. Proceedings of the Entomological Society of Washington 103: 74–80.

Pongrácz S (1913) Újabb adatok Magyarország Neuroptera-faunájához. Rovartani Lapok 20: 175–186.

Popov A (1964) What do we know on the distribution of Neuropteroidea in Bulgaria. Priroda 13: 68–72. [In Bulgarian]

Popov A (1993) Raphidiopteren und Neuropteren aus Bulgarien in den Sammlungen des Nationalmuseums in Prag. Historia Naturalis Bulgarica 4: 16–28.

Popov A (2001) The snakeflies and the lacewing insects (Insecta: Raphidioptera and Neuroptera) of the Kresna Gorge (SW Bulgaria). In: Beron P (Ed.) Biodiversity of Kresna Gorge (SW Bulgaria). National Museum of Natural History, Sofia, 131–143. [In Bulgarian]

Popov A (2002) Zoogeographical analysis of Neuroptera in Bulgaria. Acta Zoologica Academiae Scientiarum Hungaricae 48: 271–280.

Popov A (2004) List of Raphidioptera, Neuroptera and Mecoptera published from the Eastern Rhodopes (Bulgaria and Greece). In: Beron P, Popov A (Eds) Biodiversity of Eastern Rhodopes (Bulgaria and Greece). National Museum of Natural History, Sofia, 371–378.

Popov A (2007) Distribution of the families of Neuroptera with low species diversity in Bulgaria. In: Pantaleoni RA, Letardi A, Corazza C (Eds) Proceedings of the 9th International Symposium on Neuropterology, Ferrara 20-23 June 2005. Annali del Museo Civico di Storia Naturale di Ferrara 8: 117–130.

Rambur MP [1838] (1837–1840) Faune entomologique de l'Andalousie. Vol. 2. Paris.

Zakharenko AV (1982) O faune i prakticheskom znachenii setchatokrylykh Ukrainy [= On the fauna and practical meaning of the lacewings in the Ukraine]. Sbornik nauchnykh trudov Khar'kovskogo Sel'sko-Khozyaistvennogo Instituta [= Transactions of the Kharkov Agricultural Institute] 282: 20–24. [In Russian]

Zakharenko AV (1988) Setchatokrylye (Neuroptera) fauny SSSR. II. Semeistva Dilaridae, Berothidae i Sisyridae [= Neuroptera of the fauna of the USSR. II. Fam. Dilaridae, Berothidae and Sisyridae]. Entomologicheskoe Obozrenie 67: 763–768. [In Russian]

Zakharenko AV, Krivokhatsky VA (1993) Setchatokrylye (Neuroptera) evropeiskoi chasti byvshego SSSR [= Neuroptera from the European part of the former USSR]. Izvestiya Kharkovskogo Entomologicheskogo Obshchestva [= Kharkov Entomological Society Gazette] 1: 34–83. [In Russian]

Zhang W, Liu XY, Aspöck U, Aspöck H (2014a) Revision of Chinese Dilaridae (Insecta: Neuroptera) (Part I): Species of the genus *Dilar* Rambur from northern China. Zootaxa 3753: 10–24. doi: 10.11646/zootaxa.3753.1.2

Zhang W, Liu XY, Aspöck U, Aspöck H (2014b) Revision of Chinese Dilaridae (Insecta: Neuroptera) (Part II): Species of the genus *Dilar* Rambur from Tibet. Zootaxa 3878: 551–562. doi: 10.11646/zootaxa.3878.6.3

Zhang W, Liu XY, Aspöck H, Winterton SL, Aspöck U (2014c) Species of the pleasing lacewing genus *Dilar* Rambur (Neuroptera, Dilaridae) from islands of East Asia. Deutsche Entomologische Zeitschrift 61: 141–153. doi: 10.3897/dez.61.8793

Zhang W, Liu XY, Aspöck H, Aspöck U (2015) Revision of Chinese Dilaridae (Insecta: Neuroptera) (Part III): Species of the genus *Dilar* Rambur from the southern part of mainland China. Zootaxa 3974: 451–494. doi: 10.11646/zootaxa.3974.4.1

Supplementary material 1

Sources of records upon which the distribution map is based

Authors: Ulrike Aspöck, Xingyue Liu, Horst Aspöck

Data type: records data

Supplementary material 2

Records on which the distribution map is based

Authors: Ulrike Aspöck, Xingyue Liu, Horst Aspöck

Data type: records data

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PENSOFT

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Revision of the genera *Microplitis* and *Snellenius* (Hymenoptera, Braconidae, Microgastrinae) from Area de Conservacion Guanacaste, Costa Rica, with a key to all species previously described from Mesoamerica

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DNA barcoding
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Abstract

The genera *Microplitis* and *Snellenius* (Hymenoptera: Braconidae, Microgastrinae) from Area de Conservacion Guanacaste (ACG), Costa Rica, are revised. A total of 28 new species are described: 23 of *Snellenius* (the first record for Mesoamerica) and five of *Microplitis*. A key is provided to all new species and five species of *Microplitis* previously described from Mesoamerica. In ACG, all *Microplitis* were reared exclusively from Sphingidae, while all *Snellenius* were reared from Noctuoidea (Noctuidae and Erebidae). All of the wasp species with known host records are unambiguously specialists, parasitizing one or a few related hosts. Biological information (wasp cocoon and caterpillar hosts) in the Neotropical region seems to differ from similar data reported in previous works for the Oriental region -but more studies on the world fauna are needed. Although the distinction between these two genera has been controversial, we consider that the available evidence, although not conclusive, suggests that these two genera are best kept as separate (based on the presence of at least a partial epicnemial carina in *Snellenius*, which is absent in *Microplitis*). The following 28 species, all authored by Fernández-Triana & Whitfield, are described as **species nova**: *Microplitis adrianguadamuzi*, *M. alexanderrojasi*, *M. francopupulini*, *M. hebertbakeri*, *M. jorgehernandezi*, *Snellenius billburgeri*, *S. bobdressleri*, *S. donstonei*, *S. felipechavarriai*, *S. gerardoherrerai*, *S. irenebakerae*, *S. isidrochaconi*, *S. johnkressi*, *S. jorgecampabadali*, *S. jorgegomezlauritoi*, *S. josesarukhani*, *S. kerrydresslerae*, *S. lucindamcdadeae*, *S. luisdiegogomezi*, *S. mariakuzminae*, *S. mariamartachavarriae*, *S. phildevriesi*, *S. quiricojimenezi*, *S. robertoespinozai*, *S. sandyknappae*, *S. velvaruddae*, *S. vickifunkae*, *S. warrenwagneri*.

Introduction

For the past 35 years and counting, the Area de Conservacion Guanacaste (ACG) in northwestern Costa Rica has been inventorying all of its species of Lepidoptera, their host plants and their parasitoids. The survey has produced 650,000+ caterpillar rearing records and thousands of parasitoid records (e.g. Janzen et al 2009, 2011,

Fernandez-Triana et al. 2014, Fleming et al. 2014, Hansson et al. 2015).

The worldwide subfamily Microgastrinae (Hymenoptera: Braconidae) is one of the main groups with species parasitizing caterpillars (Whitfield 1995, 1997). The ACG inventory has found over a thousand undescribed species of microgastrine wasps, and our goal is to describe all of them. Here we continue with the revision of the closely related genera *Microplitis* Foerster and *Snellenius* Westwood.

Microplitis is one of the largest genera of Microgastrinae, with almost 200 known species. Although found in all regions, the greatest diversity is in the Holarctic (70% of all described species). We have seen many more undescribed species in collections, especially from the Nearctic. The diversity in the Neotropics is much lower, with only six described species before this study (Yu et al. 2012).

Snellenius is a moderately diverse genus that is restricted to the tropics. It contains 12 Oriental and Australasian species (Austin and Dangerfield 1993, Luo and You 2005, Yu et al. 2012, Long and Achterberg 2013), and four Neotropical species (Peru and Argentina) (Shenefelt 1968). We have seen more species in collections; they are mostly from South America but also from Central America and several countries in Asia. At present no specimens are known from the Afrotropics.

Methods

This study is based on almost 2,000 specimens of *Microplitis* and *Snellenius* from ACG, either reared from caterpillar hosts or collected with Malaise traps. Morphology, host caterpillars and other ecological information were considered along with sequences from the 658 bp DNA barcode region of the cytochrome c oxidase I (COI) gene (Hebert et al. 2003) when available.

Also included in the key and species treatments are five species of *Microplitis* that were previously described from Mesoamerica. While some of their holotypes were not available to study, the original descriptions were sufficiently detailed (or some species features were distinctive enough) to allow us to distinguish them from the new species described here.

Specimens of the new species are deposited in the National Museum of Natural History, Smithsonian Institution, Washington DC, United States (USNM), the Canadian National Collection of Insects, Ottawa, Canada (CNC), the Natural History Museum, London, England (BMNH), the Illinois Natural History Survey, Champaign, United States (INHS), and the Instituto Nacional de Biodiversidad, Santo Domingo, Costa Rica (INBio).

Morphological terms and measurements of structures are mostly as in Mason (1981), Huber and Sharkey (1993), Whitfield (1997), Karlsson and Ronquist (2012), and Fernández-Triana et al. (2014). Some natural history information (e.g., geographical distribution, hosts species, details of wasp cocoons) is also provided in the key whenever available. Those data are included in brackets at the end of the corresponding couplet and are intended as supplementary information that can help the user to correctly identify specimens.

Descriptions of the new species are based on the study of all female specimens that were available for study to reflect intraspecific variation, but the descriptions always include data from the holotype. A few species were described from males only (because no female specimens were available) in cases where they were distinct enough to be recognized as different; the males of those species will run through the key, but males of most species may not be readily identified unless associated with females via rearing or molecular data. A set of 31 morphological characters, including some body measurements and color characters commonly used in Microgastrinae, were used to provide uniform descriptions for all new species. The only exceptions are some *Microplitis* species that were previously extensively illustrated and described (Janzen et al. 2003); here we provide only additional measurements and do not repeat complete descriptions for them.

The descriptions are complemented by extensive photographic illustrations of every species. Photos were taken with a Keyence VHX-1000 Digital Microscope, using a lens with a range of 13–130 ×. Multiple images through the focal plane were taken of a structure and these were combined to produce a single in-focus image using software associated with the Keyence System.

Images of the holotype of *Microplitis marini* Whitfield, 2003, deposited in the NMNH, were obtained using a GT Vision EntoVision imaging system consisting of a firewire JVC KY-75 3CCD digital camera mounted on a Leica M16 zoom lens via a Leica z-step microscope stand. The camera fed a desktop computer where the Archimed software program was used to export image stacks, and the CZPBatch software program was used to generate a composite image from the exported image stacks. Composite images were edited using Adode Photoshop CS4 to remove artifacts from stack processing and standardize background color.

DNA barcodes for all ACG inventory *Microplitis* and *Snellenius* were obtained using DNA extracts prepared from single legs using a glass fibre protocol (Ivanova et al. 2006). Briefly, total genomic DNA was re-suspended in 30 µl of dH2O, and a 658-bp region near the 5' terminus of the COI gene was amplified using standard primers (LepF1–LepR1) following established protocols (Smith et al. 2006, 2007, 2008). If the initial 658 bp amplification was unsuccessful, composite sequences were generated using internal primers. All information for the sequences associated with each individual specimen can be retrieved from the Barcode of Life Data System (BOLD) (Ratnasingham and Hebert 2007) by Process ID (sequence accession) or here: http://dx.doi.org/10.5883/DS-ASMICRSN

DNA barcode-based phenograms were constructed using either a single high-quality specimen (longest read length and fewest ambiguities) for each species (Figure 234) or

using all specimens and sequence lengths for each species (Suppl. material 1).

In the taxonomic treatment of species, we give full details of the collecting locality of only the holotype. Country and province are detailed for paratypes, followed by ACG database codes (in the format "yy-SRNP-xxxxxx" for the host caterpillar and "DHJPARxxxxxxx" for an individual parasitoid specimen). These codes allow for the retrieval of detailed information of any specimen at http://janzen.sas.upenn.edu. Additionally, we included details on the paratype specimens in the Suppl. material 2.

The patronyms used for the new species honor a major proportion of the persons who have supported and contributed plant biology and plant taxonomic information towards understanding ACG biodiversity during the past five decades. Additional members of this group of very important people are honoured with patronyms in an upcoming paper on the microgastrine genus *Xanthomicrogaster*.

Results

The relationship between *Microplitis* and *Snellenius*

The genera *Microplitis* and *Snellenius* form one of the most morphologically distinct groups of microgastrines (Nixon 1965, Mason 1981, Walker et al. 1990, Shaw and Huddleston 1991, Austin and Dangerfield 1993). Austin and Dangerfield (1993) provided some shared diagnostic features: relatively large areolet in the fore wing, coarse sculpturing of the propodeum (which also has a strong median carina), distinctive shape of first mediotergite, poor separation of mediotergites 2 and 3, and short ovipositor and sheaths. Additional distinctive characters that we consider here include the small size of the metacoxa (metacoxa at most 2.0 × as long as mesocoxa, not surpassing posterior of tergum 2 (usually not surpassing tergum 1) and its length less than 0.3 × metasomal length), metatibial spurs very short (usually shorter than half length of first metatarsomere), and scutoscutellar sulcus relatively wide and deep. Only *Alloplitis* and *Philoplitis* share some of the features mentioned above, but they have either a strongly protruding scutellar disc (*Philoplitis*) or an areolated propodeum and different shape of mediotergite 1 (*Alloplitis*).

Most species of *Snellenius* are easily distinguishable from other microgastrines by having strongly excavated and sculptured notauli and scutellar disc, very wide and deep scutoscutellar sulcus, and propodeum divided into two distinct areas (faces) clearly marked by a strong angulation (observed laterally) and a transverse carina (observed dorsally). All of those features are rather unique in Microgastrinae and could be considered as autapomorphies for the genus, if not for the fact they appear to grade, from strongly excavated and sculptured notauli and scutellar disc (Figs 66, 73, 80, 93, 107, 114, 127, 134, 154, 161, 173, 187, 193, 207) to less excavated/less sculptured (a few *Snellenius*, most *Microplitis*) (Figs 16, 22, 36, 43, 51, 58, 59, 100, 121, 148, 165, 201, 214), to basically smooth and unexcavated (some *Microplitis*) (Figs 5, 11, 30).

Another character has been pointed out to separate the two genera: the presence of an epicnemial carina in *Snellenius*, which is absent in *Microplitis* (Mason 1981, Austin and Dangerfield 1992, 1993). The presence of an epicnemial carina is extremely rare within Microgastrinae; it occurs in only one other genus (i.e., *Fornicia*) (Mason 1981, Whitifield et al. 2002). It is mostly due to this character that we are keeping the two genera as separate in this paper, although in practice it may be difficult to distinguish the epicnemial carina due to setae and/or sculpture on the epicnemium and mesopleura.

In ACG we have also found clear differences in the families of Lepidoptera used as hosts by the two genera, but that does not seem to be the case in other regions (see next section). Also, in ACG all species of *Microplitis* are gregarious parasitoids, whereas all species of *Snellenius* are solitary parasitoids (Figs 216–229).

In summary, although *Microplitis* and *Snellenius* are not likely to be confused with any other genera of Microgastrinae, the limits between them have been controversial (e.g., Nixon 1965, Mason 1981, Austin and Dangerfield 1992, 1993). The available evidence, although not conclusive, suggests that these two genera are best kept separate for the time being. A comprehensive study of the world fauna will be needed to ultimately settle the issue.

Comments on the biology of *Microplitis* and *Snellenius*

Prior to the ACG inventory rearings, the only host records known for *Snellenius* were from the Oriental Region (Austin and Dangerfield 1993, Yu et al. 2012). However, for *Microplitis* there is a wealth of information about its biology, from both temperate and tropical areas (e.g. Shaw and Huddleston 1991, Austin and Dangerfield 1993, Janzen et al. 2003, Yu et al. 2012).

The accounts from earlier works are somewhat contradictory and merit further discussion here. For example, Austin and Dangerfield (1993) postulated that overwintering of *Microplitis* in the cocoon stages is a phenomenon probably restricted to extra-tropical seasonally cold regions (where cocoons are thick and dark in coloration), while cocoons of tropical species are mostly light-coloured and thin-walled, suggesting those species 'overwinter' (= dormancy during dry months) as adults. However, in ACG we have found that all of the *Microplitis* and *Snellenius* have thick hard cocoons (Figs 216–229), and most individuals of all species spend the dry months dormant in the cocoon (see also Janzen et al. 2003).

Similarly, an account of all literature records of hosts for those two genera (summarized in Austin and Dangerfield 1993) found that the majority of *Microplitis* species with known hosts parasitize Noctuoidea (Noctuidae, Notodontidae and Erebidae), while the Oriental *Snellenius* were parasitoids of Noctuidae and Sphingidae. This is in stark contrast to ACG, where

all *Microplitis* were reared exclusively from Sphingidae, while all *Snellenius* were reared from Noctuoidea (Noctuidae and Erebidae).

It is hard to tell if those differences reflect a real distinction between host species in the Neotropical vs Oriental regions (e.g., distinct lineages). More host data from other Neotropical areas, and a comprehensive study of *Snellenius* hosts worldwide, are needed.

Extensive details on the biology of three *Microplitis* species in ACG were given by Janzen et al. (2003). Their major conclusions are confirmed here: all of the species are unambiguously specialists, parasitizing one or a few related species, some species are restricted to particular habitats (e.g., dry forest), and others have only been collected at specific times of the year.

Some of the *Microplitis* and *Snellenius* species described here are morphologically cryptic (i.e., morphological differences are slight, and some characters overlap between species). However, in all cases there are consistent and clear ecological, biological and molecular differences to unambiguously recognize each individual species.

Taxonomic section

Here we describe 28 new species, 23 of *Snellenius* (the first for Mesoamerica) and five of *Microplitis*. We also refer to five previously described species of *Microplitis*: three known to occur in ACG (Janzen et al. 2003) and two from the Caribbean (Yu et al. 2012). There are a few additional ACG species in both genera, but we do not describe them until more specimens become available. We have seen in collections dozens of additional new species of *Snellenius* and *Microplitis* from the Neotropics which will be revised in future papers. An updated list of the 33 Mesoamerican species of *Microplitis* and *Snellenius*, and their hosts (where known) is shown in Table 1.

Table 1. The Mesoamerican described species of *Microplitis* and *Snellenius*. ACG: Area de Conservacion Guanacaste; OTS: Organization for Tropical Studies, Palo Verde Biological Station (for species where known distribution is restricted to those areas in Costa Rica).

Species	Hosts	Known distribution
Microplitis adrianguadamuzi sp. n.	Sphingidae: *Manduca corallina*	Costa Rica (ACG)
Microplitis alexanderrojasi sp. n.	Sphingidae: *Erinnyis oenotrus*	Costa Rica (ACG)
Microplitis chacoensis (Cameron, 1908)	Sphingidae: *Agrius cingulata*, *Erinnyis ello*, *Manduca rustica*, *M. sexta*	Argentina, Brazil, Paraguay, Uruguay, Trinidad, Venezuela
Microplitis espinachi Walker, 2003	Sphingidae: *Agrius cingulata*, *Lintneria merops*, nine species of *Manduca* but not *M. corallina*	Costa Rica (ACG)
Microplitis figueresi Walker, 2003	Sphingidae: *Erinnyis crameri*, *E. ello*	Costa Rica (ACG)
Microplitis francopupulini sp. n.	Sphingidae: *Xylophanes guianensis*	Costa Rica (ACG)
Microplitis hebertbakeri sp. n.	unknown	Costa Rica (ACG)
Microplitis jorgehernandezi sp. n.	Sphingidae: *Erinnyis alope*, *E. ello*	Costa Rica (ACG)
Microplitis marini Whitfield, 2003	Sphingidae: *Xylophanes tersa*	Costa Rica (ACG)
Microplitis sordidus (Ashmead, 1900)		Saint Vincent Island
Snellenius billburgeri sp. n.	unknown	Costa Rica (ACG)
Snellenius bobdressleri sp. n.	Erebidae: *Pseudbarydia crespula*	Costa Rica (ACG)
Snellenius donstonei sp. n.	Erebidae: *Ceromacra* Poole02	Costa Rica (ACG)
Snellenius felipechavarriai sp. n.	Erebidae: *Coenipeta bibitrix*	Costa Rica (ACG)
Snellenius gerardoherrerai sp. n.	unknown	Costa Rica (ACG)
Snellenius irenebakerae sp. n.	Noctuidae: noctJanzen01 05-SRNP-23743	Costa Rica (ACG)
Snellenius isidrochaconi sp. n.	Erebidae: 3 species of *Gonodonta*	Costa Rica (ACG), Panama
Snellenius johnkressi sp. n.	Erebidae: *Bulia mexicana*	Costa Rica (ACG)
Snellenius jorgecampabadali sp. n.		Costa Rica (OTS)
Snellenius jorgegomezlauritoi sp. n.	Noctuidae: *Stauropides persimilis*	Costa Rica (ACG)
Snellenius josesarukhani sp. n.	Erebidae: *Helia sueroides*	Costa Rica, Alajuela and Guanacaste Provinces
Snellenius kerrydresslerae sp. n.	Erebidae: *Orodesma pulverosa*	Costa Rica (ACG)
Snellenius lucindamcdadeae sp. n.	unknown	Costa Rica (ACG)
Snellenius luisdiegogomezi sp. n.	unknown	Costa Rica, Panama
Snellenius mariakuzminae sp. n.	Noctuidae: *Concana Poole01*	Costa Rica (ACG)
Snellenius mariamartachavarriae sp. n.	Noctuidae: *Catephiodes trinidadensis*	Costa Rica (ACG)
Snellenius phildevriesi sp. n.	Erebidae: 3 species of *Gonodonta*, *Hemeroblemma schausiana*DHJ02	Costa Rica (ACG)
Snellenius quiricojimenezi sp. n.	unknown	Costa Rica
Snellenius robertoespinozai sp. n.	Noctuidae: *Melipotis cellaris*	Costa Rica (ACG)
Snellenius sandyknappae sp. n.	Erebidae: *Helia argentipes*	Costa Rica (ACG)
Snellenius velvaruddae sp. n.	unknown	Costa Rica (ACG)
Snellenius vickifunkae sp. n.	unknown	Costa Rica
Snellenius warrenwagneri sp. n.	unknown	Costa Rica (ACG)

Key to ACG species of *Microplitis* and *Snellenius*

[We could not examine the type of *Microplitis sordidus* (Ashmead, 1900), originally described under the genus *Apanteles* from the island of Saint Vincent. However, Muesebeck (1958) placed the species under the genus *Microplitis*. The species is excluded from the key below, but according to the original description, it has a smooth head and mesosoma (including propodeum); no other species of *Microplitis* in Mesoamerica has a smooth head or propodeum].

1 Epicnemial carina at least partially defined (sometimes obscured by setae and/or sculpture on epicnemium and mesopleura); scutellar disc heavily sculptured, with deeper sculpture near margins, central part appearing slightly elevated and less sculptured than margins (Figs 66, 73, 75, 93, 107, 114, 127, 134, 141, 173, 180, 187, 193, 208); anteromesoscutum heavily sculptured, with notauli wide and deeply excavated (usually with numerous crenulae) (as in Figs 73, 80, 127, 134, 173, 193); central area of anteromesoscutum usually appearing raised compared to lateral areas of anteromesoscutum (as in Figs 73, 134, 173, 187, 193); scutoscutellar sulcus very wide and deep; propodeum with anterior and posterior areas separated by transverse carina, and also defined by distinct angulation between anterior and posterior areas (observed in lateral view) (as in Figs 113, 117, 119, 128, 150, 168, 176, 185); antenna in males of many species strongly flattened, with central and posterior flagellomeres distinctly widened (as in Figs 62, 63, 65, 69, 166) [Hosts in ACG: Erebidae, Noctuidae, Nolidae; all species in ACG are solitary parasitoids] [Genus *Snellenius*] 2

– Epicnemial carina absent; scutellar disc not so heavily sculptured, if with strong punctures, margins and central part of disc usually equally sculptured (Figs 5, 11, 18, 22, 31, 38, 43, 52, 55); anteromesoscutum less heavily sculptured (sometimes almost smooth), notauli faint or slightly defined (rarely deeply excavated) (as in Figs 5, 22, 30, 43, 51); central area of anteromesoscutum not appearing raised compared to lateral areas of anteromesoscutum; scutoscutellar sulcus relatively less wide and deep than previous couplet; propodeum usually without clear distinction between anterior and posterior areas, and often without strong angulation (observed in lateral view); antenna in males not flattened [Hosts in ACG: Sphingidae; all species in ACG are gregarious parasitoids] [Genus *Microplitis*] 24

2(1) T1 at least 2.8 × as long as wide at posterior margin, usually more 3

– T1 less than 2.5 × as long as wide at posterior margin (very rarely up to 2.6 ×) 11

3(2) Mesosoma and metasoma mostly dark reddish brown or black (rarely with some tergites yellow) (Figs 62, 63, 69, 83, 89, 90, 110, 117, 123, 129, 136, 143, 150, 156, 163, 176, 183, 189, 196, 203, 209) 4

– Mesosoma and metasoma with extensive orange or yellow areas (Figs 76, 103, 169, 170) 8

4(3) T1 length 4.0 × its width at posterior margin (Fig. 152); mesosoma and metasoma entirely dark reddish-brown (Figs 150–155); mesocoxa, metatrochanter and metatrochantellus entirely white-yellow, strongly contrasting with rest of leg; metatibia (entirely), most of profemur, protibia, and mesotibia reddish-brown to black (Figs 150, 151, 153) ... *Snellenius luisdiegogomezi* Fernández-Triana & Whitfield, sp. n.

– T1 length at most 2.8 × its width at posterior margin; mesosoma mostly black (rarely brown-red), metasoma mostly dark brown to black (rarely with T2–T3 yellow); mesocoxa color not strongly contrasting with color of rest of leg; anterior 0.2–0.6 of metatibia light yellow, profemur, protibia, and mesotibia entirely or mostly yellow-orange..... 5

5(4) Anterior 0.6 of metatibia light yellow (Fig. 205); T2–T3 yellow (Fig. 206); fore wing with veins 2RS, r, and 3RSa yellowish-white (Fig. 204); anteromesoscutum and scutellar disc almost entirely with coarse sculpture (Figs 207, 208) ..... *Snellenius vickifunkae* Fernández-Triana & Whitfield, sp. n.

– Anterior 0.2–0.4 of metatibia light yellow (Figs 89, 92, 143, 145, 209, 211); all tergites dark brown to black; fore wing with veins 2RS, r, and 3RSa brown (Figs 91, 210); anteromesoscutum and scutellar disc not entirely with coarse sculpture (Figs 93, 148, 214) 6

6(5) Metatibial spurs yellow orange (Fig. 145); anterior 0.1–0.2 of metatibia light yellow orange (Fig. 145); T1 2.8 × as long as wide; T1 width at half length of tergite 1.7 × its width at posterior margin..... *Snellenius lucindamcdadeae* Fernández-Triana & Whitfield, sp. n.

– Metatibial spurs yellow white (Figs 92, 211); anterior 0.3–0.5 of metatibia yellow white (Figs 92, 209, 211); T1 at least 3.0 × as long as wide; T1 width at half length of tergite at most 1.5 × its width at posterior margin 7

7(6) Scape dark brown; tegula and humeral complex yellow; flagellomere 2 3.0–3.2 × as long as wide; flagellomere 14 2.5–2.7 × as long as wide ..... *Snellenius warrenwagneri* Fernández-Triana & Whitfield, sp. n.

– Scape yellow orange; tegula and humeral complex dark brown; flagellomere 2 2.4–2.5 × as long as wide; flagellomere 14 2.0–2.3 × as long as wide ..... *Snellenius gerardoherrerai* Fernández-Triana & Whitfield, sp. n.

8(3) Mesosoma partially black and partially orange (Figs 96, 100, 102); metasoma partially brown, orange, yellow and white (Figs 96, 99, 101); metafemur brown black dorsally, yellow white ventrally (Figs 96, 98, 99) [Host: undetermined Noctuidae] ..... *Snellenius irenebakerae* Fernández-Triana & Whitfield, sp. n.

– Mesosoma and metasoma uniformly colored light yellow or yellow-orange; metafemur of different coloration 9

9(8) Body color light yellow to white (Figs 76–82); metatibia yellow except for posterior 0.2 which is light brown (Fig. 81); wings with light brown to golden infumation, veins and pterostigma mostly light brown to yellow (Fig. 77) [Hosts: Noctuidae, *Ceromacra* sp.] ..... *Snellenius donstonei* Fernández-Triana & Whitfield, sp. n.

– Body color yellow-orange (Figs 103, 169, 170); metatibia mostly or entirely dark red-brown; wings with dark brown infumation, veins and pterostigma mostly dark brown (Figs 104, 171) [Hosts: Erebidae, *Gonodonta* spp.]..... 10

10(9) Propodeum of male with one well defined transverse carina (rarely a second one is partially visible) (Fig. 174); male with posterior margin of metascutellum not forming acute projection (Fig. 173); male with interocellar area partially black; male body length 3.8 mm, and fore wing length 3.7 mm; female similar to male [Hosts: Erebidae, *Gonodonta* spp. (caterpillars feeding on *Piper* spp. and Annoncaeae) and *Hemeroblemma schausiana*DHJ02]..... ..... *Snellenius phildevriesi* Fernández-Triana & Whitfield, sp. n.

– Propodeum of male with at least two (and usually three) well defined transverse carinae (Fig. 109); male with posterior margin of metascutellum medially forming acute projection (Fig. 107); male with interocellar area orange, same color as rest of head; male body length 3.5–3.6 mm, and fore wing length 3.5 mm; female unknown [Hosts: Erebidae, *Gonodonta* spp. (caterpillars feeding on *Cissampelos* spp., Menispermaceae)]..... ..... *Snellenius isidrochaconi* Fernández-Triana & Whitfield, sp. n.

11(2) Pterostigma relatively wide (2.0 × as long as wide); *and* fore wing with basal cell virtually without setae (Fig. 118); *and* wings with most veins transparent or light yellow (except for veins r, 2RS, 3RSa, and 2M)..... .....*Snellenius jorgecampabadali* Fernández-Triana & Whitfield, sp. n.

– Pterostigma relatively narrow (2.5–3.0 × as long as wide); *and/or* fore wing with basal cell with setae; *and/or* wings with most veins brown 12

12(11) Entire body, including legs, mostly reddish (Figs 176, 183, 185, 187); ocellar area strongly raised, bounded by strong and coarse punctures (Figs 179, 180); smooth occiput delimited from coarsely sculptured vertex and gena by a keel resembling a carina (Figs 179, 180); fore wing (in female, sometimes also male) with veins 1RS and (RS+M) a entirely or partially transparent or light yellow (clearly much lighter than most of surrounding veins)..... 13

– Mesosoma entirely and most of metasoma black, legs partially black or partially yellow; ocellar area not strongly raised, not bounded by strong and coarse punctures; occiput only delimited from vertex and gena by different degree of sculpture, without keel resembling a carina; fore wing (in female and male) with veins 1RS and (RS+M)a brown (same color as surrounding veins) 14

13(12) Scutoscutellar sulcus with one carina (Fig. 187); pterostigma entirely brown (Fig. 184); T1 relatively long and wide (T1 length/width at anterior margin/maximum width/width at posterior margin: 0.66/0.30/0.34/0.25 mm); male with hyaline wings and with veins 1RS and (RS+M)a entirely or partially transparent or light yellow (clearly much lighter than most of surrounding veins) [Host: Noctuidae, *Melipotis cellaris*]..... *Snellenius robertoespinozai* Fernández-Triana & Whitfield, sp. n.

– Scutoscutellar sulcus with 3–5 carinae (Fig. 180); pterostigma with pale spot at base (Fig. 177); T1 relatively short and narrow (T1 length/width at anterior margin/maximum width/width at posterior margin: 0.48–0.51/0.17–0.20/0.21–0.23/0.19–0.20 mm); male with infumated wings and most veins brown .... *Snellenius quiricojimenezi* Fernández-Triana & Whitfield, sp. n.

14(12) Metafemur entirely yellow or orange red, metatibia usually yellow to orange except for posterior 0.2 dark brown (Figs 67, 125, 131, 156, 167, 199)..... 15

– Metafemur entirely dark brown or black, almost always metatibia dark brown or black on posterior 0.5–0.8 (Figs 74, 83, 85, 110, 112, 136, 142, 192)..... 20

15(14) Metatibia dark brown on posterior 0.5–0.8 × (Figs 67, 158); most of metasoma brown to black dorsally (at most T2 and part of T3 orange yellow) (Figs 63, 160); tegula dark brown [Known hosts: Nolidae] 16

– Metatibia dark brown on posterior 0.2 × (Figs 125, 131, 163, 167, 199); metasoma much lighter dorsally (at least T2-T3, and usually also T1, entirely orange yellow) (Fig. 128, 132, 168, 198); tegula yellow [Known hosts: Noctuidae].17

16(15) Metafemur yellow, metatibia dark brown on posterior 0.8 (Figs 156, 158); scape dark brown; male flagellomeres not strongly flattened; fore wing with vein 2SR shorter than vein r; T1 2.2 × as long as width at posterior margin; T2 mostly brownish yellow, T3 with narrow yellow band on anterior margin (Fig. 160) [Host: Nolidae, *Concana mundissima*]..... *Snellenius mariakuzminae* Fernández-Triana & Whitfield, sp. n.

– Metafemur orange red to light brown, metatibia dark brown on posterior 0.5 (Fig. 62, 67); scape yellow; male flagellomeres strongly flattened; fore wing with vein 2SR longer than vein r; T1 2.8 × as long as width at posterior margin; T2 mostly brown, T3 with posterior half yellowish (Fig. 63, inset)..... .....*Snellenius billburgeri* Fernández-Triana & Whitfield, sp. n.

17(15) - Metatibial spurs dark brown (Fig. 199); fore wing hyaline (Fig. 197); T1 at least 2.3 × as long as width at posterior margin ..... *Snellenius velvaruddae* Fernández-Triana & Whitfield, sp. n.

– Metatibial spurs yellow orange or yellow-white (Figs 125, 129, 167); fore wing slightly (Figs 130, 164) to strongly infumated (Fig. 124); T1 at most 2.2 × as long as width at posterior margin 18

18(17) Metasoma entirely yellow orange (Fig 128); T1 2.2 × as long as width at posterior margin [Host: Noctuidae, *Stauropides persimilis*]..... *Snellenius jorgegomezlauritoi* Fernández-Triana & Whitfield, sp. n.

– Metasoma dark brown beyond T4 (Figs 132, 168); T1 2.0 × as long as width at posterior margin [Hosts: Noctuidae, *Catephiodes*, *Selenisa*]..... 19

19(18) Scutoscutellar sulcus with five carinae (Fig. 165); scape entirely yellow; T4 yellow (Fig. 168) [Host: Noctuidae, *Catephiodes trinidadensis*; found on ACG, Sector Santa Rosa, 295m, dry forest] ..... *Snellenius mariamartachavarriae* Fernández-Triana & Whitfield, sp. n.

– Scutoscutellar sulcus with one carina (Figs 133, 134); scape mostly brown; T4 dark brown to black (Fig. 132) [Host: Noctuidae, *Selenisa sueroides*; found on ACG, Sector San Cristobal, 640m, rainforest] ..... *Snellenius josesarukhani* Fernández-Triana & Whitfield, sp. n.

20(14) Fore wing mostly infumated (except for basal and subbasal cells) 21

– Fore wing mostly hyaline (except sometimes a small fuscus spot near areolet) 23

21(20) Metatibial spurs yellow white; tegula lighter in color than darker humeral complex; pro- and mesocoxa dark brown to black, same as metacoxa (at most procoxa slightly lighter) (Figs 189, 191, 192) [Hosts: Erebidae, *Helia argentipes*] ..... *Snellenius sandyknappae* Fernández-Triana & Whitfield, sp. n.

– Metatibial spurs dark brown to black (Figs 74, 142); tegula same color as humeral complex; pro- and mesocoxa yellow-orange to reddish, clearly lighter than dark brown to black metacoxa [Hosts: Erebidae, *Orodesma*; Noctuidae, *Pseudbarydia*] 22

22(21) Metafemur reddish brown (partially visible in Fig. 74); T1 2.3 × as long as width at posterior margin [Host: Noctuidae, *Pseudbarydia crespula*] ..... *Snellenius bobdressleri* Fernández-Triana & Whitfield, sp. n.

– Metafemur black (Figs 136, 142); T1 2.8 × as long as width at posterior margin [Host: Erebidae, *Orodesma pulverosa*] ..... *Snellenius kerrydresslerae* Fernández-Triana & Whitfield, sp. n.

23(20) T2 relatively wide, occupying entire tergum (laterotergites not visible dorsally) (Fig. 85); T2 much wider than posterior width of T1; metafemur, most of metatibia, metatarsus and T2 red brown (Figs 83, 85, 88); scutoscutellar sulcus usually with 1 but up to 3 clearly defined carinae; T1 2.4 × as long as width at posterior margin [Host: Erebidae, *Coenipeta bibitrix*] ..... *Snellenius felipechavarriai* Fernández-Triana & Whitfield, sp. n.

– T2 quadrate, clearly defined by lateral sulcus, and relatively narrow, only occupying part of tergum (laterotergites visible dorsally) (Fig. 115); T2 narrower than posterior width of T1; metafemur, most of metatibia, metatarsus and T2 black (Figs 110, 112, 115); scutoscutellar sulcus with 3–5 (usually 4) clearly defined carinae; T1 2.4–2.6 × as long as width at posterior margin [Host: Erebidae: *Bulia mexicana*] ..... *Snellenius johnkressi* Fernández-Triana & Whitfield, sp. n.

24(1) Mesosoma and metasoma entirely orange yellow [Mostly a South American species; only record for Mesoamerica is from island of Trinidad] ..... *Microplitis chacoensis* (Cameron, 1908)

– Mesosoma and/or metasoma entirely or partially black to dark brown 25

25(24) T1 parallel-sided for most of its length, narrowing on posterior 0.1 (Fig. 41); T1 length more than 2.8 × its width at posterior margin; T1 strongly sculptured on posterior 0.6 or more; scutellar disc dull, uniformly sculptured by coarse punctures (Figs 43, 44) ..... *Microplitis hebertbakeri* Fernández-Triana & Whitfield, sp. n.

– T1 slightly widening towards posterior margin or barrel-shaped (Figs 6, 9, 14, 23, 32, 35, 48, 60); T1 length at most 2.5 × its width at posterior margin (usually less); T1 mostly smooth (except for median sulcus), at most with some sculpture on posterior 0.2–0.3 (rarely up to 0.5) and lateral margins; scutellar disc mostly smooth, at most with small and shallow punctures (Figs 5, 11, 18, 22, 31, 38, 52, 55) 26

26(25) T1 sculptured on posterior 0.3–0.5, especially near lateral margins; *and* fore wing with relatively large and quadrate areolet, vein 3RSa nearly as long or as long as vein r; *and* notauli strongly marked by relatively deep impressions [Wasp cocoons grouped in one or two large clusters dorsally on host larva. Hosts: Sphingidae, *Xylophanes*] 27

– T1 mostly smooth, with very few and shallow punctures near posterior 0.1–0.2 on lateral margins; fore wing with relatively small and often three-sided areolet, *if* areolet quadrangular then vein 3RSa much shorter than vein r; notauli usually slightly marked by relatively shallow impressions, *if* rarely with deeper depressions, not as marked as above [Wasp cocoons scattered dorsally over entire length of host larva. Hosts: Sphingidae, *Agrius*, *Erinnyis*, *Lintneria*, *Manduca*] 28

27(26) Metafemur and metatibia entirely yellow to yellow orange (Figs 53, 56, 57, 61); scape entirely black; body length (head to apex of metasoma) 3.0–3.4 mm ($\overline{X}$ = 3.2 mm); fore wing length 2.5–3.2 mm ($\overline{X}$ = 3.0 mm) [Host: Sphingidae, *Xylophanes tersa*] ..... *Microplitis marini* Whitfield, 2003

– Metafemur and metatibia entirely or mostly dark reddish brown (Figs 26, 28, 33, 34); scape entirely yellow-orange; body length (head to apex of metasoma) 3.3–4.0 mm ($\overline{X}$ = 3.6 mm); fore wing length 3.0–3.4 mm ($\overline{X}$ = 3.2 mm) [Host: Sphingidae, *Xylophanes guianensis*] ..... *Microplitis francopupulini* Fernández-Triana & Whitfield, sp. n.

28(26) Metatibia spurs, metatarsus and all coxae black (rarely reddish-brown) (Figs 7, 8; coxae reddish brown in the specimen photographed); body length 3.3–3.4 mm; fore wing length 3.2–3.3 mm; metafemur length 1.0 mm; metatibia length 1.2–1.3 mm; metafemur length 3.3–3.5 × its width [Host: *Erinnyis oenotrus*] ..... *Microplitis alexanderrojasi* Fernández-Triana & Whitfield, sp. n.

– Metatibia spurs yellow orange, metatarsus light-brown, coxae usually reddish-yellow to light brown (rarely metacoxa dark brown to black) (Figs 1, 3, 13, 21, 46, 49); body length usually less than 3.3 mm; fore wing length usually less than 3.2 mm; metafemur length at most 0.9 mm, usually less; metatibia length at most 1.0 mm, usually less;

metafemur length often less than 3.3 × its width [Hosts: *Agrius*, *Lintneria*, *Manduca*, other species of *Erinnyis* but not *E. oenotrus*]..... 29

29(28) Scape, tegula, and humeral complex dark brown to black; pro- and mesocoxae light brown, metacoxa dark brown to black; metafemur dark red orange to dark red brown on more than half its length (Figs 46–49); body length 3.2–3.5 mm; metafemur length 3.2–3.4 × its width [Hosts: *Erinnyis alope*, *E. ello*] .... *Microplitis jorgehernandezi* Fernández-Triana & Whitfield, sp. n.

– Scape yellow, tegula yellow or brown, humeral complex entirely brown or partially yellow/partially brown; pro- and mesocoxae yellow to reddish-yellow, metacoxae reddish yellow to light brown; metafemur yellow orange (Figs 1, 3, 13, 21); body length usually, but not always, less than 3.2 mm; metafemur length usually less than 3.2 × its width [Hosts: *Agrius*, *Lintneria*, *Manduca*, or *Erinnyis crameri* (with very few records of *E. ello*)]..... 30

30(29) Notauli slightly marked by fine and shallow impressions (Fig. 22) [Hosts: *Erinnyis crameri* (with very few records of *E. ello*)]..... *Microplitis figueresi* Walker, 2003

– Notauli more strongly marked by relatively deep impression and rugose anteriorly (as in Fig. 16) [Hosts: *Agrius*, *Lintneria*, *Manduca* spp.] 31

31(30) Fore wing with areolet relatively larger, vein 3RSa almost as long as vein r-m (Fig. 17); flagellomere 14 relatively shorter, 2.0–2.1 × (rarely 2.2 x) as long as wide; metatibia with posterior 0.1–0.2 black [Hosts: *Agrius cingulata*, *Lintneria merops*, several species of *Manduca* but not *M. corallina* and only two records of *M. rustica*] ....*Microplitis espinachi* Walker, 2003

– Fore wing with areolet relatively smaller, vein 3RSa much shorter than vein r-m (Fig. 2); flagellomere 14 relatively longer, 2.3–2.6 × as long as wide; metatibia with posterior 0.1 brown [Hosts: *Manduca corallina*, *M. rustica*]..... ..... *Microplitis adrianguadamuzi* Fernández-Triana & Whitfield, sp. n.

Species descriptions

Microplitis adrianguadamuzi Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/E9C0C331-6EC0-4B25-B86A-95C0EFF439C7
Figures 1–6

Holotype. Female (USNM). COSTA RICA, ACG, Guanacaste Province, Sector Santa Rosa, Bosque Humedo, 290m, 10.85145, -85.60801, 10.vii.1998. ACG database code: DHJPAR0013831.

Paratypes. 15♀, 3♂ (BMNH, CNC, INBio, INHS, USNM). COSTA RICA, ACG, database codes: DHJPAR0013831, DHJPAR0013873, DHJPAR0013891.

Diagnosis. The combination of smooth T1, notauli marked by relatively deep impression, areolet relatively smaller (vein 3RSa much shorter than vein r-m), scape yellow, metatibial spurs yellow orange, and metatarsus light brown differentiates this species from congeners.

Description (see Comments below). Female. Body length (head to apex of metasoma): 3.1–3.4 mm ($\bar{X}$ = 3.3 mm). Fore wing length: 2.9–3.2 mm ($\bar{X}$ = 3.1 mm). Antennal flagellomere 2 length/width: 2.4–2.6 × (0.25–0.26/0.10–0.11 mm). Antennal flagellomere 14 length/width: 2.2–2.4 × (0.17–0.19/0.07–0.08 mm). Length of flagellomere 2/length of flagellomere 14: 1.4–1.5 x. Metafemur length/width: 3.2–3.3 × (0.83–0.87/0.25–0.27 mm). Metatibia length: 1.00–1.09 mm ($\bar{X}$ = 1.05 mm). First segment of metatarsus length: 0.44–0.47 mm ($\bar{X}$ = 0.46 mm).

Male. As in female.

Distribution. Costa Rica, ACG.

Hosts. Sphingidae: *Manduca corallina*. Gregarious parasitoid.

Molecular data. One haplotype, three sequences (two barcode-compliant) in BOLD.

Etymology. This species is named in honour of Adrian Guadamuz in recognition of his contribution to understanding the plant biology of ACG.

Comments. This species is morphologically very similar to *M. espinachi*, which was described in detail by Janzen et al. (2003). The brief description above adds some measurements, taken from specimens included in the list of '**Specimens examined**', that allow for separation of these species.

Microplitis alexanderrojasi Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/8DDD2C4C-3EF7-4EA6-B31F-BD93ED2AA130
Figures 7–11

Holotype. Female (USNM). COSTA RICA, ACG, Guanacaste Province, Sector Santa Rosa, Area Administrativa, 295m, 10.83764, -85.61871, 17.vi.2008, ACG database code: 08-SRNP-13764.

Paratypes. 6♀, 2♂ (CNC, USNM). COSTA RICA, ACG, database codes: 08-SRNP-13764.

Diagnosis. The combination of T1 mostly smooth (with very few and shallow punctures near posterior 0.1–0.2 on lateral margins) and notauli slightly marked by relatively shallow impressions separates this species from *M. francopupulini*, *M. hebertbakeri* and *M. marini*. The dark brown to black metatibial spurs, metatarsus and coxae separate it from the rest of the ACG *Microplitis*.

Description (see Comments below). Female. Body length (head to apex of metasoma): 3.3–3.5 mm ($\bar{X}$ = 3.4 mm). Fore wing length: 3.2–3.3 mm ($\bar{X}$ = 3.3 mm).

Antennal flagellomere 2 length/width: 2.2–2.8 × (0.28–0.30/0.10–0.14 mm). Antennal flagellomere 14 length/width: 2.1–2.4 × (0.19–0.24/0.09–0.10 mm). Length of flagellomere 2/length of flagellomere 14: 1.2–1.5 x. Metafemur length/width: 3.3–3.6 × (0.96–1.00/0.27–0.30 mm). Metatibia length: 1.20–1.26 mm ($\overline{X}$ = 1.24 mm). First segment of metatarsus length: 0.51–0.55 mm ($\overline{X}$ = 0.53 mm).

Male. As in female.

Distribution. Costa Rica, ACG.

Hosts. Sphingidae: *Erinnyis oenotrus.* Gregarious parasitoid.

Molecular data. One haplotype, one sequence (barcode-complaint) in BOLD.

Etymology. This species is named in honour of Alexander Rojas in recognition of his contribution to understanding the plant biology of ACG.

Comments. This species is morphologically very similar to *M. figueresi*, which was described in detail by Janzen et al. (2003). The brief description above adds some measurements, taken from specimens included in the list of '**Specimens examined**', that allow for separation of these species.

Microplitis chacoensis (Cameron, 1908)

Microgaster chacoensis Cameron, 1908: 686. Original description.

Microplitis chacoensis (Cameron, 1908). De Santis & Esquivel, 1966: 49. Transfer to genus *Microplitis*.

Microplitis ayerzai Brethes, 1910. Janzen et al. 2003: 57. Junior synonym.

Holotype. Female (NHM) (examined). PARAGUAY, Chaco.

Specimens examined. In addition to the specimens from Argentina, Brazil, Paraguay, Uruguay, Trinidad and Venezuela mentioned in Janzen et al. (2003), we have also examined over 500 specimens from 2 localities of Argentina deposited in the CNC.

Diagnosis. This is the only *Microplitis* in Mesoamerica with the meso- and metasoma entirely orange yellow.

Distribution. South America: Argentina, Brazil, Paraguay, Uruguay, Trinidad, Venezuela. See comments below for further discussion.

Hosts. Sphingidae: *Agrius cingulata*, *Erinnyis ello*, *Manduca rustica*, *M. sexta*. Janzen et al. (2003) stated that the main hosts are *Manduca sexta* and *M. rustica*, with the other two host species being isolated records. Gregarious parasitoid.

Molecular data. One haplotype, two sequences (none barcode-compliant) in BOLD.

Comments. Janzen et al. (2003) provided an extensive description of this species and drawings of the wings, as well as parts of meso- and metasoma. They also mentioned that "It is not yet known how far north the distribution of *M. chacoensis* extends; the known distribution suggests it could be present in the eastern (wetter) portions of Panama and Costa Rica. So far our rearings of the known hosts that far north have produced only the other species covered here". Additional rearings done in ACG have failed to recover *M. chacoensis*. Based on all available information, we now consider that the distribution of the species is actually restricted to South America. Nevertheless, we decided to include the species in this paper because Trinidad is technically a Caribbean island, although it has more biogeographical affinities with South America than with Mesoamerica.

Microplitis espinachi Walker, 2003

Figures 12–18, 216

Microplitis espinachi Walker, 2003: 49. Original description.

Holotype. Female (USNM, missing) (not examined). COSTA RICA: Guanacaste province, ACG, Sector Santa Rosa, Bosque San Emilio, 300m, 10.84389, -85.61384.

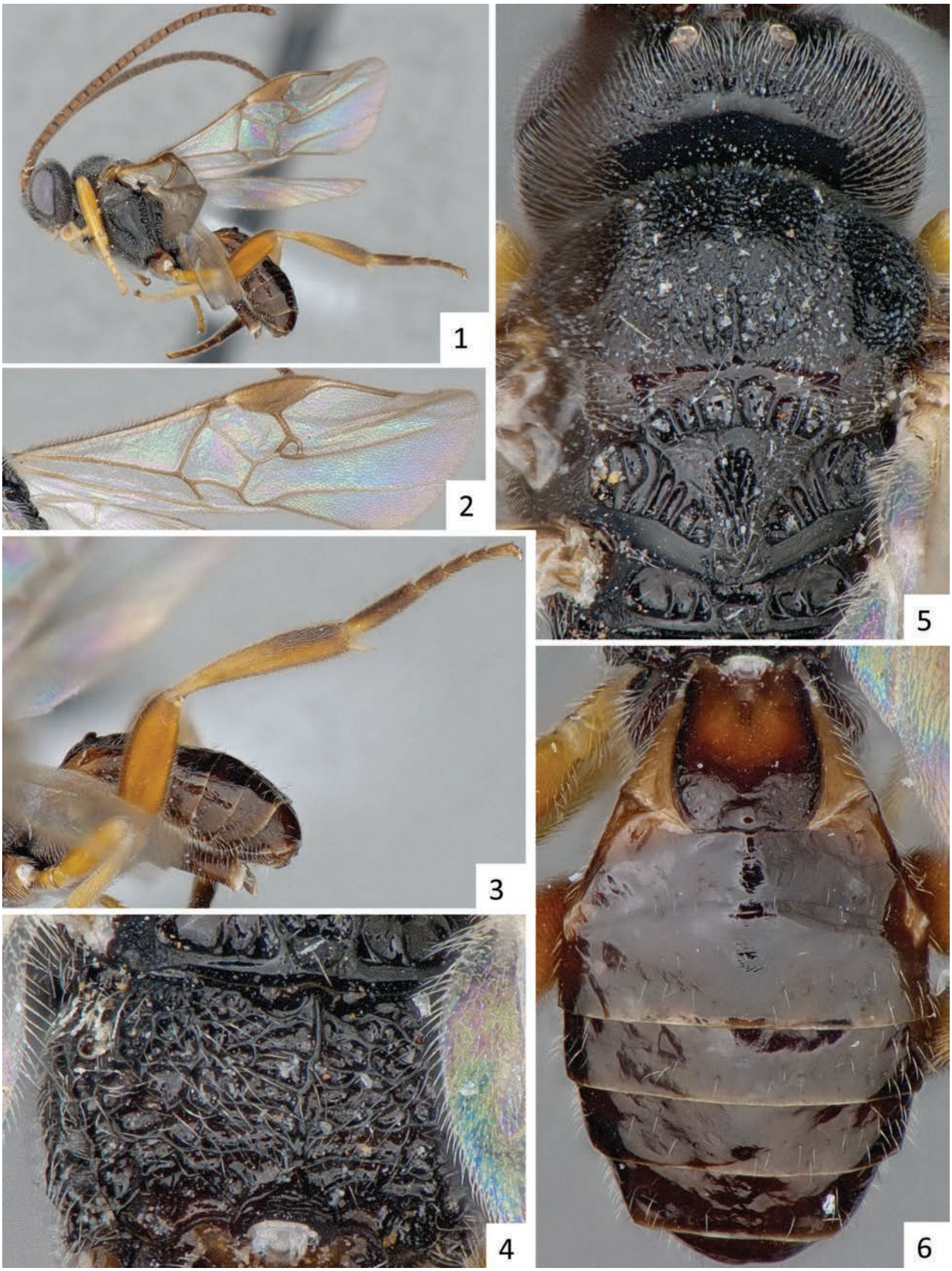
Specimens examined. 134♀, 121♂ (BMNH, CNC, INBio, INHS, USNM). COSTA RICA, ACG, database codes: DHJPAR0002885, DHJPAR0002886, DHJPAR0002888, DHJPAR0004314, DHJPAR0011916, DHJPAR0011917, DHJPAR0011919, DHJPAR0011920, DHJPAR0011921, DHJPAR0013817, DHJPAR0013818, DHJPAR0013817, DHJPAR0013332, DHJPAR0013819, DHJPAR0013820, DHJPAR0013822, DHJPAR0013829, DHJPAR0013833, DHJPAR0013846, DHJPAR0013849, DHJPAR0013857, DHJPAR0013858, DHJPAR0013863, DHJPAR0013868, DHJPAR0013871, DHJPAR0013880, DHJPAR0013884, DHJPAR0013889, DHJPAR0013890, DHJPAR0013895, DHJPAR0020150, DHJPAR0030811, DHJPAR0031061, DHJPAR0039921, DHJPAR0045166, 01-SRNP-13416, 05-SRNP-57563, 08-SRNP-13578, 08-SRNP-13740, 10-SRNP-12978.

Diagnosis. The combination of smooth T1, notauli marked by relative deep impression, areolet relatively larger (vein 3RSa as long as vein r-m), scape yellow, metatibia spurs yellow, and metatarsus brown differentiates this species from congeners.

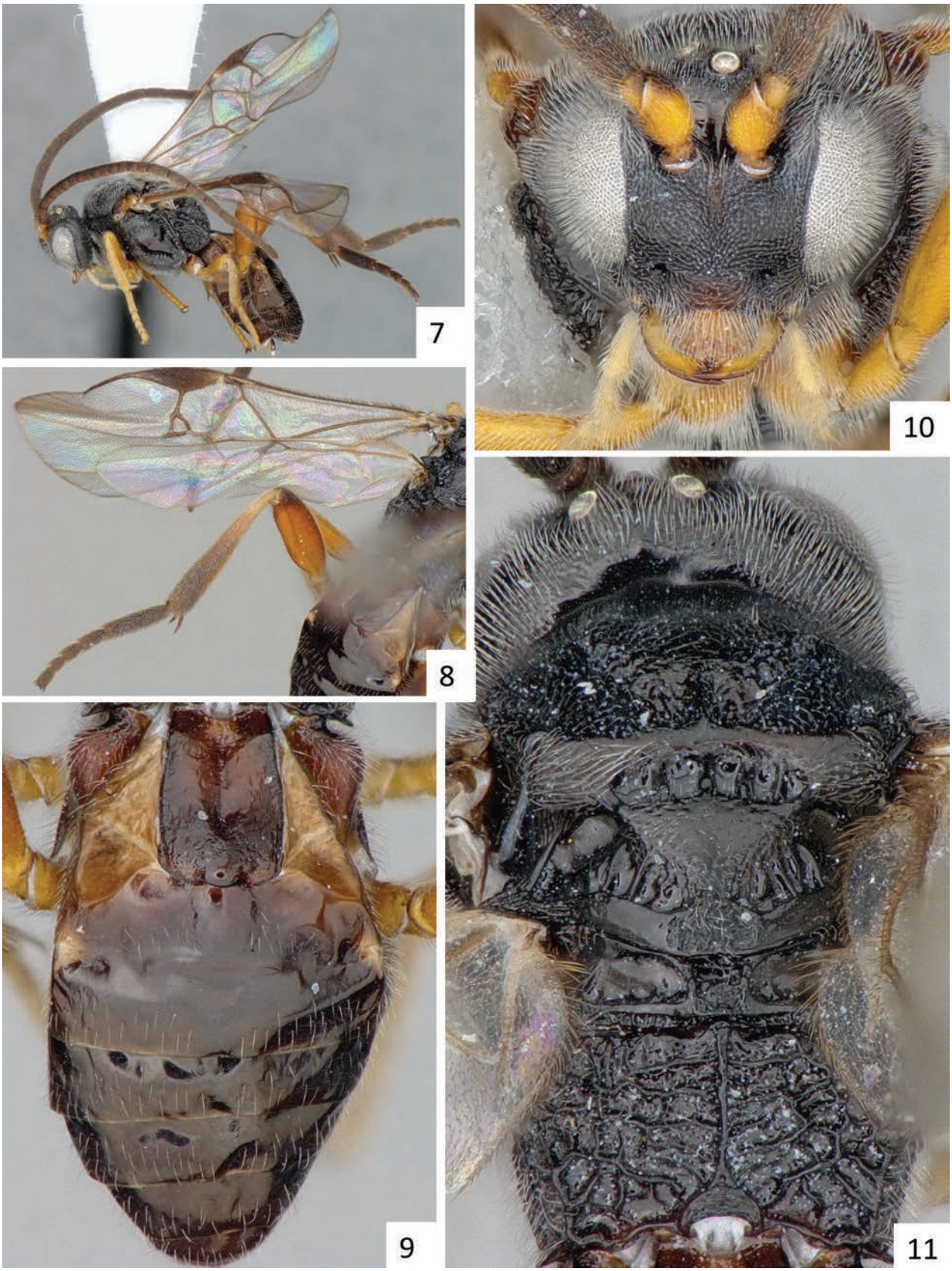
Description (see Comments below). Female. Body length (head to apex of metasoma): 2.6–3.6 mm ($\overline{X}$ = 3.1 mm). Fore wing length: 2.6–3.2 mm ($\overline{X}$ = 2.9 mm). Antennal flagellomere 2 length/width: 2.2–2.4 × (0.22–0.26/0.09–0.12 mm). Antennal flagellomere 14 length/width: 2.0–2.2 × (0.14–0.19/0.07–0.09 mm). Length of flagellomere 2/length of flagellomere 14: 1.3–1.6 x. Metafemur length/width: 2.9–3.2 × (0.72–0.88/0.24–0.29 mm). Metatibia length: 0.94–1.15 mm ($\overline{X}$ = 1.01 mm). First segment of metatarsus length: 0.35–0.48 mm ($\overline{X}$ = 0.41 mm).

Distribution. Costa Rica, ACG.

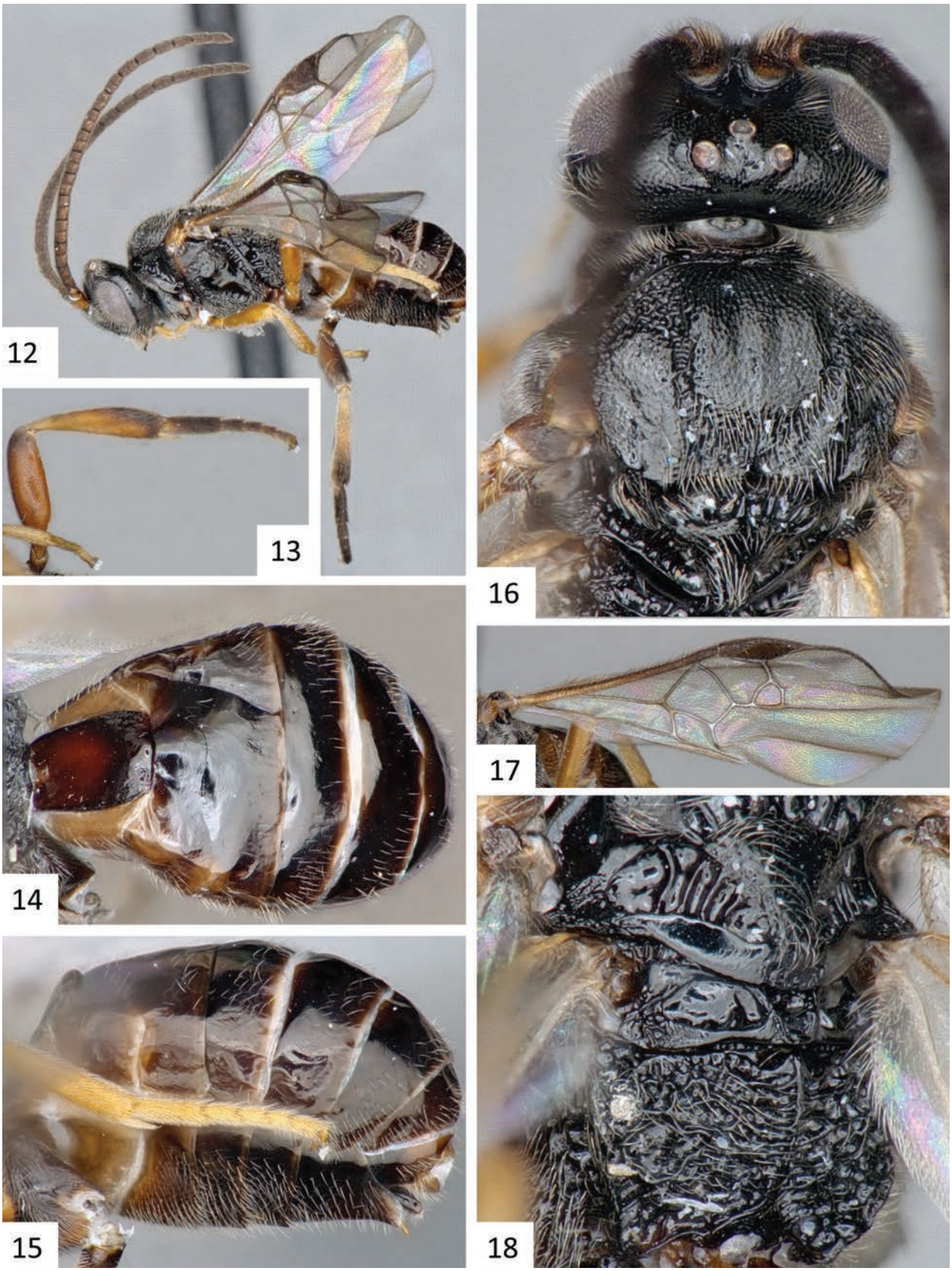
Hosts. Sphingidae: *Agrius cingulata*, *Lintneria merops*, nine species of *Manduca* but not *M. corallina* (and only two records of *M. rustica*). Gregarious parasitoid (Fig. 216).



Figures 1–6. *Microplitis adrianguadamuzi* Fernández-Triana & Whitfield. **1** Habitus, lateral view **2** Fore wing **3** Hind leg and metasoma, lateral view **4** Propodeum **5** Head and mesosoma (partially), dorsal view **6** Metasoma, dorsal view.



Figures 7–11. *Microplitis alexanderrojasi* Fernández-Triana & Whitfield. **7** Habitus, lateral view **8** Fore wing **9** Metasoma, dorsal view **10** Head, frontal view **11** Mesosoma, dorsal view.



Figures 12–18. *Microplitis espinachi* Walker. **12** Habitus, lateral view **13** Hind leg **14** Metasoma, dorsal view **15** Metasoma, lateral view **16** Head and mesosoma (partially), dorsal view **17** Fore wing **18** Scutellar disc and propodeum, dorsal view.

Molecular data. Five haplotypes, 41 sequences (38 barcode-compliant) in BOLD.

Comments. Janzen et al. (2003) provided an extensive description and several illustrations of the species. Here we only add some measurements taken to specimens included in the list of '**Specimens examined**'. The broader host records mentioned by Janzen et al. (2003) are revised here due to the fact the some of them correspond to another species, *M. adrianguadamuzi*, split from the original *M. espinachi*.

Walker in Janzen et al. (2003) indicated that the holotype and an unspecified number of paratypes for *M. espinachi* were deposited in the USNM. One of us (RRK) could not locate any of the specimens. Further, unit trays do not exist for any specimen of *M. espinachi* in the USNM, and there is no record of their existence in any USNM database. It is unlikely that specimens of this species were ever deposited in the USNM; thus, they are currently either misplaced or lost. The location of the holotype for *M. espinachi* is critical for discerning its status relative to *M. adrianguadamuzi*.

Microplitis figueresi Walker, 2003

Figures 19–24, 218, 219

Microplitis figueresi Walker, 2003: 51. Original description.

Holotype. Female (USNM, missing) (not examined). COSTA RICA: Guanacaste province, ACG, Sector Santa Rosa, Cafetal, 280m, 10.85827, -85.61089.

Specimens examined. 107♀, 101♂ (BMNH, CNC, INBio, INHS, USNM). COSTA RICA, ACG, database codes: DHJPAR0005013, DHJPAR0011918, DHJPAR0013826, DHJPAR0013827, DHJPAR0013830, DHJPAR0013834, DHJPAR0013835, DHJPAR0013838, DHJPAR0013840, DHJPAR0013841, DHJPAR0013843, DHJPAR0013844, DHJPAR0013845, DHJPAR0013847, DHJPAR0013848, DHJPAR0013853, DHJPAR0013854, DHJPAR0013856, DHJPAR0013860, DHJPAR0013861, DHJPAR0013862, DHJPAR0013864, DHJPAR0013869, DHJPAR0013872, DHJPAR0013877, DHJPAR0013884, DHJPAR0013887, DHJPAR0013888, DHJPAR0013892, DHJPAR0013894, DHJPAR0013895, DHJPAR0013897, DHJPAR0013898, DHJPAR0039906, DHJPAR0039908, DHJPAR0039909, DHJPAR0039910, DHJPAR0039911, DHJPAR0039912, DHJPAR0039913, DHJPAR0039914, DHJPAR0039915, DHJPAR0039916, DHJPAR0039917, DHJPAR0039918, DHJPAR0039919, DHJPAR0039920, 98-SRNP-1900, 98-SRNP-1901, 98-SRNP-1902, 98-SRNP-1920, 98-SRNP-1931, 98-SRNP-1949, 98-SRNP-8040, 98-SRNP-8112, 98-SRNP-8116, 99-SRNP-8701, 05-SRNP-17809, 05-SRNP-18059, 08-SRNP-13373, 08-SRNP-13374, 08-SRNP-13375, 08-SRNP-13587, 08-SRNP-13590, 08-SRNP-13594, 13-SRNP-15983.

Diagnosis. The combination of smooth T1, notauli marked by relative fine and shallow impressions, areolet relatively larger (vein 3RSa as long as vein r-m), and host (*Erinnyis* spp.) differentiates this species from congeners.

Description (see Comments below). Female. Body length (head to apex of metasoma): 2.7–3.3 mm ($\overline{X}$ = 3.1 mm). Fore wing length: 2.6–3.2 mm ($\overline{X}$ = 3.0 mm). Antennal flagellomere 2 length/width: 2.1–2.4 × (0.21–0.25/0.09–0.12 mm). Antennal flagellomere 14 length/width: 2.0–2.4 × (0.16–0.19/0.08 mm). Length of flagellomere 2/length of flagellomere 14: 1.3–1.5 x. Metafemur length/width: 2.8–3.4 × (0.73–0.90/0.21–0.30 mm). Metatibia length: 0.95–1.19 mm ($\overline{X}$ = 1.04 mm). First segment of metatarsus length: 0.36–0.46 mm ($\overline{X}$ = 0.41 mm).

Distribution. Costa Rica, ACG.

Hosts. Sphingidae: *Erinnyis crameri*, *E. ello*. Gregarious parasitoid (Figs 218, 219).

Molecular data. Six haplotypes, 57 sequences (51 barcode-compliant) in BOLD.

Comments. Janzen et al. (2003) provided an extensive description and several illustrations of the species. Here we only add some measurements taken from specimens included in the list of '**Specimens examined**'. The host records are revised due to the fact that two additional species, *M. alexanderrojasi* and *M. jorgehernandezi*, are here split from the original *M. figueresi* described in Janzen et al. (2003).

Walker in Janzen et al. (2003) indicated that the holotype and an unspecified number of paratypes for *M. figueresi* were deposited in the USNM. One of us (RRK) could not locate these specimens in the USNM as described above for *M. espinachi*. Similarly, the location of the holotype for *M. figueresi* is critical for discerning its status relative to *M. alexanderrojasi* and *M. jorgehernandezi*.

Microplitis francopupulini Fernández-Triana & Whitfield, sp. n.

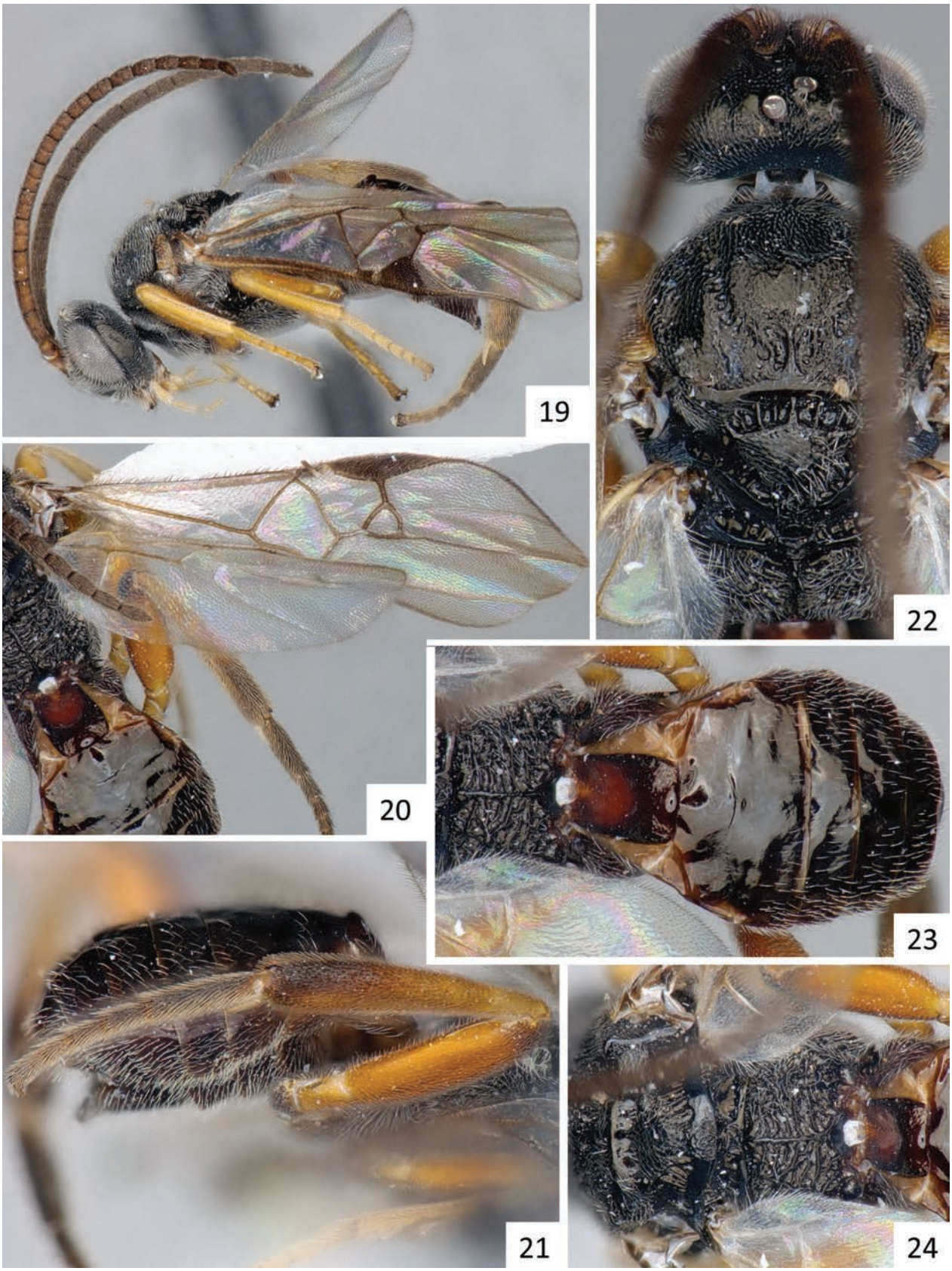
http://zoobank.org/2DE6F635-B697-41CA-9414-8454886C88BF

Figures 25–38, 217

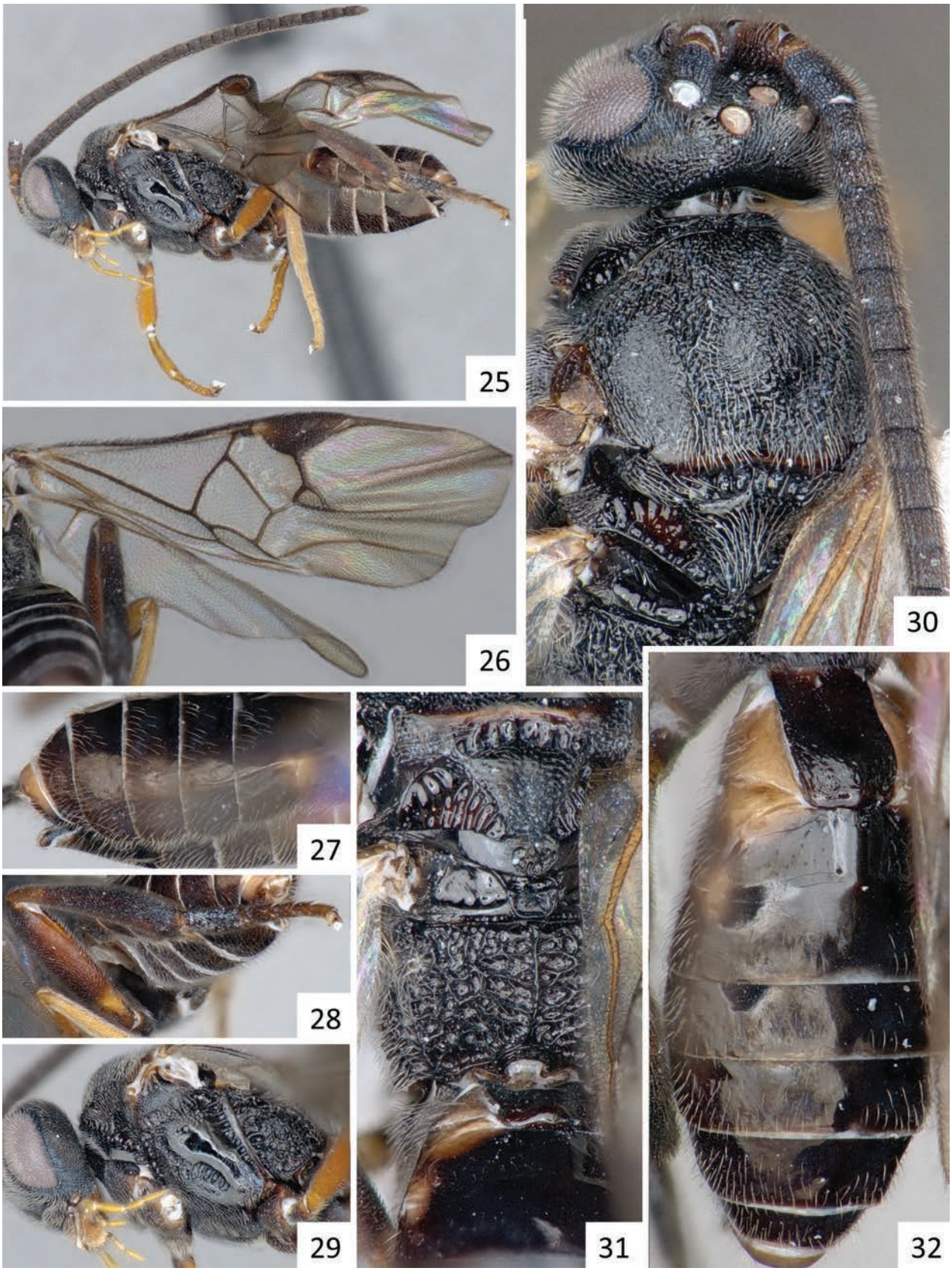
Holotype. ♀ in USNM. COSTA RICA, ACG, Alajuela Province, Sector Rincon Rain Forest, Finca Esmeralda, 123m, 10.93548, -85.25314, 10.viii.2013. ACG database code: 13-SRNP-77147.

Paratypes. 44♀, 42♂ (BMNH, CNC, INBio, INHS, USNM). COSTA RICA, ACG, database codes: DHJPAR0004093, DHJPAR0011922, DHJPAR0034274, DHJPAR0039905, DHJPAR0041831, DHJPAR0047252, DHJPAR0053775, 09-SRNP-75263, 11-SRNP-67447, 12-SRNP-75032, 13-SRNP-77147, 13-SRNP-77149.

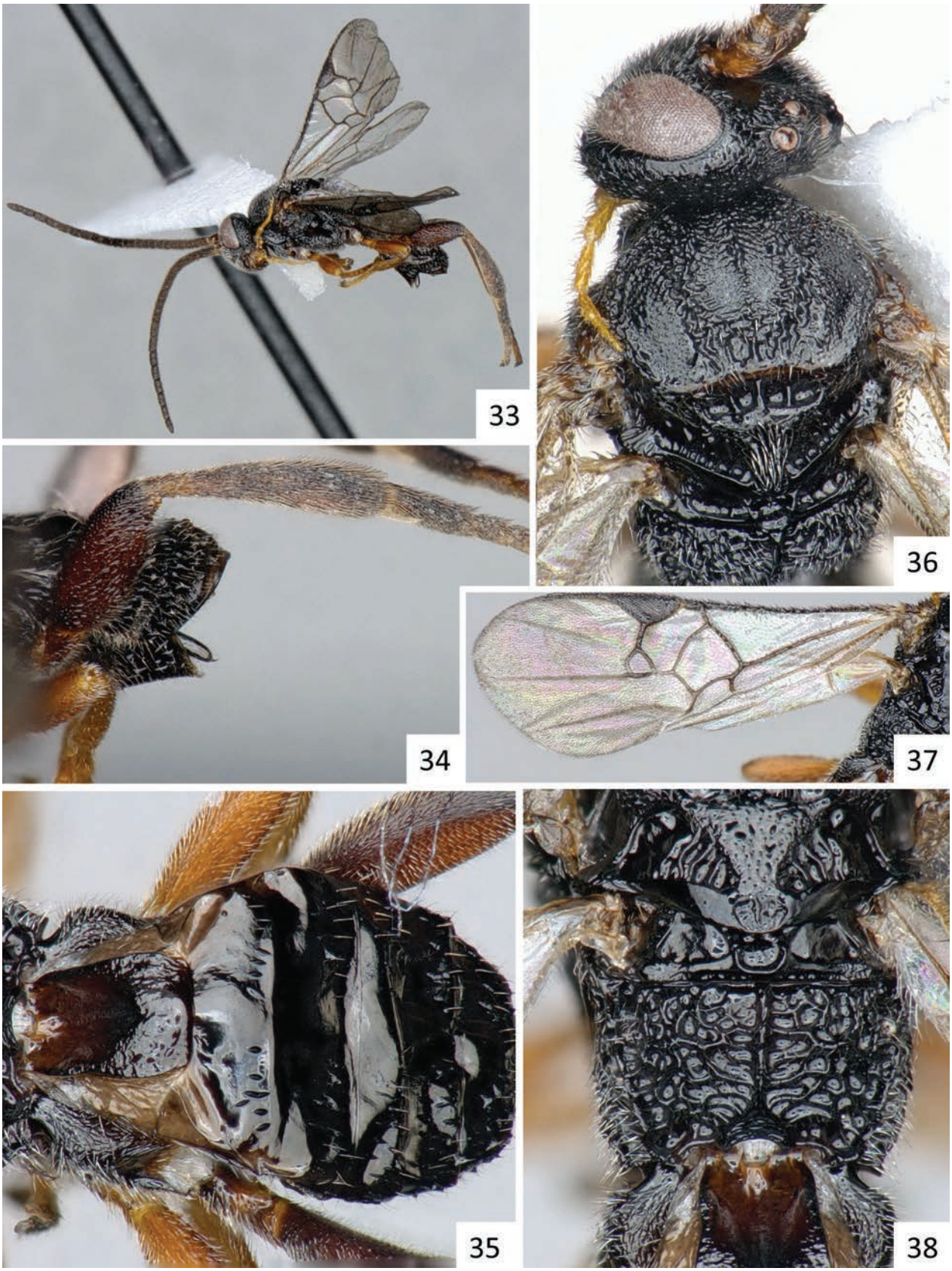
Diagnosis. The combination of T1 sculptured on posterior 0.3–0.5 (especially near lateral margins), notauli marked by relatively deep impressions, areolet relatively larger (vein 3RSa as long as vein r-m), metafemur and metatibia entirely or mostly dark reddish-brown, scape entirely yellow orange, body and fore wing length, wasp cocoons grouped in one or two large clusters dorsally on the host larva, and host species differentiates this species from congeners.



Figures 19–24. *Microplitis figueresi* Walker, 2003. **19** Habitus, lateral view **20** Wings **21** Hind leg and metasoma, lateral view **22** Head and metasoma, dorsal view **23** Propodeum and metasoma, dorsal view **24** Mesosoma (partially) and mediotergite 1, dorsal view.



Figures 25–32. *Microplitis francopupulini* Fernández-Triana & Whitfield (paratype specimen). **25** Habitus, lateral view **26** Wings **27** Metasoma, lateral view **28** Hind leg **29** Head and mesosoma (partially), lateral view **30** Head and mesosoma (partially), dorsal view **31** Scutellar disc and propodeum, dorsal view **32** Metasoma, dorsal view.



Figures 33–38. *Microplitis francopupulini* Fernández-Triana & Whitfield (holotype specimen).33- Habitus, lateral view. **34** Hind leg **35** Metasoma, dorsal view **36** Head and mesosoma (partially), dorsal view **37** Fore wing **38** Scutellar disc and propodeum, dorsal view.

Description. Female. Scape color: Yellow-orange. Mesosoma color: Black. Metasoma color: Dark brown to black. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, dark brown to black. Femora color (pro-, meso-, metafemur): Yellow, yellow, dark reddish-brown (usually with posterior 0.1–0.2 black). Tibiae color (pro-, meso-, metatibia): Yellow, yellow, dark reddish-brown (usually mostly black dorsally). Metatibia spurs color: Yellow. First segment of metatarsus color: Dark brown. Tegula and humeral complex color: Brown, brown. Wings: Hyaline. Pterostigma color: Dark brown. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.3–4.0 mm ($\bar{X}$ = 3.6 mm). Fore wing length: 3.0–3.4 mm ($\bar{X}$ = 3.2 mm). Antennal flagellomere 2 length/width: 2.3–2.5 × (0.28–0.29/0.11–0.12 mm). Antennal flagellomere 14 length/width: 2.0–2.3 × (0.19–0.21/0.08–0.10 mm). Length of flagellomere 2/length of flagellomere 14: 1.3–1.5 x. Antenna in males: Of normal appearance, not flattened. Epicnemial carina: Absent. Anteromesoscutum: With relatively shallow and sparse sculpture, central area not appearing elevated compared to lateral areas of anteromesoscutum, notauli strongly excavated. Scutellar disc sculpture: With margins and central part of disc equally sculptured. Number of carinae in scutoscutellar sulcus: Three to five. Metafemur length/width: 2.5–2.6 × (0.85–0.90/0.33–0.34 mm). Metatibia length: 1.12–1.16 mm ($\bar{X}$ = 1.14 mm). First segment of metatarsus length: 0.48–0.50 mm ($\bar{X}$ = 0.49 mm). Mediotergite 1 sculpture: Mostly sculptured.

Male. Unknown.

Distribution. Costa Rica, ACG.

Hosts. Sphingidae: *Xylophanes guianensis*. Gregarious parasitoid (Fig. 217).

Molecular data. One haplotype, nine sequences (nine barcode-compliant) in BOLD.

Etymology. This species is named in honour of Franco Pupulin in recognition of his contribution to understanding the plant biology of ACG.

Comments. This species is morphologically very similar to *M. marini*, which was described in detail by Janzen et al. (2003). The brief description above only adds some measurements, taken from specimens included in the list of '**Specimens examined**', that allow for separation of these species. Additionally, both species differ in up to 43 base pairs (> 6.5 %) in the barcoding region.

Microplitis hebertbakeri Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/BC67551E-B226-425F-94D6-69A844ED62A7
Figures 39–45

Holotype. ♀ in USNM. COSTA RICA, ACG, Guanacaste Province, Sector El Hacha, Sendero Bejuquilla, 280m, 11.03004, -85.52699, 17.v.1999. ACG database code: DHJPAR0012604.

Paratypes. 3♀, 7♂ (CNC, USNM). COSTA RICA, ACG, database codes: DHJPAR0012581, DHJPAR0012591, DHJPAR0012603, DHJPAR0012609, DHJPAR0012610, DHJPAR0012611, DHJPAR0012612, DHJPAR0012614, DHJPAR0013339, DHJPAR0031721.

Diagnosis. This is the only ACG species of *Microplitis* with T1 parallel-sided for most of its length, narrowing on posterior 0.1, its length more than 3.0 × its width at posterior margin; and scutellar disc dull, uniformly sculptured by coarse punctures.

Description. Female. Scape color: Black. Mesosoma color: Black. Metasoma color: Dark reddish-brown. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, reddish-brown. Femora color (pro-, meso-, metafemur): Yellow, yellow, orange-brown (darker dorsally). Tibiae color (pro-, meso-, metatibia): Yellow, yellow, mostly orange-brown (anterior 0.2 yellow-white, central 0.6 orange-brown, posterior 0.2 dark brown). Metatibia spurs color: White. First segment of metatarsus color: Dark brown. Tegula and humeral complex color: Yellow, yellow and brown. Wings: Hyaline. Pterostigma color: Brown with pale spot at base. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 2.8–2.9 mm. Fore wing length: 2.6–2.7 mm. Ocular-ocellar line/posterior ocellus diameter: 2.0 x. Interocellar distance/posterior ocellus diameter: 1.6 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.15/0.07/0.11 mm. Antennal flagellomere 2 length/width: 3.1 × (0.25/0.08 mm). Antennal flagellomere 14 length/width: 2.4 × (0.17/0.07 mm). Length of flagellomere 2/length of flagellomere 14: 1.5 x. Antenna in males: Of normal appearance, not flattened. Epicnemial carina: Absent. Anteromesoscutum: Slightly sculptured, with smooth areas, central area not appearing elevated compared to lateral areas of anteromesoscutum, notauli faint or poorly defined. Scutellar disc sculpture: With margins and central part of disc equally sculptured. Number of carinae in scutoscutellar sulcus: Five. Metafemur length/width: 3.3–3.6 × (0.72–0.77/0.20–0.23 mm). Metatibia length: 0.97–1.03 mm ($\bar{X}$ = 1.00 mm). First segment of metatarsus length: 0.41–0.43 mm ($\bar{X}$ = 0.42 mm). Mediotergite 1 length/width at posterior margin: 2.9–3.1 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.42–0.44/0.19–0.20/0.20–0.22/0.13–0.16 mm. Mediotergite 1 sculpture: Mostly sculptured.

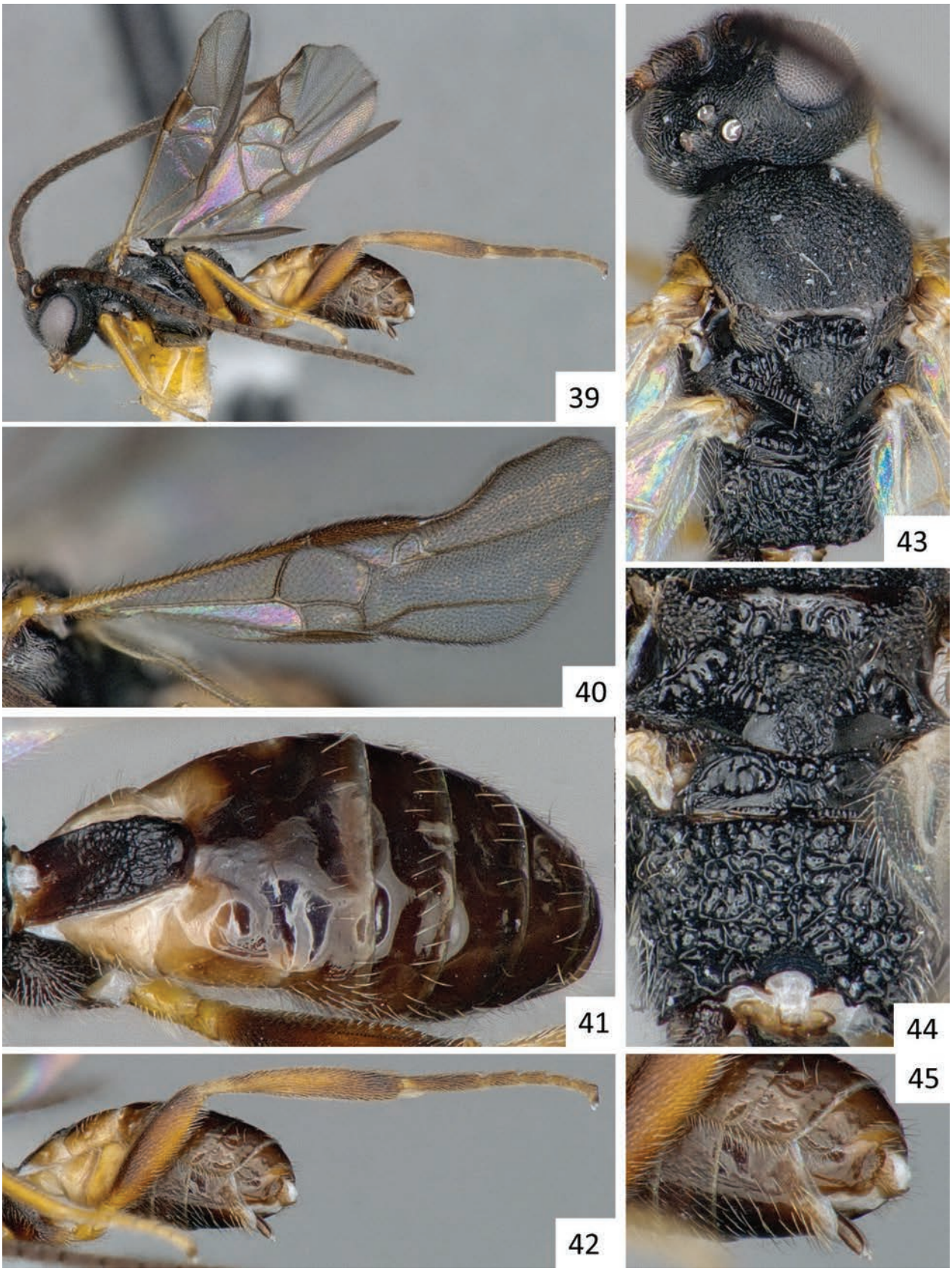
Male. As in female.

Distribution. Costa Rica, ACG.

Hosts. Unknown.

Molecular data. Three haplotype, 11 sequences (11 barcode-compliant) in BOLD.

Etymology. This species is named in honour of Hebert Baker in recognition of his contribution to understanding the plant biology of ACG.



Figures 39–45. *Microplitis hebertbakeri* Fernández-Triana & Whitfield. **39** Habitus, lateral view **40** Fore wing **41** Metasoma, dorsal view **42** Hind leg and metasoma, lateral view **43** Head and mesosoma, dorsal view **44** Scutellar disc and propodeum, dorsal view **45** Detail of hypopygium and ovipositor sheaths.

Microplitis jorgehernandezi Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/A3CFFF36-B263-428F-8A8E-034D670A9C66

Figures 46–52

Holotype. ♀ in USNM. COSTA RICA, ACG, Sector Santa Rosa, Cuesta Canyon Tigre, 270m, 10.81703, -85.64366, 20.vi.2013. ACG database code: 13-SRNP-15964.

Paratypes. 4♀, 5♂ (BMNH, CNC, INBio, INHS, USNM). COSTA RICA, ACG, database codes: DHJPAR0049814, DHJPAR0052940, 12-SRNP-12247, 13-SRNP-15964.

Diagnosis. The combination of smooth T1, notauli marked by relative fine and shallow impressions, and color of scape, tegula, and humeral complex (dark brown to black), pro- and mesocoxae (light brown), metacoxa (dark brown to black), and metafemur (dark red-orange to brown on more than half its length) differentiates this species from congeners.

Description (see Comments below). Female. Body length (head to apex of metasoma): 3.1–3.5 mm ($\overline{X}$ = 3.3 mm). Fore wing length: 2.9–3.3 mm ($\overline{X}$ = 3.1 mm). Antennal flagellomere 2 length/width: 2.4–2.6 × (0.25–0.27/0.10–0.11 mm). Antennal flagellomere 14 length/width: 2.1–2.3 × (0.18–0.20/0.08–0.09 mm). Length of flagellomere 2/length of flagellomere 14: 1.3–1.4 x. Metafemur length/width: 3.2–3.4 × (0.90–0.96/0.27–0.28 mm). Metatibia length: 1.12–1.21 mm ($\overline{X}$ = 1.15 mm). First segment of metatarsus length: 0.45–0.46 mm ($\overline{X}$ = 0.46 mm).

Male. As in female, except legs slightly lighter in color.

Distribution. Costa Rica, ACG.

Hosts. Sphingidae: *Erinnyis alope*, *E. ello*. Gregarious parasitoid.

Molecular data. One haplotype, five sequences (four barcode-compliant) in BOLD.

Etymology. This species is named in honour of Jorge Hernández in recognition of his contribution to understanding the plant biology of ACG.

Comments. This species is morphologically very similar to *M. figueresi*, which was described in detail by Janzen et al. (2003). The brief description above only adds some measurements, taken to specimens included in the list of 'Specimens examined', that allows for separation of these species.

Microplitis marini Whitfield, 2003

Figures 53–61, 220, 221, 230–233

Microplitis marini Whitfield, 2003: 52. Original description.

Holotype. Female (USNM) (examined). COSTA RICA: Guanacaste province, ACG, Sector Cacao, Sendero Arenales, 1080m, 10.92471, -85.46738.

Specimens examined. 56♀, 42♂ (BMNH, CNC, INBio, INHS, USNM). COSTA RICA, ACG, database codes: DHJPAR0004756, DHJPAR0005012, DHJPAR0013865, DHJPAR0013882, DHJPAR0013883, DHJPAR0013885, DHJPAR0020898, DHJPAR0030925, DHJPAR0030931, DHJPAR0034178, DHJPAR0034207, DHJPAR0047037, DHJPAR0052976, DHJPAR0052977, 08-SRNP-6882, 08-SRNP-72721, 12-SRNP-69030, 13-SRNP-42973, 13-SRNP-76897.

Diagnosis. The combination of T1 sculptured on posterior 0.3–0.5 (especially near lateral margins), notauli marked by relatively deep impressions, areolet relatively larger (vein 3RSa as long as vein r-m), metafemur and metatibia entirely yellow to yellow orange, scape entirely black, body and fore wing length, wasp cocoons grouped in one or two large clusters dorsally on the host larva, and host species differentiates this species from congeners.

Description (see Comments below). Female. Body length (head to apex of metasoma): 3.0–3.4 mm ($\overline{X}$ = 3.2 mm). Fore wing length: 2.5–3.2 mm ($\overline{X}$ = 3.0 mm). Antennal flagellomere 2 length/width: 2.9–3.0 × (0.24–0.27/0.08–0.09 mm). Antennal flagellomere 14 length/width: 2.2–2.4 × (0.17–0.18/0.07–0.08 mm). Length of flagellomere 2/length of flagellomere 14: 1.4–1.5 x. Metafemur length/width: 3.2–3.5 × (0.79–0.82/0.23–0.26 mm). Metatibia length: 1.00–1.16 mm ($\overline{X}$ = 1.05 mm). First segment of metatarsus length: 0.35–0.38 mm ($\overline{X}$ = 0.37 mm).

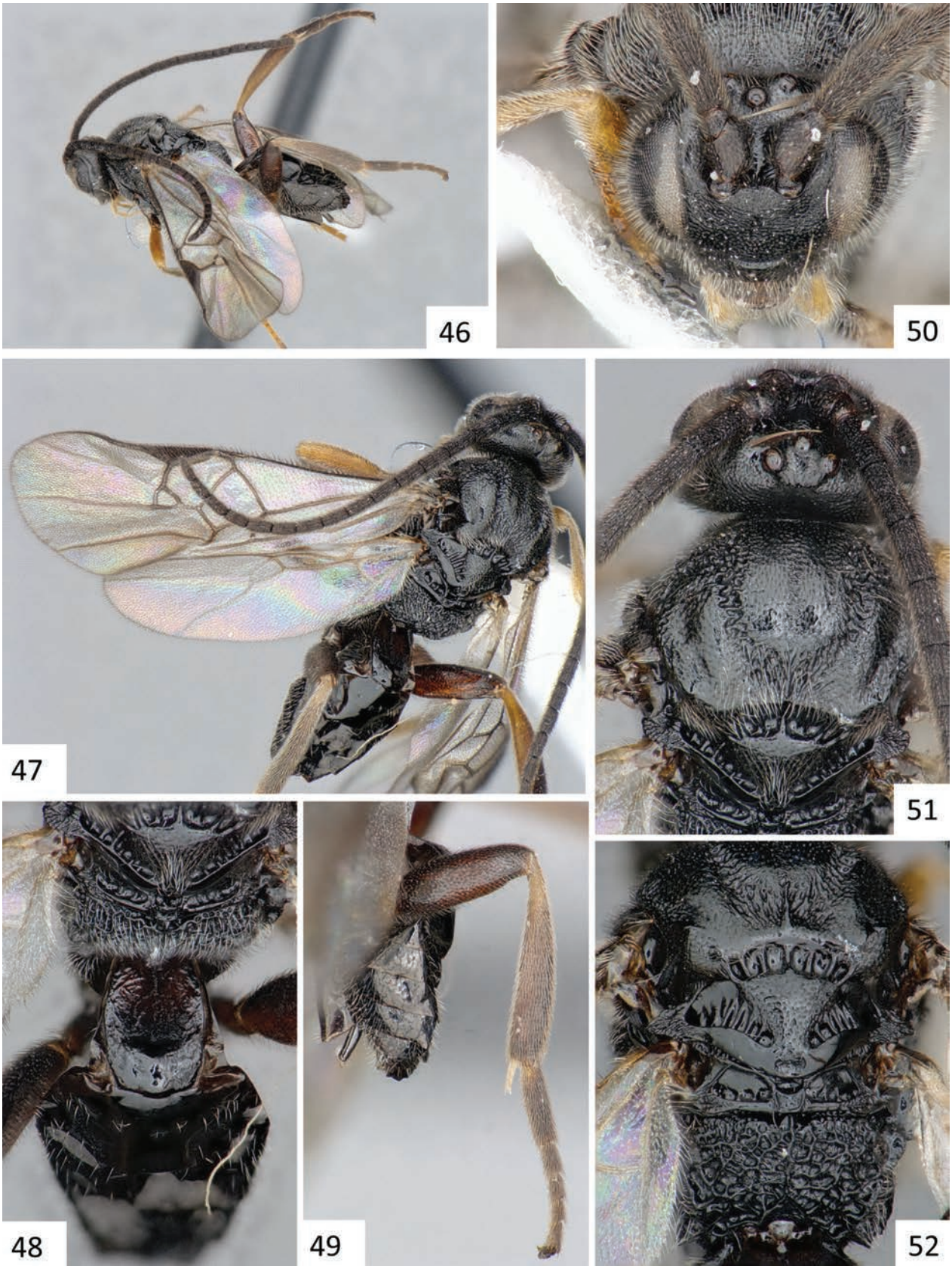
Distribution. Costa Rica, ACG.

Hosts. Sphingidae: *Xylophanes tersa*. Gregarious parasitoid (Figs 220, 221).

Molecular data. Four haplotypes, 13 sequences (11 barcode-compliant) in BOLD.

Comments. Janzen et al. (2003) provided an extensive description and several illustrations of this species. Here we only add some measurements taken from specimens included in the list of '**Specimens examined**', as well as additional color pictures of the holotype (Figs 230–233). *Microplitis marini* is morphologically similar to *M. francopupulini*, but differs in some morphological, biological and molecular traits (see **Comments** for *francopupulini* above).

The host record for *M. marini* is here limited to *Xylophanes tersa*. Janzen et al. (2003: 54) included in the original description of the species a series of 14 females and one male from Arizona (USA), reared from *X. falco*, although those specimens were left out of type series. Based on our experience with the Microgastrinae fauna of ACG, and the significant number of morphologically cryptic species found (which mostly differ in host ranges and molecular data such as DNA barcodes) we consider it unlikely that the specimens from Arizona are conspecific with those from ACG. A morphological re-examination of the US material, and (ideally) obtaining DNA barcodes for those specimens would be needed before concluding in that regard, but for now we exclude them (and their associated host record) from the species concept of *M. marini* as presented here.



Figures 46–52. *Microplitis jorgehernandezi* Fernández-Triana & Whitfield. **46** Habitus, lateral view **47** Wings and body, dorsal view **48** Mesosoma (partially) and metasoma, dorsal view **49** Hind leg and metasoma, lateral view **50** Head, frontal view **51** Head and mesosoma (partially), dorsal view **52** Scutellar disc and propodeum, dorsal view.

Microplitis sordidus (Ashmead, 1900)

Apanteles sordidus Ashmead, 1900: 279. Original description.
Microplitis sordidus (Ashmead, 1900). Muesebeck 1958: 427. Transfer to genus *Microplitis*.
Microplitis carinata Ashmead, 1900: 293. Synonymized under *sordidus* by Muesebeck (1958: 427).

Holotype. Male (BMNH) (not examined).

Hosts. Unknown.

Distribution. Saint Vincent Island.

Comments. No molecular or biological data are available for this species. The original description mentions that the type has smooth head and mesosoma (including propodeum). No other species of *Microplitis* in Mesoamerica has a smooth head or propodeum.

Snellenius billburgeri Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/A83FF860-2BC9-44B3-BF4F-B5C3B514EDDC
Figures 62–68

Holotype. ♂ in CNC. COSTA RICA: ACG, Guanacaste Province, Santa Rosa National Park headquarters, 200m, Malaise trap, 27-30.vi.1997, L.J. van der Ent.

Diagnosis. The color combination (metafemur orange-red, metatibia dark brown on posterior 0.5, scape yellow, T2 mostly brown, T3 with posterior half yellowish), fore wing with vein 2SR longer than vein r, and T1 2.8 × as long as width at posterior margin differentiates this species from congeners.

Description. Male. Scape color: Yellow. Mesosoma color: Dark reddish-brown. Metasoma color: Reddish-brown except for T2–T3 partially yellow. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, reddish-brown. Femora color (pro-, meso-, metafemur): Yellow, yellow, reddish-brown. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, anterior 0.3 yellow-white, median 0.3 orange, posterior 0.3 dark brown. Metatibia spurs color: Yellow. First segment of metatarsus color: Dark reddish-brown. Tegula and humeral complex color: Yellow, and basally yellow/posteriorly brown. Wings: Hyaline. Pterostigma color: Brown with pale spot at base. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.4 mm. Fore wing length: 3.0 mm. Ocular-ocellar line/posterior ocellus diameter: 1.6 x. Interocellar distance/posterior ocellus diameter: 2.0 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.14/0.10/0.18 mm. Antenna in males: Strongly flattened. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One centrally, with other four smaller and partially defined carinae. Metafemur length/width: 3.0 × (0.86/0.29 mm). Metatibia length: 1.10 mm. First segment of metatarsus length: 0.45 mm. Mediotergite 1 length/width at posterior margin: 2.8 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.54/0.29/0.27/0.19 mm. Mediotergite 1 sculpture: Fully sculptured.

Female. Unknown.

Distribution. Costa Rica, ACG.

Hosts. Unknown.

Molecular data. None.

Etymology. This species is named in honour of Bill Burger in recognition of his contribution to understanding the plant biology of ACG.

Snellenius bobdressleri Fernández-Triana & Whitfield, sp. n.

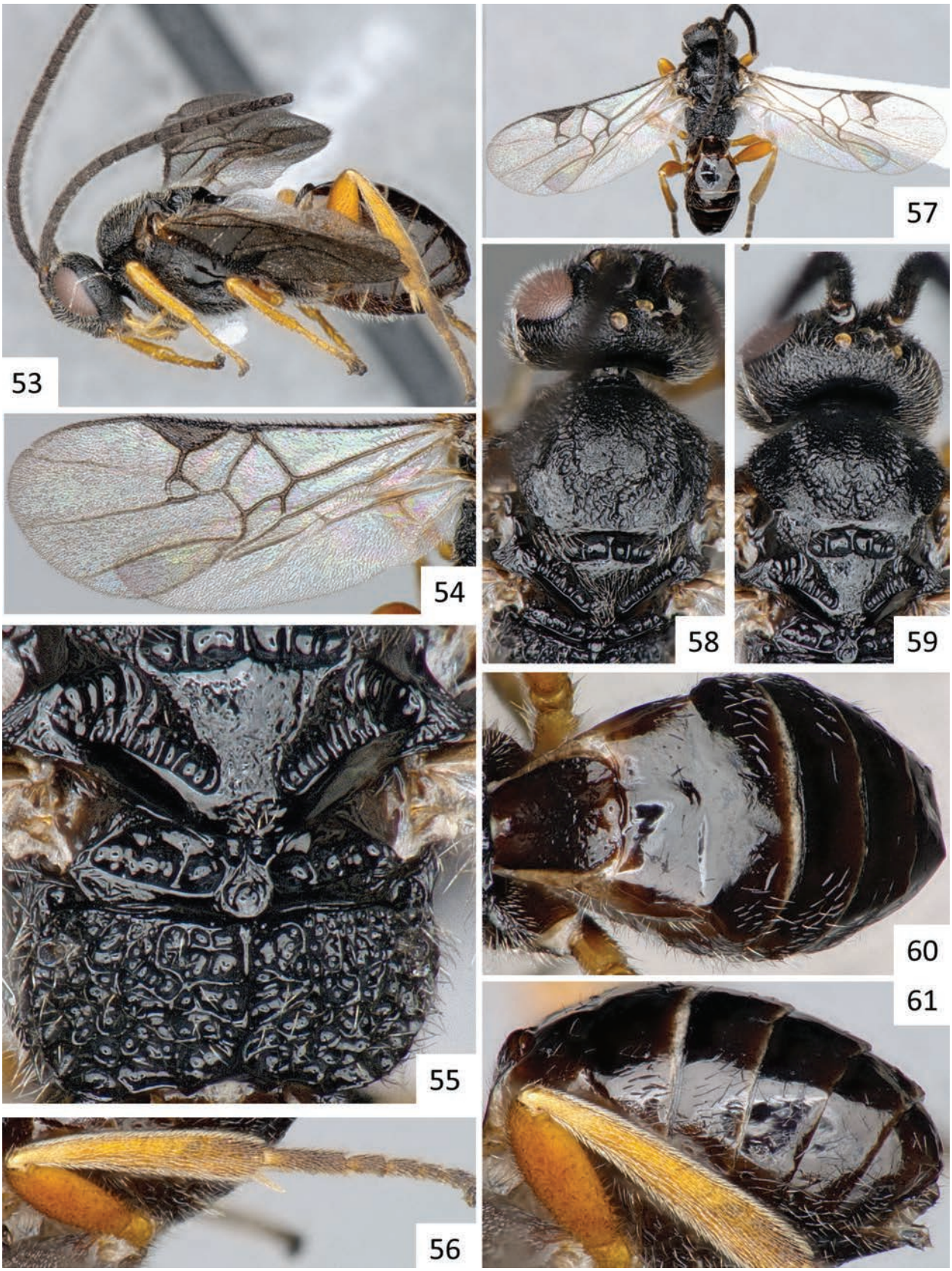
http://zoobank.org/D281F37C-693D-4552-9D12-1855EF5BF3E5
Figures 69–75, 226

Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector El Hacha, Animas, 195m, 11.05011, -85.58663, 16.iv.2013. ACG database code: DHJPAR0052256.

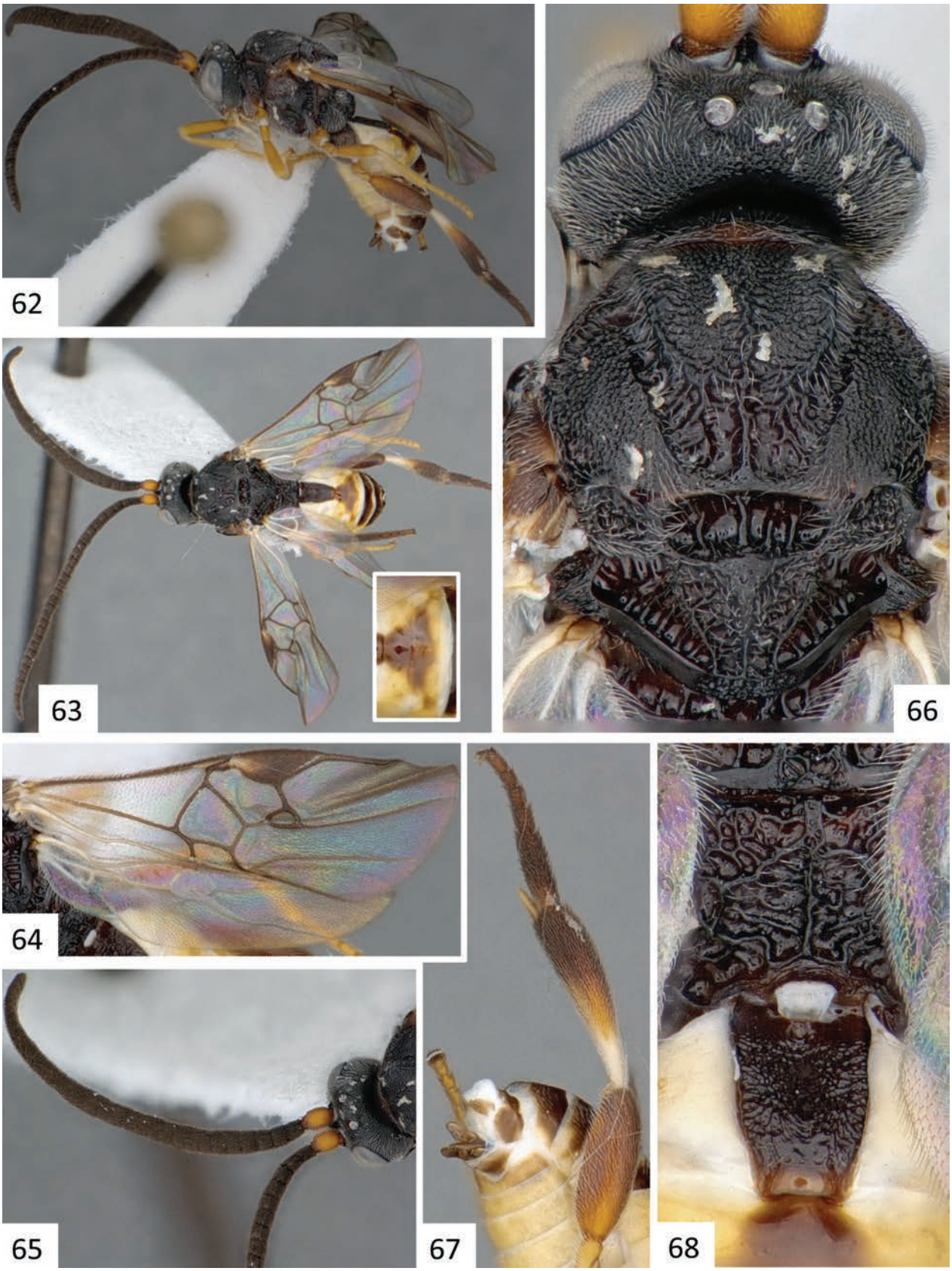
Paratypes. 1♀, 1♂ (CNC). COSTA RICA, ACG, database codes: DHJPAR0052334, DHJPAR0053888.

Diagnosis. The fore wing mostly infumated, dark reddish-brown metafemur, and T1 2.3 × as long as width at posterior margin differentiates this species from congeners.

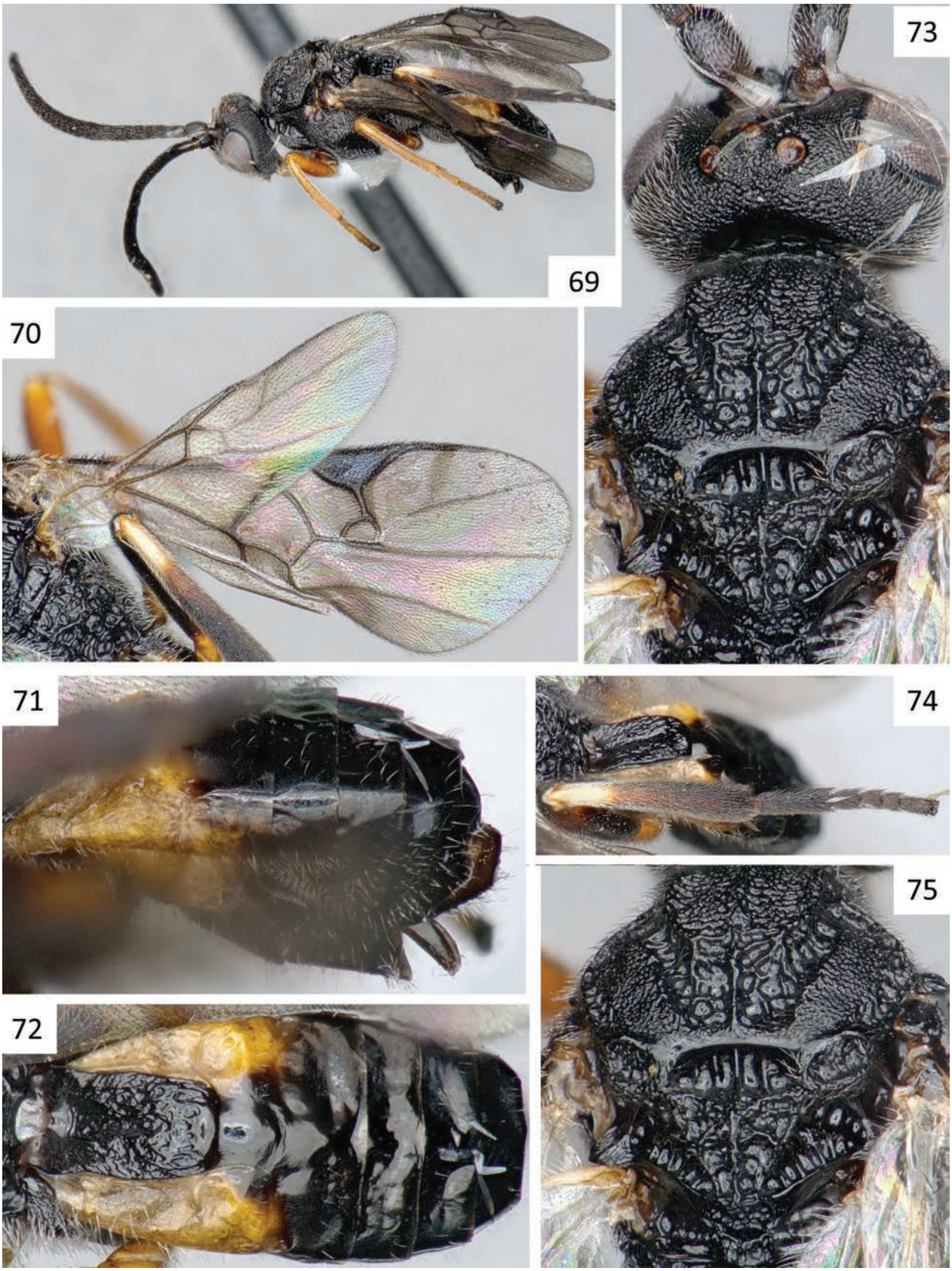
Description. Female. Scape color: Black. Mesosoma color: Black. Metasoma color: Dark brown to black. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, black. Femora color (pro-, meso-, metafemur): Yellow, orange-brown, dark reddish-brown. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, yellow-white on anterior 0.2–0.3 and dark brown to black on posterior 0.7–0.8. Metatibia spurs color: Black. First segment of metatarsus color: Black. Tegula and humeral complex color: Black, black. Wings: Mostly infumated. Pterostigma color: Dark brown. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.5–3.6 mm. Fore wing length: 3.0 mm. Ocular-ocellar line/posterior ocellus diameter: 1.9-2.1 x. Interocellar distance/posterior ocellus diameter: 1.8–1.9 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.19/0.09–0.10/0.17–0.18 mm. Antennal flagellomere 2 length/width: 2.6 × (0.29–0.31/0.11–0.12 mm). Antennal flagellomere 14 length/width: 1.6–1.7 × (0.19–0.20/0.12 mm). Length of flagellomere 2/length of flagellomere 14: 1.5–1.6 x. Antenna in males: Strongly flattened. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less



Figures 53–61. *Microplitis marini* Whitfield, 2003. **53** Habitus, lateral view **54** Wings **55** Scutellar disc and propodeum, dorsal view **56** Hind leg **57** Habitus, dorsal view. **58**, **59** Head and mesosoma (partially), dorsal view, images taken under slightly different angles.



Figures 62–68. *Snellenius billburgeri* Fernández-Triana & Whitfield. **62** Habitus, lateral view **63** Habitus, dorsal view (inset: details of mediotergites 2 and 3) **64** Fore wing **65** Male antenna **66** Head and mesosoma (partially), dorsal view **67** Hind leg and metasoma (partially), lateral view **68** Propodeum (partially) and mediotergite 1, dorsal view.



Figures 69–75. *Snellenius bobdressleri* Fernández-Triana & Whitfield. **69** Habitus, lateral view **70** Wings **71** Metasoma, lateral view **72** Metasoma, dorsal view **73** Head and mesosoma (partially), dorsal view **74** Hind leg and mediotergite 1, dorsal view **75** Anteromesoscutum and scutellar disc, dorsal view.

sculptured. Number of carinae in scutoscutellar sulcus: One centrally, with other 2–4 smaller and partially defined carinae. Metafemur length/width: 3.5 × (0.97/0.28 mm). Metatibia length: 1.26 mm. First segment of metatarsus length: 0.49 mm. Mediotergite 1 length/width at posterior margin: 2.2–2.3 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.58–0.60/0.30–0.31/0.30–0.32/0.26–0.27 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. As female but with all femora orange, metatibia mostly orange (only posterior 0.2 dark brown), T3 entirely yellow, and T2 light brown.

Distribution. Costa Rica, ACG.

Hosts. Erebidae: *Pseudbarydia crespula*. Solitary parasitoid (Fig. 226).

Molecular data. Two haplotypes, three sequences (three barcode-compliant) in BOLD.

Etymology. This species is named in honour of Bob Dressler in recognition of his contribution to understanding the plant biology of ACG.

Snellenius donstonei Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/3F8DEBCE-DE88-4F19-9951-08AA42CF18C0
Figures 76–82

Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector Pitilla, Amonias, 390m, 11.04249, -85.40339. ACG database code: DHJPAR0050115.

Paratypes. 1♀ (CNC). COSTA RICA, ACG, database code: DHJPAR0050129.

Diagnosis. The unique color pattern characterizes this species: body color light yellow to white; metatibia mostly yellow, wings with golden infumation, veins and pterostigma mostly yellowish.

Description. Female. Scape color: Yellow. Mesosoma color: Yellow. Metasoma color: Yellow. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, yellow. Femora color (pro-, meso-, metafemur): Yellow, yellow, yellow. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, mostly yellow with posterior 0.1–0.2 brown. Metatibia spurs color: Yellow. First segment of metatarsus color: Brown. Tegula and humeral complex color: Yellow, yellow. Wings: Infumated. Pterostigma color: Light brown. Fore wing veins 1RS and (RS+M)a: Entirely or partially transparent or light yellow (but most other veins also same color). Body length (head to apex of metasoma): 3.6–3.7 mm. Fore wing length: 3.6 mm. Ocular-ocellar line/posterior ocellus diameter: 2.0 x. Interocellar distance/posterior ocellus diameter: 1.8 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.16/0.08/0.14 mm. Antennal flagellomere 2 length/width: 2.4 × (0.31/0.13 mm). Antennal flagellomere 14 length/width: 2.1 × (0.21/0.10 mm). Length of flagellomere 2/length of flagellomere 14: 1.5 x. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One. Metafemur length/width: 3.5 × (0.97/0.28 mm). Metatibia length: 1.30 mm. First segment of metatarsus length: 0.51 mm. Mediotergite 1 length/width at posterior margin: 2.7 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.52/0.20/0.16/0.19 mm. Mediotergite 1 sculpture: Partially sculptured.

Male. Unknown.

Distribution. Costa Rica, ACG.

Hosts. Erebidae: *Ceromacra* sp. (with interim name *Ceromacra* Poole02). Solitary parasitoid.

Molecular data. None.

Etymology. This species is named in honour of Don Stone in recognition of his contribution to understanding the plant biology of ACG.

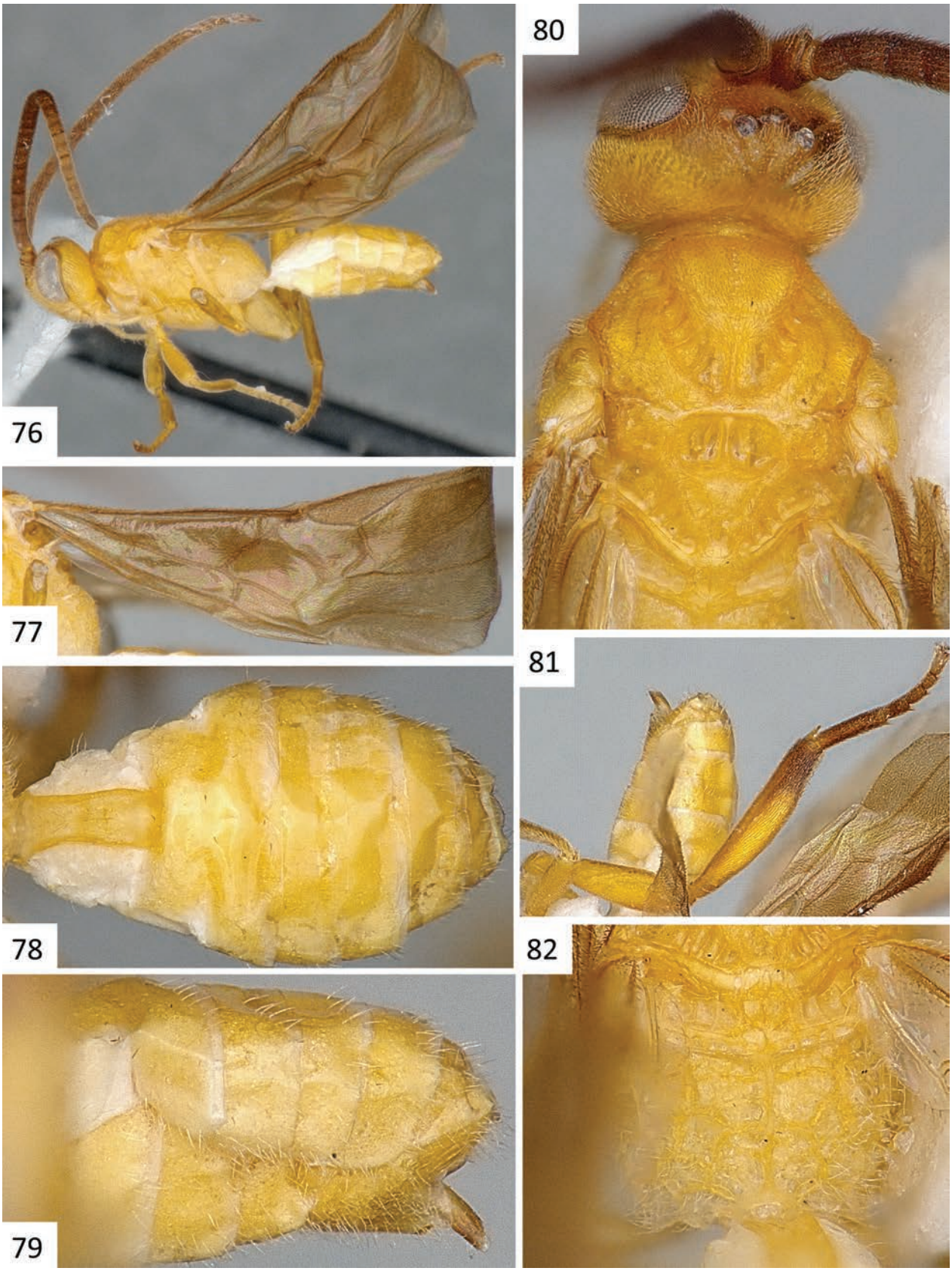
Snellenius felipechavarriai Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/4639DDBE-D5BB-4213-816D-B4238BC783AA
Figures 83–88, 222

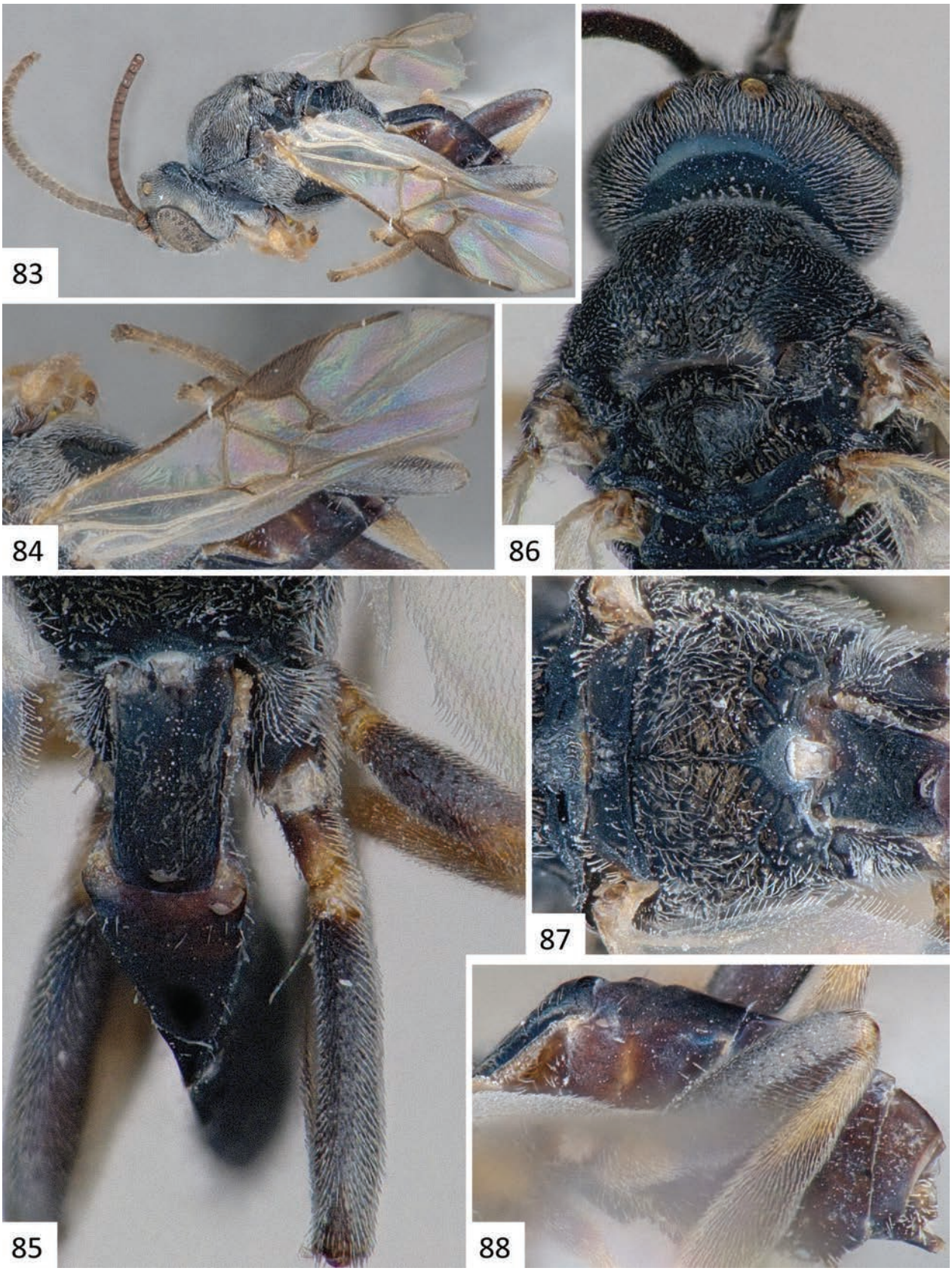
Holotype. ♀ in CNC. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Area Administrativa, 295m, 10.83764, -85.61871. ACG database code: DHJPAR0004293.

Diagnosis. The combination of hyaline wings, mesosoma and metasoma mostly black or dark reddish brown, and metafemur and metatibia (posterior 0.6) dark brown, separates this species from all other ACG *Snellenius*, except for *S. johnkressi*. It is distinguishable from the latter species by wider T2 and scutoscutellar sulcus with only one clearly defined carina (3–5 carinae in *S. johnkressi*).

Description. Female. Scape color: Brown. Mesosoma color: Black. Metasoma color: Dark brown to black, except for reddish-brown T2–T3. Coxae color (pro-, meso-, metacoxa): Light brown, brown, brown. Femora color (pro-, meso-, metafemur): Orange, dark brown, dark brown. Tibiae color (pro-, meso-, metatibia): Orange, orange-brown, anterior 0.2 yellow-white, posterior 0.8 dark brown. Metatibia spurs color: Yellow-white. First segment of metatarsus color: Dark brown. Tegula and humeral complex color: Black, dark brown to black. Wings: Hyaline. Pterostigma color: Brown. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins, although slightly lighter). Body length (head to apex of metasoma): 2.9 mm. Fore wing length: 2.6 mm. Ocular-ocellar line/posterior ocellus diameter: 1.6 x. Interocellar distance/posterior ocellus diameter: 2.0 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.14/0.09/0.18 mm. Antennal flagellomere 2 length/width: (0.21/0.08 mm). Antennal flagellomere 14 missing. Epicnemial carina: Present but weakly defined. Anteromesoscutum: With relatively shallower and



Figures 76–82. *Snellenius donstonei* Fernández-Triana & Whitfield. **76** Habitus, lateral view **77** Fore wing **78** Metasoma, dorsal view **79** Metasoma, lateral view **80** Head and mesosoma (partially), dorsal view **81** Hind leg and metasoma (partially), lateral view **82** Propodeum (partially), dorsal view.



Figures 83–88. *Snellenius felipechavarriai* Fernández-Triana & Whitfield. **83** Habitus, dorso-lateral view **84** Wings **85** Propodeum (partially) and mediotergite 1, dorsal view **86** Head and mesosoma (partially), dorsal view **87** Propodeum and mediotergite 1, dorsal view **88** Metasoma lateral view.

sparser sculpture, central area not appearing elevated compared to lateral areas of anteromesoscutum, notauli slightly to strongly excavated. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One centrally, with other 4 smaller and partially defined carinae. Metafemur length/width: 3.3 × (0.75/0.23 mm). Metatibia length: 0.98 mm. First segment of metatarsus length: 0.35 mm. Mediotergite 1 length/width at posterior margin: 2.0 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.52/0.28/0.26/0.26 mm. Mediotergite 1 sculpture: Partially sculptured.

Male. Unknown.

Distribution. Costa Rica, ACG.

Host. Erebidae: *Coenipeta bibitrix.* Solitary parasitoid (Fig. 222).

Molecular data. One haplotype, four sequences (none barcode-compliant) in BOLD.

Etymology. This species is named in honour of Felipe Chavarría in recognition of his contribution to understanding the plant biology of ACG.

Snellenius gerardoherrerai Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/CFF3F012-1792-4D88-8A6F-E869FC4E7A3A
Figures 89–95

Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Bosque San Emilio, 300m, 10.84389, -85.61384. ACG database code: DHJPAR0013326.

Paratypes. 6♀ (BMNH, CNC). COSTA RICA, ACG, database codes: DHJPAR0012579, DHJPAR0012580, DHJPAR0012583, DHJPAR0012584, DHJPAR0012608, DHJPAR0013330.

Diagnosis. The combination of T1 length at least 3.0 × its width at posterior margin, body mostly dark reddish-brown to brown, metatibia dark brown on posterior 0.8, and metatibial spurs yellow-white separates this species from all other ACG *Snellenius*, except for *S. warrenwagneri*. It is distinguishable from the latter species by having scape yellow-orange, tegula and humeral complex dark brown, and relatively shorter flagellomeres (flagellomere 2 2.4–2.5 × as long as wide, flagellomere 14 2.0–2.3 × as long as wide).

Description. Female. Scape color: Yellow-orange. Mesosoma color: Dark reddish-brown. Metasoma color: Dark reddish-brown. Coxae color (pro-, meso-, metacoxa): Yellow, yellow-brown, dark brown. Femora color (pro-, meso-, metafemur): Yellow, yellow, dark reddish-brown. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, anterior 0.2 yellow-white and posterior 0.8 dark brown. Metatibia spurs color: Yellow-white. First segment of metatarsus color: Dark brown to black. Tegula and humeral complex color: Half pale, half dark. Wings: Hyaline. Pterostigma color: Brown with pale spot at base. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 2.9–3.2 mm ($\bar{X}$ = 3.0 mm). Fore wing length: 2.5–2.8 ($\bar{X}$ = 2.6 mm). Ocular-ocellar line/posterior ocellus diameter: 1.8–2.0 x. Interocellar distance/posterior ocellus diameter: 1.7–1.9 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.16/0.15/0.08-0.09 mm. Antennal flagellomere 2 length/width: 2.3–2.5 × (0.23–0.25/0.10 mm). Antennal flagellomere 14 length/width: 1.9–2.0 × (0.17–0.18/0.09 mm). Length of flagellomere 2/length of flagellomere 14: 1.3–1.4 x. Antenna in males: Strongly flattened. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One centrally, with other 2–4 smaller and partially defined carinae. Metafemur length/width: 32.–3.3 × (0.75–0.80/0.23–0.25 mm). Metatibia length: 0.96–0.99 mm. First segment of metatarsus length: 0.35–0.36 mm. Mediotergite 1 length/width at posterior margin: 3.0–3.1 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: (0.43–0.45/0.22–0.24/0.22/0.14–0.15 mm). Mediotergite 1 sculpture: Fully sculptured.

Male. As female but with T2–T3 mostly yellow.

Distribution. Costa Rica, ACG.

Host. Unknown.

Molecular data. Three haplotypes, seven sequences (seven barcode-compliant) in BOLD.

Etymology. This species is named in honour of Gerardo Herrera in recognition of his contribution to understanding the plant biology of ACG.

Snellenius irenebakerae Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/0ED1F02A-99BE-4EDD-A7D3-5490060E82A9
Figures 96–102

Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Bosque San Emilio, 300m, 10.84389, -85.61384. ACG database code: DHJPAR0013323.

Paratypes. 5♀, 3♂ (BMNH, CNC, INBio, INHS, USNM). COSTA RICA, ACG, database codes: DHJPAR0013315, DHJPAR0013316, DHJPAR0013319, DHJPAR0013320, DHJPAR0013325, DHJPAR0024714; 1♂, Costa Rica, ACG, Guanacaste, Santa Rosa National Park, 300m, regenerating woodland less than 10 years old, 5-26.vii.1986, I. Gauld; 1♂, Costa Rica, ACG, Guanacaste, Cerro El Hacha, NW of Volcan Orosi, 300m, 1988.

Diagnosis. This is one of the most easily identifiable species of *Snellenius* in the region, based on the unique color pattern of mesosoma and hind legs.

Description. Female. Scape color: Orange-brown. Mesosoma color: Partially orange (mostly on anterome-

soscutum and parts of propleuron, pronotum, mesopleuron, scutellar complex, metascutellum). Metasoma color: Dark brown, except for light yellow T2. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, yellow. Femora color (pro-, meso-, metafemur): Yellow, yellow, mostly reddish-brown (except for yellow ventraly). Tibiae color (pro-, meso-, metatibia): Yellow, yellow, dark brown (except for anterior 0.1 which is yellow-orange). Metatibia spurs color: Yellow-white. First segment of metatarsus color: Dark brown. Tegula and humeral complex color: Yellow, yellow. Wings: Hyaline. Pterostigma color: Brown, with very small pale spot at base. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.2–3.4 mm. Fore wing length: 3.1–3.2 mm. Ocular-ocellar line/posterior ocellus diameter: 1.9 x. Interocellar distance/posterior ocellus diameter: 1.8–1.9 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.13–0.15/0.07–0.08/0.13–0.14 mm. Antennal flagellomere 2 length/width: 3.0 × (0.27/0.09–0.10 mm). Antennal flagellomere 14 length/width: 2.2 × (0.20–0.21/0.09–0.10 mm). Length of flagellomere 2/length of flagellomere 14: 1.3–1.4 x. Antenna in males: Of normal appearance, not flattened. Epicnemial carina: Present but weakly defined. Anteromesoscutum: With relatively shallower and sparser sculpture, central area not appearing elevated compared to lateral areas of anteromesoscutum, notauli strongly excavated. Scutellar disc sculpture: With margins and central part of disc equally sculptured. Number of carinae in scutoscutellar sulcus: Three or four. Metafemur length/width: 3.3 × (0.86–0.87/0.25–0.26 mm). Metatibia length: 1.08–1.12 mm ($\overline{X}$ = 1.10 mm). First segment of metatarsus length: 0.38–0.41 mm ($\overline{X}$ = 0.40 mm). Mediotergite 1 length/width at posterior margin: 3.0–3.1 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.45–0.48/0.26–0.24/0.22–0.20/0.15–0.16 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. As in female.

Distribution. Costa Rica, ACG.

Host. Noctuidae: An undetermined species with interim name ‘noctJanzen01 05-SRNP-23743’. Solitary parasitoid.

Molecular data. Two haplotypes, nine sequences (nine barcode-compliant) in BOLD.

Etymology. This species is named in honour of Irene Baker in recognition of her contribution to understanding the plant biology of ACG.

Snellenius isidrochaconi Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/FB2EFE89-5F12-456B-AA76-6935A3F58D98
Figures 103–109, 227

Holotype. ♂ in CNC. COSTA RICA: ACG, Guanacaste Province, Sector Pitilla, Amonias, 390m, 11.04249, -85.40339. ACG database code: DHJPAR0020741.

Paratypes. 2♂ (CNC, USNM). COSTA RICA, ACG, database codes: DHJPAR0049417, 08-SRNP-31574.

Other specimen examined. 1♀, DNA voucher code: CNCHYM 07055, Panama, Gamboa, Canal Zone, vii.1967, W&M Wirth.

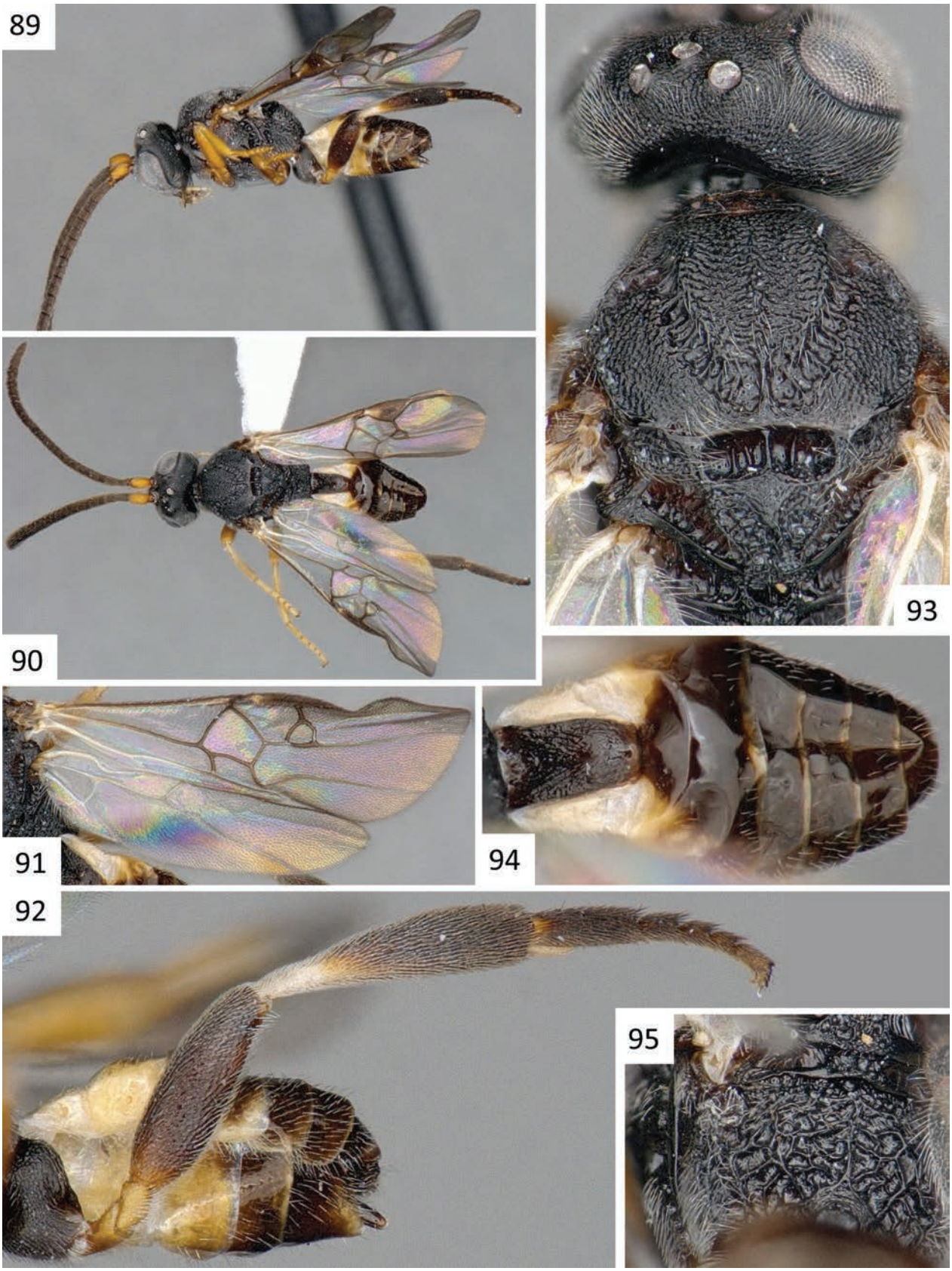
Diagnosis. The combination of body color (yellow orange), metatibia (mostly or entirely dark red brown) and wings (with dark brown infumation, veins and pterostigma mostly brown), as well as hosts (Erebidae, *Gonodonta* spp.) separates this species from all other ACG *Snellenius* except for *S. phildevriesi*. No female specimens are known from *S. isidrochaconi* but males are distinguishable from *S. phildevriesi* by slight differences in size, interocellar area color, carination pattern in the propodeum, and the presence of a rather acute projection on the posterior margin of the metascutellum. Additionally, the two species have over 4 % of base pair differences in the barcoding region, and the caterpillars that they parasitize, although belonging to the same genus (*Gonodonta*), feed on host plants in different families.

Description. Male. Scape color: Partially brown, partially yellow. Mesosoma color: Yellow orange. Metasoma color: Yellow orange. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, yellow. Femora color (pro-, meso-, metafemur): Yellow, yellow, yellow. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, anterior 0.8 reddish orange and posterior 0.2 dark brown to black. Metatibia spurs color: Brown. First segment of metatarsus color: Dark brown to black. Tegula and humeral complex color: Yellow, yellow. Wings: Infumated. Pterostigma color: Dark brown. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.5–3.6 mm (3.6 mm). Fore wing length: 3.5 mm. Antenna in males: Flattened on central and apical segments. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly raised and less sculptured. Number of carinae in scutoscutellar sulcus: One. Metafemur length: 0.94–0.97 mm ($\overline{X}$ = 0.96 mm). Metatibia length: 1.24–1.30 mm ($\overline{X}$ = 1.27 mm). First segment of metatarsus length: 0.48–0.50 mm (0.49 mm). Mediotergite 1 length/width at posterior margin: 3.4–3.7 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.55–0.58/0.21–0.22/0.17–0.18/0.15–0.17 mm). Mediotergite 1 sculpture: Partially sculptured.

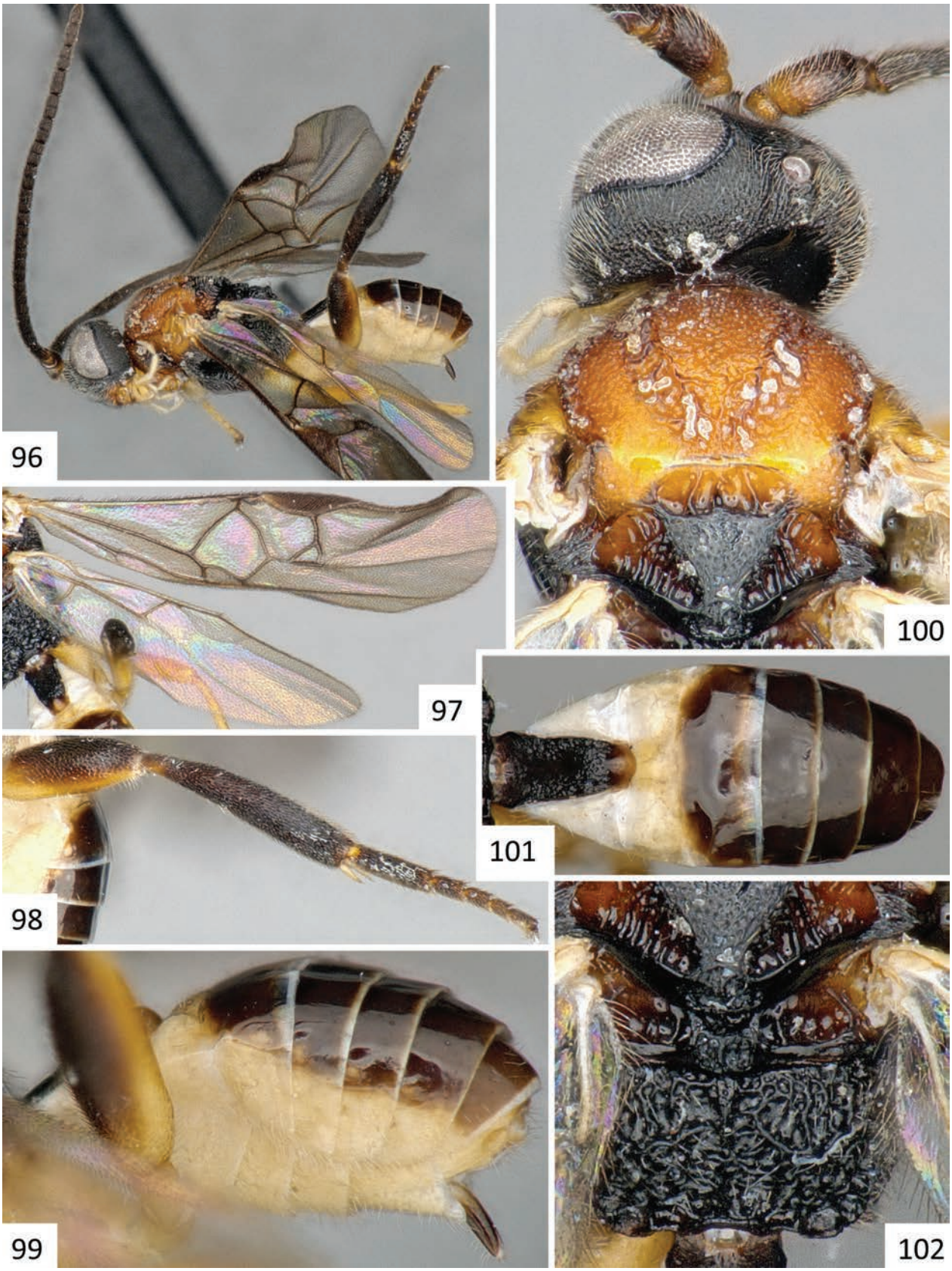
Female. One female specimen, from Panama, is associated with the male specimens with some question due to the fact it is from a different country and there is no other known female associated with this species. Thus, it is excluded from the type series and was not used to characterize the species.

Distribution. Costa Rica (ACG) and Panama.

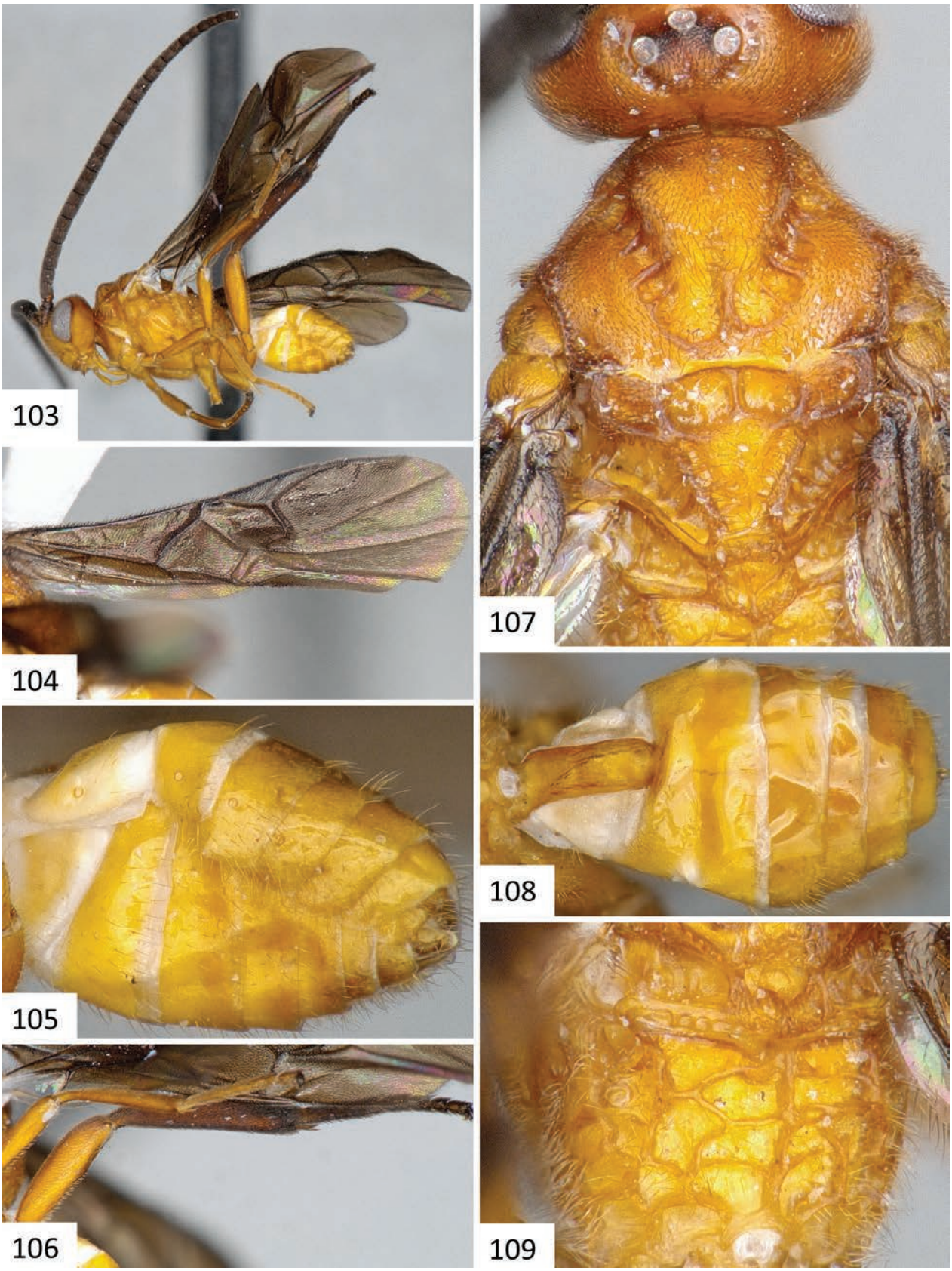
Host. Erebidae: three species of *Gonodonta* feeding on *Cissampelos* spp. (Menispermaceae). Solitary parasitoid (Fig. 227).



Figures 89–95. *Snellenius gerardoherrerai* Fernández-Triana & Whitfield. **89** Habitus, lateral view **90** Habitus, dorsal view **91** Wings **92** Hind leg and metasoma, lateral view **93** Head and mesosoma (partially), dorsal view **94** Metasoma, dorsal view **95** Propodeum (partially), dorsal view.



Figures 96–102. *Snellenius irenebakerae* Fernández-Triana & Whitfield. **96** Habitus, lateral view **97** Wings **98** Hind leg and metasoma (partially), lateral view **99** Metasoma, lateral view **100** Head and mesosoma (partially), dorsal view **101** Metasoma, dorsal view **102** Scutellar disc (partially) and propodeum, dorsal view.



Figures 103–109. *Snellenius isidrochaconi* Fernández-Triana & Whitfield. **103** Habitus, lateral view **104** Fore wing **105** Metasoma, lateral view **106** Middle and hind legs **107** Head and mesosoma (partially), dorsal view **108** Metasoma, dorsal view **109** Propodeum, dorsal view.

Molecular data. One haplotype, seven sequences (five barcode-compliant) in BOLD.

Etymology. This species is named in honour of Isidro Chacón in recognition of his contribution to understanding the plant biology of ACG.

Comments. Only males were available to describe this species (but see comment on a female above), and they were almost indistinguishable from males of the morphologically similar *S. phildevriesi*. Thus, the description provided above only includes those characters that differ from males of *S. phildevriesi*.

Snellenius johnkressi Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/9897EF83-1F78-464C-9985-6343956A9669
Figures 110–116

Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Argelia, 5m, 10.78004, -85.66405. ACG database code: DHJPAR0053098.

Paratypes. 10♀, 11♂ (BMNH, CNC, INBio, INHS, USNM). COSTA RICA, ACG, database codes: DHJPAR0053008, DHJPAR0053009, DHJPAR0053012, DHJPAR0053015, DHJPAR0053018, DHJPAR0053042, DHJPAR0053048, DHJPAR0053068, DHJPAR0053072, DHJPAR0053074, DHJPAR0053077, DHJPAR0053078, DHJPAR0053081, DHJPAR0053085, DHJPAR0053087, DHJPAR0053091, DHJPAR0053097, DHJPAR0053103, DHJPAR0053104, DHJPAR0053113.

Diagnosis. The combination of hyaline wings, mesosoma and metasoma mostly black or dark reddish brown, metafemur and metatibia (posterior 0.6) dark brown separates this species from all other ACG *Snellenius* except for *S. felipechavarriai*. It is distinguishable from the latter species by narrower T2 and scutoscutellar sulcus with 3–5 carinae (only one clearly defined carina in *S. felipechavarriai*).

Description. Female. Scape color: Dark brown. Mesosoma color: Black. Metasoma color: Dark brown to black. Coxae color (pro-, meso-, metacoxa): Orange, orange brown, black. Femora color (pro-, meso-, metafemur): Orange, dark brown, black. Tibiae color (pro-, meso-, metatibia): Orange, orange brown, yellow white on anterior 0.2 and dark brown to black on posterior 0.8. Metatibia spurs color: Yellow white. First segment of metatarsus color: Dark brown to black. Tegula and humeral complex color: Dark orange to dark brown, brown to black. Wings: Hyaline. Pterostigma color: Brown. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.0 mm (2.9–3.0 mm). Fore wing length: 2.8 mm (2.8–2.9 mm). Ocular-ocellar line/posterior ocellus diameter: 1.8–2.0 x. Interocellar distance/posterior ocellus diameter: 2.0–2.1 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.14–0.16/0.07–0.09/0.15–0.18 mm. Antennal flagellomere 2 length/width: 2.7–3.1 × (0.26–0.28/0.08–0.10 mm). Antennal flagellomere 14 length/width: 1.8–2.0 × (0.14–0.18/0.07–0.10 mm). Length of flagellomere 2/length of flagellomere 14: 1.6–1.9 x. Antenna in males: Of normal appearance, not flattened. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: Three complete, two incomplete. Metafemur length/width: 3.4–3.6 × (0.77–0.86/0.23–0.25 mm). Metatibia length: 1.11 mm (1.07–1.15) mm. First segment of metatarsus length: 0.44 mm (0.42–0.45 mm). Mediotergite 1 length/width at posterior margin: 2.3–2.4 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.50–0.53/0.30/0.27–0.29/0.21–0.23 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. As in female but scape and T1 orange yellow, and T2 partially yellow, orange yellow, or light brown.

Distribution. Costa Rica, ACG.

Hosts. Erebidae: *Bulia mexicana*. Solitary parasitoid.

Molecular data. Six haplotypes, 20 sequences (20 barcode-compliant) in BOLD.

Etymology. This species is named in honour of John Kress in recognition of his contribution to understanding the plant biology of ACG.

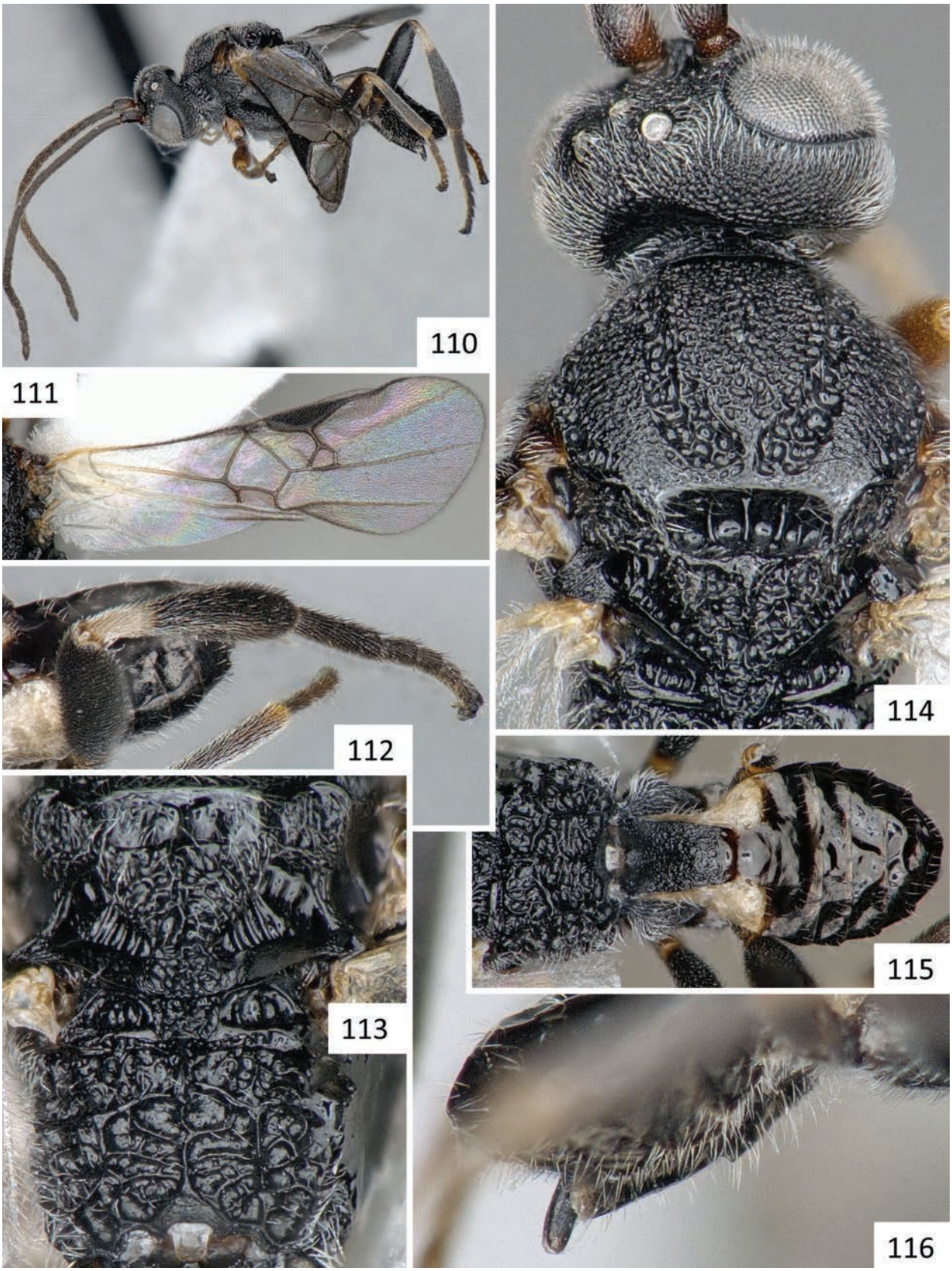
Snellenius jorgecampabadali Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/FD2FD00D-76AB-46C9-89F3-4D293CEA0EED
Figures 117–122

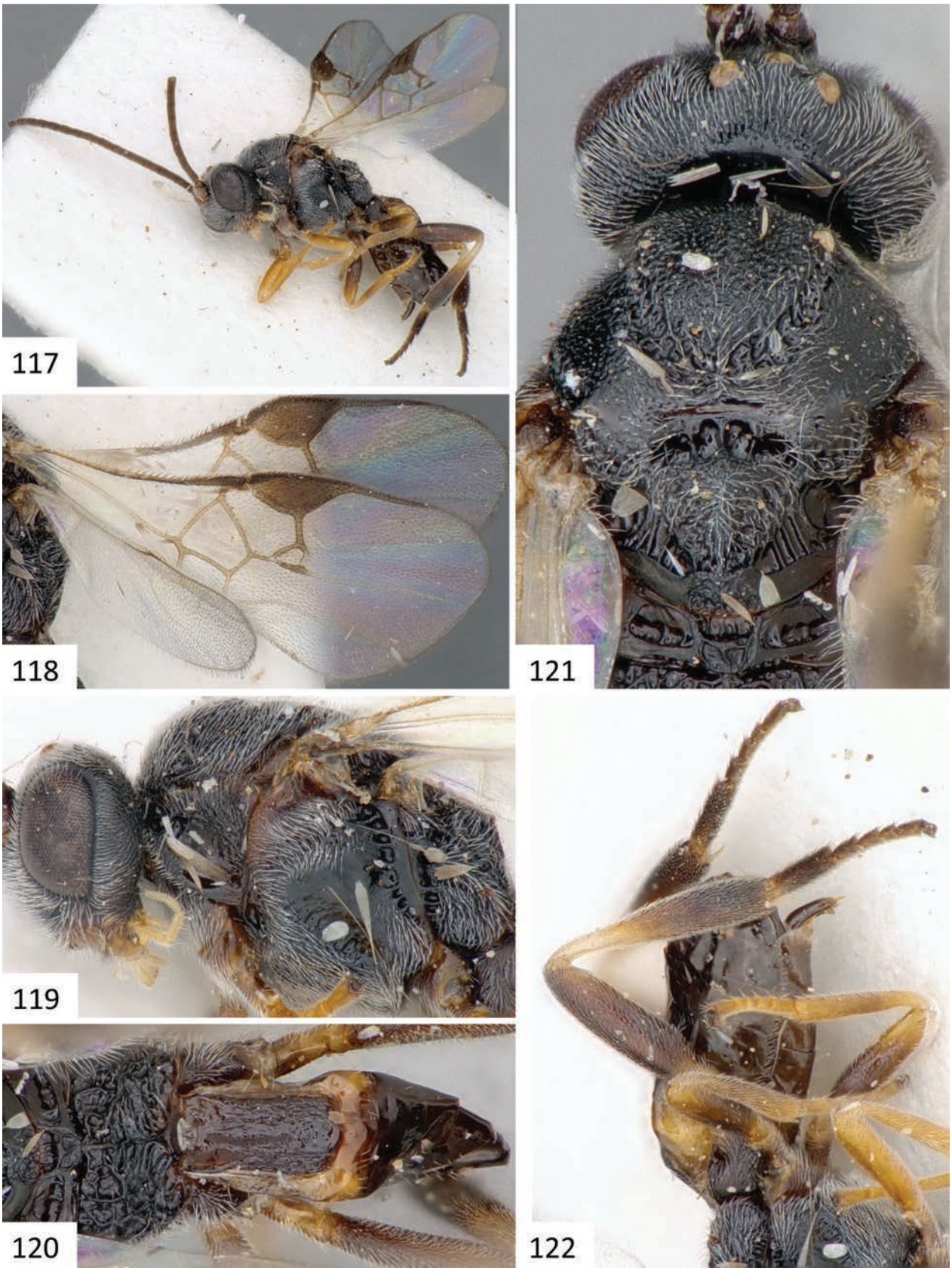
Holotype. ♀ in INBio. COSTA RICA: Guanacaste Province, OTS Palo Verde Biological Station, 10m, 25.iii–21.iv.1992, A. Gutierrez coll. Second label with code: INBio CRI000 874631.

Diagnosis. The combination of pterostigma relatively wider (2.0 × as long as wide), fore wing with basal cell virtually without setae, wings with most veins transparent or light yellow (except for veins r, 2RS, 3RSa, and 2M), and T1 length 2.6 × its width at posterior margin separate this species from all other ACG *Snellenius*.

Description. Female. Scape color: Yellow brown. Mesosoma color: Black. Metasoma color: T2 yellow brown, T1 and T3+ dark reddish brown. Coxae color (pro-, meso-, metacoxa): Yellow brown, yellow brown, dark brown to black. Femora color (pro-, meso-, metafemur): Yellow, mostly brown, brown. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, anterior 0.4 yellow and posterior 0.6 dark brown. Metatibia spurs color: Yellow. First segment of metatarsus color: Brown. Tegula and humeral complex color: Half pale, half dark. Wings: Hyaline. Pterostigma color: Brown. Fore wing veins 1RS and (RS+M)a: Entirely or partially transparent or light yellow (clearly much lighter than most of surrounding



Figures 110–116. *Snellenius johnkressi* Fernández-Triana & Whitfield. **110** Habitus, lateral view **111** Wings **112** Hind leg and metasoma (partially), lateral view **113** Scutellar disc and propodeum, dorsal view **114** Head and mesosoma (partially), dorsal view **115** Propodeum and metasoma, dorsal view **116** Detail of hypopygium and ovipositor sheaths.



Figures 117–122. *Snellenius jorgecampabadali* Fernández-Triana & Whitfield. **117** Habitus, lateral view **118** Wings **119** Head and mesosoma, lateral view **120** Propodeum and metasoma, dorsal view **121** Head and mesosoma (partially), dorsal view **122** Hind leg and metasoma, lateral view.

veins). Body length (head to apex of metasoma): 3.0 mm. Fore wing length: 2.5 mm. Ocular-ocellar line/posterior ocellus diameter: 1.6 x. Interocellar distance/posterior ocellus diameter: 2.0 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.14/0.09/0.18 mm. Antennal flagellomere 2 length/width: 2.8 × (0.22–0.08 mm). Antennal flagellomere 14 length/width: 1.7 × (0.10/0.06 mm). Length of flagellomere 2/length of flagellomere 14: 2.2 x. Epicnemial carina: Present but weakly defined. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Number of carinae in scutoscutellar sulcus: One. Metafemur length/width: 3.3 × (0.72/0.22 mm). Metatibia length: 0.98 mm. First segment of metatarsus length: 0.32 mm. Mediotergite 1 length/width at posterior margin: 2.6 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.58/0.23/0.22/0.22 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. Unknown.

Distribution. Costa Rica, Guanacaste Province, OTS Biological Station.

Host. Unknown.

Molecular data. None.

Etymology. This species is named in honour of Sr. Jorge R. Campabadal (RIP), the first Costa Rican administrator of the Organization for Tropical Studies, in recognition of his key role in founding the OTS Palo Verde Biological Field Station.

Snellenius jorgegomezlauritoi Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/E303F53F-6DC1-4F33-BA87-75F8EBF47C3A
Figures 123–128

Holotype. ♀ in CNC. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Area Administrativa, 295 meters, 10.83764, -85.61871. ACG database code: 90-SRNP-2193.

Diagnosis. The combination of metasoma entirely light orange yellow, the metasoma black, and wings infumated separate this species from all other ACG *Snellenius*.

Description. Female. Scape color: Light brown yellow. Mesosoma color: Black. Metasoma color: Light orange yellow. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, yellow. Femora color (pro-, meso-, metafemur): Yellow, yellow, yellow. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, mostly light yellow brown (with only posterior 0.1 brown). Metatibia spurs color: Light yellow brown. First segment of metatarsus color: Brown. Tegula and humeral complex color: Yellow, light brown yellow. Wings: Infumated. Pterostigma color: Brown. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.2 mm. Fore wing length: 3.2 mm. Ocular-ocellar line/posterior ocellus diameter: 1.9 x. Interocellar distance/posterior ocellus diameter: 1.6 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.17/0.09/0.14 mm. Antennal flagellomere 2 length/width: 2.8 × (0.28/0.10 mm). Antennal flagellomere 14 length/width: 2.0 × (0.20/0.10 mm). Length of flagellomere 2/length of flagellomere 14: 1.4 x. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One complete, four partial. Metafemur length/width: 3.8 × (0.88/0.23 mm). Metatibia length: 1.15 mm. First segment of metatarsus length: 0.48 mm. Mediotergite 1 length/width at posterior margin: 2.2 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.52/0.24/0.26/0.24 mm. Mediotergite 1 sculpture: Mostly sculptured.

Male. Unknown.

Distribution. Costa Rica, ACG.

Host. Noctuidae: *Stauropides persimilis*. Solitary parasitoid.

Molecular data. None.

Etymology. This species is named in honour of Jorge Gómez Laurito in recognition of his contribution to understanding the plant biology of ACG.

Snellenius josesarukhani Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/88177F35-0806-4187-B171-538B52970444
Figures 129–135

Holotype. ♂ in CNC. COSTA RICA: ACG, Alajuela Province, Sector San Cristobal, Estacion San Cristobal, 640m, 10.87097, -85.39144. ACG database code: 98-SRNP-6841.

Paratype. 1♂ (CNC). COSTA RICA, Guanacaste Province, 3 km W of Arenal, 500m, 23.ix.1972. DNA Voucher code: CNCHYM 07141.

Diagnosis. The combination of metasoma with T2–T3 entirely yellow and dark brown beyond T4, relatively wide T2 (1.9 × as long as wide at posterior margin), wings slightly infumated, metatibia spurs yellow white, metafemur entirely yellow orange, and metatibia mostly light in color (yellow orange, with anterior 0.2 yellow white, and only posterior 0.2 brown), separate this species from all other ACG *Snellenius*, except for *S. mariamartachavarriae*. It is distinguishable from the latter species by having one carina in the scutoscutellar sulcus, scape mostly brown, T4 dark brown to black, and host species (*Selenisa* sp.) found in rainforest.

Description. Male. Scape color: Mostly dark brown. Mesosoma color: Black. Metasoma color: Dark redish brown, except for yellow T2–T3. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, yellow brown. Femora color (pro-, meso-, metafemur): Yellow orange, yellow orange, yellow orange. Tibiae color (pro-, meso-, metatibia): Yellow orange, yellow orange, mostly yellow orange (but with anterior 0.2 yellow white, and posterior 0.2 brown). Metatibia spurs color: Yellow white. First segment of metatarsus color: Brown. Tegula and humeral complex color: Yellow, mostly brown. Wings: Slightly infumated. Pterostigma color: Brown, with very small pale spot at base. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.0–3.2 mm. Fore wing length: 2.8–3.0 mm. Ocular-ocellar line/posterior ocellus diameter: 2.1 x. Interocellar distance/posterior ocellus diameter: 2.1 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.17/0.08/0.17 mm. Antenna in males: Flattened. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One. Metafemur length/width: 3.2 × (0.80/0.25 mm). Metatibia length: 1.02 mm. First segment of metatarsus length: 0.41 mm. Mediotergite 1 length/width at posterior margin: 1.9 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.48/0.25/0.24/0.25 mm. Mediotergite 1 sculpture: Fully sculptured.

Female. Unknown.

Distribution. Costa Rica, Guanacaste Province.

Host. Erebidae: *Helia sueroides*. Solitary parasitoid.

Molecular data. One haplotype, one sequence (not barcode-compliant) in BOLD.

Comments. The paratype has a partial barcode (275 bp) that does not match any other *Snellenius* in BOLD.

Etymology. This species is named in honour of José Sarukhan in recognition of his contribution to understanding the plant biology of ACG.

Snellenius kerrydresslerae Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/47049BFE-C223-4A22-95BF-6350955D2B0F
Figures 136–142, 223

Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector Santa Elena, Vado Quebrada Calera, 305m, 10.86677, -85.6465. ACG database code: DHJPAR0013881.

Paratypes. 7♀, 3♂ (BMNH, CNC, USNM). COSTA RICA, ACG, database codes: DHJPAR0004092, DHJPAR0004095, DHJPAR0004309, DHJPAR0004310, DHJPAR0004311, DHJPAR0004312, DHJPAR0004313, DHJPAR0013821, DHJPAR0013899, 03-SRNP-14142.

Diagnosis. The fore wing mostly infumated, black metafemur, and T1 2.8 × as long as width at posterior margin differentiates this species from congeners.

Description. Female. Scape color: Dark brown. Mesosoma color: Black. Metasoma color: Black. Coxae color (pro-, meso-, metacoxa): Yellow, brown, dark brown to black. Femora color (pro-, meso-, metafemur): orange yellow, mostly brown, black. Tibiae color (pro-, meso-, metatibia): orange yellow, orange yellow, anterior 0.2 orange yellow and posterior 0.8 dark brown to black. Metatibia spurs color: Dark brown to black. First segment of metatarsus color: Dark brown to black. Tegula and humeral complex color: Dark, dark. Wings: Infumated. Pterostigma color: mostly dark, with small pale spot at base. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.4–3.6 mm ($\bar{X}$ = 3.5 mm). Fore wing length: 3.1–3.2 mm ($\bar{X}$ = 3.1 mm). Ocular-ocellar line/posterior ocellus diameter: 2.0 x. Interocellar distance/posterior ocellus diameter: 2.0 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.18/0.09/0.18 mm. Antennal flagellomere 2 length/width: 2.5–2.7 × (0.32/0.12–0.13 mm). Antennal flagellomere 14 length/width: 1.5–1.6 × (0.19/0.12–0.13 mm). Length of flagellomere 2/length of flagellomere 14: 1.7 x. Antenna in males: Strongly flattened. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: Three. Metafemur length/width: 3.7 × (0.95/0.26 mm). Metatibia length: 1.25–1.30 mm. First segment of metatarsus length: 0.48–0.50 mm. Mediotergite 1 length/width at posterior margin: 2.7 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.59–0.60/0.28–0.29/0.27/0.22 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. As female but with T2 (entirely) and T3 (partially) yellow to light yellow brown.

Distribution. Costa Rica, ACG.

Host. Erebidae, *Orodesma pulverosa.* Solitary parasitoid (Fig. 223).

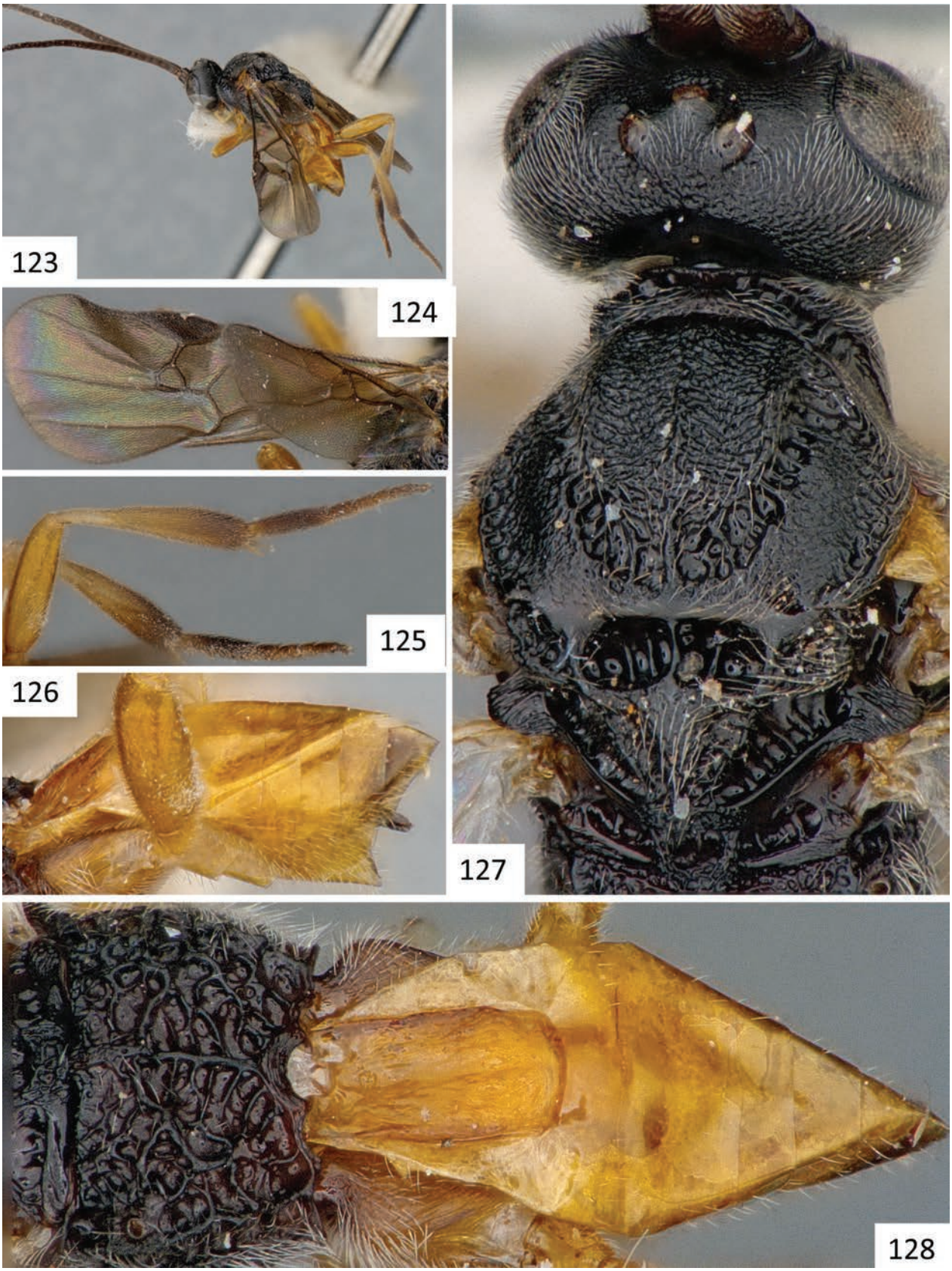
Molecular data. One haplotype, ten sequences (10 barcode-compliant) in BOLD.

Etymology. This species is named in honour of Kerry Dressler in recognition of her contribution to understanding the plant biology of ACG.

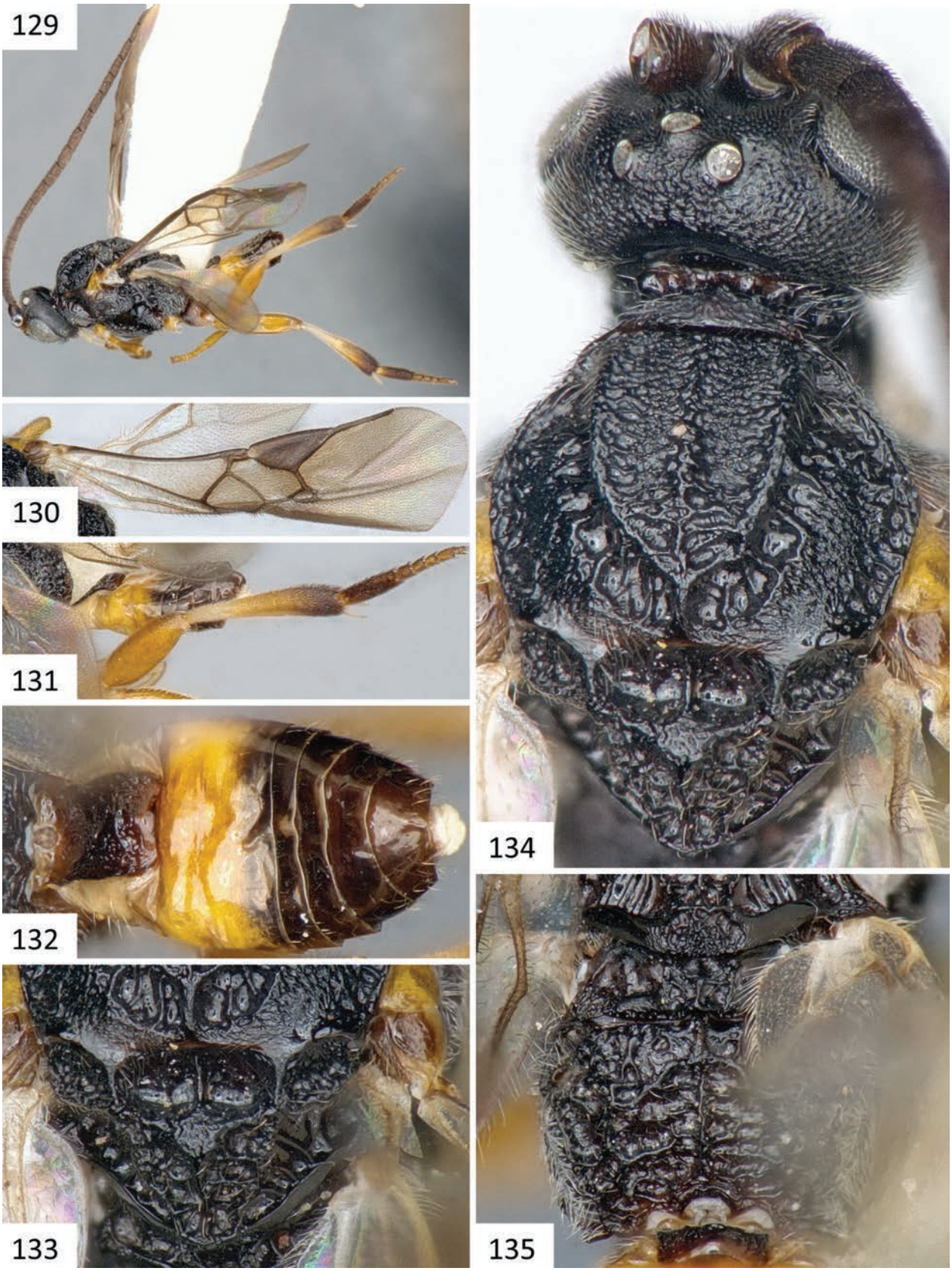
Snellenius lucindamcdadeae Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/FFB42CDD-1C15-47D2-8D34-C30A73B89E67
Figures 143–149

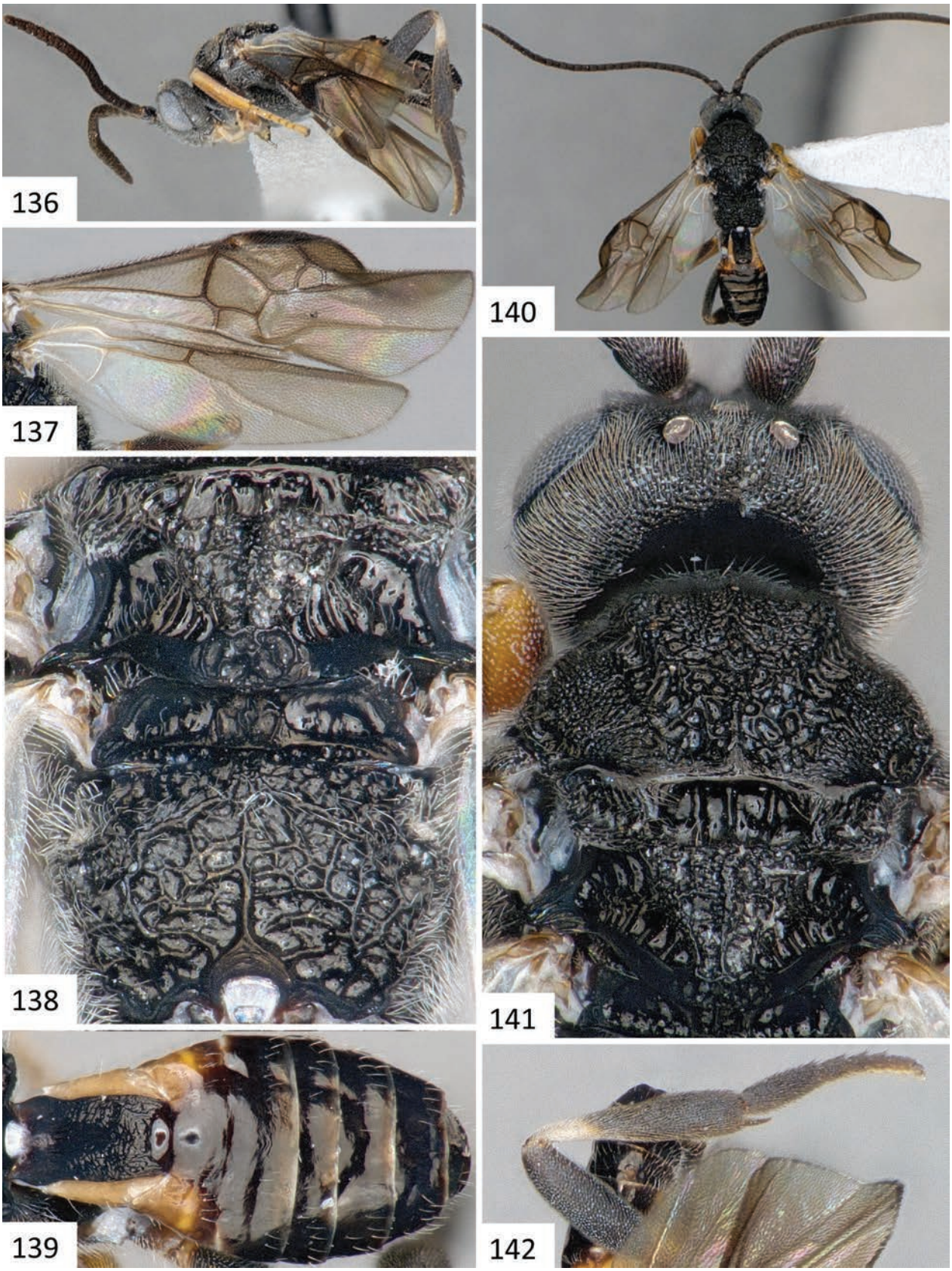
Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Bosque San



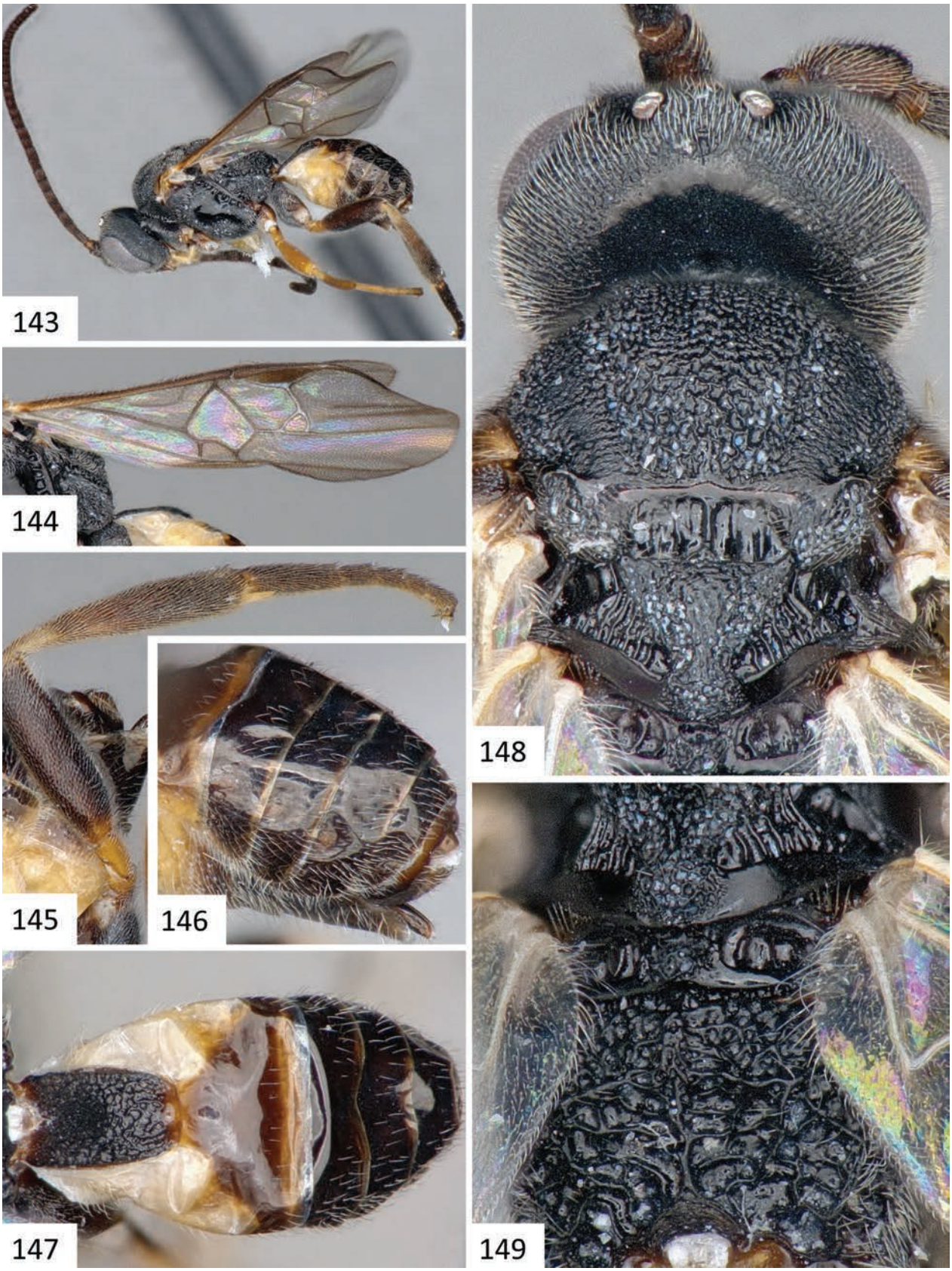
Figures 123–128. *Snellenius jorgegomezlauritoi* Fernández-Triana & Whitfield. **123** Habitus, lateral view **124** Wings **125** Middle and hind legs **126** Metasoma, lateral view **127** Hind leg and metasoma (partially), lateral view **128** Propodeum and metasoma, dorsal view.



Figures 129–135. *Snellenius josesarukhani* Fernández-Triana & Whitfield. **129** Habitus, lateral view **130** Wings **131** Hind leg and metasoma (partially), lateral view **132** Metasoma, dorsal view **133** Scutellar disc, dorsal view **134** Head and mesosoma (partially), dorsal view **135** Propodeum, dorsal view.



Figures 136–142. *Snellenius kerrydresslerae* Fernández-Triana & Whitfield. **136** Habitus, lateral view **137** Wings **138** Scutellar disc and propodeum, dorsal view **139** Metasoma, dorsal view **140** Habitus, dorsal view **141** Head and mesosoma (partially), dorsal view **142** Hind leg and metasoma (partially), lateral view.



Figures 143–149. *Snellenius lucindamcdadeae* Fernández-Triana & Whitfield. **143** Habitus, lateral view **144** Fore wing **145** Hind leg **146** Metasoma (partially), lateral view **147** Metasoma, dorsal view **148** Head and mesosoma (partially), dorsal view **149** Scutellar disc (partially) and propodeum, dorsal view.

Emilio, 300m, 10.84389, -85.61384. ACG database code: DHJPAR0013314.

Paratypes. 1♀, 4♂ (CNC, USNM). COSTA RICA, ACG, database codes: DHJPAR0013318, DHJPAR0013321, DHJPAR0013336, DHJPAR0013340, DHJPAR0013341.

Diagnosis. The combination of dark brown to black body, T1 length 2.8 × its width at posterior margin, mostly brown metatibia, and fore wing with veins 2RS, r, and 3RSa brown, differentiates this species from congeners.

Description. Female. Scape color: Dark brown. Mesosoma color: Black. Metasoma color: Dark brown to reddish brown. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, dark brown. Femora color (pro-, meso-, metafemur): Yellow, yellow, dark brown. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, anterior 0.2 yellow and posterior 0.8 dark brown. Metatibia spurs color: Yellow orange. First segment of metatarsus color: Dark brown. Tegula and humeral complex color: Yellow, half yellow and half brown. Wings: Hyaline. Pterostigma color: Brown with pale spot at base. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.1–3.2 mm. Fore wing length: 2.9–3.0 mm. Ocular-ocellar line/posterior ocellus diameter: 1.9 x. Interocellar distance/posterior ocellus diameter: 1.9 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.17/0.09/0.17 mm. Antennal flagellomere 2 length/width: 3.3 × (0.30/0.09 mm). Antennal flagellomere 14 length/width: 2.1 × (0.17/0.08 mm). Length of flagellomere 2/length of flagellomere 14: 1.8 x. Antenna in males: Of normal appearance, not flattened. Epicnemial carina: Present. Anteromesoscutum: With relatively shallower and sparser sculpture, central area not appearing elevated compared to lateral areas of anteromesoscutum, notauli slightly to strongly excavated. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly raised and less sculptured. Number of carinae in scutoscutellar sulcus: Four to five. Metafemur length/width: 3.8 × (0.98/0.26 mm). Metatibia length: 1.30 mm. First segment of metatarsus length: 0.57–0.58 mm,. Mediotergite 1 length/width at posterior margin: 2.8 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.62/0.29–0.30/0.30–0.31/0.22 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. As in female.

Distribution. Costa Rica, ACG.

Host. Unknown.

Molecular data. Three haplotypes, six sequences (six barcode-compliant) in BOLD.

Etymology. This species is named in honour of Lucinda McDade in recognition of her contribution to understanding the plant biology of ACG.

Snellenius luisdiegogomezi Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/F7C3E5C0-011C-49D0-B477-2D0683A9EDDA
Figures 150–155

Holotype. ♀ in CNC. COSTA RICA: San Vito, Las Cruces, 17.viii-12.ix.1988, B. Gill. Second Label: DNA Voucher code CNCHYM 07140.

Paratypes. 3♀, 5♂, Costa Rica: Puntarenas, Golfo Dulce, 15 km W of Piedras Blancas, 100m, xi.1990 and xii.1990, P. Hanson; 2♀, 1♂, Costa Rica, Limon, 16 km W of Guapiles, 400m, i-iii and iv-v.1989, P. Hanson; 1♀, Costa Rica: Limon, 4 km NE of Bribri, 50m, ix-xi.1989, P. Hanson; Panama, Gamboa, Canal Zone, Pipeline Road, vii.1967, Malaise trap, W.W.Wirth, DNA Voucher CNCHYM 07044.

Diagnosis. The unique combination of dark reddish brown body and relatively long and thin T1 (its length 4.0 × its width at posterior margin), separate this species from all other ACG *Snellenius*.

Description. Female. Scape color: Dark brown. Mesosoma color: Dark reddish brown. Metasoma color: Dark reddish brown. Coxae color (pro-, meso-, metacoxa): Brown, white, brown. Femora color (pro-, meso-, metafemur): Mostly brown, mostly brown, dark reddish brown. Tibiae color (pro-, meso-, metatibia): Mostly brown, mostly brown, dark reddish brown. Metatibia spurs color: Orange brown. First segment of metatarsus color: Reddish brown. Tegula and humeral complex color: Brown, brown. Wings: Infumated. Pterostigma color: Brown with pale spot at base. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 2.4–2.9 mm ($\bar{X}$ = 2.7 mm). Fore wing length: 2.4–3.0 mm ($\bar{X}$ = 2.7 mm). Ocular-ocellar line/posterior ocellus diameter: 1.9 x. Interocellar distance/posterior ocellus diameter: 1.6 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.13/0.07/0.11 mm. Antennal flagellomere 2 lengtwh/width: 3.8–3.9 × (0.23–0.27/0.06–0.07 mm). Antennal flagellomere 14 length/width: 2.3–2.6 × (0.23–0.27/0.16–0.18 mm). Length of flagellomere 2/length of flagellomere 14: 1.4–1.5 x. Antenna in males: Of normal appearance, not flattened. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly raised and less sculptured. Number of carinae in scutoscutellar sulcus: One. Metafemur length/width: 3.8–3.9 × (0.71–0.78/0.18–0.20 mm). Metatibia length: 0.98–1.00 mm. First segment of metatarsus length: 0.38–0.40 mm. Mediotergite 1 length/width at posterior margin: 3.9–4.2 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.41–0.44/0.15–0.16/0.12–0.13/0.10–0.11 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. Some males have middle coxa, trochanter and trochantellus darker.

Distribution. Costa Rica, Panama.

Host. Unknown.

Molecular data. One haplotype, one sequence (not barcode-compliant) in BOLD.

Etymology. This species is named in honour of Luis Diego Gómez in recognition of his contribution to understanding the plant biology of ACG.

Snellenius mariakuzminae Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/1B2DC50E-3426-48D6-8CF5-6B8FDB61CBE5
Figures 156–162

Holotype. ♂ in CNC. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Area Administrativa, 295m, 10.83764, -85.61871. ACG database code: DHJPAR0031634.

Diagnosis. The color combination (metafemur yellow, metatibia dark brown on posterior 0.8, scape brown, T2 and part of T3 light yellow brown), fore wing with vein 2SR shorter than vein r, and T1 2.2 × as long as width at posterior margin, differentiates this species from congeners.

Description. Male. Scape color: Brown. Mesosoma color: Black. Metasoma color: Dark brown, except for light yellow brown T2 and part of T3. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, dark brown. Femora color (pro-, meso-, metafemur): Yellow, yellow, yellow. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, anterior 0.2 white and posterior 0.8 brown. Metatibia spurs color: Yellow. First segment of metatarsus color: Brown. Tegula and humeral complex color: Dark, half pale and half dark. Wings: Mostly hyaline. Pterostigma color: Brown with pale spot at base. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 2.8 mm. Fore wing length: 2.4 mm. Ocular-ocellar line/posterior ocellus diameter: 1.6 x. Interocellar distance/posterior ocellus diameter: 1.8 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: (0.14/0.09/0.16 mm). Antenna in males: Slightly flattened. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One. Metafemur length/width: 3.5 × (0.70/0.20 mm). Metatibia length: 0.90 mm. First segment of metatarsus length: 0.31 mm. Mediotergite 1 length/width at posterior margin: 2.2 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.48/0.23/0.24/0.22 mm. Mediotergite 1 sculpture: Sculptured on posterior 0.5.

Female. Unknown.

Distribution. Costa Rica, ACG.

Host. Noctuidae: *Concana* Poole01. Solitary parasitoid.

Molecular data. Two haplotypes, two sequences (one barcode-compliant) in BOLD.

Comments. We have only seen one specimen, which has a full barcode (658 bp). In BOLD there is another partial sequence for a specimen we have not been able to study for this paper.

Etymology. This species is named in honour of María Kuzmin in recognition of her contribution to understanding the plant biology of ACG.

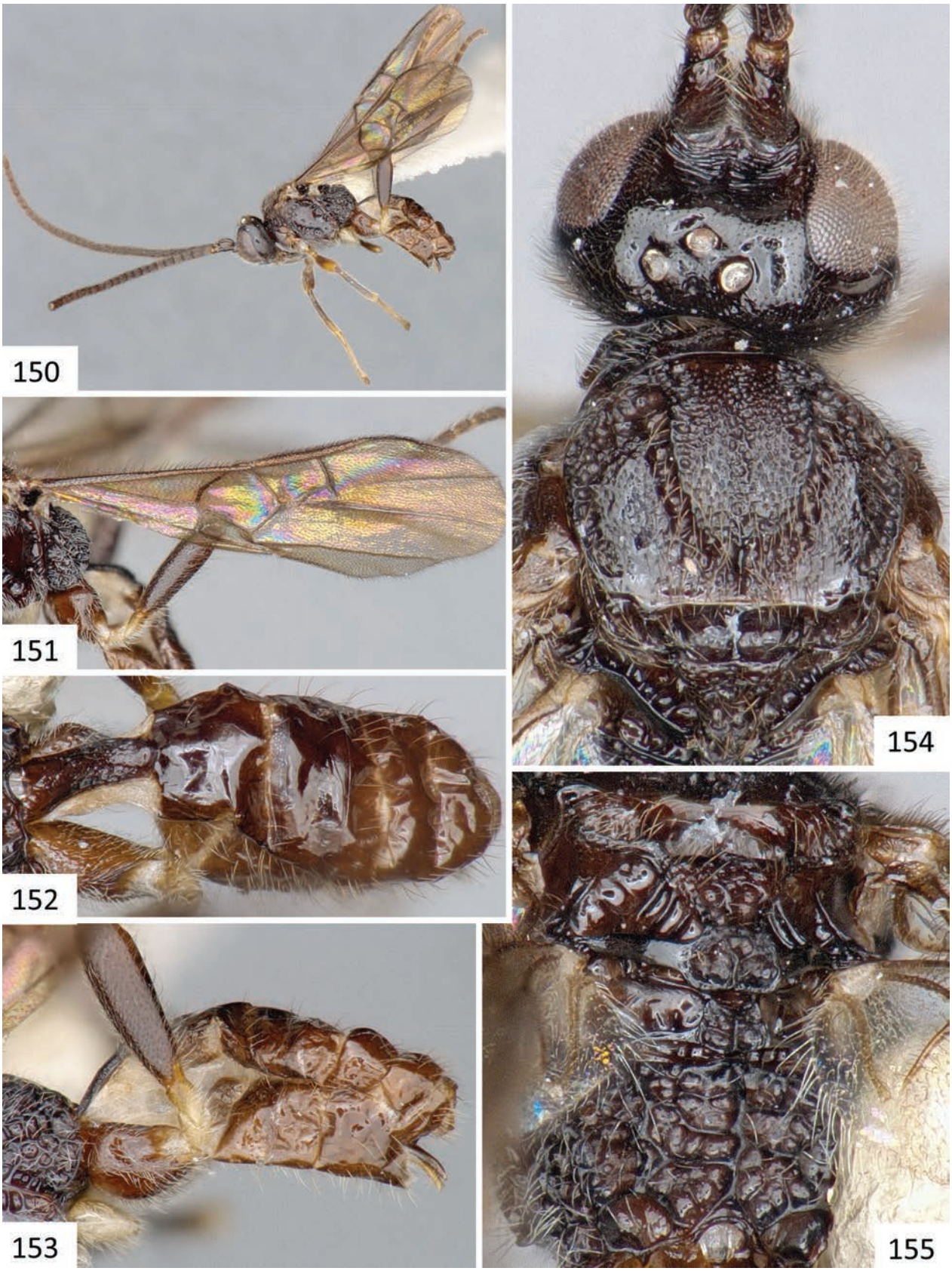
Snellenius mariamartachavarriae Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/CDBE2D1E-B1C4-4DAF-BEC6-4BF0B15319FA
Figures 163–168

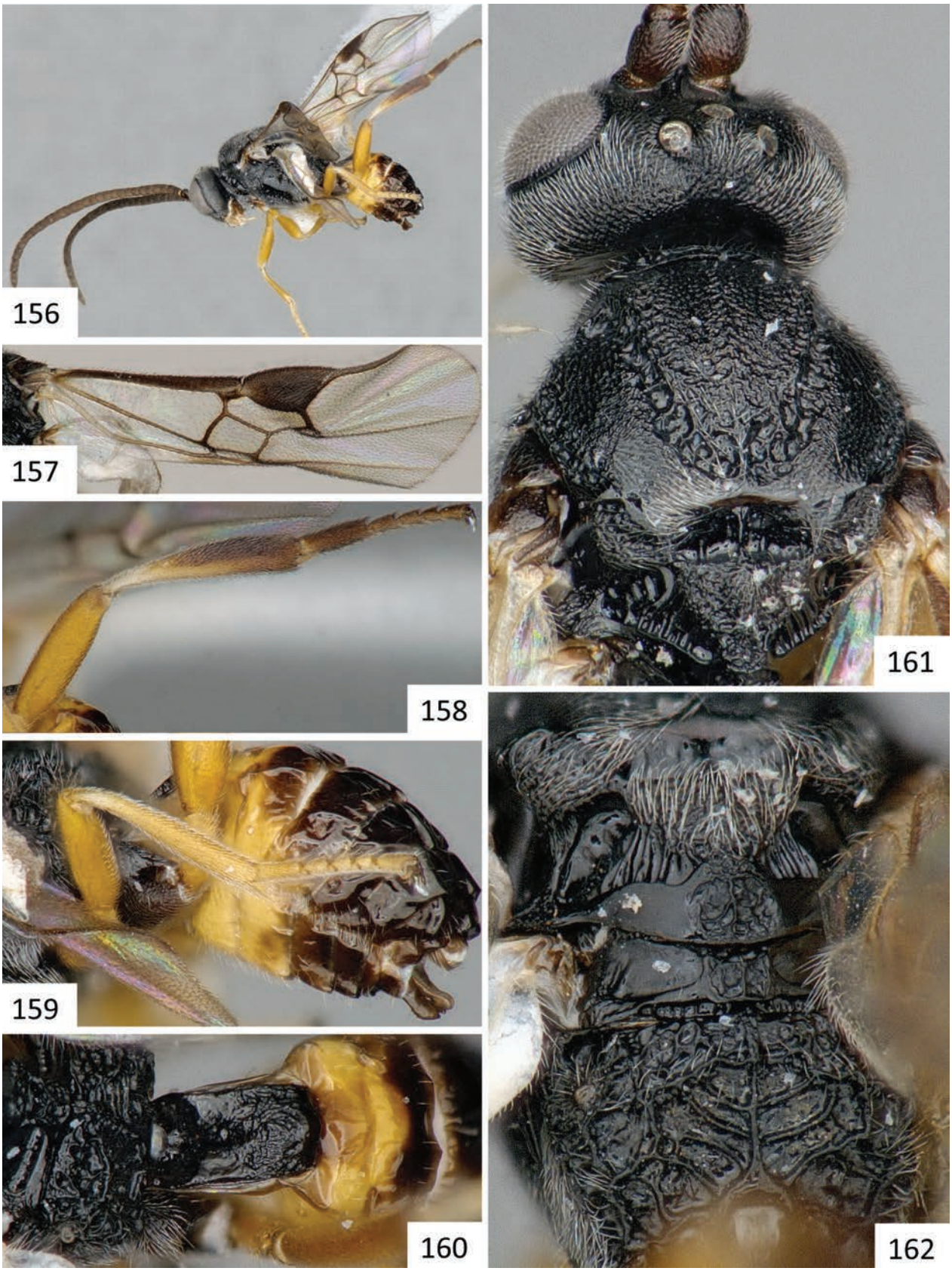
Holotype. ♂ in CNC. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Casona Santa Rosa, 295m, 10.83381, -85.61271. ACG database code: 91-SRNP-864.

Diagnosis. The combination of metasoma with T2–T3 entirely yellow and dark brown beyond T4, relatively wide T2 (1.9 × as long as wide at posterior margin), wings slightly infumated, metatibia spurs yellow white, metafemur entirely yellow orange, and metatibia mostly light in color (yellow orange, with anterior 0.2 yellow white, and only posterior 0.2 brown), separate this species from all other ACG *Snellenius*, except for *S. josesarukhani*. It is distinguishable from the latter species by having five carinae in the scutoscutellar sulcus, scape and T4 entirely yellow, and host species (*Catephiodes* sp.) found in dry forest.

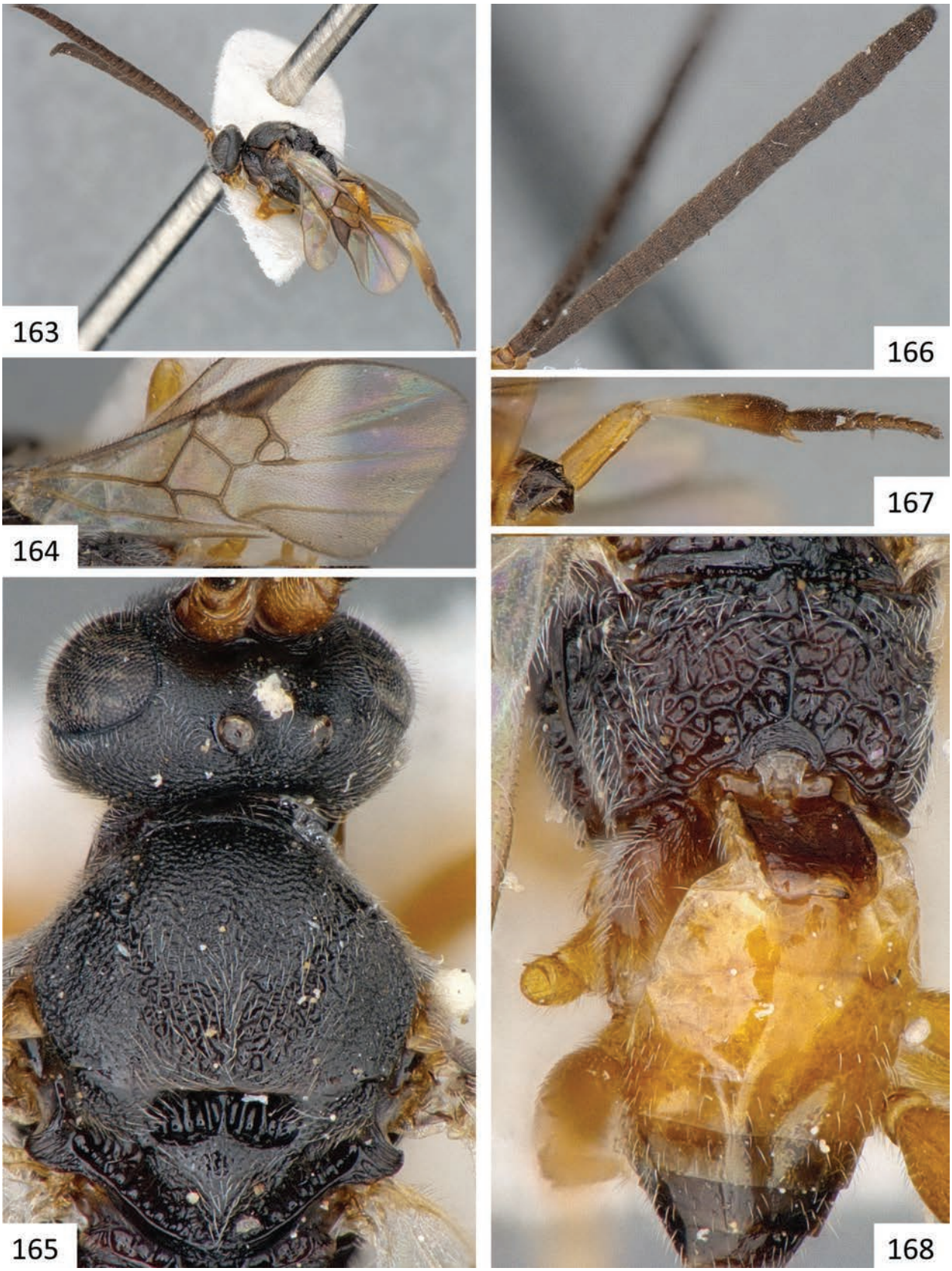
Description. Male. Scape color: Yellow. Mesosoma color: Reddish brown. Metasoma color: Mostly yellow orange, with only T5+ dark brown to black. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, yellow. Femora color (pro-, meso-, metafemur): Yellow, yellow, yellow. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, anterior 0.8 yellow and posterior 0.2 brown. Metatibia spurs color: Yellow. First segment of metatarsus color: Brown. Tegula and humeral complex color: Yellow, half pale and half dark. Wings: Hyaline. Pterostigma color: Brown with pale area centrally. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 2.8 mm. Fore wing length: 2.7 mm. Ocular-ocellar line/posterior ocellus diameter: 1.8 x. Interocellar distance/posterior ocellus diameter: 1.3 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.18/0.10/0.13 mm. Antenna in males: Strongly flattened. Epicnemial carina: Present. Anteromesoscutum: With relatively shallower and sparser sculpture, central area not appearing elevated compared to lateral areas of anteromesoscutum, notauli slightly to strongly excavated. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: Five. Metafemur length/width: 3.3 × (0.77/0.23 mm). Metatibia length: 0.98 mm. First segment of metatarsus length: 0.40 mm. Mediotergite 1 length/width at posterior margin: 2.0 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.49/0.24/0.27/0.24 mm. Mediotergite 1 sculpture: Fully sculptured.



Figures 150–155. *Snellenius luisdiegogomezi* Fernández-Triana & Whitfield. **150** Habitus, lateral view **151** Fore wing **152** Metasoma, dorsal view **153** Metasoma, lateral view **154** Head and mesosoma (partially), dorsal view **155** Scutellar disc and propodeum, dorsal view.



Figures 156–162. *Snellenius mariakuzminae* Fernández-Triana & Whitfield. **156** Habitus, lateral view **157** Fore wing **158** Hind leg **159** Metasoma, lateral view **160** Propodeum and metasoma (partially), dorsal view **161** Head and mesosoma (partially), dorsal view **162** Scutellar disc and propodeum, dorsal view.



Figures 163–168. *Snellenius mariamartachavarriae* Fernández-Triana & Whitfield. **163** Habitus, lateral view **164** Fore wing **165** Head and mesosoma (partially), dorsal view **166** Antenna (male) **167** Hind leg **168** Propodeum and metasoma, dorsal view.

Female. Unknown.

Distribution. Costa Rica, ACG.

Host. Noctuidae: *Catephiodes trinidadensis*. Solitary parasitoid.

Molecular data. None.

Etymology. This species is named in honour of María Marta Chavarría in recognition of her contribution to understanding the plant biology of ACG.

Snellenius phildevriesi Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/2D4F837F-1457-46E3-907C-854297231E38
Figures 169–175, 228, 229

Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector Del Oro, Bosque Aguirre, 620m, 11.00060, -85.43800. ACG database code: DHJPAR0041580.

Paratypes. 3♀, 4♂ (BMNH, CNC, USNM, INBio, INHS). COSTA RICA, ACG, database codes: DHJPAR0005014, DHJPAR0040510, DHJPAR0040517, DHJPAR0041587, DHJPAR0041956, DHJPAR0045347.

Diagnosis. The combination of body color (yellow orange), metatibia (mostly or entirely dark red brown) and wings (with dark brown infumation, veins and pterostigma mostly brown), as well as hosts (Erebidae, *Gonodonta* spp) separates this species from all other ACG *Snellenius* except for *S. isidrochaconi*. No female specimens are known from *S. isidrochaconi* but males of both species are distinguishable by slight differences in size, interocellar area color, carination pattern in the propodeum, and the absence in *S. phildevriesi* of a rather acute projection on the posterior margin of the metascutellum. Additionally, the two species have over 4 % of base pair differences in the barcoding region, and the caterpillars that they parasitize, although belonging to the same genus (*Gonodonta*), feed on host plants in different families.

Description. Female. Scape color: Partially brown, partially yellow. Mesosoma color: Yellow orange. Metasoma color: Yellow orange. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, yellow. Femora color (pro-, meso-, metafemur): Yellow, yellow, yellow. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, anterior 0.8 reddish orange and posterior 0.2 dark brown to black. Metatibia spurs color: Brown. First segment of metatarsus color: Dark brown to black. Tegula and humeral complex color: Yellow, yellow. Wings: Infumated. Pterostigma color: Dark brown. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.8 mm. Fore wing length: 3.6–3.7 mm ($\overline{X}$ = 3.7 mm). Ocular-ocellar line/posterior ocellus diameter: 1.9 x. Interocellar distance/posterior ocellus diameter: 1.3–1.6 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.17/0.09/0.12–0.14 mm. Antennal flagellomere 2 length/width: 2.2–2.3 × (0.32–0.33/0.14–0.15 mm). Antennal flagellomere 14 length/width: 1.9–2.1 × (0.21–0.22/0.10–0.11 mm). Length of flagellomere 2/length of flagellomere 14: 1.4–1.6 x. Antenna in males: Flattened on central and apical segments. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One. Metafemur length/width: 3.7–4.1 × (0.95–0.98/0.24–0.26 mm). Metatibia length: 1.40 mm. First segment of metatarsus length: 0.45–0.50 mm. Mediotergite 1 length/width at posterior margin: 3.2–3.5 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.57–0.59/0.19–0.20/0.16–0.17/0.17–0.18 mm. Mediotergite 1 sculpture: Partially sculptured.

Male. Similar to female. The following morphological details are provided to allow for comparison against the morphologically similar *S. isidrochaconi* (see Comments below). Body length (head to apex of metasoma): 3.8 mm. Fore wing length: 3.6–3.7 mm ($\overline{X}$ = 3.7 mm). Metafemur length: 0.98–1.00 mm. Metatibia length: 1.30–1.40 mm. First segment of metatarsus length: 0.52–0.56 mm. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.57–0.58/0.21–0.22/0.17–0.20/0.17–0.19 mm.

Distribution. Costa Rica, ACG.

Host. Erebidae: three species of *Gonodonta* (feeding on *Piper* and Annonaceae), and *Hemeroblemma schausiana*DHJ02. Solitary parasitoid (Figs 228, 229).

Molecular data. Five haplotypes, 10 sequences (10 barcode-compliant) in BOLD.

Etymology. This species is named in honour of Phil deVries in recognition of his contribution to understanding the plant biology of ACG.

Comments. One male specimen was significantly much smaller than the rest (3.2 mm of body and fore wing lengths), and it was excluded from the description provided above.

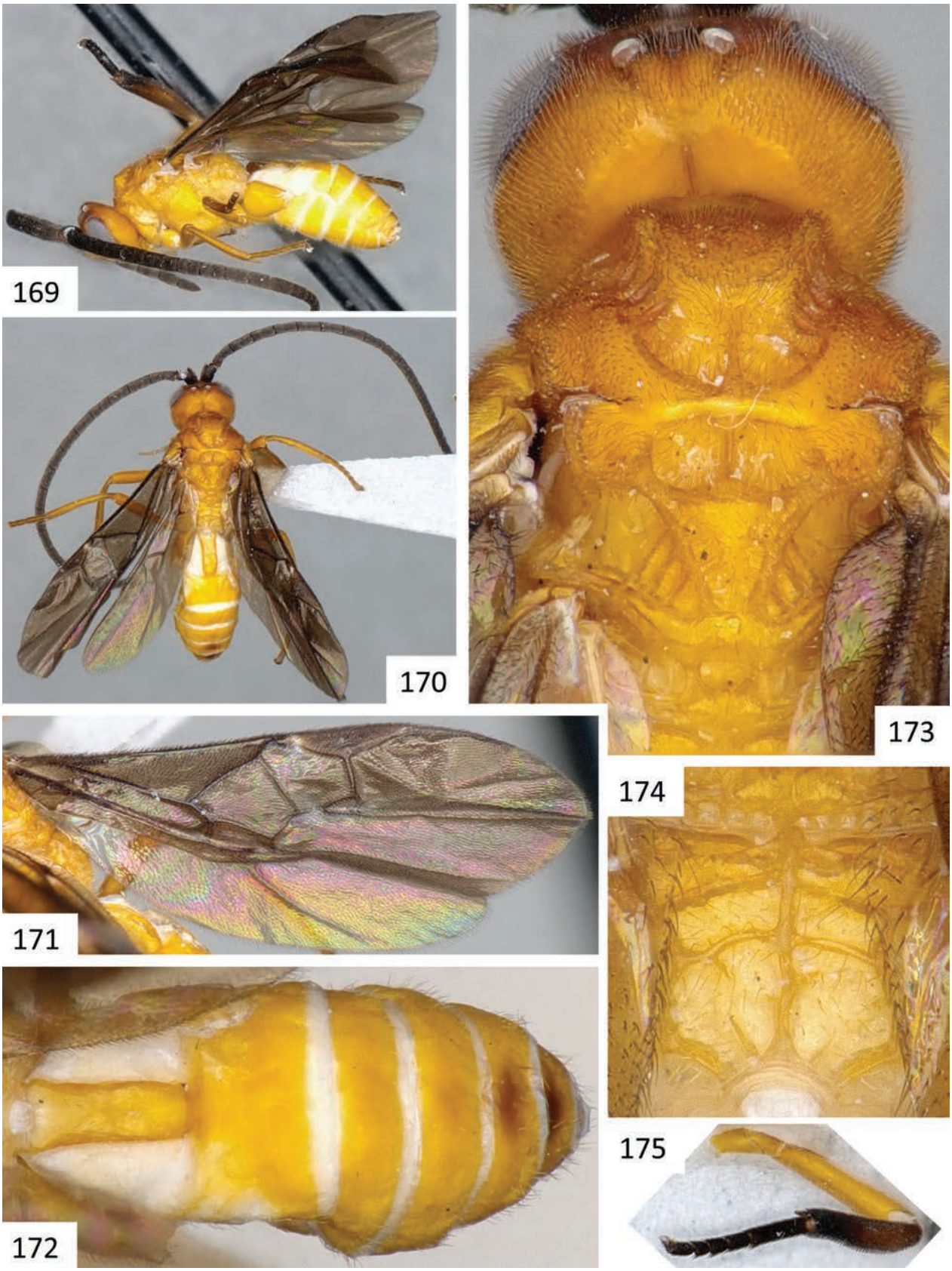
Snellenius quiricojimenezi Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/E3A50C2F-7983-46FE-8B19-60DFC45CC9D9
Figures 176–182

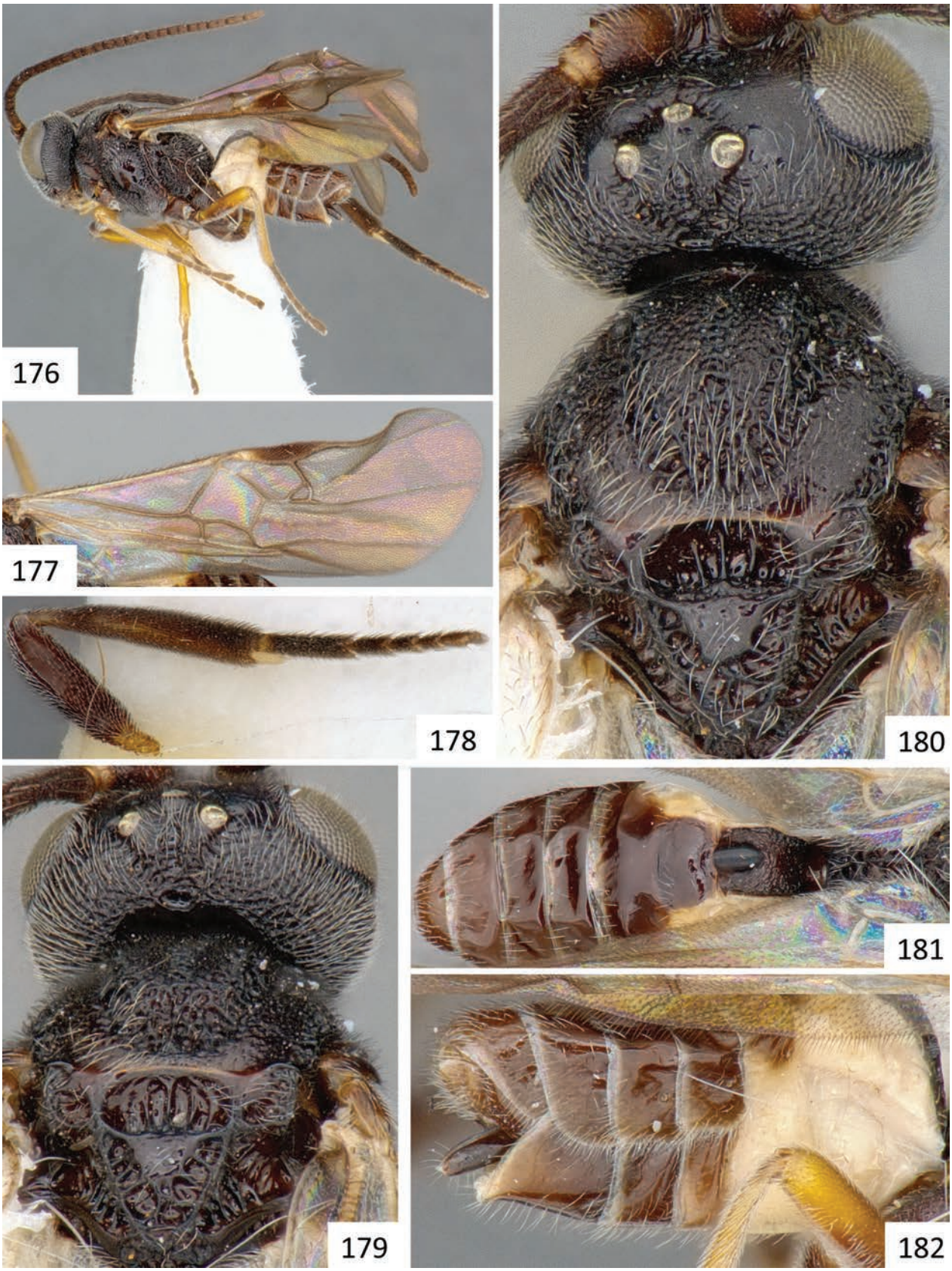
Holotype. ♀ in CNC. COSTA RICA: ACG, Guanacaste Province, Cerro El Hacha, NW Volcan Orosi, 300, 1988.

Paratypes. 4♀, 11♂ (BMNH, CNC, USNM, INBio, INHS). COSTA RICA, from the following localities (provinces): ACG, Santa Rosa Headquarters, Cerro El Hacha, and Hacienda El Vieja (Guanacaste), Chiles de Aqua (Alajuela), Rincon, Golfo Dulce (Puntarenas), La Selva (Heredia), Turrialba (Cartago), and San Jose.

Diagnosis. This species is characterized by T1 length 2.6 × or less its width at posterior margin, fore wing veins 1RS and (RS+M)a light yellow (clearly much lighter



Figures 169–175. *Snellenius phildevriesi* Fernández-Triana & Whitfield. **169** Habitus, lateral view **170** Habitus, dorsal view **171** Wings **172** Metasoma, dorsal view **173** Head and mesosoma (partially), dorsal view **174** Propodeum, dorsal view **175** Hind leg.



Figures 176–182. *Snellenius quiricojimenezi* Fernández-Triana & Whitfield. **176** Habitus, lateral view **177** Fore wing **178** Hind leg. **179, 180** Head and mesosoma (partially), dorsal view, images taken under slightly different angles **181** Metasoma, dorsal view **182** Metasoma, lateral view.

than most of surrounding veins), body color dark reddish brown, ocellar area strongly raised (bounded by strong and coarse punctures), and smooth occiput delimited from coarsely sculptured vertex and gena by a keel resembling a carina. The only ACG *Snellenius* that might be confused with *S. quiricojimenezi* is *S. robertoespinozai*, but the latter has a relatively longer and wider T1, pterostigma entirely brown (pterostigma brown with pale spot at base in *S. quiricojimenezi*), and scutoscutellar sulcus with one carina (scutoscutellar sulcus with three to five carinae in *S. quiricojimenezi*).

Description. Female. Scape color: Brown to dark brown. Mesosoma color: Dark reddish brown. Metasoma color: Dark reddish brown. Coxae color (pro-, meso-, metacoxa): Yellow brown, brown, brown. Femora color (pro-, meso-, metafemur): Yellow, partially yellow and partially brown, brown. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, brown. Metatibia spurs color: Yellow. First segment of metatarsus color: Dark brown. Tegula and humeral complex color: Brown, brown. Wings: Hyaline. Pterostigma color: Brown with pale spot at base. Fore wing veins 1RS and (RS+M)a: Entirely or partially transparent or light yellow (clearly much lighter than most of surrounding veins). Body length (head to apex of metasoma): 2.9–3.1 mm ($\bar{X}$ = 3.0 mm). Fore wing length: 2.9–3.1 mm ($\bar{X}$ = 3.0 mm). Ocular-ocellar line/posterior ocellus diameter: 2.1–2.3 x. Interocellar distance/posterior ocellus diameter: 2.0 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.15/0.07/0.13–0.14 mm. Antennal flagellomere 2 length/width: 3.3–3.5 × (0.28/0.08 mm). Antennal flagellomere 14 length/width: 2.1–2.4 × (0.17/0.07–0.08 mm). Length of flagellomere 2/length of flagellomere 14: 1.6 x. Antenna in males: Of normal appearance, not flattened. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly raised and less sculptured. Number of carinae in scutoscutellar sulcus: Three to five (some incomplete laterally). Metafemur length/width: 4.2–4.3 × (0.85–0.87/0.20 mm). Metatibia length: 1.16–1.20 mm. First segment of metatarsus length: 0.45–0.47 mm. Mediotergite 1 length/width at posterior margin: 2.6 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.48–0.51/0.18–0.20/0.21–0.23/0.19–0.20 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. As female except for wings mostly infumated.

Distribution. Costa Rica.

Host. Unknown.

Molecular data. None.

Etymology. This species is named in honour of Quirico Jiménez in recognition of his contribution to understanding the plant biology of ACG.

Comments. The apparent sexual dimorphism observed (females with hyaline wings, males with infumated wings, specimens from the same locality) is unique among all species of *Snellenius* and *Microplitis* studied in this paper.

Snellenius robertoespinozai Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/73597BFB-0527-4CA9-83C7-D2A42D819C8D
Figures 183–188

Holotype. ♂ in CNC. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Argelia, 5m, 10.78004, -85.66405. ACG database code: 94-SRNP-1817.

Diagnosis. This species is characterized by T1 length 2.6 × its width at posterior margin, fore wing veins 1RS and (RS+M)a light yellow (clearly much lighter than most of surrounding veins), body color reddish brown, ocellar area strongly raised (bounded by strong and coarse punctures), and smooth occiput delimited from coarsely sculptured vertex and gena by a keel resembling a carina. The only ACG *Snellenius* that might be confused with *S. robertoespinozai* is *S. quiricojimenezi*, but the latter has a relatively shorter and narrower T1, pterostigma brown with pale spot at base (pterostigma brown in *S. robertoespinozai*), and scutoscutellar sulcus with three to five carinae (scutoscutellar sulcus with one carina in *S. robertoespinozai*).

Description. Male. Scape color: Light brown. Mesosoma color: Reddish brown. Metasoma color: Reddish brown. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, reddish yellow. Femora color (pro-, meso-, metafemur): Yellow, yellow, light reddish yellow. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, reddish brown. Metatibia spurs color: White yellow. First segment of metatarsus color: Brown. Tegula and humeral complex color: Brown, brown. Wings: Hyaline. Pterostigma color: Brown. Fore wing veins 1RS and (RS+M)a: Entirely or partially transparent or light yellow (clearly much lighter than most of surrounding veins). Body length (head to apex of metasoma): 3.6 mm. Fore wing length: 3.4 mm. Ocular-ocellar line/posterior ocellus diameter: 1.6 x. Interocellar distance/posterior ocellus diameter: 1.7 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.14/0.09/0.15 mm. Antenna in males: Strongly flattened (but posterior half of antenna missing). Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly raised and less sculptured. Number of carinae in scutoscutellar sulcus: One. Metafemur length/width: 3.7 × (1.00/0.27 mm). Metatibia length: 1.24 mm. First segment of metatarsus length: 0.47 mm. Mediotergite 1 length/width at posterior margin: 2.6 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.66/0.30/0.34/0.25 mm. Mediotergite 1 sculpture: Fully sculptured.

Female. Unknown.

Distribution. Costa Rica, ACG.

Host. Noctuidae: *Melipotis cellaris*. Solitary parasitoid.

Molecular data. None.

Etymology. This species is named in honour of Roberto Espinoza in recognition of his contribution to understanding the plant biology of ACG.

Snellenius sandyknappae Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/04C5EDAC-BDF0-4C7F-B260-4CAD89A5137C
Figures 189–195, 224, 225

Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector Pitilla, Pasmompa, 440m, 11.01926, -85.40997. ACG database code: DHJPAR0020763.

Paratypes. 11♀, 6♂ (BMNH, CNC, USNM, INBio, INHS). COSTA RICA, ACG, database codes: DHJPAR0020493, DHJPAR0020585, DHJPAR0020586, DHJPAR0020587, DHJPAR0020588, DHJPAR0020589, DHJPAR0020759, DHJPAR0020760, DHJPAR0020761, DHJPAR0020762, DHJPAR0020764, DHJPAR0020766, DHJPAR0020767, DHJPAR0020768, DHJPAR0020769, DHJPAR0030871, 07-SNRP-33753.

Diagnosis. The unique combination of wings slightly infumated, body mostly black (at the lightest dark brown), tegula clearly lighter in color than darker humeral complex, all coxae dark brown to black, metatibial spurs yellow white, and host (*Helia argentipes*) separate this species from all other ACG *Snellenius*.

Description. Female. Scape color: Dark brown to black. Mesosoma color: Black. Metasoma color: Dark brown to black. Coxae color (pro-, meso-, metacoxa): Brown, black, black. Femora color (pro-, meso-, metafemur): Yellow brown, brown, black. Tibiae color (pro-, meso-, metatibia): Yellow brown, brown, black (except for anterior 0.1–0.2 white). Metatibia spurs color: Yellowish white. First segment of metatarsus color: Dark brown to black. Tegula and humeral complex color: Brown, dark brown. Wings: Slightly infumated. Pterostigma color: Brown. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.2–3.4 mm. Fore wing length: 2.8–3.1 mm. Ocular-ocellar line/posterior ocellus diameter: 2.3–2.4 x. Interocellar distance/posterior ocellus diameter: 2.0–2.1 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.16–0.17/0.07/0.14–0.15 mm. Antennal flagellomere 2 length/width: 3.1–3.2 × (0.28–0.29/0.09 mm). Antennal flagellomere 14 length/width: 2.2–2.3 × (0.19–0.20/0.08–0.09 mm). Length of flagellomere 2/length of flagellomere 14: 1.4–1.5 x. Antenna in males: Strongly flattened. Epicnemial carina: Present. Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One. Metafemur length/width: 3.7–3.8 × (0.90–0.93/0.24–0.25 mm). Metatibia length: 1.20 mm (1.18–1.22 mm). First segment of metatarsus length: 0.44–0.45 mm. Mediotergite 1 length/width at posterior margin: 1.8 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.46–0.47/0.25–0.26/0.24/0.25–0.26 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. As female but T2 yellow or light brown.

Distribution. Costa Rica, ACG.

Host. Erebidae, *Helia argentipes.* Solitary parasitoid (Figs 224, 225).

Molecular data. One haplotype, 18 sequences (18 barcode-compliant) in BOLD.

Etymology. This species is named in honour of Sandy Knapp in recognition of her contribution to understanding the plant biology of ACG.

Snellenius velvaruddae Fernández-Triana & Whitfield, sp. n.

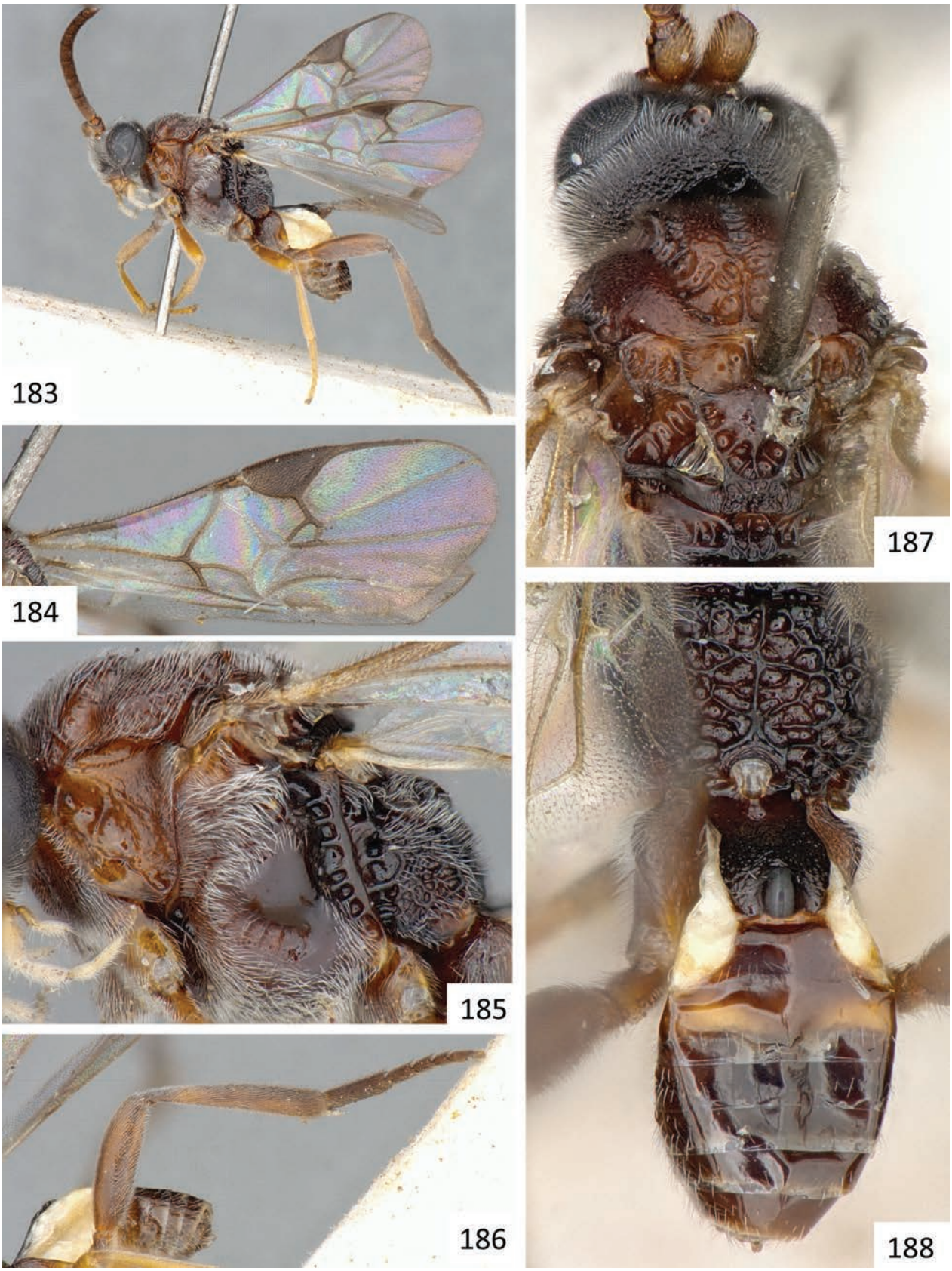
http://zoobank.org/2DE877BC-E0F0-4460-B051-512982E87D63
Figures 196–202

Holotype. ♀ in CNC. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Bosque San Emilio, 300m, 10.84389, -85.61384. ACG database code: DHJPAR0013342.

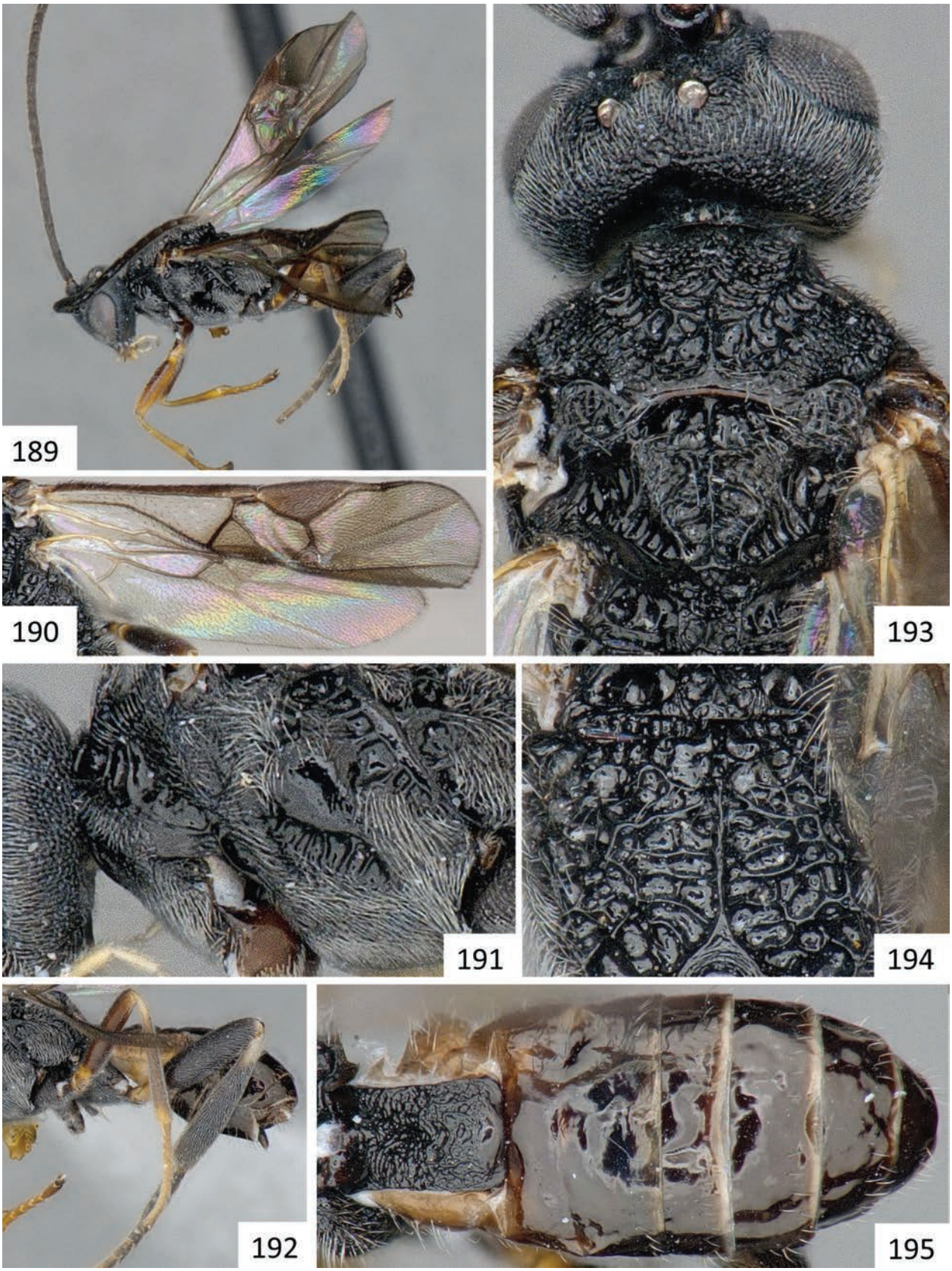
Paratype.♀ (CNC). COSTA RICA, ACG, database code: DHJPAR0013338.

Diagnosis. The combination of metasoma color (T1–T2 orange yellow, T3 yellow, T4 light brown, T5+ brown), metatibia spurs orange brown, fore wing hyaline, and T1 length at least 2.3 × its width at posterior margin separate this species from all other ACG *Snellenius*.

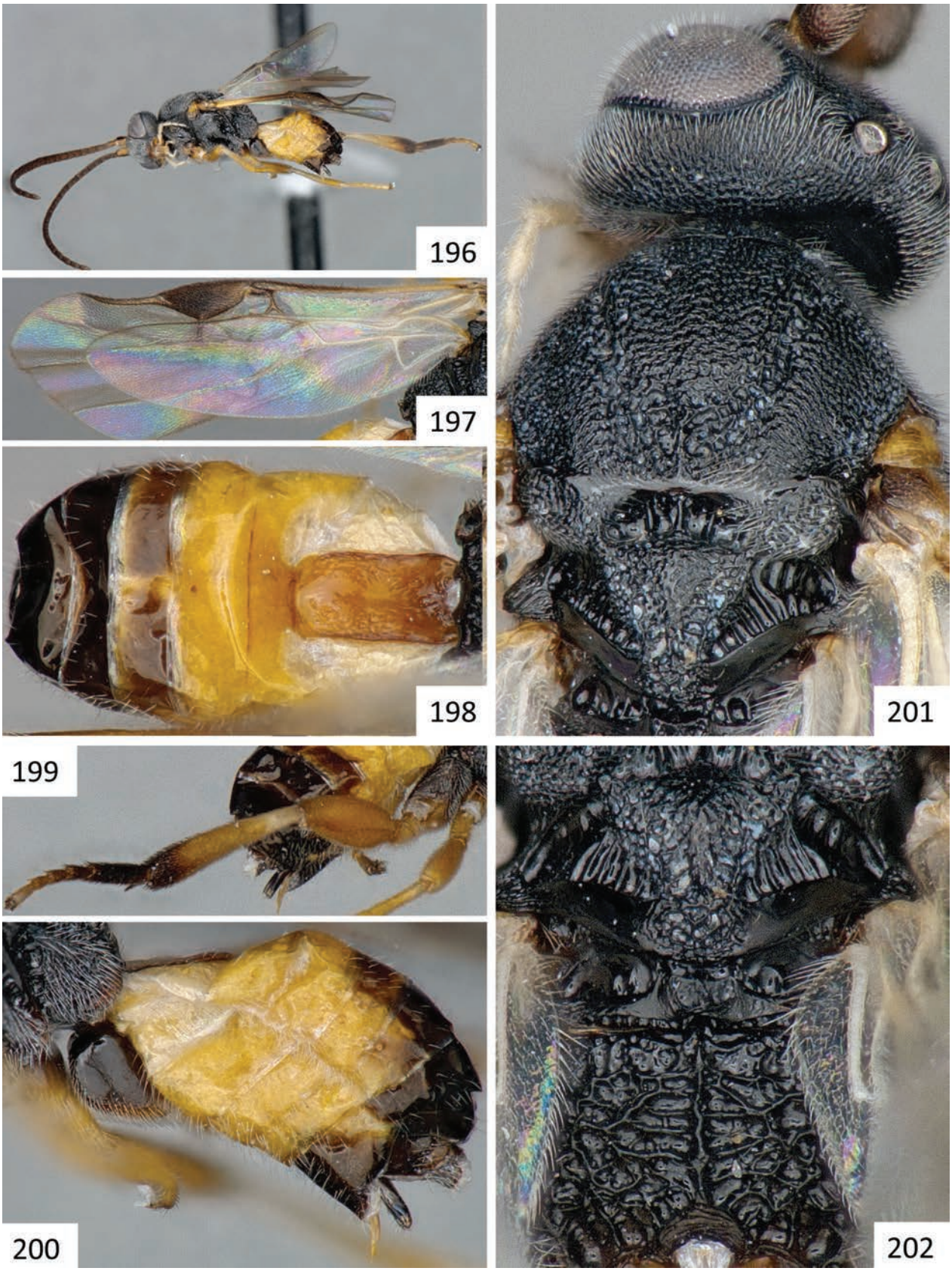
Description. Female. Scape color: Half yellow, half brown. Mesosoma color: Black. Metasoma color: T1–T2 orange yellow, T3 yellow, T4 light brown, T5+ brown. Coxae color (pro-, meso-, metacoxa): Yellow, light brown, brown. Femora color (pro-, meso-, metafemur): Orange yellow, orange yellow to light brown, brown. Tibiae color (pro-, meso-, metatibia): Orange yellow, orange yellow, mostly orange yellow (but with anterior 0.2 yellow white and posterior 0.2 brown). Metatibia spurs color: Orange brown. First segment of metatarsus color: Brown. Tegula and humeral complex color: Yellow, half yellow and half brown. Wings: Hyaline. Pterostigma color: Brown. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 3.2–3.3 mm. Fore wing length: 2.9–3.0 mm. Ocular-ocellar line/posterior ocellus diameter: 1.9 x. Interocellar distance/posterior ocellus diameter: 1.7 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.17–0.18/0.08–0.09/0.15 mm. Antennal flagellomere 2 length/width: 2.6–2.8 × (0.25–0.26/0.09–0.10 mm). Antennal flagellomere 14 length/



Figures 183–188. *Snellenius robertoespinozai* Fernández-Triana & Whitfield. **183** Habitus, lateral view **184** Fore wing **185** Mesosoma, lateral view **186** Hind leg and metasoma (partially), lateral view **187** Head and mesosoma (partially), dorsal view **188** Propodeum and metasoma, dorsal view.



Figures 189–195. *Snellenius sandyknappae* Fernández-Triana & Whitfield. **189** Habitus, lateral view **190** Wings **191** Head and mesosoma (partially), lateral view **192** Hind leg and metasoma (partially), lateral view **193** Head and mesosoma (partially), dorsal view **194** Propodeum, dorsal view **195** Metasoma, dorsal view.



Figures 196–202. *Snellenius velvaruddae* Fernández-Triana & Whitfield. **196** Habitus, lateral view **197** Wings **198** Metasoma, dorsal view **199** Hind leg and metasoma (partially), lateral view **200** Metapleuron and metasoma, lateral view **201** Head and mesosoma (partially), dorsal view **202** Scutellar disc and propodeum, dorsal view.

width: 2.1–2.3 × (0.17/0.07–0.08 mm). Length of flagellomere 2/length of flagellomere 14: 1.5 x. Epicnemial carina: Present. Anteromesoscutum: With relatively shallower and sparser sculpture, central area not appearing elevated compared to lateral areas of anteromesoscutum, notauli slightly to strongly excavated. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One centrally, with four other smaller and partially defined carinae. Metafemur length/width: 3.2–3.4 × (0.86–0.87/0.25–0.27 mm). Metatibia length: 1.07 mm (1.05–1.10 mm). First segment of metatarsus length: 0.42 mm (0.41–0.43 mm). Mediotergite 1 length/width at posterior margin: 2.3–2.4 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.52–0.54/0.26–0.27/0.25–0.26/0.22–0.24 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. Unknown.

Host. Unknown.

Molecular data. One haplotype, two sequences (two barcode-compliant) in BOLD.

Etymology. This species is named in honour of in recognition of Velva Rudd in recognition of her contribution to understanding the plant biology of ACG.

Snellenius vickifunkae Fernández-Triana & Whitfield, sp. n.

http://zoobank.org/248221A4-E63A-426F-A757-474D20808749
Figures 203–208

Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Bosque Humedo, 290m, 10.85145, -85.60801. ACG database code: DHJPAR0024695.

Paratypes. 1♀ (CNC) COSTA RICA, ACG, database code: DHJPAR0013327; 1♀ (CNC) Costa Rica: San Jose, Ciudad Colon, 800m, xii.1989-i.1990, L. Fournier.

Diagnosis. The combination of body color (mesosoma dark brown to black, metasoma with T1 reddish brown with posterior 0.1 orange brown, T2-T3 yellow, rest of metasoma dark brown), anterior 0.6 of metatibia light yellow, and fore wing veins 1RS and (RS+M)a transparent or light yellow (clearly much lighter than most of surrounding veins) separate this species from all other ACG *Snellenius*.

Description. Female. Scape color: Dark brown. Mesosoma color: Dark brown to black. Metasoma color: T1 reddish brown with posterior 0.1 orange brown, T2-T3 yellow, rest of metasoma dark brown. Coxae color (pro-, meso-, metacoxa): Brown, brown, dark brown (holotype) or yellow, yellow, dark brown (paratype). Femora color (pro-, meso-, metafemur): Yellow, yellow (but partially brown), dark brown. Tibiae color (pro-, meso-, metatibia): Orange yellow, orange yellow, anterior 0.6 light yellow and posterior 0.4 dark brown. Metatibia spurs color: Yellow. First segment of metatarsus color: Dark brown. Tegula and humeral complex color: Dark brown, dark brown (holotype) or dark brown, yellow (paratype). Wings: Hyaline. Pterostigma color: Brown with small pale spot at base. Fore wing veins 1RS and (RS+M)a: Entirely or partially transparent or light yellow (clearly much lighter than most of surrounding veins). Body length (head to apex of metasoma): 2.5–2.6 mm. Fore wing length: 2.2–2.3 mm. Ocular-ocellar line/posterior ocellus diameter: 2.1–2.2 x. Interocellar distance/posterior ocellus diameter: 1.8–2.0 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.13–0.14/0.06/0.11–0.13 mm. Antennal flagellomere 2 length/width: 2.7–3.0 × (0.21/0.07–0.08 mm). Antennal flagellomere 14 length/width: 2.5 × (0.15/0.06 mm). Length of flagellomere 2/length of flagellomere 14: 1.4 x. Epicnemial carina: Present. Anteromesoscutum: With relatively shallower and sparser sculpture, central area not appearing elevated compared to lateral areas of anteromesoscutum, notauli slightly to strongly excavated. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly raised and less sculptured. Number of carinae in scutoscutellar sulcus: Four to five. Metafemur length/width: 4.0–4.1 × (0.70–0.72/0.17–0.18 mm). Metatibia length: 0.93–1.00 mm. First segment of metatarsus length: 0.39–0.40 mm. Mediotergite 1 length/width at posterior margin: 2.7–2.8 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.36–0.40/0.18–0.20/0.19–0.22/0.13–0.15 mm. Mediotergite 1 sculpture: Mostly sculptured.

Male. Unknown.

Distribution. Costa Rica.

Host. Unknown.

Molecular data. Two haplotypes, two sequences (two barcode-compliant) in BOLD.

Comments. One of the paratypes (DHJPAR0013327), which is in bad condition, has a brown metafemur. However, the holotype, which is in good condition, has a black metafemur.

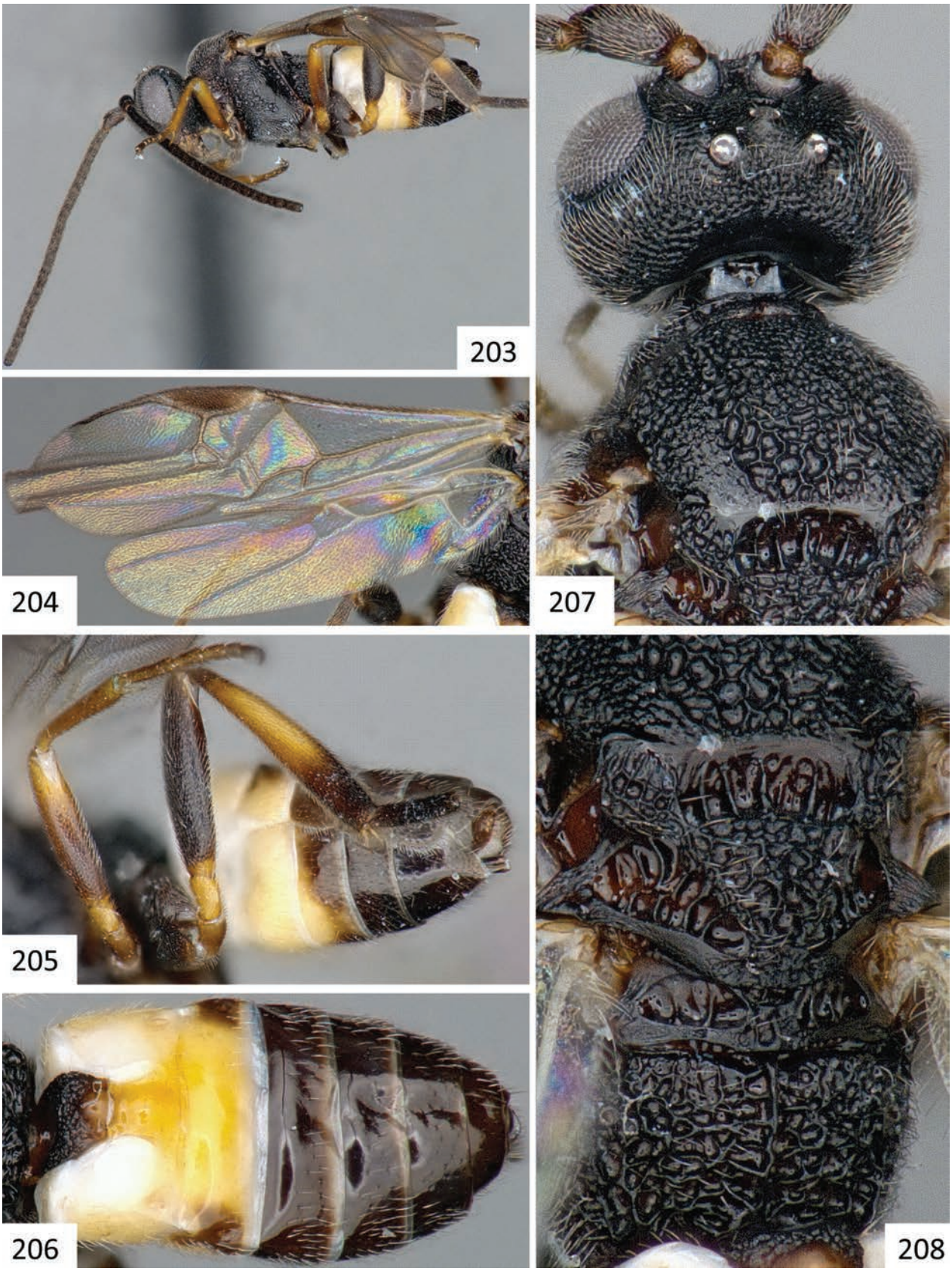
Etymology. This species is named in honour of Vicki Funk in recognition of her contribution to understanding the plant biology of ACG.

Snellenius warrenwagneri Fernández-Triana & Whitfield, sp. n.

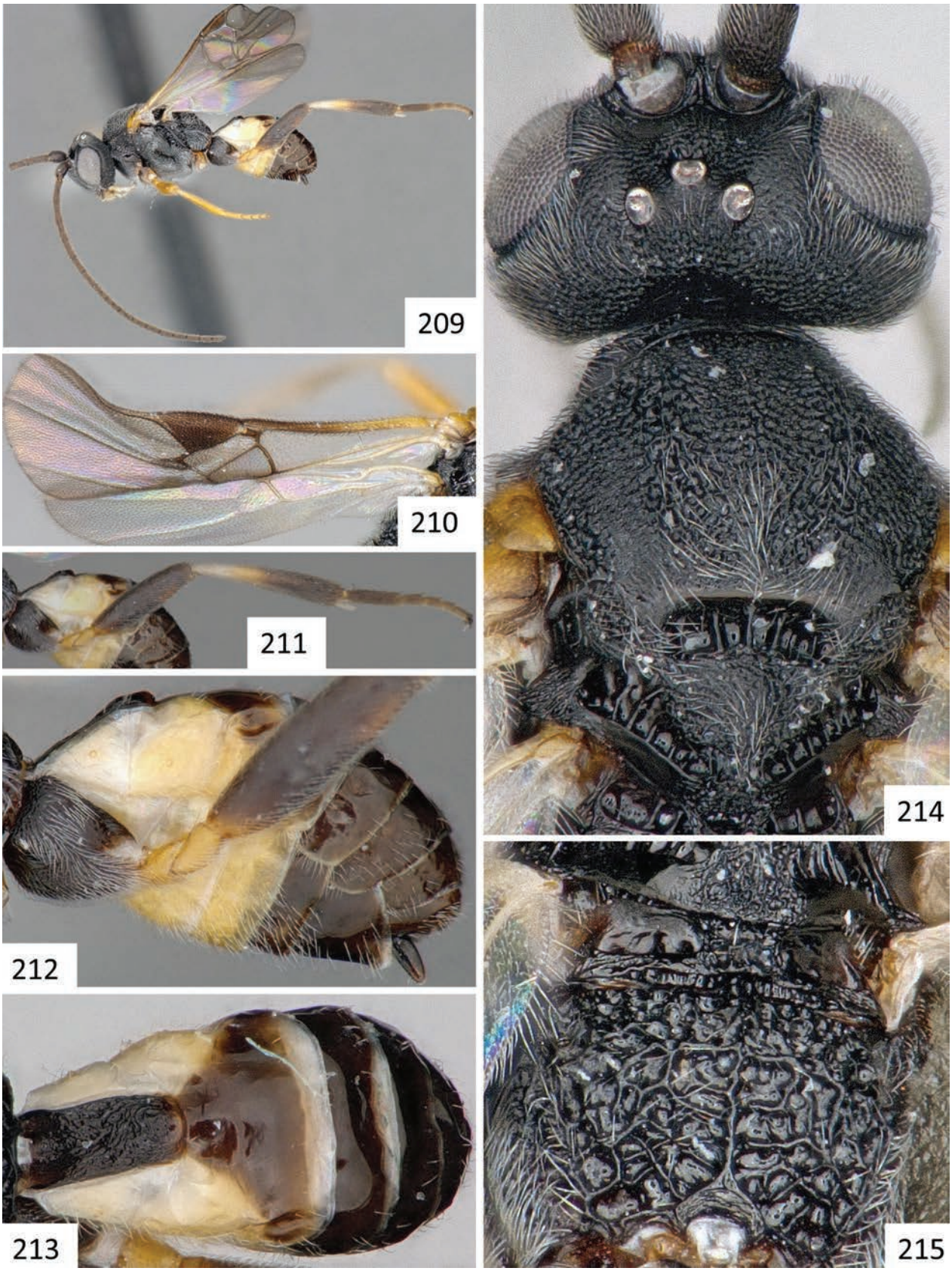
http://zoobank.org/B6D76719-7AB6-4609-9041-F736534A6F6A
Figures 209–215

Holotype. ♀ in USNM. COSTA RICA: ACG, Guanacaste Province, Sector Santa Rosa, Bosque San Emilio, 300m, 10.84389, -85.61384. ACG database code: DHJPAR0013328.

Paratypes. 5♀, 5♂ (BMNH, CNC, USNM, INBio, INHS). COSTA RICA, ACG, database codes: DHJPAR0012601, DHJPAR0013317, DHJPAR0013329, DHJPAR0013331, DHJPAR0013333, DHJPAR0013334, DHJPAR0013335, DHJPAR0013337, DHJPAR0024712, DHJPAR0024713.

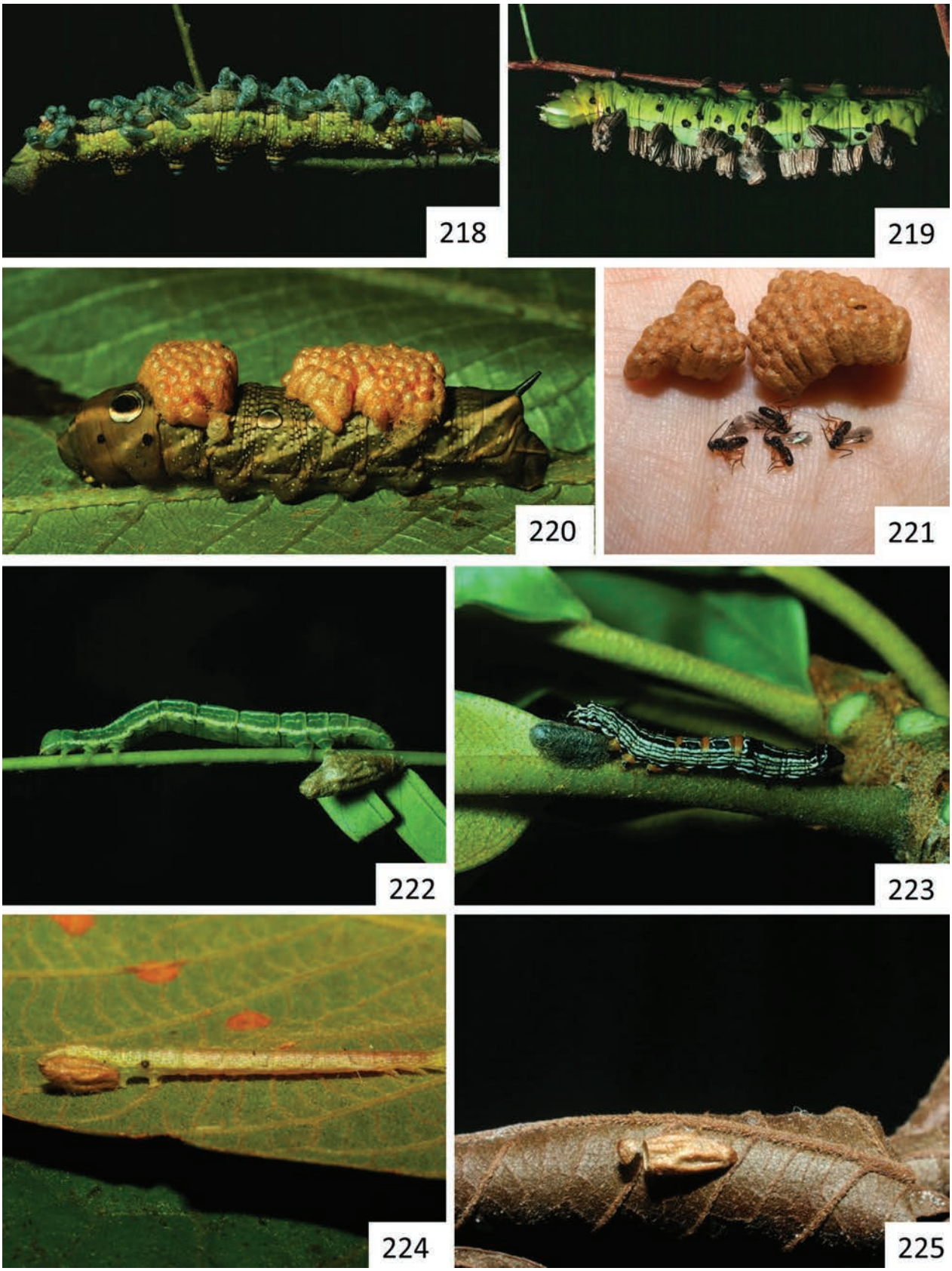


Figures 203–208. *Snellenius vickifunkae* Fernández-Triana & Whitfield. **203** Habitus, lateral view **204** Wings **205** Middle and hind legs and metasoma (partially), lateral view **206** Metasoma, dorsal view **207** Head and mesosoma (partially), dorsal view **208** Scutellar disc and propodeum, dorsal view.



Figures 209–215. *Snellenius warrenwagneri* Fernández-Triana & Whitfield. **209** Habitus, lateral view **210** Wings **211** Hind leg and metasoma (partially), lateral view **212** Metasoma, lateral view **213** Metasoma, dorsal view **214** Head and mesosoma (partially), dorsal view **215** Propodeum, dorsal view.

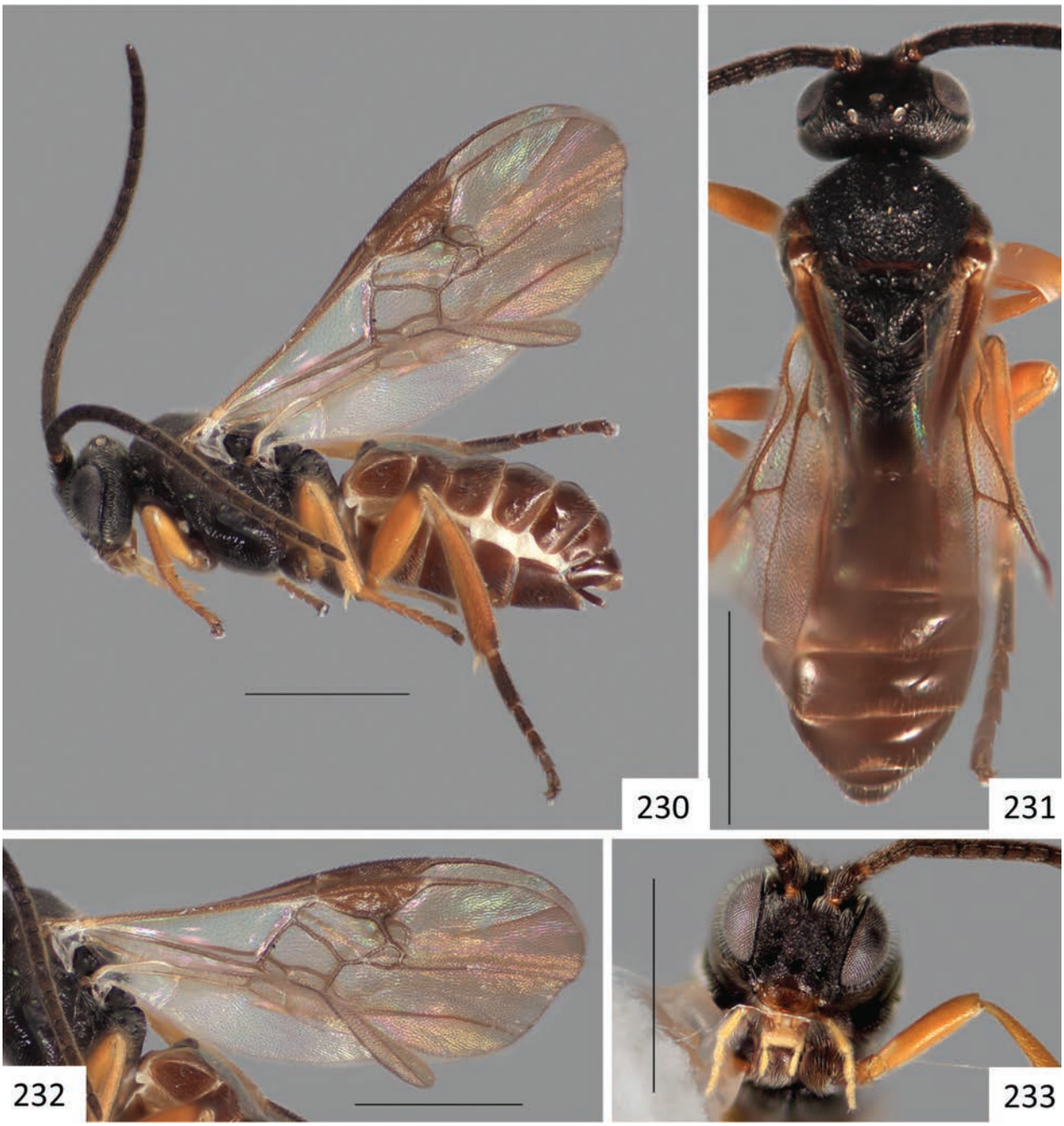
Figures 216–229. Host parasitized larvae and cocoons of *Microplitis* and *Snellenius* species of Area de Conservación de Guanacaste, Costa Rica. **216** *Microplitis espinachi* Walker **217** *Microplitis francopupulini* Fernández-Triana & Whitfield.



Figures 218–225. 218–219 *Microplitis figueresi* Walker, 2003 **220–221** *Microplitis marini* Whitfield, 2003 **222** *Snellenius felipechavarriai* Fernández-Triana & Whitfield **223** *Snellenius kerrydresslerae* Fernández-Triana & Whitfield **224–225** *Snellenius sandyknappae* Fernández-Triana & Whitfield

Figures 226–227. 226 *Snellenius bobdressleri* Fernández-Triana & Whitfield **227** *Snellenius isidrochaconi* Fernández-Triana & Whitfield.

Figures 228–229. *Snellenius phildevriesi* Fernández-Triana & Whitfield.



Figures 230–233. *Microplitis marini* Whitfield, 2003, female holotype; all scale bars are 1 mm. **230** Habitus, lateral view **231** Habitus, dorsal view **232** Wings **233** Head, frontal view.

Diagnosis. The combination of T1 length at least 3.0 × its width at posterior margin, body mostly dark reddish brown to brown, metatibia dark brown on posterior 0.8, and metatibial spurs yellow white separates this species from all other ACG *Snellenius*, except for *S. gerardoherrerai*. It is distinguishable from the latter species by having scape dark brown, tegula and humeral complex yellow, and relatively longer flagellomeres (flagellomere 2 3.0–3.2 × as long as wide, flagellomere 14 2.5–2.7 × as long as wide).

Description. Female. Scape color: Dark brown to black. Mesosoma color: Black. Metasoma color: Dark brown. Coxae color (pro-, meso-, metacoxa): Yellow, yellow, reddish brown. Femora color (pro-, meso-, metafemur): Yellow, orange brown, dark reddish brown. Tibiae color (pro-, meso-, metatibia): Yellow, yellow, yellow white on anterior 0.4 and dark brown on posterior 0.6. Metatibia spurs color: White. First segment of metatarsus color: Dark brown. Tegula and humeral complex color: Yellow, yellow (rarely yellow, partially yellow and partially brown). Wings: Hyaline. Pterostigma color: Brown with small pale spot at base. Fore wing veins 1RS and (RS+M)a: Brown (same color as surrounding veins). Body length (head to apex of metasoma): 2.9–3.2 mm ($\bar{X}$ = 3.0 mm). Fore wing length: 2.5–2.7 mm ($\bar{X}$ = 2.6 mm). Ocular-ocellar

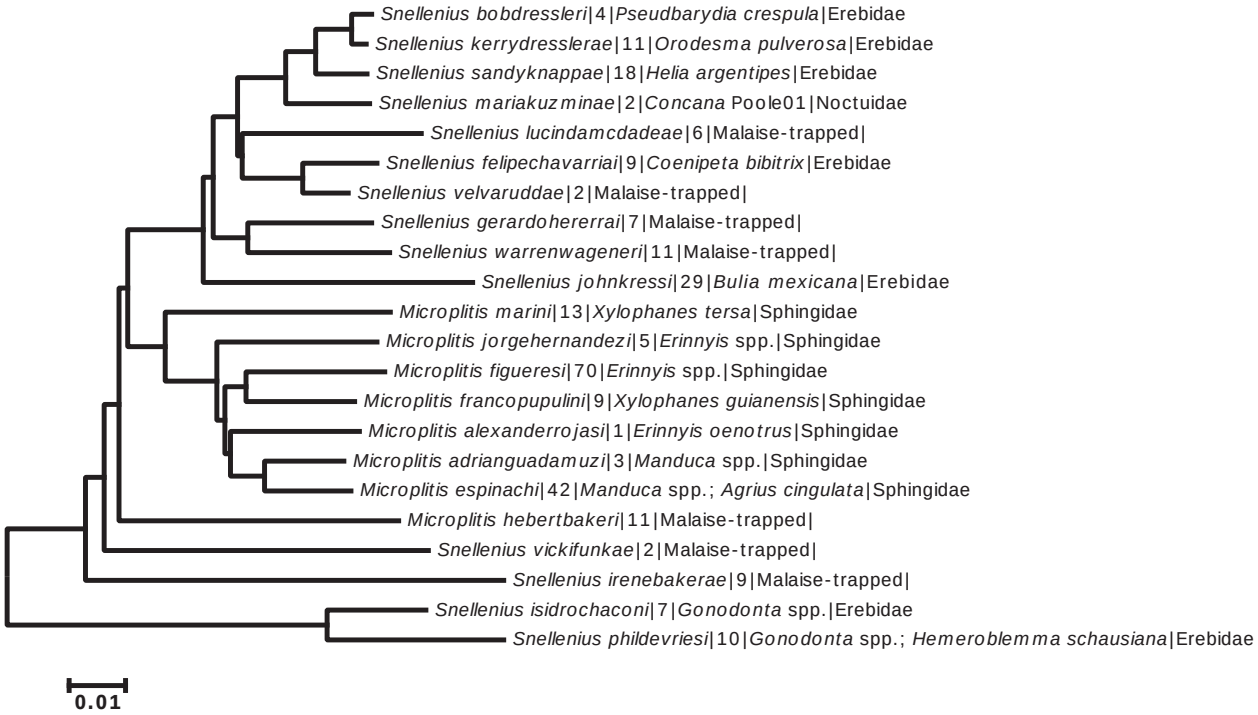


Figure 234. Interspecific variation of DNA barcodes among species of ACG *Microplitis* and *Snellenius* displayed using the Neighbor-Joining method (Saitou and Nei 1987) with distances computed using the Kimura 2-parameter method (Kimura 1980) conducted in MEGA6 (Tamura et al 2013). When there was more than one sequence available for each species, the representative sequence was selected based on quality (longest read length with the fewest ambiguities). Tip labels are the species name|number of barcoded specimens in the ACG database at the time of writing |host species|host family.

line/posterior ocellus diameter: 1.9–2.0 x. Interocellar distance/posterior ocellus diameter: 1.7–1.8 x. Ocular-ocellar line/posterior ocellus diameter/interocellar distance: 0.14–0.15/0.07–0.08/0.12–0.14 mm. Antennal flagellomere 2 length/width: 3.0–3.1 × (0.24–0.25/0.08 mm). Antennal flagellomere 14 length/width: 2.2–2.7 × (0.15–0.16/0.06–0.07). Length of flagellomere 2/length of flagellomere 14: 1.5–1.7 x. Antenna in males: Of normal appearance, not flattened. Epicnemial carina: Present (partially visible). Anteromesoscutum: With strong, coarse sculpture, central area appearing elevated compared to lateral areas of anteromesoscutum, notauli wide and deeply excavated, with numerous crenulae. Scutellar disc sculpture: With deeper sculpture near margins, central part appearing slightly elevated and less sculptured. Number of carinae in scutoscutellar sulcus: One complete and up to four incomplete. Metafemur length/width: 3.6–3.8 × (0.80/0.21–0.22 mm). Metatibia length: 1.05–1.08 mm. First segment of metatarsus length: 0.38–0.40 mm. Mediotergite 1 length/width at posterior margin: 2.5–2.7 x. Mediotergite 1 length/width at anterior margin/maximum width/width at posterior margin: 0.43–0.46/0.20/0.19–0.20/0.17 mm. Mediotergite 1 sculpture: Fully sculptured.

Male. As in female but with lighter coloration on metafemur.

Distribution. Costa Rica, ACG.

Host. Unknown.

Molecular data. Four haplotypes, 10 sequences (10 barcode-compliant) in BOLD.

Etymology. This species is named in honour of Warren Wagner in recognition of his contribution to understanding the plant biology of ACG.

Acknowledgements

We emphatically and gratefully acknowledge the support of the ACG parataxonomist team (Janzen et al. 2009, Janzen and Hallwachs 2011) in finding and rearing these caterpillars, their parasites and their hyperparasites, and Area de Conservacion Guanacaste (ACG) for preserving the forests in which they live, and the Guanacaste Dry Forest Conservation Fund, the Wege Foundation, the International Conservation Fund of Canada, the JRS Biodiversity Foundation, Jessie Hill, Steve Stroud, Permian Global, and the University of Pennsylvania for funding portions of the research. This study was also supported by NSF DEB 0515699 to DHJ and by a Natural Sciences and Engineering Research Council of Canada (NSERC) Discovery Grant to MAS. Laboratory analyses of these sequences were funded by the Government of Canada through Genome Canada and the Ontario Genomics Institute (2008-0GI-ICI-03). JBW would like to acknowledge the USDA NRI program for support from two grants, awarded in 2000 and 2003, which supported earlier work

on some of the species in this study. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the USDA. USDA is an equal opportunity provider and employer.

References

Austin AD, Dangerfield PC (1992) Synopsis of Australasian Microgastrinae (Hymenoptera: Braconidae), with a key to genera and description of new taxa. Invertebrate Taxonomy 6(1): 1–76. doi: 10.1071/IT9920001

Austin AD, Dangerfield PC (1993) Systematics of Australian and New Guinean Microplitis Foerster and Snellenius Westwood (Hymenoptera: Braconidae: Microgastrinae), with a review of their biology and host relationships. Invertebrate Taxonomy 7(5): 1097–1166. doi: 10.1071/IT9931097

Fernández-Triana J, Whitfield JB, Rodriguez JJ, Smith MA, Janzen DH, Hallwachs W, Hajibabaei M, Burns JM, Solis MA, Brown J, Cardinal S, Goulet H, Hebert PDN (2014) Review of Apanteles (Hymenoptera: Braconidae, Microgastrinae) from Area de Conservación Guanacaste, northwestern Costa Rica, with keys to all described species from Mesoamerica. ZooKeys 383: 1–565. doi: 10.3897/zookeys.383.6418

Fleming A, Wood DM, Smith MA, Hallwachs W, Janzen D (2014) Revision of the New World species of Houghia Coquillett (Diptera, Tachinidae) reared from caterpillars in Area de Conservación Guanacaste, Costa Rica. Zootaxa 3858(1): 1–90. doi: 10.11646/zootaxa.3858.1.1

Hansson C, Smith MA, Janzen DH, Hallwachs W (2015) Integrative taxonomy of New World Euplectrus Westwood (Hymenoptera, Eulophidae), with focus on 55 new species from Area de Conservación Guanacaste, northwestern Costa Rica. ZooKeys 485: 1–236. doi: 10.3897/zookeys.485.9124

Hebert PDN, Cywinska A, Ball SL, deWaard JR (2003) Biological identifications through DNA barcodes. Proceedings of the Royal Society B 270: 313–321. doi: 10.1098/rspb.2002.2218

Huber JT, Sharkey MJ (1993) Structure. In: Goulet H, Huber JT (Eds) Hymenoptera of the world: an identification guide to families. Agriculture Canada Research Branch, Monograph No. 1894E, Ottawa, Canada, 13–59.

Ivanova NV, deWaard JR, Hebert PDN (2006) An inexpensive, automation-friendly protocol for recovering high-quality DNA. Molecular Ecology Notes 6: 998–1002. doi: 10.1111/j.1471-8286.2006.01428.x

Janzen DH, Walker AK, Whitfield JB, Delvare G, Gauld ID (2003) Host-specific and hyperparasitoids of three new Costa Rican species of Microplitis Foerster (Hymenoptera: Braconidae: Microgastrinae), parasitoids of sphingid caterpillars. Journal of Hymenoptera Research 12(1): 42–76.

Janzen DH, Hallwachs W, Blandin P, Burns JM, Cadiou J, Chacon I, Dapkey T, Deans AR, Epstein ME, Espinoza B, Franclemont JG, Haber WA, Hajibabaei M, Hall JPW, Hebert PDN, Gauld ID, Harvey DJ, Hausmann A, Kitching I, Lafontaine D, Landry J, Lemaire C, Miller JY, Miller JS, Miller L, Miller SE, Montero J, Munroe E, Rab Green S, Ratnasingham S, Rawlins JE, Robbins RK, Rodriguez JJ, Rougerie R, Sharkey MJ, Smith MA, Solis MA, Sullivan JB, Thiaucourt P, Wahl DB, Weller SJ, Whitfield JB, Willmott KR, Wood DM, Woodley NE, Wilson JJ (2009) Integration of DNA barcoding into an ongoing inventory of complex tropical biodiversity. Molecular Ecology Resources 9 (Supplement 1): 1–26. doi: 10.1111/j.1755-0998.2009.02628.x

Janzen DH, Hallwachs W (2011) Joining inventory by parataxonomists with DNA barcoding of a large complex tropical conserved wildland in northwestern Costa Rica. PLoS ONE 6(8): e18123. doi: 10.1371/journal.pone.0018123

Karlsson D, Ronquist F (2012) Skeletal morphology of Opius dissitus and Biosteres carbonarius (Hymenoptera: Braconidae), with a discussion of terminology. PLoS ONE 7(4): e32573. doi: 10.1371/journal.pone.0032573

Kimura M (1980) A simple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences. Journal of Molecular Evolution 16: 111–120. doi: 10.1007/BF01731581

Long K, van Achterberg K (2013) New records of the genus Snellenius Westwood, 1882 (Hymenoptera: Braconidae: Microgastrinae) from Vietnam, with description of two new species. TAP CHI SINH HOC 35(3): 272–280. doi: 10.15625/0866-7160/v35n3.3371

Luo Q, You L (2005) Descriptions of two new species of the genus Snellenius Westwood (Hymenoptera, Braconidae, Microgastrinae) from China. Acta Zootaxonomica Sinica 30(1): 170–174. [In Chinese with English summary]

Mason WRM (1981) The polyphyletic nature of Apanteles Foerster (Hymenoptera: Braconidae): A phylogeny and reclassification of Microgastrinae. Memoirs of the Entomological Society of Canada, Ottawa, Canada, 147 pp.

Nixon G (1965) A reclassification of the tribe Microgasterini (Hymenoptera: Braconidae). Bulletin of the British Museum (Natural History), Entomology series, Supplement 2: 1–284.

Ratnasingham S, Hebert PDN (2007) BOLD: The Barcode of Life Data System (www.barcodinglife.org). Molecular Ecology Notes 7: 355–364. doi: 10.1111/j.1471-8286.2007.01678.x

Saitou N, Nei M (1987) The neighbor-joining method: A new method for reconstructing phylogenetic trees. Molecular Biology and Evolution 4: 406–425.

Shaw MR, Huddleston T (1991) Classification and biology of Braconid wasps (Hymenoptera: Braconidae). Handbooks for the Identification of British Insects 7(11): 1–126.

Shenefelt RD (1968) Snellenius in the Neotropical Region. Proceedings of the Entomological Society of Washington 70(4): 339–345.

Smith MA, Woodley NE, Janzen DH, Hallwachs W, Hebert PDN (2006) DNA barcodes reveal cryptic host-specificity within the presumed polyphagous members of a genus of parasitoid flies (Diptera: Tachinidae). Proceedings of the National Academy of Sciences 103: 3657–3662. doi: 10.1073/pnas.0511318103

Smith MA, Wood DM, Janzen DH, Hallwachs W, Hebert PDN (2007) DNA barcodes affirm that 16 species of apparently generalist tropical parasitoid flies (Diptera, Tachinidae) are not all generalists. Proceedings of the National Academy of Sciences 104: 4967–4972. doi: 10.1073/pnas.0700050104

Smith MA, Rodriguez JJ, Whitfield JB, Deans AR, Janzen DH, Hallwachs W, Hebert PDN (2008) Extreme diversity of tropical parasitoid wasps exposed by iterative integration of natural history, DNA barcoding, morphology, and collections. Proceedings of the National Academy of Sciences 105: 12359–12364. doi: 10.1073/pnas.0805319105

Tamura K, Stecher G, Peterson D, Filipski A, Kumar S (2013) MEGA6: Molecular Evolutionary Genetics Analysis version 6.0. Molecular Biology and Evolution 30: 2725–2729. doi: 10.1093/molbev/mst197

Walker AK, Kitching IJ, Austin AD (1990) A reassessment of the phylogenetic relationships within the Microgastrinae (Hymenoptera: Braconidae). Cladistics 6: 291–306. doi: 10.1111/j.1096-0031.1990.tb00546.x

Whitfield JB (1995) Checklist of the Microgastrinae (Hymenoptera: Braconidae) in America north of Mexico. Journal of the Kansas Entomological Society 68: 245–262.

Whitfield JB (1997) Subfamily Microgastrinae. In: Wharton RA, Marsh PM, Sharkey MJ (Eds) Manual of the New World genera of the family Braconidae (Hymenoptera). Special Publication No. 1, International Society of Hymenopterists, Washington, D.C., 333–364.

Whitfield JB, Mardulyn P, Austin AD, Dowton M (2002) Phylogenetic relationships among microgastrine braconid wasp genera based on data from the 16S, COI and 28S genes and morphology. Systematic Entomology 27(3): 337–359. doi: 10.1046/j.1365-3113.2002.00183.x

Yu DSK, van Achterberg C, Horstmann K (2012) Taxapad 2012, Ichneumonoidea 2011. Database on flash-drive. www.taxapad.com, Ottawa, Ontario, Canada.

Supplementary material 1

Interspecific variation of DNA barcodes among species of ACG *Microplitis* and *Snellenius*

Authors: Jose L. Fernandez-Triana, James B. Whitfield, M. Alex Smith, Robert R. Kula, Winnie Hallwachs, Daniel H. Janzen

Data type: K2P tree based on DNA barcodes.

Explanation note: Interspecific variation of DNA barcodes among species of ACG *Microplitis* and *Snellenius* displayed using the Neighbor-Joining method (Saitou and Nei 1987) with distances computed using the Kimura 2-parameter method (Kimura 1980) conducted in BOLD (Ratnasingham and Hebert 2007). Tip labels are the species name|sample accession|sequence length and number of ambiguities|host species|.

Supplementary material 2

Additional information for paratype specimens of the new species of *Microplitis* and *Snellenius*

Authors: Jose L. Fernandez-Triana, James B. Whitfield, M. Alex Smith, Robert R. Kula, Winnie Hallwachs, Daniel H. Janzen

Data type: Specimens data.

Explanation note: Additional information for paratype specimens of the new species of *Microplitis* and *Snellenius* described from Area de Conservacion Guanacaste, Costa Rica.

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PENSOFT

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New species, new synonymies and a new record of the genus *Cryptogonus* Mulsant, 1850 (Coleoptera, Coccinellidae) from China

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http://zoobank.org/F4F3EB99-1A69-4FCE-865A-96F22988F346

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Abstract

Three new species of the genus *Cryptogonus* Mulsant, 1850 from China are described and illustrated: *C. dulongjiangensis*, *C. fusiformis* and *C. reniformis* Huo and Ren. *Cryptogonus octoguttatus* Mader, 1954 and *C. kurosawai* Sasaji, 1968 are recognized as synonymous with *C. schraiki* Mader, 1933. *Cryptogonus hingstoni* Kapur, 1948 is newly recorded from China. A species list of the genus *Cryptogonus* is presented.

Key Words

Cryptogonus
new species
new synonymy
new record
China

Introduction

The genus *Cryptogonus* belongs to Aspidimerini (Coleoptera, Coccinellidae). The Aspidimerini species are widely distributed in South and Southeast Asia. They are natural enemies of coccidae, aphidae, aleyrodidae and have important application value in the control of insect pests.

The genus *Cryptogonus* was erected by Mulsant (1850) with *C. orbiculus* (Gyllenhal, 1808) as the type species by monotypy. Weise (1900) separated the genera *Cryptogonus* and *Aspidimerus* Mulsant, 1850 from Scymnini based on the structure of male genitalia and erected the tribe Aspidimerini with *Aspidimerus* Mulsant, 1850 as the type genus. Kapur (1948) revised the tribe Aspidimerini and proposed two new genera: *Pseudaspidimerus* Kapur and *Acarinus* Kapur, and subdivided the genus *Cryptogonus* into six species groups based on the shape of prosternal carinae. In Kapur's revision, 19 *Cryptogonus* species were included, and then during the past several decades 30 new species were attributed to this genus (Mader 1954, Sasaji 1968, Bielawski 1972, 1979, Ghorpade 1974, Pang and Mao 1979, Hoàng 1982, 1985, Cao and Xiao 1984, Canepari 1986, Kuznotsov and Pang Hong 1991, Xiao and Li 1992, Yu 1995, Pang 1998). Among those 30 new species, *C. nigritus* Pang & Mao, 1979 and *C. montanus* Hoàng, 1985 were transferred to *Aspidimerus* Mulsant, 1850 and *Trigonocarinatus* Huo & Ren, 2015, respectively (Kovář 2007, Huo et al. 2015).

During studies on Aspidimerini from the Oriental Region, the genus *Aspidimerus* from China and *Pseudaspidimerus* from Laos have been reviewed (Huo et al. 2013, 2014). In the present paper, three new species of the genus *Cryptogonus* Kapur, 1948 from China are described and illustrated. *Cryptogonus octoguttatus* Mader, 1954 and *C. kurosawai* Sasaji, 1968 are recognized as synonymous with *C. schraiki* Mader, 1933. *Cryptogonus hingstoni* Kapur, 1948 is newly recorded from China. A species list of the genus *Cryptogonus* is also presented.

Material and methods

All studied materials were deposited in the Department of Entomology, South China Agricultural University (SCAU). Type specimens designated in the current article were deposited in SCAU and the Institute of Zoology (IOZ), Chinese Academy of Science, Beijing.

Measurements were made using an ocular micrometer attached to a stereomicroscope (SteREO Discovery V20, Zeiss) as follows: (TL) total length, from apical margin of clypeus to apex of elytra; (TW) total width, across both elytra at widest part; (TH) total height, through the highest point of elytra to elytral outer margins; (HW) head width, including eyes; (PL) pronotal length, from middle of anterior margin to base of pronotum; (PW) pronotal width at widest part; (EL) elytral length, along suture, from apex to base including scutellum; (EW) elytral width, across both elytra at widest part; (ID) interocular distance, nearest distance between two eyes. Morphological terms follow Ślipiński (2007) and Ślipiński and Tomaszewska (2010) and are applied as in our previous studies on Chinese species of former Scymninae (e.g. Chen et al. 2013, Chen et al. 2014).

External morphology was observed with a stereomicroscope (SteREO Discovery V20, Zeiss). Male and female genitalia were dissected, cleared in 10% NaOH solution by boiling for several minutes and observed under a compound microscope, Olympus BX51. Images were photographed with digital cameras (AxioCam HRc and Coolsnap-Procf & CRI Micro*Color). The software AXIOVISION REL. 4.8 and IMAGE-PRO PLUS 5.1 were used to capture images from both cameras. Images were cleaned up and arranged in plates with ADOBE PHOTOSHOP CS5.

Taxonomy

Description of new species

Cryptogonus dulongjiangensis Huo & Ren, sp. n.

http://zoobank.org/451E691D-0181-454D-AC81-58830AA25652
Figure 1

Diagnosis. This species can be distinguished from other *Cryptogonus* species by its long penis, regularly narrowing to pointed apex, penis capsule with both branches very short (Fig. 1e).

Description. TL: 2.37–2.60 mm, TW: 1.86–2.11 mm, TH: 1.21–1.32 mm, TL/TW: 1.23–1.27; PL/PW: 0.51–0.53; EL/EW: 0.99–1.00, HW/PW: 0.61–0.63; PW/EW: 0.71–0.73. ID/HW: 0.49–0.53.

Body rounded, densely covered with short pubescence, golden on head and pronotum and silver white on elytra (Fig. 1a–c). Head yellow in male and black in female, clypeus dark brown. Pronotum black except a triangular yellow spot at anterior corner in male. Scutellum and elytra black. Ventral side black except legs and abdomen partially yellow to dark brown.

Punctures on frons coarse and dense, 0.3–0.5 diameters apart. Punctures on pronotum and elytra fine and sparse, 1–3 diameters apart. Punctures on metaventrite fine and sparse at middle, 5 diameters apart, coarse and dense on both sides, 0.2 diameters apart.

Male genitalia. Penis long, regularly narrowing to pointed apex (Fig. 1f), penis capsule with both branches very short (Fig. 1e). Tegminal strut as long as tegmen (Fig. 1h). Parameres 2 times length of phallobase with apices sparsely setose. Penis guide, in lateral view, gradually narrowing to pointed apex. In ventral view, subparallel at basal 2/3, narrowing to pointed apex (Fig. 1g).

Female genitalia. Coxites subtriangular (Fig. 1i), with dense, long terminal setae. Spermatheca missing.

Types. Holotype: 1 male, **CHINA: Yunnan Prov.:** Qinglandan, Maku Village, Dulongjiang, Gongshan County, 27°41.12′N, 98°16.35′E, ca 1260 m, 4–7.VIII.2010, Wang XM et al. leg. (SCAU). **Paratypes (2): CHINA: Yunnan Prov.:** 1 male, Maku Village, Dulongjiang, Gongshan County, 27°40.57′N, 98°18.15′E, ca 1600 m, 1.VIII.2010, Wang XM et al. leg; 1 female, Bapo Village, Dulongjiang, Gongshan County, 27°44.08′N, 98°20.59′E, ca 1400 m, 28.VII.2010, Wang XM et al. leg. (SCAU).

Distribution. China (Yunnan).

Etymology. The specific epithet refers to the type locality, Dulongjiang, Yunnan.

Cryptogonus fusiformis Huo & Ren, sp. n.

http://zoobank.org/BAD66DB0-5B95-4DF4-949E-EEA46932F585
Figure 2

Diagnosis. This species can be distinguished from other *Cryptogonus* species by its fusiform penis guide in ventral view (Fig. 2f).

Description. TL: 2.68 mm, TW: 2.14 mm, TH: 1.36 mm, TL/TW: 1.25; PL/PW: 0.51; EL/EW: 1.00, HW/PW: 0.58; PW/EW: 0.72. ID/HW: 0.50.

Body rounded, densely covered with short, silver white pubescence (Fig. 2a–b). Base of head yellow, anterior part black and clypeus dark brown. Dorsum entirely black. Ventral side black except legs and abdomen partially reddish brown.

Punctures on frons dense and coarse, 0.5–1.0 diameters apart. Punctures on pronotum and elytra fine and sparse, 2–4 diameters apart. Punctures on metaventrite fine and sparse at middle, 5 diameters apart, coarse and dense on both sides, 0.3 diameters apart.

Male genitalia. Penis long with apex pointed. Penis capsule with longer outer branch and short inner one. Tegminal strut slightly longer than tegmen. Parameres 2 times length of phallobase with apex densely setose (Fig. 2g). Penis guide, in lateral view strongly curved as S-shape, equivalent to parameres, in ventral view gradually broadening toward midlength, narrowing to pointed apex (Fig. 2f).

Female genitalia. Unknown.

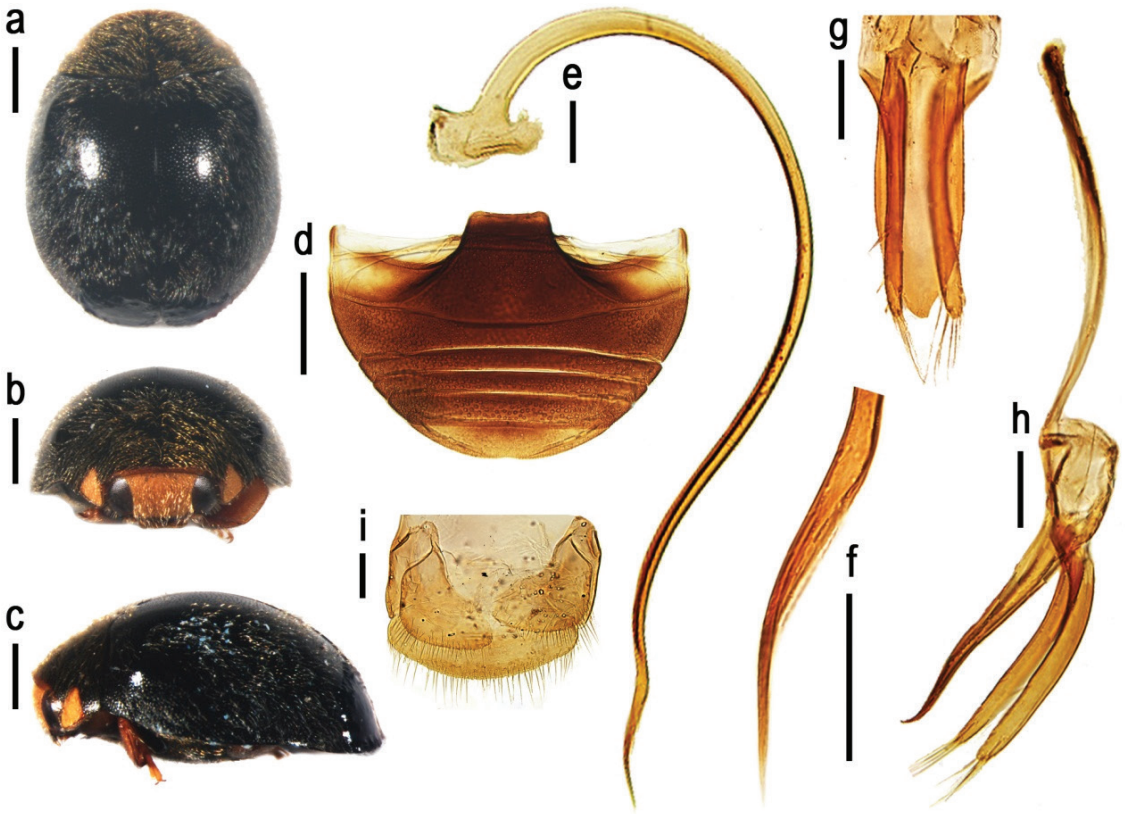

Figure 1. *Cryptogonus dulongjiangensis* Huo et Ren, sp. n. (**a**) dorsal view; (**b**) frontal view; (**c**) lateral view; (**d**) abdomen, male; (**e**) penis; (**f**) apex of penis; (**g**) ventral view of tegmen; (**h**) lateral view of tegmen; (**i**) coxites. Scale bars: **a–d**, 0.5 mm; **e–h**, 0.1 mm.

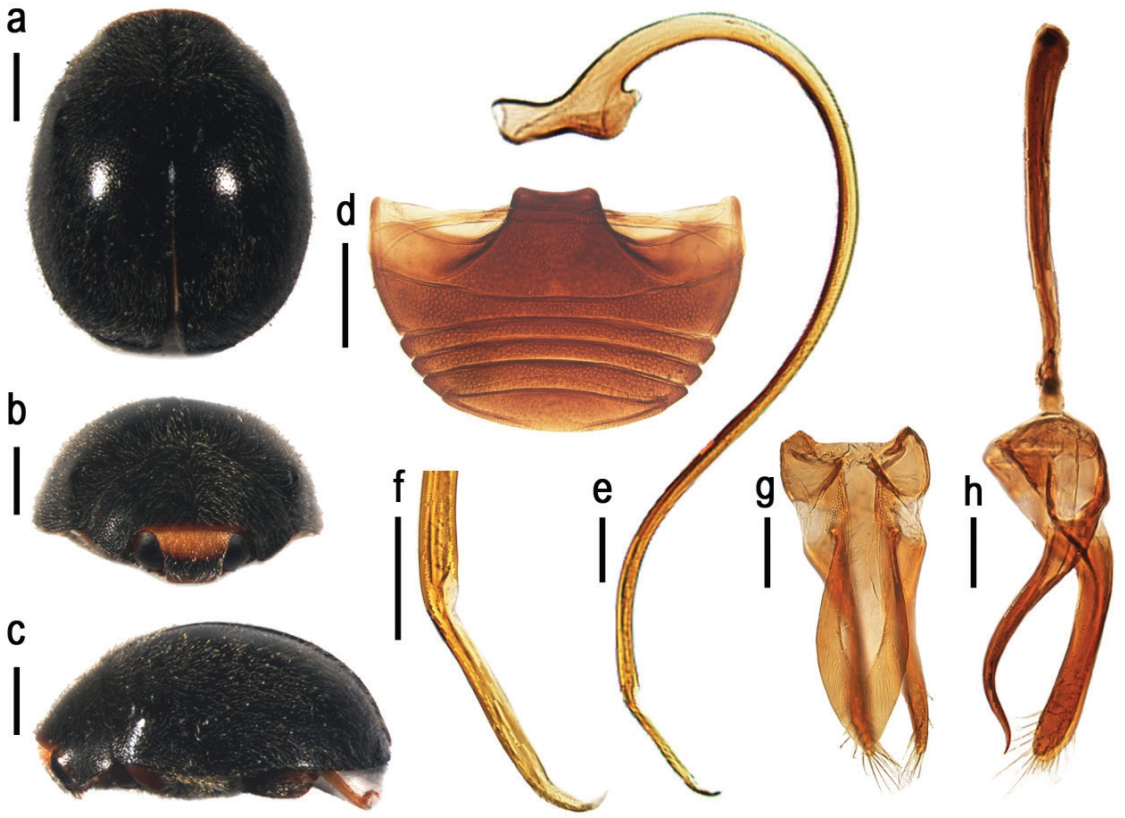

Figure 2. *Cryptogonus fusiformis* Huo et Ren, sp. n. (**a**) dorsal view; (**b**) frontal view; (**c**) lateral view; (**d**) abdomen, male; (**e**) penis; (**f**) apex of penis; (**g**) ventral view of tegmen; (**h**) lateral view of tegmen. Scale bars: **a–d**, 0.5 mm; **e–g**, 0.1 mm.

Types. Holotype: 1 male, **CHINA: Yunnan Prov.**: Mengdui Town, Zhenkang County, 23°54.16′N, 98°54.02′E, ca 1400 m, 18.V.2008, Wang XM et al. leg. (SCAU).

Distribution. China (Yunnan).

Etymology. The specific epithet is a Latin adjective referring to its fusiform penis guide in ventral view.

Cryptogonus reniformis Huo & Ren, sp. n.

http://zoobank.org/DE7458AF-F2EE-4020-88E0-37465A5B1E96
Figure 3

Diagnosis. This species can be easily identified by its reniform spot on elytra and trifurcate penis apex (Fig. 3a, h).

Description. TL: 1.90–2.40 mm, TW: 1.52–1.94 mm, TH: 1.00–1.27 mm, TL/TW: 1.24–1.25; PL/PW: 0.53–0.55; EL/EW: 0.96–1.01, HW/PW: 0.61–0.64; PW/EW: 0.71–0.72. ID/HW: 0.49–0.52.

Body rounded, densely covered with short, silver white pubescence (Fig. 3a–c). Head yellowish in male and black in female, clypeus dark brown. Pronotum black except a triangular yellowish spot at anterior corner in male. Scutellum black. Elytra black with a reniform spot at middle (Fig. 3a). Underside black except legs partially yellowish.

Punctures on frons coarse and dense, 0.5–1.5 diameters apart. Punctures on pronotum and elytra fine and sparse, 2–4 diameters apart. Punctures on metaventrite fine and sparse at middle, 8 diameters apart, coarse and dense on both sides, 0.5 diameters apart.

Male genitalia. Penis long with apex trifurcate (Fig. 3h). Penis capsule with outer branch bigger than inner one, anterior margin deeply concave (Fig. 3g). Tegminal strut as long as tegmen. Parameres 2 times length of phallobase with apex sparsely setose (Fig. 3j). Penis guide, in lateral view gradually narrowing to pointed apex, a little longer than parameres, in ventral view 3 times as long as wide, slightly broadening to apical 1/3, gradually narrowing to rounded apex (Fig. 3i).

Female genitalia. Coxites reniform with a small projection on the apical end (Fig. 3e). Spermatheca short and strongly arcuate without ramus (Fig. 3f).

Types. Holotype: 1 male, **CHINA: Yunnan Prov.:** Qinglandan, Maku Village, Dulongjiang, Gongshan County, 27°41.12′N, 98°16.35′E, ca 1260 m, 4–7. VIII.2010, Wang XM et al. leg. (SCAU). **Paratypes (38): CHINA: Yunnan Prov.:** 6 males, 14 females (2 males and 2 females in IOZ, 4 males and 12 females in SCAU), with the same data as holotype; 1 male, Kongdang Village, Dulongjiang, Gongshan County, 27°52.18′N, 98°20.24′E, ca 1600 m, 27.VII.2010, Wang XM et al. leg. (SCAU); 4 males, Bapo Village, Dulongjiang, Gongshan County, 27°44.09′N, 98°21.02′E, ca 1400 m, 28.VII.2010, Wang XM et al. leg. (SCAU); 3 males, 3 females, Bapo Village–Maku Village, Dulongjiang, Gongshan County, 27°42.49′N, 98°20.18′E, ca 1450 m, 29.VII.2010, Wang XM et al. leg. (SCAU); 4 males, 1 female, Maku Village, Dulongjiang, Gongshan County, 27°40.57′N, 98°18.15′E, ca 1600 m, 1.VIII.2010, Wang XM et al. leg. (SCAU); **Tibet:** 2 females, Beibeng Village, Motuo County, ca 850 m, 4.X.2011, Huo LZ et al. leg. (SCAU).

Distribution. China (Tibet, Yunnan).

Etymology. The specific epithet is a Latin adjective referring to its reniform spot on elytra.

New synonymies and new record

Cryptogonus schraiki Mader, 1933

Figures 4, 5

Cryptogonus schraiki Mader, 1933: 80; Kapur 1948: 101; Pang and Mao 1979: 69; Kovář 2007: 576; Ren et al. 2009: 120.

Cryptogonus octoguttatus Mader, 1954: 129; Pang and Mao 1979: 68; Kovář 2007: 576; Ren et al. 2009: 118. **Syn. n.**

Cryptogonus kurosawai Sasaji, 1968: 11; Yu 1995: 140, 2011: 161; Kovář 2007: 576. **Syn. n.**

Remarks. Leopold Mader described *C. schraiki* Mader, 1933 from Sichuan, China with a brief description of elytral coloration (Fig. 4a–i). Kapur (1948) reviewed this species and illustrated its appearance. Later, Mader described *C. octoguttatus* Mader, 1954 also from Sichuan, China, only with description of elytral coloration. Sasaji (1968) described *C. kurosawai* Sasaji, 1968 from Taiwan, China. Photographs of the holotype were available on the website of The Digital Museum of Natural & Science. Pang and Mao (1979) reviewed *C. schraiki* and *C. octoguttatus* and illustrated their appearance and male genitalia, but didn't notice the similarities of these two species. We examined these three species from China and found that they are just the same species with different elytral coloration. The elytral coloration is variable, from entirely black to entirely yellowish (Fig. 5a–l). Besides, we found the male genitalia of specimens are slightly different, even in the same coloration. Sometimes penis guide equal to, slightly longer or shorter than parameres. They are considered as individual differences.

Material examined. 205 specimens from China were examined (see the details in supplementary material).

Distribution. China (Anhui, Fujian, Gansu, Guangdong, Guizhou, Hubei, Hunan, Sichuan, Taiwan, Yunnan).

Cryptogonus hingstoni Kapur, 1948

Figure 6

Cryptogonus hingstoni Kapur, 1948: 103; Kapur 1963: 24; Kovář 2007: 575.

Remarks. Kapur (1948) described this species from Sikkim, India. Two specimens from Tibet, China match the description except coloration variation on elytra. In the

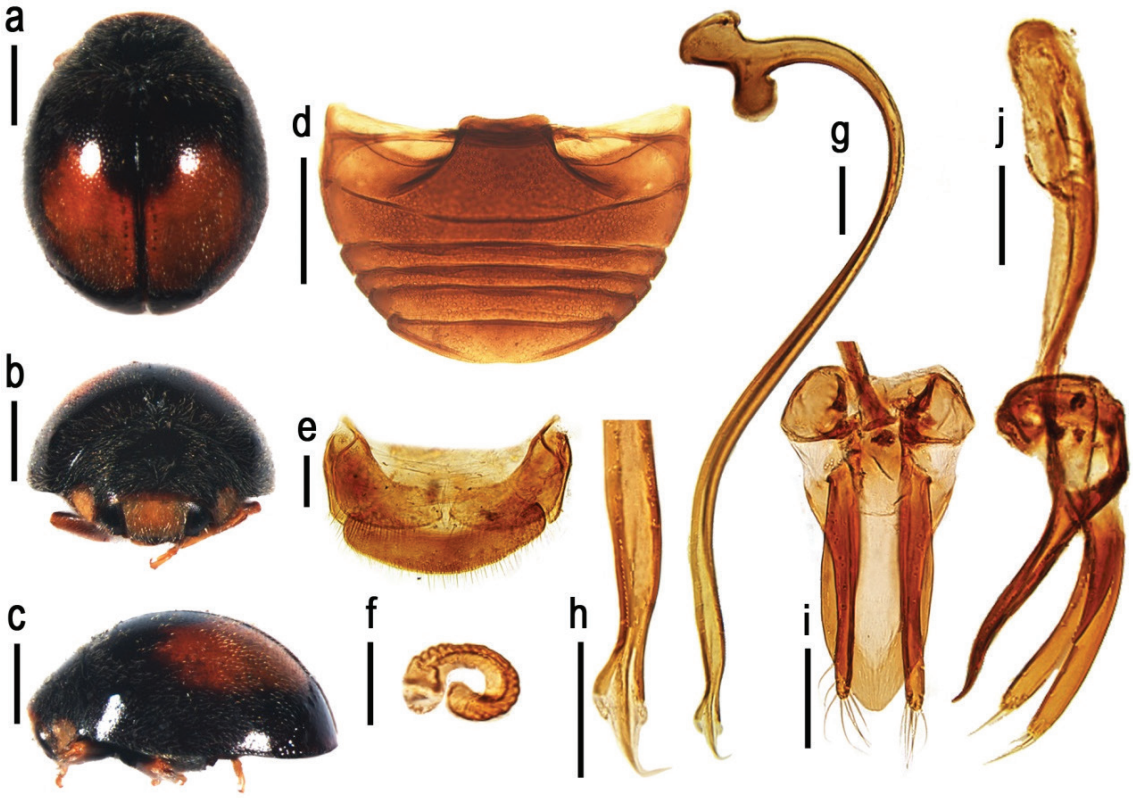

Figure 3. *Cryptogonus reniformis* Huo & Ren, sp. n. (**a**) dorsal view; (**b**) frontal view; (**c**) lateral view; (**d**) abdomen, male; (**e**) coxites; (**f**) spermatheca; (**g**) penis; (**h**) apex of penis; (**i**) ventral view of tegmen; (**j**) lateral view of tegmen. Scale bars: **a–d**, 0.5 mm; **e, g–j**, 0.1 mm; **f**, 0.05 mm.

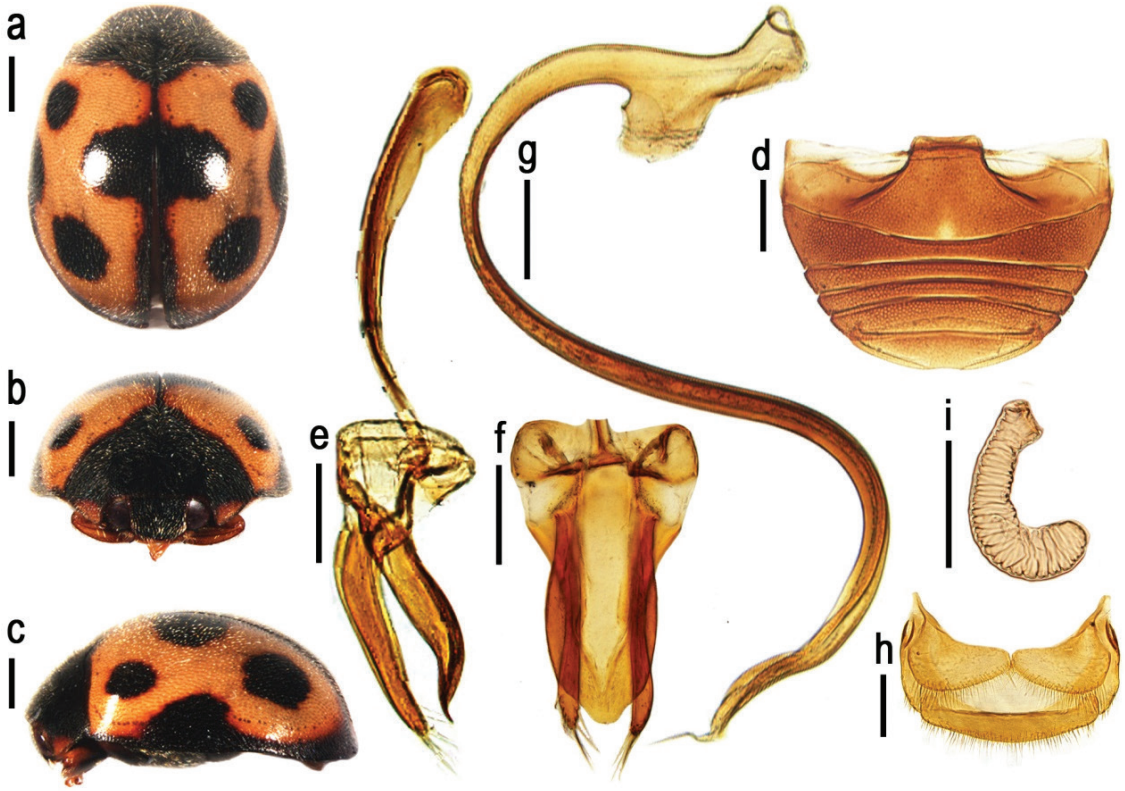

Figure 4. *Cryptogonus schraiki* Mader, 1933. (**a**) dorsal view; (**b**) frontal view; (**c**) lateral view; (**d**) abdomen, male; (**e**) lateral view of tegmen; (**f**) ventral view of tegmen; (**g**) penis; (**h**) coxites; (**i**) spermatheca. Scale bars: **a–d**, 0.5 mm; **e–h**, 0.2 mm; **i**, 0.1 mm.

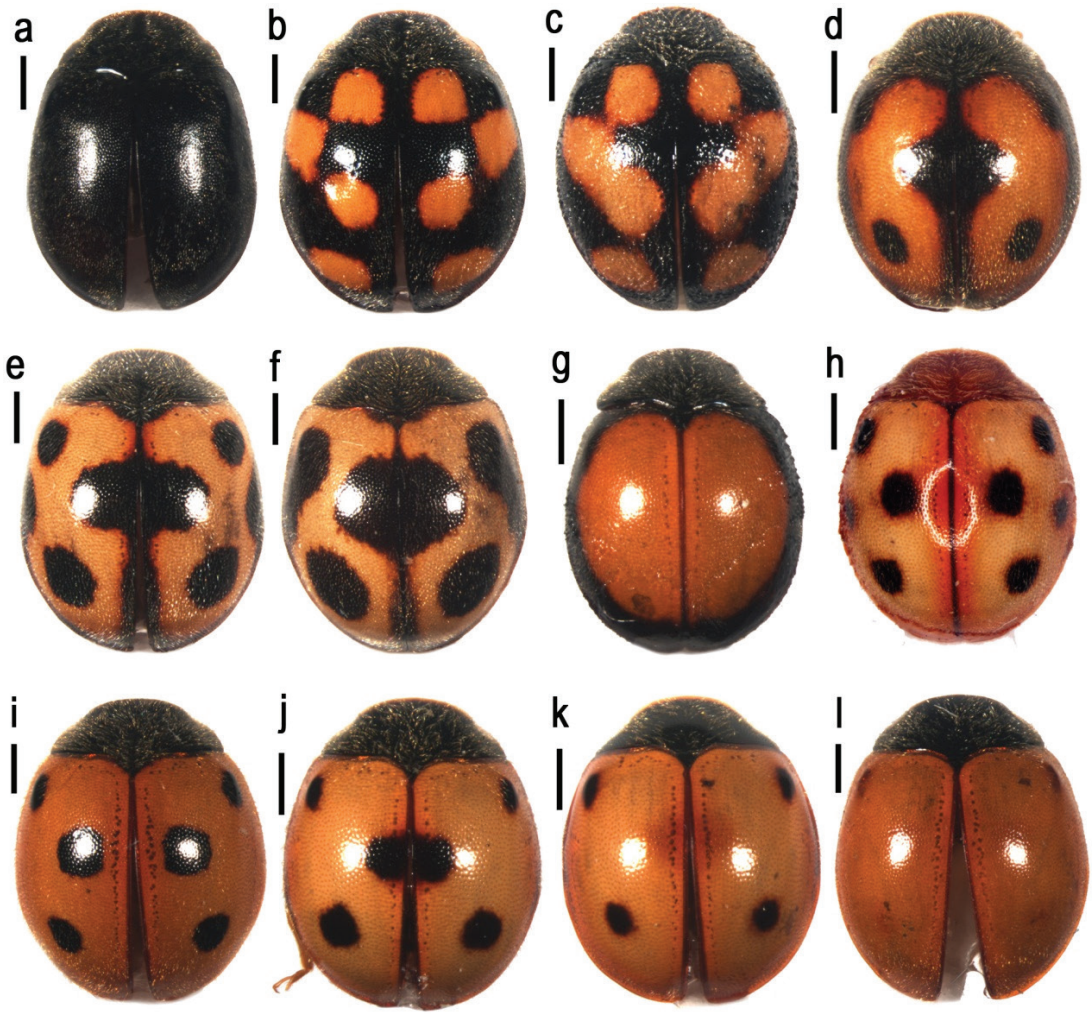

Figure 5. Different elytral coloration of *Cryptogonus schraiki* Mader, 1933. Scale bars: **a–l**, 0.5 mm.

original description, the spots on sutural and middle part of the elytron distinctly larger than that on humeral callus, the spot on pronotum is oval. However, in the present specimens we examined, the spots on sutural and middle part are as large as that on humeral callus, the spot on pronotum is triangular (Fig. 6a–c).

Material examined. CHINA: Tibet: 1 male, Bangxin Village, Motuo County, 29°34.58′N, 95°23.60′E, ca 1840 m, 12.X.2011, Huo LZ et al. leg; 1 female, Beibeng Village–Hanmi Village, Motuo County, 29°14.31′N, 95°10.58′E, ca 800–2100 m, 5-8.X.2011, Huo LZ et al. leg.

Distribution. China (Tibet) **new distribution**, India (Sikkim).

List of the genus *Cryptogonus* Mulsant

1. *Cryptogonus angusticarinatus* Sasaji, 1968
2. *Cryptogonus ariasi* (Mulsant, 1853)
3. *Cryptogonus bilineatus* Kapur, 1948
4. *Cryptogonus bimaculatus* Kapur, 1948
5. *Cryptogonus brachylobius* Pang, 1998
6. *Cryptogonus bryanti* Kapur, 1948
7. *Cryptogonus complexus* Kapur, 1948
8. *Cryptogonus deltodirus* Kapur, 1948
9. *Cryptogonus deltoides* Kapur, 1948
10. *Cryptogonus downingi* Kapur, 1948
11. *Cryptogonus dulongjiangensis* Huo & Ren, **sp. n.**
12. *Cryptogonus forficulae* Cao & Xiao, 1984
13. *Cryptogonus fractemaculatus* Pang, 1998
14. *Cryptogonus fulvoterminatus* Boheman, 1858
15. *Cryptogonus fusiformis* Huo & Ren, **sp. n.**
16. *Cryptogonus guangdongiensis* Pang & Mao, 1979
17. *Cryptogonus hainanensis* Pang & Mao, 1979
18. *Cryptogonus hanoiensi* Hoàng, 1982
19. *Cryptogonus himalayensis* Kapur, 1948
20. *Cryptogonus hingstoni* Kapur, 1948
21. *Cryptogonus horishanus* (Ohta, 1929)
22. *Cryptogonus kapuri* Ghorpade, 1974: 55
23. *Cryptogonus laetus* (Weise, 1885)
24. *Cryptogonus langchanhensis* Hoàng, 1982
25. *Cryptogonus lepidus* (Weise, 1885)
26. *Cryptogonus lijiangiensis* Pang & Mao, 1979
27. *Cryptogonus linguilatus* Pang, 1998
28. *Cryptogonus lobulus* Xiao, 1992
29. *Cryptogonus loebli* Canepari, 1986: 27
30. *Cryptogonus nepalensis* Bielawski, 1972

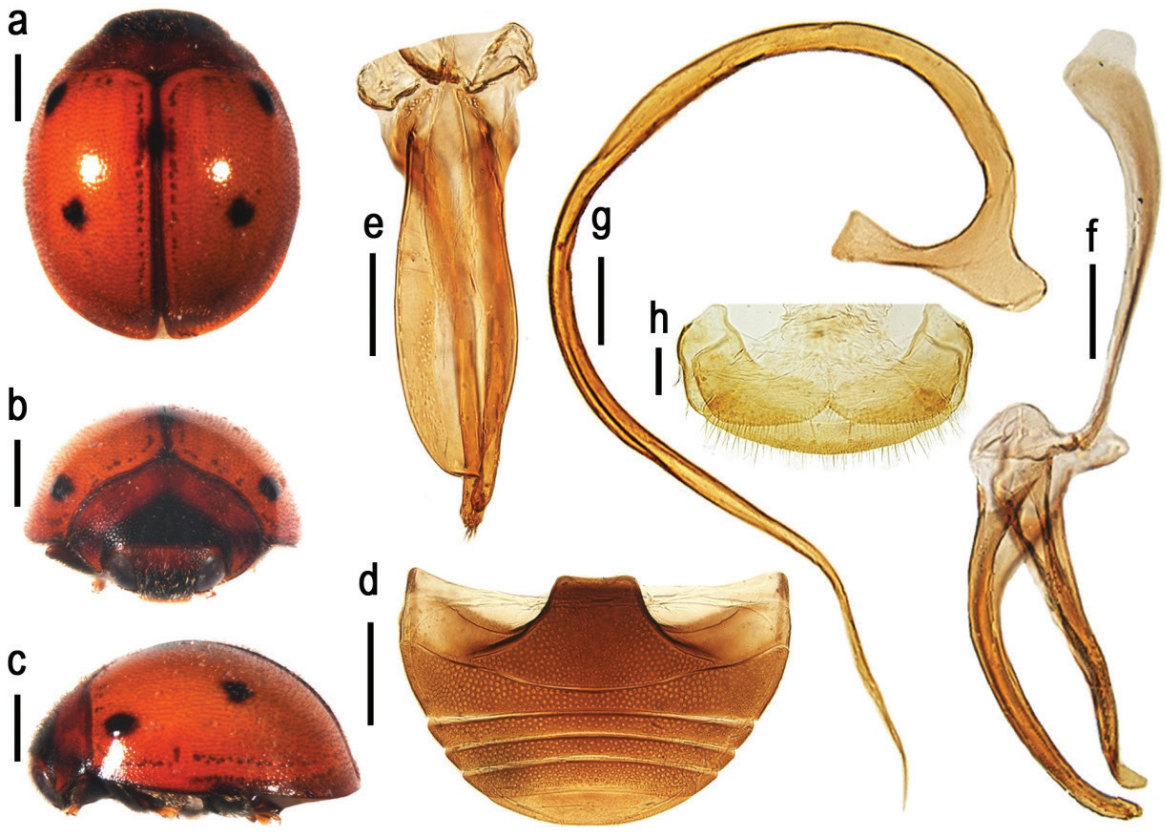

Figure 6. *Cryptogonus hingstoni* Kapur, 1948. (**a**) dorsal view; (**b**) frontal view; (**c**) lateral view; (**d**) abdomen, male; (**e**) ventral view of tegmen; (**f**) lateral view of tegmen; (**g**) penis; (**h**) coxites. Scale bars: **a–d**, 0.5 mm; **e–h**, 0.1 mm.

Cryptogonus nepalensis bhutanensis Bielawski, 1979
31. *Cryptogonus nitidus* Kapur, 1948
32. *Cryptogonus ocellatus* Hoàng, 1985
33. *Cryptogonus ohtai* Sasaji, 1968
34. *Cryptogonus orbiculus* (Gyllenhal, 1808)
35. *Cryptogonus parorbiculus* Kuznotsov & Pang Hong, 1991
36. *Cryptogonus polytrichus* Kuznotsov & Pang Hong, 1991
37. *Cryptogonus postmedialis* Kapur, 1948: 95
38. *Cryptogonus qianjiangensis* Xiao, 1992
39. *Cryptogonus quadriguttatus* (Weise, 1895)
40. *Cryptogonus reniformis* Huo & Ren, **sp. n.**
41. *Cryptogonus robustus* Yu, 1995
42. *Cryptogonus sagittiformis* Pang & Mao, 1979
43. *Cryptogonus schraiki* Mader, 1933
44. *Cryptogonus trifurcatus* Pang & Mao, 1979
45. *Cryptogonus trioblitus* (Gorham, 1895)
46. *Cryptogonus tristis* (Weise, 1910)
47. *Cryptogonus wuzhishanus* Pang & Mao, 1979
48. *Cryptogonus xiushanensis* Xiao, 1993
49. *Cryptogonus yunnanensis* Cao & Xiao, 1984

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References

Bielawski R (1972) Die Marienkäfer (Coleoptera: Coccinellidae) aus Nepal. Fragmenta Faunistica 18: 283–312. doi: 10.3161/00159301FF1972.18.16.283

Bielawski R (1979) Ergebnisse der Bhutan-Expedition 1972 des Naturhistorischen Museums in Basal, Coleoptera: Fam. Coccinellidae. Entomologica Basiliensia 4: 83–125.

Boheman CH (1859) Coleoptera. Species novas descripsit. In: Virgin C (Ed.) Kongliga Svenska Fregatten Eugenies Resa omkring jorden under befäl af C.A. Virgin Ahren 1851–1853. Vetenskapliga iakttagelser på H.M. Konung Oscar Den Förstes befallning utgifna af K. Svenska Vetenskaps Akademien, Zoologi III, Inseckter. P.A. Norstedt & söner, Stockholm, Sweden, 113–218.

Canepari C (1986) On some coccinellids of northern India and Nepal in the Geneva Museum of Natural History (Coleoptera Coccinellidae). Revue Suisse de Zoologie 93(1): 21–36.

Cao CY, Xiao NN (1984) New species of Coccinellidae from Yunnan, China. Entomotaxonomia 6(2–3): 109–125.

Chen XS, Li WJ, Wang XM, Ren SX (2014) A review of the subgenus *Neopullus* of *Scymnus* (Coleoptera: Coccinellidae) from China. Annales Zoologici 64(2): 299–326. doi: 10.3161/000345413X672483

Chen XS, Wang XM, Ren SX (2013) A review of the subgenus *Scymnus* of *Scymnus* from China (Coleoptera: Coccinellidae). Annales Zoologici 63(3): 417–499. doi: 10.3161/000345413X672483

Ghorpade KD (1974) Description of a new *Cryptogonus* Mulsant from Bangalore, Southern India. Oriental Insects 8(1): 55–60. doi: 10.1080/00305316.1974.10434442

Gorham HS (1895) On the Coccinellidae collected by Mr. L. Fea in Burma. Annali del Museo Civicodi Storia Naturale, Genova (2)34: 683–695.

Gyllenhal L (1808) Synonymia Insectorum, oder: versuch einer synonymie aller bisher bekannten Insecten, nach Fabricii Systema Eleutheratorum geordnet von C. J. Schönherr. Erster Band, Eleutherata oder Käfer. Zweiter Theil. C.F. Marquard, Stockholm, 424 pp.

Hoàng DN (1982) Coccinellidae of Vietnam Part I. Nha xuat ban khoa hoc va ky thuat, Hanoi, 211 pp.

Hoàng DN (1985) To the knowledge of ladybirds from Plateau Tay Nguyen, South Vietnam. Nauka, Moscow, 30–49. http://www.zin.ru/animalia/coleoptera/pdf/Hoàng85b.pdf

Huo LZ, Chen XS, Li WJ, Wang XM, Ren SX (2015) A new genus of the tribe Aspidimerini (Coleoptera Coccinellidae) from the Oriental Region. Annales Zoologici 65(2): 171–185. doi: 10.3161/00034541ANZ2015.65.2.005

Huo LZ, Wang XM, Chen XS, Ren SX (2013) The genus *Aspidimerus* Mulsant, 1850 (Coleoptera, Coccinellidae) from China, with descriptions of two new species. ZooKeys 348: 47–75. doi: 10.3897/zookeys.348.5746

Huo LZ, Wang XM, Chen XS, Ren SX (2014) The genus *Pseudaspidimerus* Kapur, 1948 (Coleoptera: Coccinellidae) from Laos, with descriptions of two new species. The Pan-Pacific Entomologist 90(4): 182–190. doi: 10.3956/2014-90.4.182

Kapur AP (1948) A revision of the tribe Aspidimerini Weise (Coleoptera, Coccinellidae). Transactions of the Royal Entomological Society of London 99: 77–128. doi: 10.1111/j.1365-2311.1948.tb01233.x

Kapur AP (1963) The Coccinellidae of the Third Mount Everest Expedition, 1924 (Coleoptera). Bulletin of the British Museum (Natural History) Entomology 14: 1–48.

Kovář I (2007) Coccinellidae. In: Löbl I, Smetana A (Eds) Catalogue of Palaearctic Coleoptera, Volume 4. Apollo Books, Stenstrup, 568–631.

Kuznetsov V, Pang H (1991) Description of Four New Aspidimerini (Coleoptera, Coccinellidae) from Vietnam. Elytra, Tokyo 19(2): 185–190.

Mader L (1933) Über bekannte und neue Coccinelliden. Entomologischen Anzeiger 5: 79–83. http://www.zobodat.at/pdf/EntAnz_13_0079-0084.pdf

Mader L (1954) Weiteres über Coccinelliden aus der Sammlung des Naturhistorischen Museums in Wien. Koleopterologische Rundschau, 32(1951–1954): 123–131.

Mulsant E (1850) Species des Coléoptères trimères sécuripalpes. Annales des Sciences Physiques et Naturelles, d'Agriculture et d'Industrie, Lyon (2) 2: 1–1104. doi: 10.5962/bhl.title.8953

Ohta Y (1929) Scymninen Japans. Insecta Matsumurana 4(1–2): 1–16.

Pang H (1998) The new record and new species of Aspidimerinae (Coleoptera: Coccinellidae) from China. Entomotaxonomia 20(3): 185–193.

Pang XF, Mao JL (1979) Economic Entomology of China 14: Coleoptera Coccinellidae II. Science Press, Beijing, 170 pp.

Poorani J (2002) An annotated checklist of the Coccinellidae (Coleoptera) (excluding Epilachninae) of the Indian subregion. Oriental Insects 36: 307–383. doi: 10.1080/00305316.2002.10417335

Ren SX, Wang XM, Pang H, Peng ZQ, Zeng T (2009) Colored pictorial handbook of ladybird beetles in China. Science Press, Beijing, 336 pp.

Sasaji H (1968) A revision of the Formosan Coccinellidae (II): Tribe Stethorini, Aspidimerini and Chilocorini (Coleoptera). Etizenia, Fukui (32): 1–24.

Ślipiński A (2007) Australian ladybird beetles (Coleoptera: Coccinellidae) their biology and classification. ABRS, Canberra, 286 pp.

Ślipiński A, Tomaszewska W (2010) Coccinellidae Latreille, 1802. In: Leschen RAB, Beutel RG, Lawrence JF (Eds) Handbook of Zoology, 2, Coleoptera. Walter de Gruyter GmbH & Co KG, Berlin, New York, 454–472.

The Digital Museum of Natural & Science: *Cryptogonus kurosawai* Sasaji, 1968. http://digimuse.nmns.edu.tw/Demo_2011/showMetadata.aspx?ObjectId=0900000181d6eb28&TypeKind=suMeta&Type=-type_minsect&Part=2-2&Domain=az&Field=i1&Language=CHI

Weise J (1895) Deutsche Entomologische Zeitschrift, 1895: 326.

Weise J (1900) Coccinelliden aus Ceylon gesammelt von Dr. Horn. Deutsche Entomologische Zeitschrift 44: 417–448. doi: 10.1002/mmnd.48019000237

Weise J (1910) Uber Chrysomeliden und Coccinelliden der Philippinen. Philippine Journal of Science 5D(4): 229–232.

Xiao NN, Li HX (1992) Coleoptera: Coccinellidae. In: Huang FS (Ed.) Insects of Wuling Mountains area, southwestern China. Science Press, Beijing, 368–390.

Yu GY (1995) The Coccinellidae (Excluding Epilachninae) collected by J. Klapperich in 1977 on Taiwan. Spixiana 18(2): 123–144. http://biostor.org/reference/52566

Yu GY (2011) The Coccinellidae of Taiwan. Chemical Industry Press, Beijing, 198 pp.

Supplementary material 1

Specimens examined of *Cryptogonus schraiki* Mader, 1933

Authors: Lizhi Huo, Wenjing Li, Xiaosheng Chen, Shunxiang Ren, Xingmin Wang

Data type: Specimens examined.

Explanation note: 205 specimens of *Cryptogonus schraiki* Mader, 1933 were examined in the present study.

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PENSOFT

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Contribution to the knowledge of the subgenus *Scymnus* (*Parapullus*) Yang, 1978 (Coleoptera, Coccinellidae), with description of eight new species

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http://zoobank.org/075E2200-7B72-481B-8D15-87708FD1A8BE

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Abstract

Eight new species of the subgenus *Scymnus* (*Parapullus*) Yang, 1978 from China are described and illustrated: *S.* (*P.*) *hastatus* **sp. n.**, *S.* (*P.*) *baxianshanensis* **sp. n.**, *S.* (*P.*) *laojielingensis* **sp. n.**, *S.* (*P.*) *annuliformis* **sp. n.**, *S.* (*P.*) *papillatus* **sp. n.**, *S.* (*P.*) *dichotomus* **sp. n.**, *S.* (*P.*) *shenmuensis* **sp. n.** and *S.* (*P.*) *yanzigouensis* **sp. n.** Diagnoses and distributions are provided for each species. An updated key to the Chinese species of the subgenus *Parapullus* is given. A catalogue to all known species of this subgenus is also presented.

Key Words

Coccinellidae
Scymnus (*Parapullus*)
taxonomy
new species
distribution
catalogue
China

Introduction

The subgenus *Scymnus* (*Parapullus*) was created by Yang (1978), with type species *Scymnus* (*Parapullus*) *secula* Yang, 1978 described from Taiwan. The distinguished characters includes: abdominal postcoxal lines distinctly incomplete laterally, antennae composed of ten antennomeres, parameres of the tegmen usually with two groups of long setae inserted in different directions.

Parapullus is a small subgenus of *Scymnus*, currently comprising of 12 described species worldwide and mainly distributed in the Old World (Yang 1978, Pang and Yu 1993, Yu et al. 2000, Chen et al. 2012). In China, eight species have been documented prior to the present work (Chen et al. 2012). In present study examination of ladybird specimens newly collected from various parts of China was done together with coccinellid collection of South China Agricultural University revealing eight new species belonging to subgenus *Parapullus* and reported herein.

In this paper, eight new species are described and illustrated in detail, and a key to the Chinese species of the subgenus *Parapullus* is updated. Maps of the distribution of the species occurring in China are given. A catalogue to the worldwide species of this subgenus is also presented.

Material and methods

Measurements were made using a micrometer attached to a dissecting microscope as follows: total length (TL), from apical margin of clypeus to apex of elytra; total width (TW), across both elytra at widest part; total height (TH), at highest part of elytra; elytral length (EL), along

suture from base to apex including scutellum; elytral width (EW), equal to TW; pronotal length (PL), from the middle of anterior margin to the base of pronotum; pronotal width (PW), at widest part; head width (HW), at widest part including eyes.

External morphology was observed with a dissecting stereoscope (SteREO Discovery V20). Male and female genitalia were dissected, cleared in 10% solution of NaOH by boiling for several minutes, and examined on slides with an Olympus BX51 compound microscope. After examination, the genitalia were transferred to a small card covered with neutral balsam and pinned beneath the specimen. Photographs of the whole beetles and their genitalia were executed on digital cameras (Coolsnap-Pro*cf* & CRI Micro*Color and AxioCam HRc) and composite images generated with IMAGE-PRO PLUS 5.1 and AXIO VISION REL. 4.8 softwares. The final plates were prepared using ADOBE PHOTOSHOP CS 8.0.

Morphological terminology use in this paper follows Ślipiński (2007) and Ślipiński and Tomaszewska (2010). Type specimens designated in the present paper are deposited in the Department of Entomology, South China Agricultural University, Guangzhou, China (SCAU).

Taxonomy

Scymnus (*Parapullus*) *hastatus* sp. n.

http://zoobank.org/E974785F-794F-4A8F-B996-22ED5BC0BF27
Figs 1, 9

Diagnosis. This species is easily confused with several species having unicolourous reddish brown body in this subgenus, but can be recognized by the stout penis guide with a hook-like appendage at apex in lateral view (Fig. 1h).

Description. TL: 2.31–2.43 mm, TW: 1.53–1.67 mm, TH: 0.98–1.04 mm, TL/TW: 1.46–1.51, PL/PW: 0.56–0.57, EL/EW: 1.13–1.16, HW/PW: 0.59–0.62, PW/EW: 0.73–0.74.

Body elongate oval, moderately convex, entirely reddish brown, dorsum covered with white pubescence (Fig. 1a–c).

Head with fine frontal punctures, as large as eye facets, 1.0–2.0 diameters apart. Eyes densely faceted, interocular distance 0.51 times head width. Pronotal punctures as large as those on frons, 2.0–3.0 diameters apart. Surface of elytra with punctures larger than those on pronotum, separated by 2.5–3.0 diameters. Prosternal process trapezoidal, 2 times as long as its width at base; with lateral carinae distinct, extending to anterior margin of prosternum, distinctly convergent anteriorly. Abdominal postcoxal lines weakly recurved and distinctly incomplete laterally (Fig. 1d), reaching 6/7 length of abdominal ventrite 1, area enclosed by lines coarsely punctate, broadly smooth along line. Abdominal ventrite 5 in male with apex truncate.

Male genitalia: penis stout, unevenly sinuated (Fig. 1e). Penis capsule highly sclerotized with small inner arm and large outer arm (Fig. 1e). Apex of penis strongly curved with distinctly membranous appendage (Fig. 1f). Tegmen extremely stout (Fig. 1g–h) with penis guide narrowest at base, gradually expanding to a spade-like apex bearing with a digitations in ventral view (Fig. 1g); in lateral view, penis guide strongly raised at middle with a hook-like appendage at apex (Fig. 1h). Parameres slender with rounded apex, slightly longer than penis guide, densely covered with two groups of long setae at apices (Fig. 1h).

Female unknown.

Type materials. Holotype: male, No. SCAU (E) 11346, **China: Gansu:** Dongshan, Xinglongshan National Nature Reserve, Yuzhong County, Lanzhou City, 35°47.83'N, 104°3.93'E, ca 2300 m, 3. VIII. 2007, Liang JB leg. **Paratypes (3):** 3♂ with same data as holotype.

Distribution. China (Gansu).

Etymology. The species name is derived from the Latin adjective *hastatus* referring to its penis guide with halberd-like apex in ventral view.

Scymnus (*Parapullus*) *baxianshanensis* sp. n.

http://zoobank.org/33254854-37B7-4933-8555-241DB7137AAA
Figs 2, 9

Diagnosis. This species is most similar to *Scymnus* (*Parapullus*) *alishanensis* Pang & Yu, 1993 in general appearance and male genitalia, but can be distinguished from it by having parameres as long as half length of penis guide (Fig. 2h) and penis guide constricted at middle part in ventral view (Fig. 2g). In *S.* (*P.*) *alishanensis*, its parameres are longer than half length of penis guide and penis guide constricted near middle part in ventral view.

Description. TL: 2.20–2.48 mm, TW: 1.60–1.71 mm, TH: 1.06–1.18 mm, TL/TW: 1.38–1.45, PL/PW: 0.54–0.55, EL/EW: 1.06–1.09, HW/PW: 0.59–0.60, PW/EW: 0.70–0.75.

Body elongate oval, moderately convex, entirely reddish brown, dorsum covered with white pubescence (Fig. 2a–c).

Head with fine frontal punctures, slightly smaller than eye facets, 0.5–1.0 diameter apart. Eyes densely faceted, interocular distance 0.49 times head width. Pronotal punctures larger than those on frons, 1.0–2.0 diameters apart. Surface of elytra with punctures much larger than those on pronotum, separated by 1.0–2.0 diameters. Prosternal process trapezoidal, 2 times as long as its width at base; with lateral carinae distinct, extending to anterior margin of prosternum, slightly convergent anteriorly. Abdominal postcoxal lines weakly recurved and distinctly incomplete laterally (Fig. 2d), reaching 6/7 length of abdominal ventrite 1, area enclosed by lines finely punctate, narrowly smooth along line. Abdominal ventrite 5 in both sexes with apex truncate.

Male genitalia: penis stout (Fig. 2e). Penis capsule deeply emarginated medially with small inner arm and large outer arm. Apex of penis slender, forming a hook-

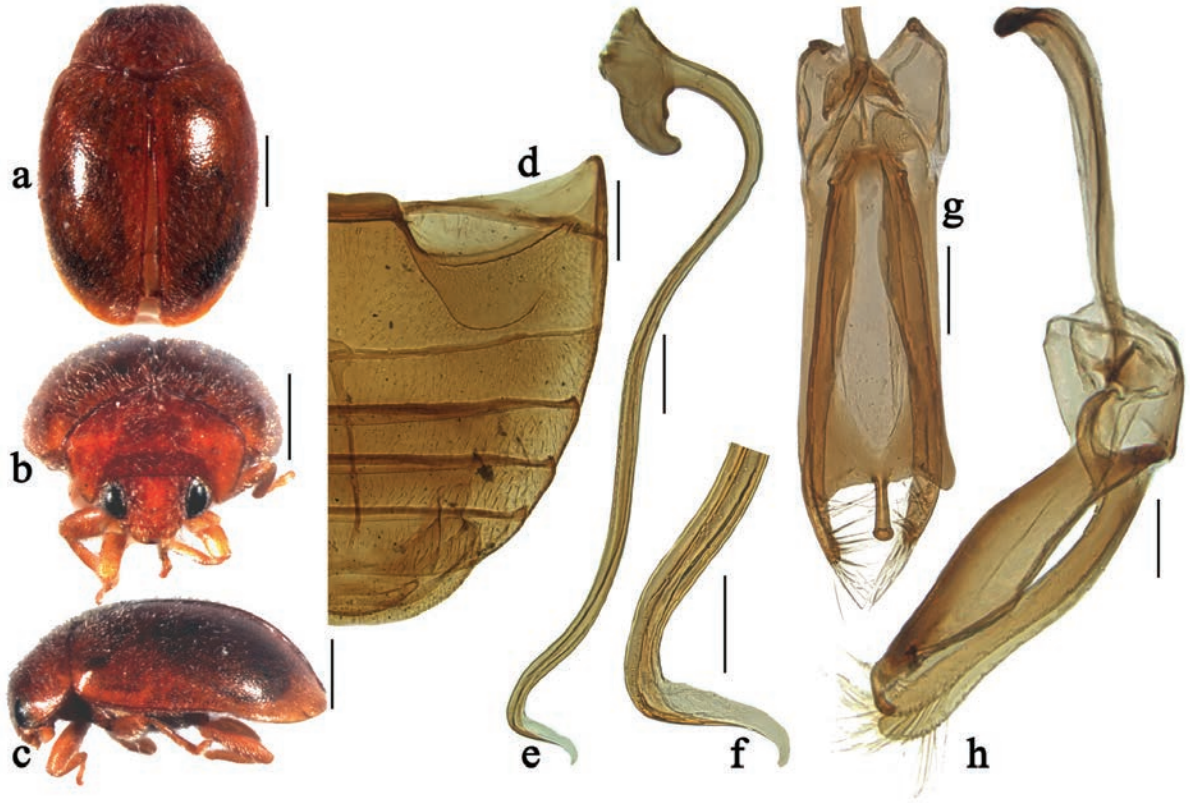

Figure 1. *Scymnus* (*Parapullus*) *hastatus* sp. n.: **a** dorsal view; **b** anterior view; **c** lateral view; **d** abdomen; **e** penis; **f** apex of penis; **g** tegmen, ventral view; **h** tegmen, lateral view. Scale bars: **a–c** 0.5 mm, **d** 0.2 mm, **e–h** 0.1 mm.

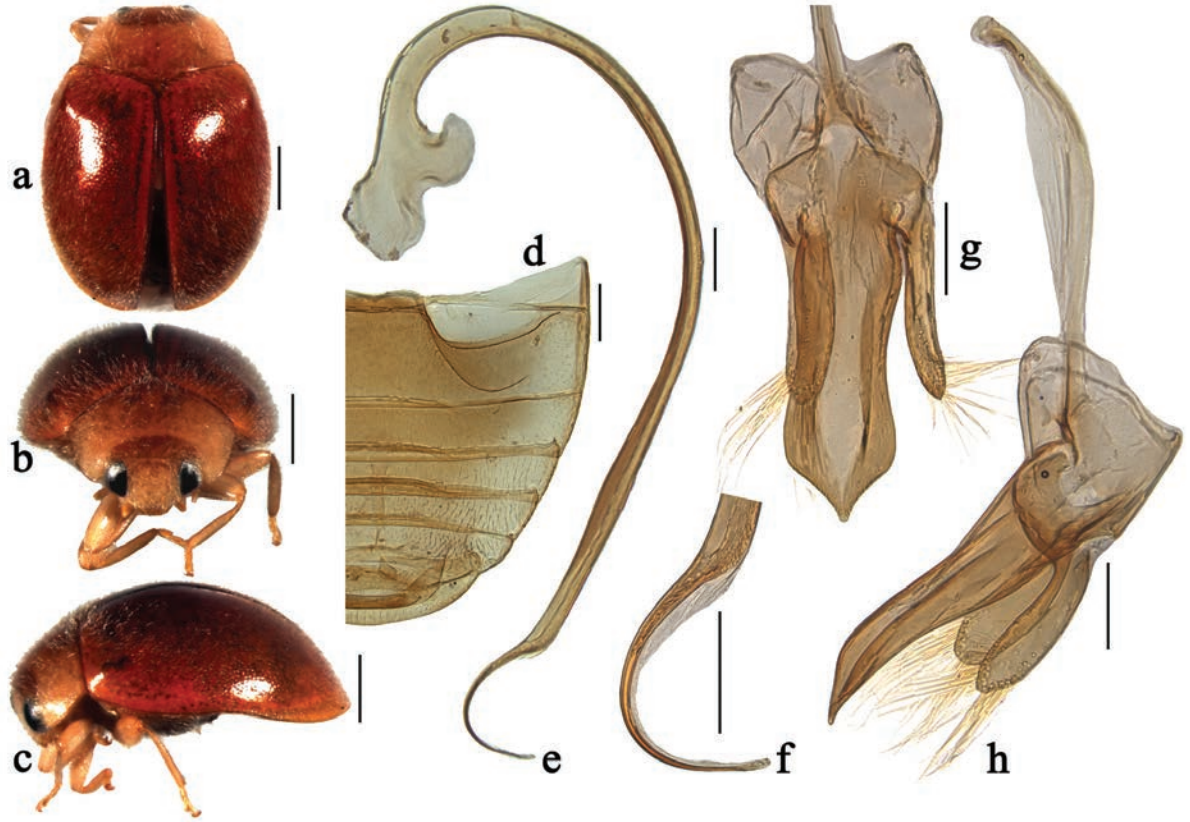

Figure 2. *Scymnus* (*Parapullus*) *baxianshanensis* sp. n.: **a** dorsal view; **b** anterior view; **c** lateral view; **d** abdomen; **e** penis; **f** apex of penis; **g** tegmen, ventral view; **h** tegmen, lateral view. Scale bars: **a–c** 0.5 mm, **d** 0.2 mm, **e–h** 0.1 mm.

shaped (Fig. 2f). Tegmen stout (Figs 2g–h) with penis guide slightly constricted at middle part, expanding toward apex, then tapering abruptly to blunt apex in ventral view (Fig. 2g). Parameres narrow, as long as half length of penis guide, densely covered with two groups of long setae at apices (Fig. 2h).

Female similar to male except for sexual characters.

Type materials. Holotype: male, No. SCAU (E) 11532, **China: Tianjin:** Baxianshan National Nature Reserve, Ji County, 40°11.27'N, 117°33.19'E, ca 500 m, 14. VII. 2011, Chen XS leg. **Paratypes (3):** 1♂2♀ with same data as holotype.

Distribution. China (Tianjin).

Etymology. The specific epithet refers to its type locality, Baxianshan National Nature Reserve, Tianjin.

Scymnus (*Parapullus*) *laojielingensis* sp. n.

http://zoobank.org/6457D29C-A8B3-440B-B5E6-24B57BA824B4
Figs 3, 10

Diagnosis. This species is similar to *Scymnus* (*Parapullus*) *parallelicus* Chen, Ren & Wang, 2012 in general appearance and male genitalia, but can be distinguished from it by having strongly sinuated apex of penis with membranous appendage (Fig. 3f), the apical 1/4 length of parameres covered with several long setae at inner sides in lateral view (Fig. 3h), and the area enclosed by the abdominal postcoxal lines with coarse punctures (Fig. 3d).

Description. TL: 2.21–2.38 mm, TW: 1.58–1.71 mm, TH: 1.01–1.16 mm, TL/TW: 1.39–1.40, PL/PW: 0.51–0.52, EL/EW: 1.08–1.12, HW/PW: 0.56, PW/EW: 0.72.

Body elongate oval, moderately convex, entirely reddish brown, dorsum covered with white pubescence (Fig. 3a–c).

Head with fine frontal punctures, as large as eye facets, 0.5–1.0 diameter apart. Eyes densely faceted, interocular distance 0.47 times head width. Pronotal punctures similar to those on frons, 1.0–2.0 diameters apart. Surface of elytra with punctures larger than those on pronotum, separated by 2.0–3.0 diameters. Prosternal process trapezoidal, 2.5 times as long as its width at base; with lateral carinae distinct, extending to anterior margin of prosternum, distinctly convergent anteriorly. Abdominal postcoxal lines weakly recurved and distinctly incomplete laterally (Fig. 3d), reaching 5/6 length of abdominal ventrite 1, area enclosed by lines coarsely punctate, narrowly smooth along line. Abdominal ventrite 5 in male with apex rounded.

Male genitalia: penis stout (Fig. 3e). Penis capsule with small inner arm and large outer arm. Apex of penis strongly sinuated with membranous appendage (Fig. 3f). Tegmen stout (Fig. 3g–h) with penis guide with parallel sides from base to 3/4 length, then tapering gradually to blunt apex in ventral view (Fig. 3g) and its apex slightly curved outwardly in lateral view (Fig. 3h). Parameres longer than half length of penis guide, densely covered with a group of long setae at apices, and its apical 1/4 length covered with several stout setae at inner sides (Fig. 3h).

Female externally similar to male but with abdominal ventrite 5 truncate apically.

Type materials. Holotype: male, No. SCAU (E) 11534, **China: Henan:** Laojieling National Nature Reserve, Xixia County, Nanyang City, 33°37.63'N, 111°45.85'E, ca 1400 m, 9. VII. 2009, Chen XS leg. **Paratypes (3):** 1♂2♀ with same data as holotype.

Distribution. China (Henan).

Etymology. The specific epithet refers to its type locality, Laojieling National Nature Reserve, Henan Province.

Scymnus (*Parapullus*) *annuliformis* sp. n.

http://zoobank.org/0F93276E-3C30-4E20-A485-8705A4B5F300
Figs 4, 10

Diagnosis. This species is similar to *Scymnus* (*Parapullus*) *parallelicus* Chen, Ren & Wang, 2012 in general appearance and male genitalia, but can be separated from it by having slender, ring shaped apex of penis (Fig. 4f) and the abdominal postcoxal lines strongly recurved toward base of ventrite (Fig. 4d). It also resembles *Scymnus* (*Parapullus*) *malleatus* Chen, Ren & Wang, 2012, particularly the ring shaped apex of penis, but can be recognized from it by having narrow and short parameres (Fig. 4h) and the different shape of penis capsule.

Description. TL: 2.28–2.34 mm, TW: 1.58–1.71 mm, TH: 1.06–1.15 mm, TL/TW: 1.37–1.44, PL/PW: 0.51–0.53, EL/EW: 1.07–1.13, HW/PW: 0.60–0.61, PW/EW: 0.67–0.71.

Body oval, moderately convex, entirely reddish brown, dorsum covered with white pubescence (Fig. 4a–c).

Head with fine frontal punctures, as large as eye facets, 1.0–2.0 diameters apart. Eyes densely faceted, interocular distance 0.49 times head width. Pronotal punctures larger than those on frons, 1.0–2.0 diameters apart. Surface of elytra with punctures larger than those on pronotum, separated by 2.0–3.0 diameters. Prosternal process trapezoidal, 2.5 times as long as its width at base; with lateral carinae distinct, extending to anterior margin of prosternum, slightly convergent anteriorly. Abdominal postcoxal lines strongly recurved and distinctly incomplete laterally (Fig. 4d), reaching 5/6 length of abdominal ventrite 1, area enclosed by lines finely punctate, broadly smooth along line. Abdominal ventrite 5 in both sexes with apex truncate.

Male genitalia: penis moderately stout (Fig. 4e). Penis capsule with small inner arm and large outer arm. Apex of penis slender, ring shaped (Fig. 4f). Tegmen stout (Fig. 4g–h) with penis guide parallel sided from base to 3/4 length, then tapering gradually to blunt apex in ventral view (Fig. 4g). Parameres stout with obliquely truncate apex, longer than half length of penis guide, densely covered with two groups of long setae at apices (Fig. 4h).

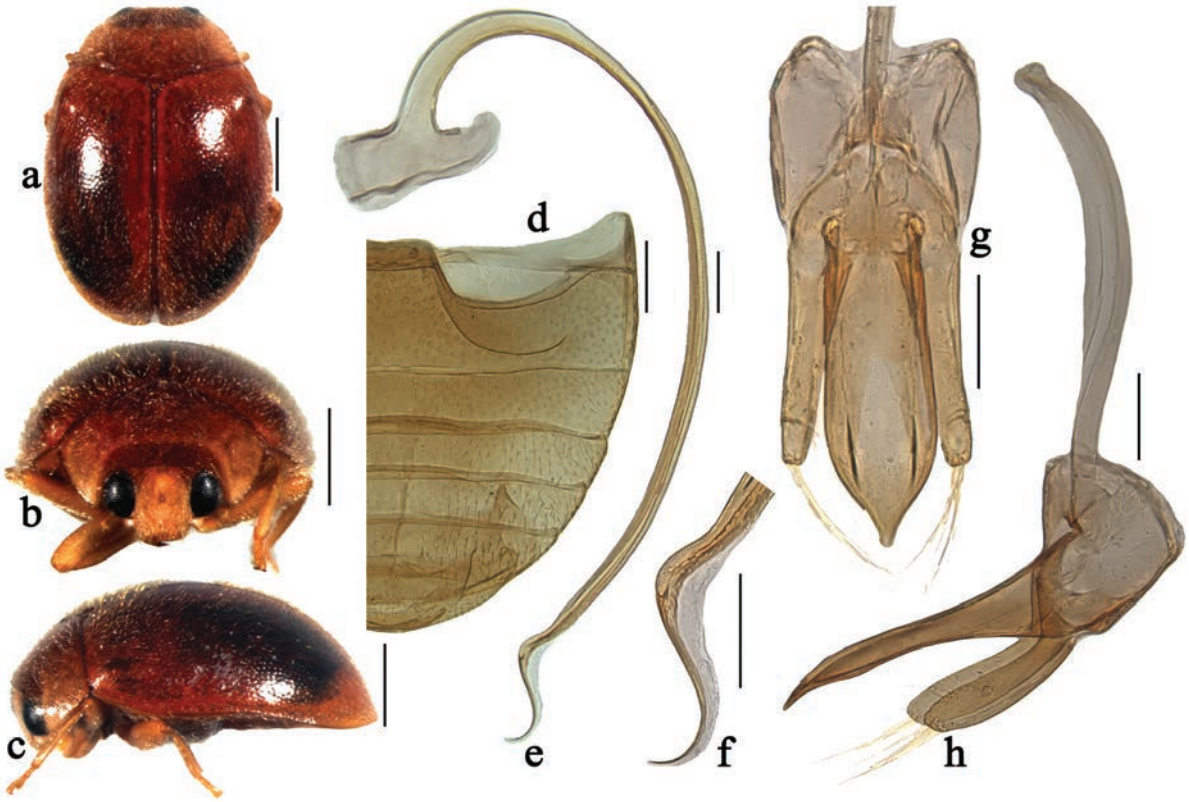

Figure 3. *Scymnus* (*Parapullus*) *laojielingensis* sp. n.: **a** dorsal view; **b** anterior view; **c** lateral view; **d** abdomen; **e** penis; **f** apex of penis; **g** tegmen, ventral view; **h** tegmen, lateral view. Scale bars: **a–c** 0.5 mm, **d** 0.2 mm, **e–h** 0.1 mm.

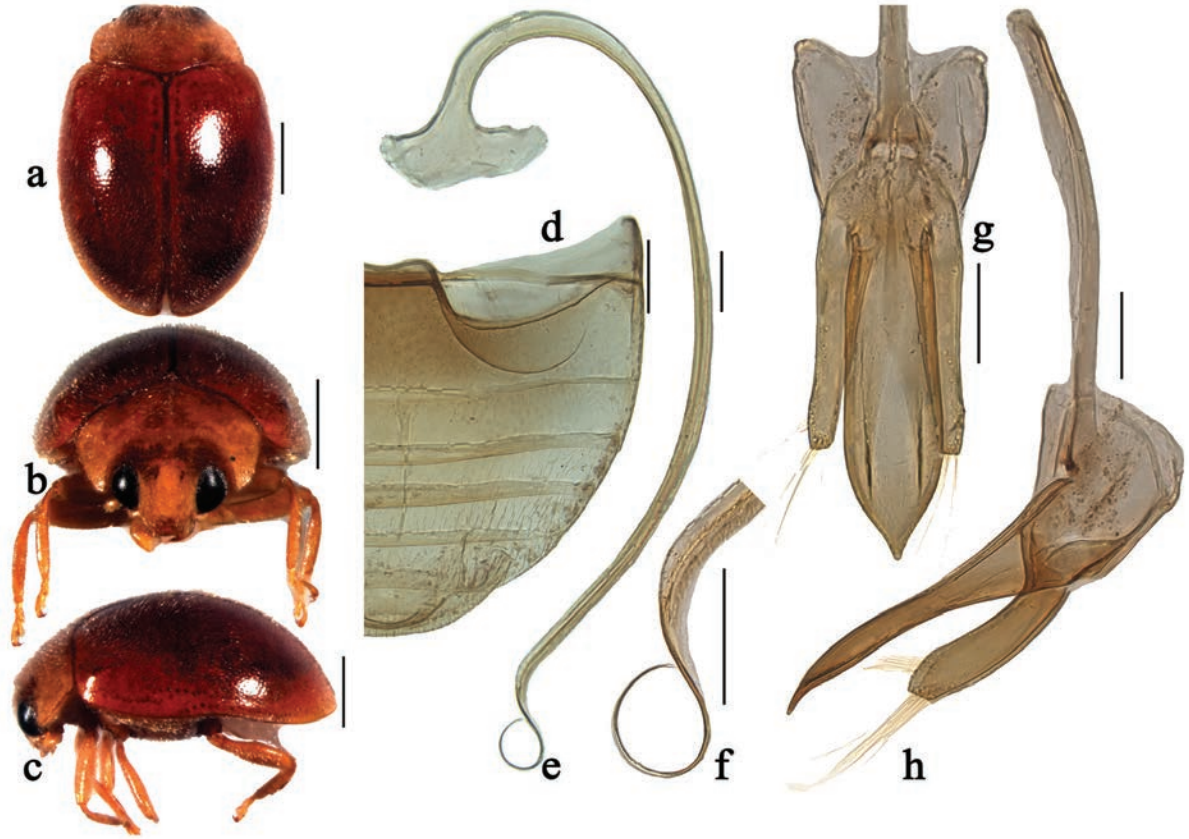

Figure 4. *Scymnus* (*Parapullus*) *annuliformis* sp. n.: **a** dorsal view; **b** anterior view; **c** lateral view; **d** abdomen; **e** penis; **f** apex of penis; **g** tegmen, ventral view; **h** tegmen, lateral view. Scale bars: **a–c** 0.5 mm, **d** 0.2 mm, **e–h** 0.1 mm.

Female similar to male except for sexual characters.

Type materials. Holotype: male, No. SCAU (E) 11527, **China: Anhui:** Hongshan, Yaoluoping National Nature Reserve, Yuexi County, 31°0.85'N, 116°8.67'E, ca 800 m, 30. IX. 2010, Wang XM leg. **Paratypes (9): Anhui:** 1♂ with same data as holotype. 1♂, Yaoluoping National Nature Reserve, Yuexi County, 30°58.95'N, 116°4.83'E, ca 1000 m, 28. IX. 2010, Li WJ leg. **Tibet:** 1♀, Cibagou National Nature Reserve, Chayu County, 28°33.69'N, 97°5.10'E, ca 2000 m, 13. X. 2007, Chen XS leg. 2♀, Xiachayu Town, Chayu County, 28°30.04'N, 97°0.84'E, ca 1800 m, 14. X. 2007, Chen XS leg. 1♂, Xiayadong Village, Yadong County, 28°29.29'N, 97°1.36'E, ca 2800 m, 29-30. IX. 2009, Chen XS leg. 1♀, Motuo County, Linzhi City, 29°19.30'N, 95°18.33'E, ca 760 m, 17. X. 2009, Chen XS leg. 1♀, Lebu Village, Cuona County, 27°48.63'N, 91°44.98'E, ca 2400 m, 24. X. 2011, Li WJ leg. 1♂, Mama Village, Cuona County, 27°47.44'N, 91°46.56'E, ca 2800 m, 25. X. 2011, Huo LZ leg.

Distribution. China (Anhui, Tibet).

Etymology. The specific epithet refers to its penis with ring shaped apex.

Scymnus (*Parapullus*) *papillatus* sp. n.

http://zoobank.org/54FE83B5-3AD8-4D2A-8373-E5B0180B5615
Figs 5, 11

Diagnosis. This species is similar to *Scymnus* (*Parapullus*) *solus* Chen, Ren & Wang, 2012 in general appearance and male genitalia, but can be separated from it by having a papilla bearing a stout seta at the apical 1/3 length of paramere (Fig. 5h).

Description. TL: 1.98–2.36 mm, TW: 1.39–1.66 mm, TH: 0.92–1.09 mm, TL/TW: 1.42, PL/PW: 0.50–0.55, EL/EW: 1.09–1.12, HW/PW: 0.59–0.60, PW/EW: 0.70–0.73.

Body elongate oval, moderately convex, dorsum covered with white pubescence (Fig. 5a–c). Head, antennae and mouthparts brown. Pronotum dark brown. Scutellum black. Elytra black with apical 1/4 brown. Prothoracic hypomeron and prosternum brown. Mesoventrite, metaventrite and elytral epipleura black. Legs brown.

Head with fine frontal punctures, as large as eye facets, 0.5–1.0 diameter apart. Eyes densely faceted, interocular distance 0.50 times head width. Pronotal punctures larger than those on frons, 1.5–3.0 diameters apart. Surface of elytra with punctures as large as those on pronotum, separated by 1.0–2.0 diameters. Prosternal process trapezoidal, 2.3 times as long as its width at base; with lateral carinae distinct, extending to anterior margin of prosternum, distinctly convergent anteriorly. Abdominal postcoxal lines weakly recurved and distinctly incomplete laterally (Fig. 5d), nearly extending to posterior margins of abdominal ventrite 1, area enclosed by lines finely punctate, narrowly smooth along line. Abdominal ventrite 5 in male with apex truncate.

Male genitalia: penis stout and long (Fig. 5e). Penis capsule with outer arm large and inner arm strongly curved. Apex of penis unevenly curved, forming a large hook (Fig. 5f). Tegmen stout (Fig. 5g–h) with penis guide narrowest at base, expanding toward apex, then tapering abruptly to blunt apex in ventral view (Fig. 5g). Parameres obliquely truncated apically, longer than half length of penis guide, densely covered with a group of long setae at apices, and its apical 1/3 length with a papilla bearing a stout seta on inner side (Fig. 5h).

Female externally similar to male but with abdominal ventrite 5 rounded apically.

Type materials. Holotype: male, No. 20050319043, **China: Guangdong:** Xiaohuangshan, Nanling National Nature Reserve, Shaoguan City, 24°54.76'N, 113°2.83'E, ca 800 m, 1. X. 2004, Ren SX leg. **Paratypes (12): Guangdong:** 1♂ with same data as holotype except "Chen JJ leg". **Hunan:** 1♂, Mangshan National Nature Reserve, Yizhang County, 24°58.83'N, 112°53.14'E, ca 700 m, 2. X. 2004, Ren SX leg. **Tianjin:** 3♂6♀, Baxianshan National Nature Reserve, Ji County, 40°11.27'N, 117°33.19'E, ca 500 m, 14. VII. 2011, Chen XS leg. **Shanxi:** 1♂, Lishan National Nature Reserve, Yuanqu County, 35°28.39'N, 112°9.45'E, ca 1200 m, 3. VIII. 2011, Chen XS leg.

Distribution. China (Shanxi, Tianjin, Hunan, Guangdong).

Etymology. The specific epithet refers to its paramere with a papilla on the inner side of the apical 1/3 length.

Scymnus (*Parapullus*) *dichotomus* sp. n.

http://zoobank.org/8D650875-A228-462F-9A0A-FAC4133A1697
Figs 6, 11

Diagnosis. This species is similar to *Scymnus* (*Parapullus*) *aduncatus* Chen, Ren & Wang, 2012 in general appearance, but can be distinguished from it by having robust basal part of penis guide in lateral view (Fig. 6h) and the blunt apex in lateral view (Fig. 6g).

Description. TL: 2.16 mm, TW: 1.46 mm, TH: 0.97 mm, TL/TW: 1.48, PL/PW: 0.52, EL/EW: 1.14, HW/PW: 0.63, PW/EW: 0.71.

Body elongate oval, moderately convex, dorsum covered with white pubescence (Figs 6a–c). Head, antennae and mouthparts brown. Pronotum yellowish brown. Scutellum black. Elytra black with apical 1/6 yellowish brown. Prothoracic hypomeron and prosternum yellowish brown. Mesoventrite, metaventrite and elytral epipleura black. Legs brown.

Head with fine frontal punctures, as large as eye facets, 1.0–2.0 diameters apart. Eyes densely faceted, interocular distance 0.49 times head width. Pronotal punctures larger than those on frons, 1.0–2.0 diameters apart. Surface of elytra with punctures similar to those on pronotum, separated by 2.0–3.0 diameters. Prosternal process trapezoidal, 2 times as long as its width at base; with lateral carinae distinct, extending to anterior margin of prosternum, slightly convergent anteriorly. Abdominal postcoxal lines weakly recurved and distinctly incomplete laterally (Fig.

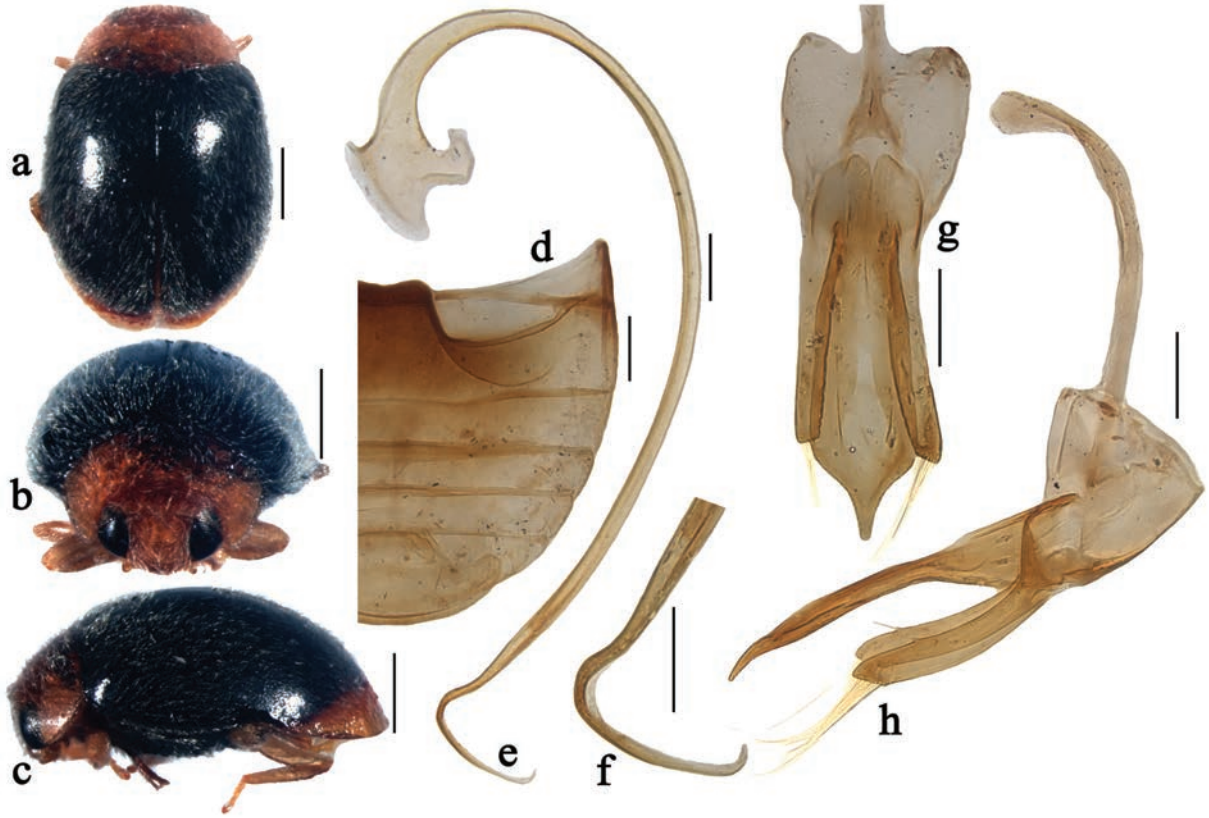

Figure 5. *Scymnus* (*Parapullus*) *papillatus* sp. n.: **a** dorsal view; **b** anterior view; **c** lateral view; **d** abdomen; **e** penis; **f** apex of penis; **g** tegmen, ventral view; **h** tegmen, lateral view. Scale bars: **a–c** 0.5 mm, **d** 0.2 mm, **e–h** 0.1 mm.

Figure 6. *Scymnus* (*Parapullus*) *dichotomus* sp. n.: **a** dorsal view; **b** anterior view; **c** lateral view; **d** abdomen; **e** penis; **f** apex of penis; **g** tegmen, ventral view; **h** tegmen, lateral view. Scale bars: **a–c** 0.5 mm, **d** 0.2 mm, **e–h** 0.1 mm.

6d), reaching 4/5 length of abdominal ventrite 1, area enclosed by lines finely punctate, broadly smooth along line. Abdominal ventrite 5 in male with apex truncate.

Male genitalia: penis slender (Fig. 6e). Penis capsule stout with outer arm large and inner arm strongly curved upwardly. Apex of penis simple (Fig. 6f). Tegmen stout (Figs 6g–h) with penis guide narrowest at base, expanding toward apex, then tapering abruptly to blunt apex in ventral view (Fig. 6g) and strongly curved outwardly in lateral view (Fig. 6h). Parameres slightly constricted at base, distinctly shorter than penis guide, densely covered with two groups of long setae at apices (Fig. 6h).

Female unknown.

Type material. Holotype: male, No. SCAU (E) 11388, **China: Yunnan:** Xujiaba, Ailaoshan National Nature Reserve, Jingdong County, 24°32.77'N, 101°01.69'E, ca 2500 m, 17. VIII. 2013, Chen XS leg.

Distribution. China (Yunnan).

Etymology. The specific epithet refers to its apex of paramere densely covered with two groups of long setae.

Scymnus (*Parapullus*) *shenmuensis* sp. n.

http://zoobank.org/99B80354-E9DD-4153-930A-27AB9F692328
Figs 7, 12

Diagnosis. This species is similar to *Scymnus* (*Parapullus*) *secula* Yang, 1978 in general appearance and male genitalia, but can be separated from it by the brown pronotum with a large black marking (Fig. 7a–b) and the apex of penis stout, hook-shaped (Fig. 7f).

Description. TL: 2.18 mm, TW: 1.46 mm, TH: 0.98 mm, TL/TW: 1.49, PL/PW: 0.46, EL/EW: 1.20, HW/PW: 0.57, PW/EW: 0.77.

Body elongate oval, slightly convex, dorsum covered with white pubescence (Figs 7a–c). Head, antennae and mouthparts dark brown. Pronotum brown with a large black marking. Scutellum black. Elytra black with apical 1/6 yellowish brown. Prothoracic hypomeron and prosternum brown. Mesoventrite, metaventrite and elytral epipleura black. Legs brown.

Head with fine frontal punctures, slightly larger than eye facets, 0.5–1.0 diameter apart. Eyes densely faceted, interocular distance 0.50 times head width. Pronotal punctures as large as those on frons, 1.0–2.0 diameters apart. Surface of elytra with punctures larger than those on pronotum, separated by 2.0–3.0 diameters. Prosternal process trapezoidal, 2 times as long as its width at base; with lateral carinae distinct, extending to anterior margin of prosternum, slightly convergent anteriorly. Abdominal postcoxal lines strongly recurved and distinctly incomplete laterally (Fig. 7d), reaching 5/6 length of abdominal ventrite 1, area enclosed by lines irregularly punctate, narrowly smooth along line. Abdominal ventrite 5 in male with apical margin shallowly emarginated medially.

Male genitalia: penis stout (Fig. 7e). Penis capsule with small inner arm and large outer arm. Apex of penis stout with membranous appendage, hook-shaped (Fig. 7f). Tegmen stout (Figs 7g–h) with penis guide narrowest at base, expanding toward apex, then tapering abruptly to blunt apex in ventral view (Fig. 7g) and its apex slightly curved outwardly in lateral view (Fig. 7h). Parameres slightly curved at base, distinctly shorter than penis guide, densely covered with two groups of long setae at apices (Fig. 7h).

Female unknown.

Type material. Holotype: male, No. SCAU (E) 11455, **China: Taiwan:** Shenmu Railway Station, Alishan Mountains, Jiayi County, 23°31.12'N, 120°48.37'E, ca 2200 m, 23. X. 2012, Chen XS leg.

Distribution. China (Taiwan).

Etymology. The specific epithet refers to its type locality, Shenmu Railway Station in Alishan Mountains, Taiwan.

Scymnus (*Parapullus*) *yanzigouensis* sp. n.

http://zoobank.org/1CC0B157-15A9-4F86-85AA-29FB14857F92
Figs 8, 12

Diagnosis. This species is similar to *Scymnus* (*Parapullus*) *nanlingicus* Chen, Ren & Wang, 2012 in general appearance and male genitalia, but can be separated from it by having broad area enclosed by abdominal postcoxal lines (Fig. 8d) and the parameres narrowest at base, expanding toward apex in lateral view (Fig. 8h).

Description. TL: 2.20–2.42 mm, TW: 1.52–1.67 mm, TH: 0.99–1.05 mm, TL/TW: 1.45, PL/PW: 0.51, EL/EW: 1.13–1.14, HW/PW: 0.56–0.58, PW/EW: 0.73–0.74.

Body oval, moderately convex, dorsum covered with white pubescence (Fig. 8a–c). Head, antennae and mouthparts brown. Pronotum yellowish brown. Scutellum dark brown. Elytra black with apical 1/4 yellowish brown. Prothoracic hypomeron and prosternum yellowish brown. Mesoventrite, metaventrite and elytral epipleura black. Legs brown.

Head with fine frontal punctures, as large as eye facets, 0.5–1.0 diameters apart. Eyes densely faceted, interocular distance 0.47 times head width. Pronotal punctures similar to those on frons, 1.0–2.0 diameters apart. Surface of elytra with punctures larger than those on pronotum, separated by 2.0–3.0 diameters. Prosternal process rectangular, 2 times as long as its width at base; with lateral carinae distinct, parallel, extending to anterior margin of prosternum. Abdominal postcoxal lines strongly recurved and distinctly incomplete laterally (Fig. 8d), reaching 7/8 length of abdominal ventrite 1, area enclosed by lines irregularly punctate, broadly smooth along line. Abdominal ventrite 5 in male with apex truncate.

Male genitalia: penis stout (Fig. 8e). Penis capsule with outer arm stout and inner arm strongly curved, hook-shaped. Apex of penis simple (Fig. 8f). Tegmen stout (Fig. 8g–h) with penis guide parallel sided from base to 4/5 length, then tapering abruptly to blunt apex in ventral view (Fig. 8g). Parameres narrowest at base, expanding toward apex, distinctly shorter than penis guide, densely covered with two groups of long setae at apices (Fig. 8h).

Female unknown.

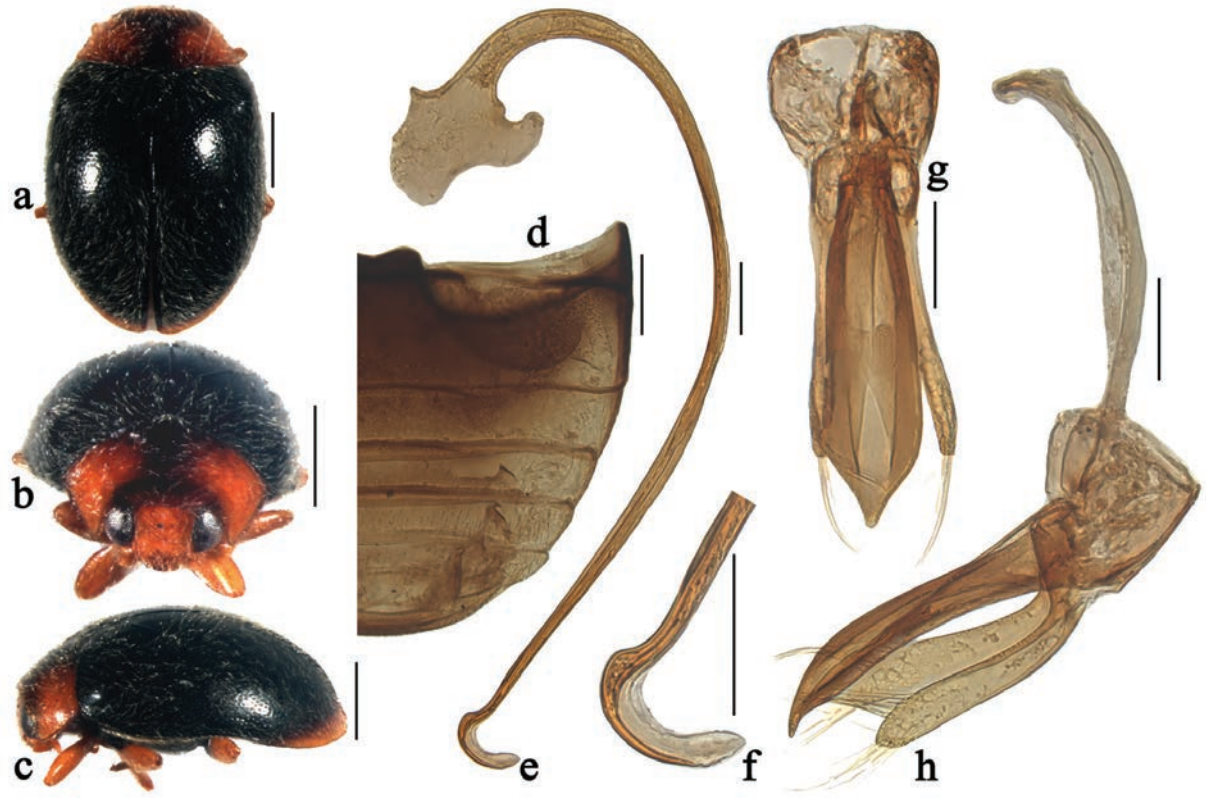

Figure 7. *Scymnus* (*Parapullus*) *shenmuensis* sp. n.: **a** dorsal view; **b** anterior view; **c** lateral view; **d** abdomen; **e** penis; **f** apex of penis; **g** tegmen, ventral view; **h** tegmen, lateral view. Scale bars: **a–c** 0.5 mm, **d** 0.2 mm, **e–h** 0.1 mm.

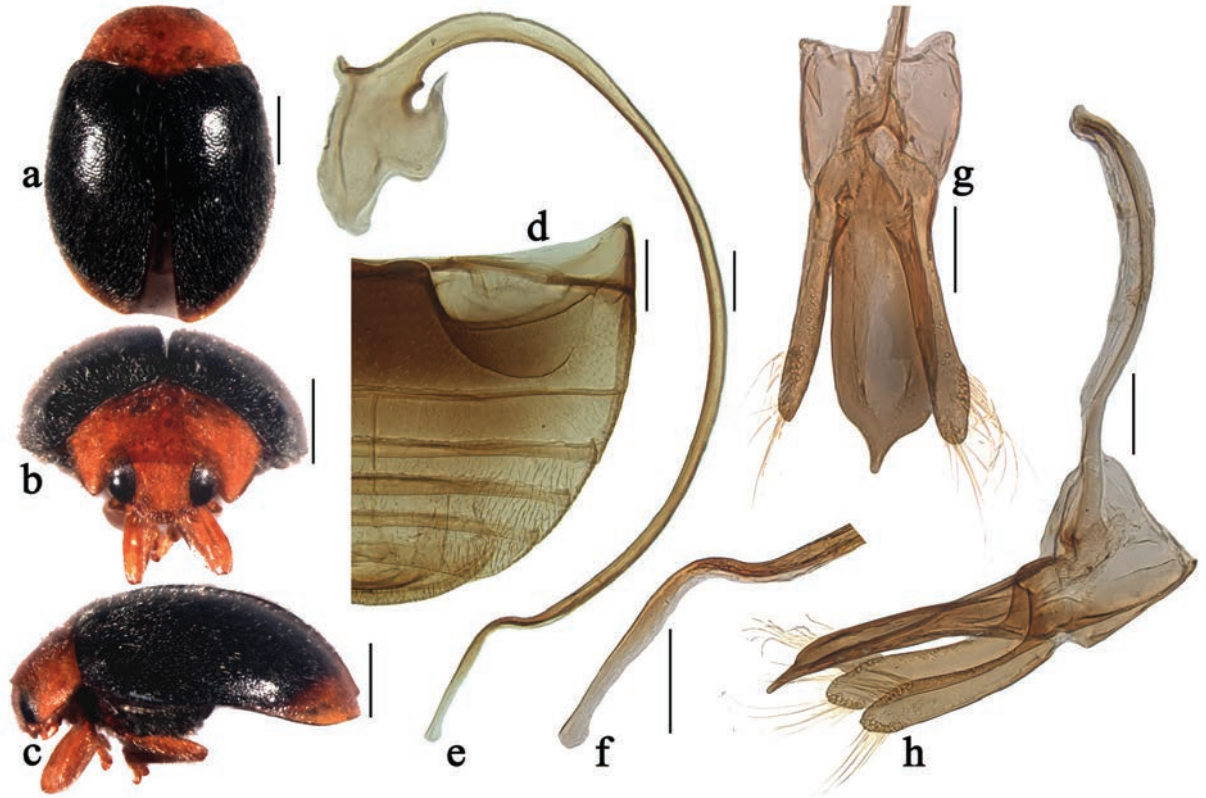

Figure 8. *Scymnus* (*Parapullus*) *yanzigouensis* sp. n.: **a** dorsal view; **b** anterior view; **c** lateral view; **d** abdomen; **e** penis; **f** apex of penis; **g** tegmen, ventral view; **h** tegmen, lateral view. Scale bars: **a–c** 0.5 mm, **d** 0.2 mm, **e–h** 0.1 mm.

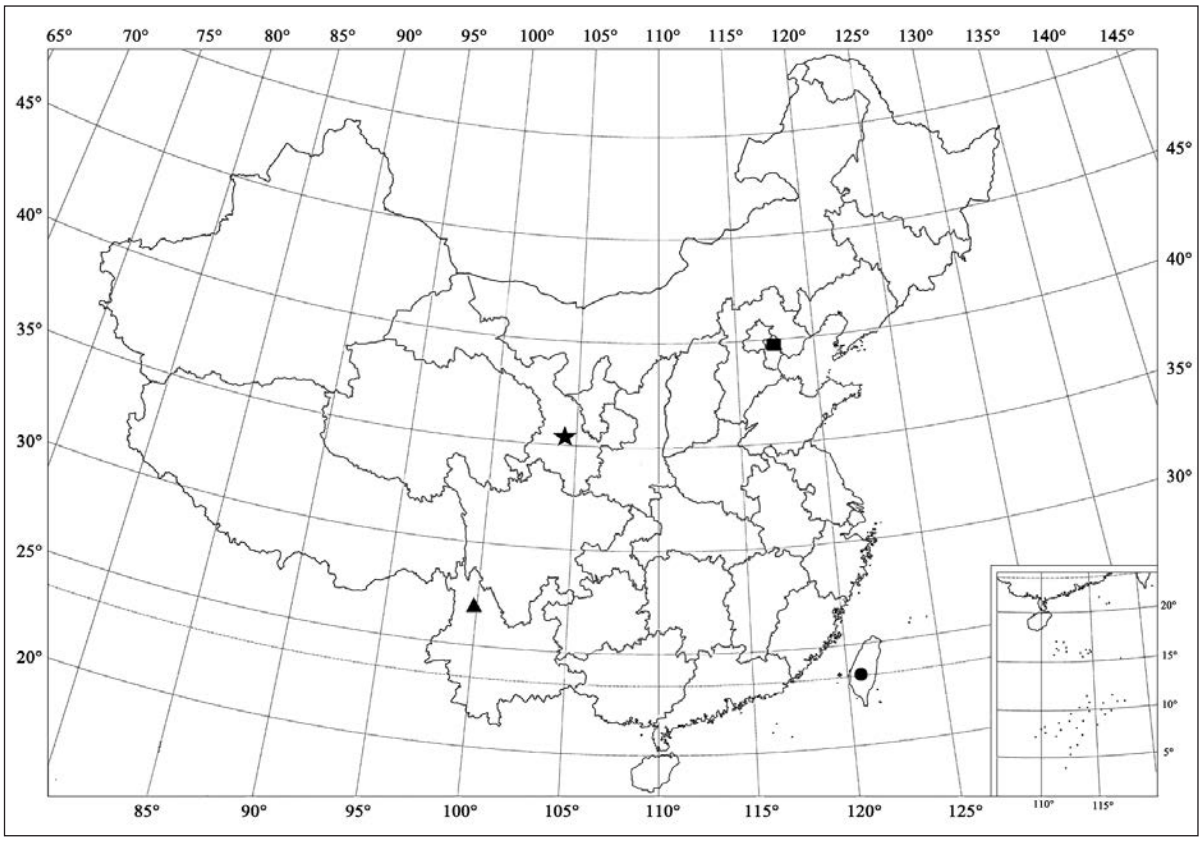

Figure 9. Distribution map. *Scymnus* (*Parapullus*) *hastatus* sp. n. (★); *Scymnus* (*Parapullus*) *tsugae* Yu & Yao (▲); *Scymnus* (*Parapullus*) *alishanensis* Pang & Yu (●); *Scymnus* (*Parapullus*) *baxianshanensis* sp. n. (■).

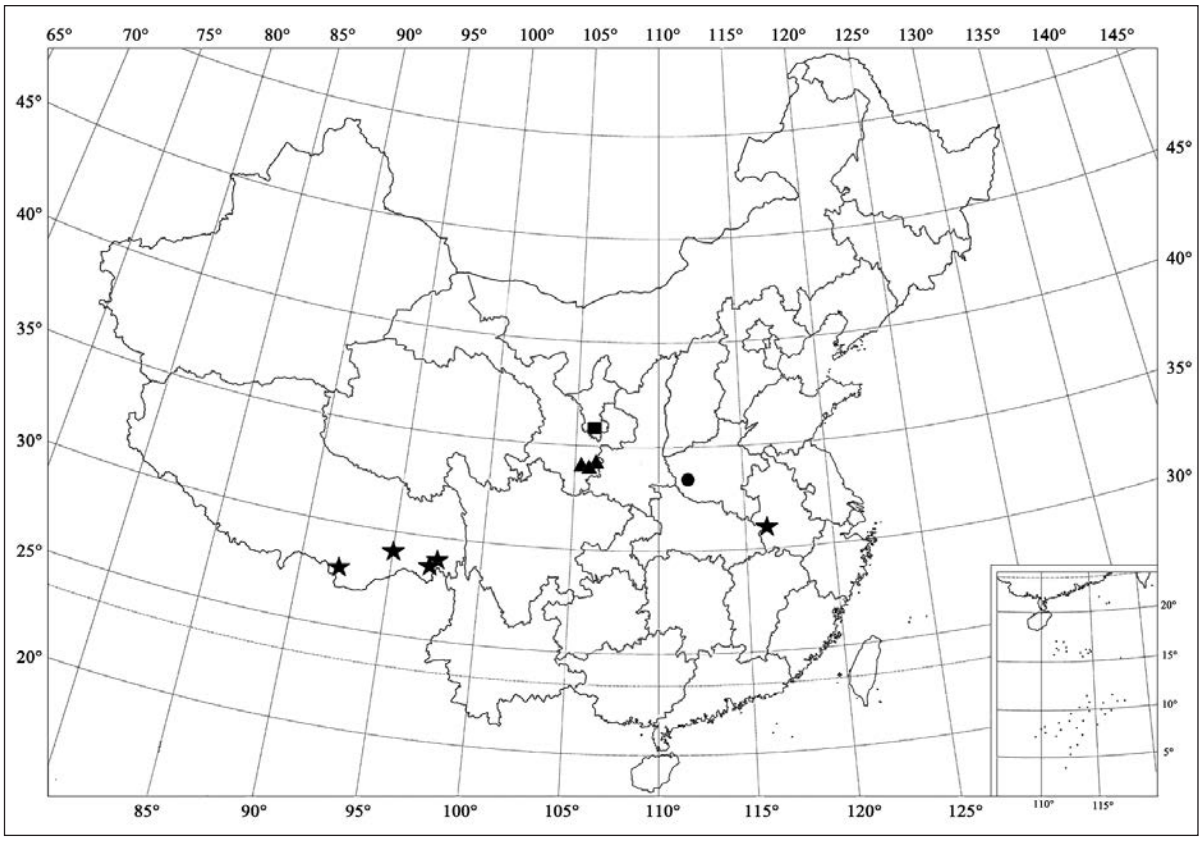

Figure 10. Distribution map. *Scymnus* (*Parapullus*) *laojielingensis* sp. n. (●); *Scymnus* (*Parapullus*) *parallelicus* Chen, Ren & Wang (▲); *Scymnus* (*Parapullus*) *annuliformis* sp. n. (★); *Scymnus* (*Parapullus*) *malleatus* Chen, Ren & Wang (■).

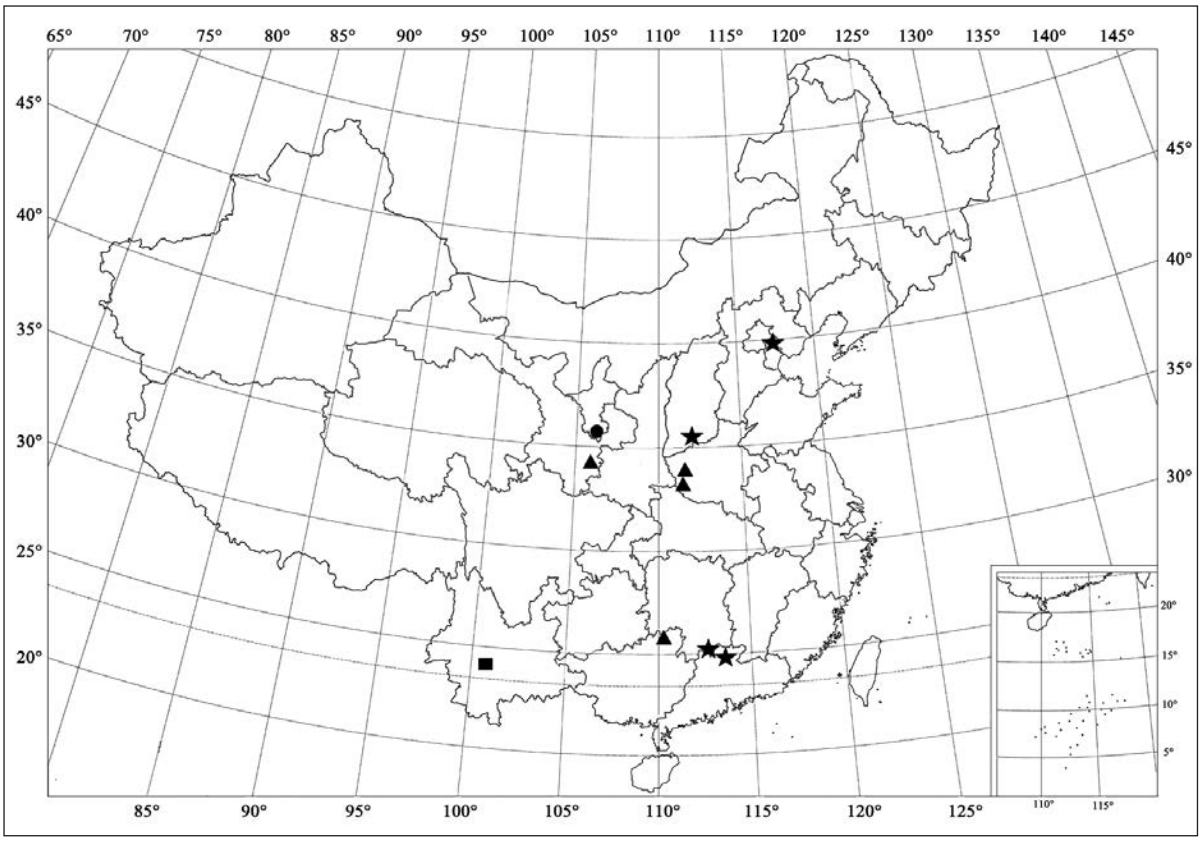

Figure 11. Distribution map. *Scymnus* (*Parapullus*) *papillatus* sp. n. (★); *Scymnus* (*Parapullus*) *solus* Chen, Ren & Wang (▲); *Scymnus* (*Parapullus*) *aduncatus* Chen, Ren & Wang (●); *Scymnus* (*Parapullus*) *dichotomus* sp. n. (■).

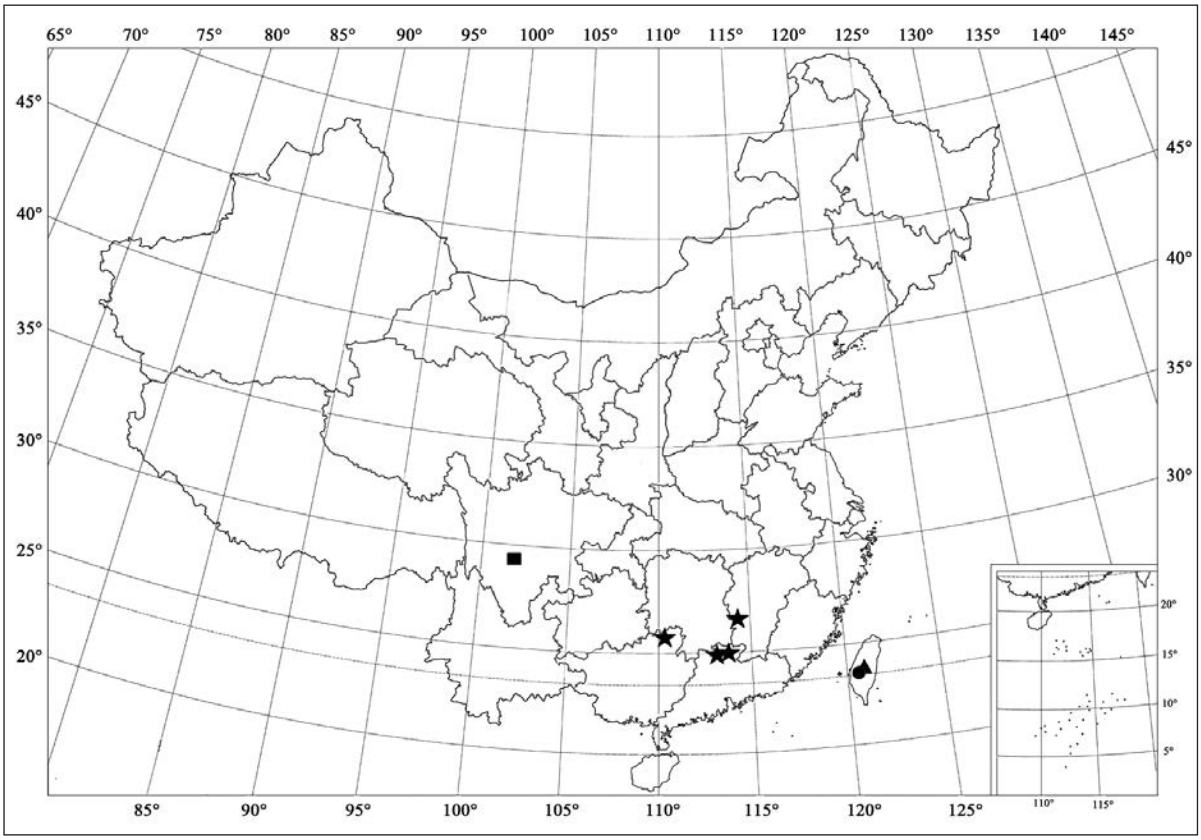

Figure 12. Distribution map. *Scymnus* (*Parapullus*) *shenmuensis* sp. n. (●); *Scymnus* (*Parapullus*) *secula* Yang (▲); *Scymnus* (*Parapullus*) *nanlingicus* Chen, Ren & Wang (★); *Scymnus* (*Parapullus*) *yanzigouensis* sp. n. (■).

Type materials. Holotype: male, No. SCAU (E) 11531, **China: Sichuan:** Yanzigou, Gonggashan National Nature Reserve, Luding County, 29°41.92'N, 102°0.22'E, ca 2500 m, 28. IX. 2007, Chen XS leg. **Paratypes (1):** 1♂ with same data as holotype.

Distribution. China (Sichuan).

Etymology. The specific epithet refers to its type locality, Yanzigou Scenic Spots, Gonggashan National Nature Reserve, Sichuan Province.

Key to the Chinese species of the subgenus *Scymnus* (*Parapullus*) Yang

1	Elytra reddish brown	2
–	Elytra black	9
2	Penis guide not with parallel sided in ventral view	3
–	Penis guide with parallel sided in ventral view	6
3	Parameres slender, slightly longer than penis guide (Fig. 1h); penis guide not constricted medially; apex of penis guide with hook-like appendage in lateral view (Fig. 1h)	*S.* (*P.*) *hastatus* sp. n.
–	Parameres stout, distinctly shorter than penis guide; penis guide constricted medially	4
4	Penis capsule not emarginated medially; parameres broad, distinctly expanding toward apex	*S.* (*P.*) *tsugae* Yu & Yao
–	Penis capsule deeply emarginated medially	5
5	Parameres as long as 3/4 length of penis guide	*S.* (*P.*) *alishanensis* Pang & Yu
–	Parameres as long as 1/2 length of penis guide (Fig. 2h)	*S.* (*P.*) *baxianshanensis* sp. n.
6	Apex of penis stout with membranous appendage (Fig. 3f)	*S.* (*P.*) *laojielingensis* sp. n.
–	Apex of penis slender without membranous appendage	7
7	Prosternal process rectangular	*S.* (*P.*) *parallelicus* Chen, Ren & Wang
–	Prosternal process trapezoidal	8
8	Abdominal postcoxal lines strongly recurved laterally (Fig. 4d); parameres narrow in lateral view (Fig. 4h)	*S.* (*P.*) *annuliformis* sp. n.
–	Abdominal postcoxal lines weakly recurved laterally; parameres broad in lateral view	*S.* (*P.*) *malleatus* Chen, Ren & Wang
9	Apex of parameres densely covered with one group of setae	10
–	Apex of parameres densely covered with two groups of setae	11
10	On the inner side of paramere with a papilla bearing a stout seta at apical 1/3 length (Fig. 5h)	*S.* (*P.*) *papillatus* sp. n.
–	On the inner side of paramere smooth, not with a papilla appendage	*S.* (*P.*) *solus* Chen, Ren & Wang
11	Penis guide strongly curved in lateral view	12
–	Penis guide straight or with apex slightly curved outwardly	13
12	Prosternal process with lateral carinae parallel	*S.* (*P.*) *aduncatus* Chen, Ren & Wang
–	Prosternal process with lateral carinae convergent anteriorly	*S.* (*P.*) *dichotomus* sp. n.
13	Pronotum brown with a large black marking (Fig. 7a)	*S.* (*P.*) *shenmuensis* sp. n.
–	Pronotum entirely brown	14
14	Penis capsule with outer arm narrow, sub-quadrate	*S.* (*P.*) *secula* Yang
–	Penis capsule with outer arm broad, truncate	15
15	Area enclosed by abdominal postcoxal lines relatively narrow	*S.* (*P.*) *nanlingicus* Chen, Ren & Wang
–	Area enclosed by abdominal postcoxal lines relatively broad (Fig. 8d)	*S.* (*P.*) *yanzigouensis* sp. n.

Catalogue of the subgenus *Scymnus* (*Parapullus*) Yang, 1978

***Scymnus* (*Parapullus*) *abietis* (Paykull, 1798)**

Coccinella abietis Paykull, 1798: 154.
Scymnus abietis: Mulsant 1850: 975; Weise 1879: 142; Korschefsky 1931: 117; Gourreau 1974: 109.
Scymnus semilimbatus Fleischer, 1927: 260.
Scymnus (*Scymnus*) *abietis*: Bielawski 1968: 22; 1975: 249; Soares et al. 2003: 27.
Scymnus (*Parapullus*) *abietis*: Pang and Yu 1993: 228; Kovář 2007: 584; Coutanceau 2009: 5; Chen et al. 2012: 22; Borowski 2015: 91.

Distribution. Austria, Belgium, Bulgaria, Belarus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Norway, Poland, Romania, Russia, Slovakia, Sweden, Switzerland, Ukraine, Serbia and Montenegro, Mongolia.

***Scymnus* (*Parapullus*) *aduncatus* Chen, Ren & Wang, 2012**

Scymnus (*Parapullus*) *aduncatus* Chen, Ren & Wang, 2012: 30.
Distribution. China (Ningxia).

***Scymnus* (*Parapullus*) *alishanensis* Pang & Yu, 1993**

Scymnus (*Parapullus*) *alishanensis* Pang & Yu, 1993: 230; Yu et al. 2000: 168; Pang et al. 2004: 82; Kovář 2007: 584; Ren et al. 2009: 68; Chen et al. 2012: 26.
Distribution. China (Taiwan).

***Scymnus* (*Parapullus*) *annuliformis* sp. n.**
Distribution. China (Anhui, Tibet).

***Scymnus* (*Parapullus*) *baxianshanensis* sp. n.**
Distribution. China (Tianjin).

***Scymnus* (*Parapullus*) *coosi* Hatch, 1961**

Scymnus (*Scymnus*) *coosi* Hatch, 1961: 152. Gordon 1976: 20; 1985: 120.
Scymnus (*Parapullus*) *coosi*: Pang and Yu 1993: 229; Chen et al. 2012: 22.
Distribution. USA.

***Scymnus* (*Parapullus*) *dichotomus* sp. n.**
Distribution. China (Yunnan).

***Scymnus* (*Parapullus*) *difficilis* Casey, 1899**

Scymnus (*Scymnus*) *difficilis* Casey, 1899: 154; Leng 1920: 214; Korschefsky 1931: 157; Gordon 1976: 19; 1985: 120.
Scymnus (*Parapullus*) *difficilis*: Pang and Yu 1993: 229; Chen et al. 22.
Distribution. USA.

***Scymnus* (*Parapullus*) *hastatus* sp. n.**
Distribution. China (Gansu).

***Scymnus* (*Parapullus*) *laojielingensis* sp. n.**
Distribution. China (Henan).

***Scymnus* (*Parapullus*) *malleatus* Chen, Ren & Wang, 2012**

Scymnus (*Parapullus*) *malleatus* Chen, Ren & Wang, 2012: 24.
Distribution. China (Ningxia).

***Scymnus* (*Parapullus*) *nanlingicus* Chen, Ren & Wang, 2012**

Scymnus (*Parapullus*) *nanlingicus* Chen, Ren & Wang, 2012: 32.
Distribution. China (Jiangxi, Guangdong, Guangxi).

***Scymnus* (*Parapullus*) *nebulosus* LeConte, 1852**

Scymnus nebulosus LeConte, 1852: 137; Crotch 1874a: 262; Horn 1895: 95; Steinweden 1929: 29.
Scymnus (*Scymnus*) *nebulosus*: Casey 1899: 154; Leng 1920: 214; Korschefsky 1931: 163; Chapin 1974: 22; Gordon 1976: 13; 1985: 119.
Scymnus infuscatus Boheman, 1859: 208; Leng 1920: 214; Korschefsky 1931: 160; Gordon 1976: 15; 1985: 119. Synonymized by Gordon 1976: 15.
Scymnus phelpsii Crotch, 1874b: 77; Horn 1895: 96; Gordon 1976: 15; 1985: 120. Synonymized by Gordon 1976: 15.
Scymnus (*Scymnus*) *phelpsii*: Casey 1899: 154; Leng 1920: 214; Korschefsky 1931: 165; Malkin 1943: 194; Hatch 1961: 153; Belicek 1976: 302; Gordon 1976: 15; 1985: 120.
Scymnus (*Scymnus*) *harneyi* Hatch, 1961: 152; Gordon 1976: 15; 1985: 120. Synonymized by Gordon 1976: 15.
Scymnus (*Parapullus*) *nebulosus*: Pang and Yu 1993: 229; Chen et al. 2012: 22.
Distribution. Canada, USA.

***Scymnus* (*Parapullus*) *papillatus* sp. n.**
Distribution. China (Shanxi, Tianjin, Hunan, Guangdong).

***Scymnus* (*Parapullus*) *parallelicus* Chen, Ren & Wang, 2012**

Scymnus (*Parapullus*) *parallelicus* Chen, Ren & Wang, 2012: 24.
Distribution. China (Gansu).

***Scymnus* (*Parapullus*) *secula* Yang, 1978**

Scymnus (*Parapullus*) *secula* Yang, 1978: 27; Pang and Yu 1993: 229; Yu et al. 2000: 167; Pang et al. 2004: 82; Kovář 2007: 584; Ren et al. 2009: 68; Chen et al. 2012: 32.
Distribution. China (Taiwan).

***Scymnus* (*Parapullus*) *shenmuensis* sp. n.**
Distribution. China (Taiwan).

***Scymnus* (*Parapullus*) *solus* Chen, Ren & Wang, 2012**

Scymnus (*Parapullus*) *solus* Chen, Ren & Wang, 2012: 29.
Distribution. China (Gansu, Henan, Guangxi).

***Scymnus* (*Parapullus*) *tsugae* Yu & Yao, 2000**

Scymnus (*Parapullus*) *tsugae* Yu & Yao in Yu et al. 2000: 168; Pang et al. 2004: 82; Kovář 2007: 584; Chen et al. 2012: 29.
Distribution. China (Yunnan).

***Scymnus* (*Parapullus*) *yanzigouensis* sp. n.**
Distribution. China (Sichuan).

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References

Belicek J (1976) Coccinellidae of western Canada and Alaska with analyses of the transmontane zoogeographic relationships between the fauna of British Columbia and Alberta (Insecta: Coleoptera: Coccinellidae). Quaestiones Entomologicae 12: 283–409.

Bielawski R (1968) Ergebnisse der zoologischen Forschungen von Dr. Z. Kaszab in der Mongolei Nr. 170. Coccinellidae IV (Coleoptera). Fragmenta Faunistica 15(3): 21–30. doi: 10.3161/00159301FF1968.15.3.021

Bielawski R (1975) Ergebnisse der zoologischen Forschungen von Dr. Z. Kaszab in der Mongolei Nr. 352. Coccinellidae V und VI (Coleoptera). Fragmenta Faunistica 20(16): 247–271.

Boheman CH (1859) Coleoptera. Species novas descripsit. In: Kongliga Svenska Fregatten Eugenies Resa Omkring Jorden unter Befall of C. A. Virgin, 1851–1853. Norstedt & Söner, Stockholm. Zoologi. III. Insekter, 113–218.

Borowski J (2015) Beetles (Coleoptera) of the Rogów region. Part II: ladybirds (Coccinellidae). International Letters of Natural Sciences 34: 90–101. doi: 10.18052/www.scipress.com/ILNS.34.90

Casey TL (1899) A revision of the American Coccinellidae. Journal of the New York Entomological Society 7(2): 71–169.

Chapin JB (1974) The Coccinellidae of Louisiana (Insecta: Coleoptera). Louisiana Agricultural Experiment Station Bulletin 682: 2–87.

Chen XS, Ren SX, Wang XM (2012) Revision of the subgenus *Scymnus* (*Parapullus*) Yang from China (Coleoptera: Coccinellidae). Zootaxa 3174: 22–34.

Coutanceau JP (2009) Liste synonymique des Coléoptères Coccinellidae de France continentale et de Corse. Harmonia 3: 3–14.

Crotch GR (1874a) A revision of the Coleopterous family Coccinellidae. Cambriage University Press, London, 311 pp. doi: 10.5962/bhl.title.8975

Crotch GR (1874b) Descriptions of new species of Coleoptera from the Pacific Coast of the United States. Transactions of the American Entomological Society 5: 73–80.

Fleischer A (1927–1930) Přehled brouků fauny Československé republiky. Práce z entomologického oddělení Moravského zemského musea, Brno, č. 1. 486 pp.

Gordon RD (1976) The Scymnini (Coleoptera: Coccinellidae) of the United States and Canada: Key to genera and revision of *Scymnus*, *Nephus* and *Diomus*. Bulletin of the Buffalo Society of Natural Sciences 28: 1–362.

Gordon RD (1985) The Coccinellidae (Coleoptera) of America North of Mexico. Journal of the New York Entomological Society 93(1): 1–912.

Gourreau JM (1974) Systematique de la tribu des Scymnini (Coccinellidae). Institut National de la Recherche Agronomique, Paris, 221 pp.

Hatch MH (1961) Beetles of the Pacific Northwest, Part III: Pselaphidae and Diversicornia. University Washington Press, Seattle, 503 pp.

Horn GH (1895) Studies in Coccinellidae. Transactions of the American Entomological Society 22: 81–114.

Korschefsky R (1931) Coleopterorum Catologus. Pars 118. Coccinellidae. I. Berlin, 224 pp.

Kovář I (2007) New nomenclatorial and taxonomic acts and comments. Coccinellidae. In: Löbl I, Smetana A (Eds) Catalogue of Palaearctic Coleoptera, Volume 4. Apollo Books, Stenstrup, 71–73, 568–631.

LeConte JL (1852) Remarks upon the Coccinellidae of the United States. Proceeding of the Academy of Natural Science of Philadelphia 6: 129–145.

Leng CW (1920) Catalogue of the Coleoptera of America, north of Mexico. Mount Vernon, New York, 470 pp.

Malkin B (1943) A catalogue of Oregon Coccinellidae. Journal of the New York Entomological Society 51: 191–198.

Mulsant E (1850) Species de Coléoptères Trimères Sécuripalpes. Annales des Sciences Physiques et Naturelles, d'Agriculture et d'Industrie, publiées par la Société nationale d' Agriculture, etc., de Lyon, Deuxième Série 2: xv + 1–1104 pp (part 1 pp. 1–450; part 2 pp. 451–1104).

Pang XF, Yu GY (1993) Validity of *Scymnus* (*Parapullus*) Yang with description of a new species (Coleoptera: Coccinellidae) from Taiwan. The Coleopterists Bulletin 47(3): 228–231.

Pang H, Ren SX, Zeng T, Pang XF (2004) Biodiversity and their utilization of Coccinellidae in China. Science and Technology Press of Guangdong, Guangzhou, 168 pp. [In Chinese]

Paykull G (1798) Anmårkningar vid genus *Coccinella*, och beskisning öfver de Svånska arter deraf som åro med fina hår beströdde. Kongliga Vetenskaps Akademiens nya Handlingar 19: 144–156.

Ren SX, Wang XM, Pang H, Peng ZQ, Zeng T (2009) Colored pictorial handbook of ladybird beetles in China. Science Press, Beijing, 336 pp. [In Chinese]

Ślipiński A (2007)Australian ladybird beetles (Coleoptera: Coccinellidae): their biology and classification. ABRS, Canberra, 286 pp.

Ślipiński A, Tomaszewska W (2010) Coccinellidae Latreille, 1802. In: Leschen RAB, Beutel RG, Lawrence JF (Eds) Handbook of Zoology, Vol. 2, Coleoptera. Walter de Gruyter GmbH & Co. KG, Berlin/New York, 454–472.

Soares AO, Elias RB, Raimundo A (2003) New records of Scymnini (Coleoptera: Coccinellidae) to Madeira Island. Boletim do Museu Municipal do Funchal 54(311): 25–29.

Steinweden JB (1929) Notes on the origin of the wax secretions of certain coccinellid larvae. Pan-Pacific Entomologist 6: 26–32.

Weise J (1879) Bestimmungs Tabellen der europaischen Coleopteren II. Coccinellidae. Zeitschrift für Entomologie (N. F.) (Breslau) 7: 88–156.

Yang CT (1978) A new subgenus and species of Coccinellidae. Bulletin of the Society of Entomology 13(1): 27–28.

Yu GY, Montgomery ME, Yao DF (2000) Lady beetles (Coleoptera: Coccinellidae) from Chinese hemlocks infected with the hemlock woolly adelgid, *Adelges tsugae* Annand (Homoptera: Adelgidae). The Coleopterists Bulletin 54(2): 154–199. doi: 10.1649/0010-065X(2000)054[0154:LBCCFC]2.0.CO;2

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PENSOFT

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A new genus and two new species of Pterostichini from China, with "sphodrine-like" parameres (Coleoptera, Carabidae)

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Abstract

A new genus of Pterostichini, *Apophylon* Guéorguiev & Sciaky, **gen. n.** (type species: *Apophylon schillhammeri* Guéorguiev & Sciaky, **sp. n.**) is proposed for *Apophylon schillhammeri* Guéorguiev & Sciaky, **sp. n.** (type locality: China, SE Guizhou Province, Leishan County, SE Kaili) and *Apophylon pangu* Guéorguiev & Sciaky, **sp. n.** (type locality: China, NW Hunan Province, Wulingyuan District, near the town of Wulingyuan). These two species share a unique combination of characters, not known in any other Pterostichini. The new genus can be distinguished by having (1) a left paramere without transverse apophysis; (2) a falcate right paramere, with styloid apex, broadened medial part and subbasal hasp; (3) a median lobe with dorsal ostium; (4) metatarsomeres 1-2 setose on the medioventral surface, in addition to the lateroventral setae; (5) meso- and metatarsomeres 1–4 with two dorsolateral grooves diverging distally; and (6) elytral striae with shining isodiametric microreticulation, which is in contrast to less shining transverse-mesh microreticulation on the elytral intervals.

Introduction

This paper describes a new genus and two new species of pterostichine beetles from China. As frequently occurs, especially in terms of individual collections from little investigated areas, one species is described upon a single male specimen. As these species have been rarely collected in the past, we do not anticipate additional specimens to be available for study in the near future. The uniqueness of these beetles persuaded us to describe these species with a hope that this will encourage more investigations in the region.

The first author visited the Naturhistorisches Museum Wien, Vienna in 2011 borrowing a small collection of unidentified carabids. Among those was a single male specimen with a habitus rather unusual for a Pterostichini found in the region. The examination of the genitalia and various characters revealed a species with retained primitive features of the median lobe of the aedeagus and parameres. The combination of characters states are evidence that the specimen in question belongs to a new species and is both generically distinctive and systematically isolated from all other pterostichines. Some years earlier, four adult specimens similar to the above specimen had been borrowed for study from the NMW by the second author. These specimens had only been partly studied since they were teneral and very fragile. The subsequent study and comparison of these five specimens showed that they belong to two related species from a peculiar lineage of the tribe Pterostichini. The following character states: 1/ mandibular scrobe without seta; 2/ basal bulb of the aedeagus closed dorsally; 3/ parameres unsetose and dissimilar in shape, left paramere conchoid; 4/ frons with two supraorbital setae; 5/ antennae filiform, with segments 1–3 without pubescence; 6/ labial palpomere 2 with two median setae; 7/ apicolateral elytral

plica present, externally visible; and 8/ elytron with parascutellar pore inside base of second stria, determine the inclusion of the new taxa into this tribe.

Materials and methods

Measurements were made with a calibrated ocular micrometer mounted on a stereoscopic binocular Olympus SZX10 microscope. Photos were taken with a Zeiss Stemi 2000 microscope equipped with an AxioCam ERc 5s camera and were stacked using the free software CombineZM of Alan Hadley (version 26 April 2008). Drawings were made using a Zeiss transmitted-light microscope.

Measurements: body length from the apex of the longer mandible in closed position to the apex of the longer elytron (BL); body width as maximum distance across the widest point of elytra (BW); linear distance from apex of longer mandibular to the imaginary line connecting the posterior end of tempora (HL); maximum linear distance across the head, including the eyes (HW); length of pronotum, measured along the midline, from the apical margin to the basal margin (PL); maximum width of pronotum (PW); width of the pronotal apex, between the tips of the fore angles (PaW); width of the pronotal base, between the tips of the hind angles (PbW); length of elytra, from the basis of scutellum to the apex of the longer elytron (EL); maximum width of elytra (EW).

The examined material is deposited in the following collections:

NMNHS National Museum of Natural History, Sofia (Borislav Guéorguiev)
NMW Naturhistorisches Museum Wien, Vienna, Austria (Harald Schillhammer)
cRS collection Riccardo Sciaky, Milano, Italy

For naming the units of the female genital tract, we follow the scheme used by Liebherr and Will (1998) and borrow some terms from Ball and Shpeley (2013). The distribution map was made using the online mapping software SimpleMappr (©David P. Shorthouse)

Taxonomy

PTEROSTICHINI Bonelli, 1810

Diagnosis. Integument glabrous; frons usually with two pair of supraorbital setae (one seta in *Haptotapinus* Reitter, 1886, *Haptoderotapinus* Jedlička, 1930 and *Unitrichus* Sciaky, 1997, three or more setae in *Rambousekiella* Knirsch, 1925 and *Ethira* Andrewes, 1936); mandibular scrobe without seta; antennae filiform, antennomeres 1–3 glabrous (antennomere 3 pubescent in *Molops* Bonelli, 1810, *Rambousekiella* Knirsch, 1925, and a few West Mediterranean genera), scape attached to pedicel centrically; penultimate labial palpomere usually with two median setae, without apical setae (2–5 median setae and 1–3 apical setae in some species of *Cyclotrachelus* Chaudoir, 1838, cfr. Bousquet 1999: 195, 1–5 apical setae in *Steropanus* Fairmaire, 1888); pronotum usually with one anterolateral and one posterolateral seta (two or more anterolateral setae in *Parapterostichus* Desbrochers des Loges, 1906 and *Ethira* Andrewes, 1936, posterior setae absent in *Tapinopterus* Schaum, 1858, *Speluncarius* Reitter, 1886 and *Neostomis* Bousquet, 1983); procoxal cavities uniperforated and closed; mesocoxal cavities conjunct (mesepimeron does not reach the middle coxal cavity); metepisternum separated from metepimeron by distinct suture, laterally not coadunate with elytral epipleuron; elytron with parascutellar pore (if present) near or inside base of the second stria and apicolateral plica (secondarily lost in several groups); protibia with outer apical angle not produced; posterior margin of mesofemur with at least two long setae; metacoxa usually with two lateral setae (a third seta at medial position in *Cryobius* Chaudoir, 1838, *Tapinopterus* Schaum, 1858, *Speluncarius* Reitter, 1886, *Rambousekiella* Knirsch, 1925 and *Pseudorambousekiella* Schweiger, 1967); claws smooth; median lobe of aedeagus tube-like, with basal bulb closed dorsally; parameres without setae, the left paramere mostly conchoid; gonocoxal rami absent.

The lack of synapomorphies, in either adult or larval stages, yet discovered to suggest that the tribe (about 2500 species) forms a monophyletic lineage, arrives at the conclusion that it is an evolutionary grade (Bousquet 2012).

Apophylon Guéorguiev & Sciaky, gen. n.

http://zoobank.org/15484C26-BD49-4303-8232-D877C8DACEEF

Type species. *Apophylon schillhammeri* sp. n.

Diagnosis. The following combination of morphological features distinguishes this taxon from all the other Pterostichini known to date:

1) mentum transverse, weakly emarginate;
2) pronotal basal impressions, lateral margins and basal part of midline, as well as the elytral striae both grooved and widened;
3) elytral microreticulation double, isodiametric within the striae, transverse-mesh on the intervals;
4) apicolateral plica of elytron large and visible;
5) parascutellar striola absent, i.e. striola anastomosing in full with stria 1;
6) angular base of stria 1 absent;
7) stria 7 shallow (punctiform) in anterior half;
8) parascutellar setiferous punctures present at base of stria 2;
9) no discal setiferous punctures in interval 3;
10) remnants of both stria 9 and interval 10 present along penultimate fifth of elytron;
11) meso- and metatarsomeres 1–4 with two dorsolateral grooves divergent distally;

12) metatarsomeres 1–2 (and sometimes metatarsomere 3) setose on medioventral surface, in addition to the lateroventral setae;
13) tarsomere 4 moderately emarginate along apical margin in all legs;
14) abdominal sternite 6 bisinuate and bordered along apical margin in both sexes, flat and smooth in males, impressed and rugose on apical part in females.
15) median lobe of aedeagus with dorsal ostium;
16) left paramere without transverse apophysis;
17) right paramere falcate, with styloid apex, medial part broadened and hasp situated at subbasal position;
18) laterotergite and basal gonocoxite 1 both with trichoid setae;
19) apical gonocoxite narrowed distally, with apex widely rounded, two ensiform setae, two nematiform setae, and a lots of pit pegs on dorsal and ventral surfaces.

Description. *Habitus*. Size medium (ca. 12.5–13.5 mm) for Oriental Pterostichini, shape elongate, subparallel (Figs 1, 11). *Tegument*. Glabrous throughout (excl. antennomeres 4–11), dorsally smooth; sternal parts partly punctate, namely postgenae, proepisterna, mesosternum and mesosterna, gula of head, prosternum and proepipleura impunctate, abdomen mostly impunctate, slightly wrinkled laterally. *Color*. Body dark brown to black on dorsal and ventral surface, antennae, palpomeres and legs red-brown to black. *Microsculpture*. Present (*A. pangu*) or largely reduced (*A. schillhammeri*); striae of elytra with shiny isodiametric microreticulation, in contrast to less shiny, transverse-mesh microreticulation on elytral intervals. *Head*. Eyes large, laterally protruding, tempora minute; frons with two well-developed and relatively deep furrows, divergent backward, reaching anterior supraorbital punctures; two pairs of supraorbital punctures, anterior puncture just before middle of eye, posterior one at posterior fifth of eye; antennae long, filiform, with segments 1–3 and basal fifth of segment 4 glabrous, pubescent from antennomere 4, scape shorter than antennomere 3, with single dorsal seta distally, pedicel with one ventral seta, not eccentrically attached to scape, segment 3 with six apical setae, end of antennomere 8 and antennomeres 9–11 exceeding posterior margin of pronotum; labrum subrectangular, with anterior margin concave in middle and six equidistant setae, middle four shorter than lateral two; clypeus subtrapezoid, with anterior margin straight and with two punctures removed from anterior margin at distance of one and a half diameters of puncture and closer to lateral margins than to anterior margin; mandibles large, elongate, more or less pointed and hooked at apex; maxillae shorter than mandibles, stipes with two long lateroventral setae; ligula with two setae, paraglossae long, glabrous (Fig. 3); labial palpomeres elongate, fusiform, with penultimate segment bisetose; maxillary palpi considerably longer than labial palpi, with glabrous and elongate segments; labium with distinct suture between mentum and submentum, mentum transverse, weakly emarginate, sides of sinus widely divergent, epilobes narrow, median tooth large, weakly emarginate, slightly bifid in front, bordered posteriorly, labial setae long, paramedial pits indistinct; submentum with two medial setae, without lateral setae (Fig. 3). *Thorax*. Pronotum subcordate, wider than long, widest before middle; midline narrow anteriorly and wide posteriorly, not reaching anterior and posterior borders; anterotransverse sulcus superficial; two basal impressions, linear, wide, deep, and divergent to base; anterior border slightly narrower than basal border, concave medially, finely rimmed laterally, rim obliterated medially; sides rounded anteriorly, sinuate before posterior angles, with wide and grooved lateral margin from each side; basal border slightly convex, oblique towards angles, not rimmed; anterior angles rounded, hardly protruding; posterior angles distinct, obtuse, slightly outward protruded; anterolateral and posterolateral setiferous punctures present. Elytra elongate, not fused, widest after middle, with slightly convex disc and subapical sinuation; apicolateral plica present, large and visible from above and at sides; basal border complete, touching stria 1; shoulders completely rounded, without denticles; striae wide, deep, impunctate; stria 7 shallow along anterior half of elytron, with one or two preapical setiferous punctures (posterior one closer to apex of elytron than to suture) (Figs 4, 13); stria 9 present along penultimate fifth of elytron; parascutellar striola anastomosing with stria 1, angular base of stria 1 absent; intervals smooth, 7–8 almost fused anteriorly; interval 9 beginning from umbilicate puncture III, not reaching apex; interval 10 present at penultimate fifth of elytron; parascutellar setiferous punctures present, small, situated at base of stria 2; no discal setae in interval 3; umbilicate series mostly with 16 pores (sometimes 15, 17, or 18), indistinctly divided into humeral and apical groups by an interruption between pores VII and VIII, interruption as long as double distance between pores VI and VII, humeral group of seven pores, I-III situated before beginning of interval 8, IV-VII within stria 8, III larger than rest, apical group of nine pores, all within stria 8, pores XI and XVI larger than others. Hind wings present. Prosternum smooth, prosternal process unbordered, proepipleura broadened posteriorly. Metasternum smooth, mostly impunctate, finely punctate only laterally, metepisterna finely punctate, twice longer than wide, strongly narrowed posteriorly. Legs moderately long and slender; procoxa without seta; mesocoxa with one lateral and one medial seta; metacoxa with two lateral setae, one anterolateral and one posterolateral seta, without medial seta, with metacoxal sulcus arcuate and ended before lateral end of coxa; protrochanter with one anterior seta at distal position; mesotrochanter with one posterior seta at distal position; metatrochanter without seta (but one female paratype of *A. pangu* with a seta at proximal position on left metatrochanter); profemur with three long setae on posterior surface, one proximal, one medioventral and one distal seta; mesofemur with three long setae

on anterior surface, two closely situated proximal setae and one medioventral seta; metafemur with two long setae on anterior surface, one proximal seta and one medioventral seta; protibia rather dilated distally in both sexes, with two long clip setae; mesotibia nearly as long as mesofemur, with ventral ctenidium well differentiated; metatibia longer than metafemur; all tarsomeres dorsally glabrous (only tarsomere 5 with a pair of subapical setae), with two rows of lateroventral setae, glabrous on medioventral surface, except for metatarsomeres 1–2 (and sometimes metatarsomere 3) which are setose also medioventrally (Fig. 5), tarsomere 4 with apical emargination from above in all legs, meso- and metatarsomeres 1–4 with two dorsolateral grooves, posteriorly divergent (Fig. 6); male protarsomeres 1–3 strongly and symmetrically expanded, biseriate squamose beneath, segment 1 and 2 nearly equal in width, segment 3 flatter and narrower than previous two; tarsal claws smooth, one seta at base of each tarsal claw. *Abdomen*. Sternites 3–5 each with a pair of ambulatory setae, sternites 4–6 without transverse sulci, terminal sternite 6 in both sexes bisinuate and bordered marginally, in males flat and smooth with two large terminal setiferous punctures (Fig. 7), in females apically impressed and rugose, with four terminal setiferous punctures (Fig. 17). *Male genitalia*: aedeagus (Figs 8–10, 14–16). Median lobe of aedeagus long, in lateral view strongly arcuate ventrally, with basal bulb large and well developed, basal orifice concave, medial part narrower than bulb, apical lamella slightly bent ventrally; median lobe dorsally elongate, slightly bent to right apically, with left margin straight to slightly concave and right margin convex, apical lamella somewhat narrowed before tip, thereupon widened, subapical orifice (ostium) on dorsal side, elongate, extended over entire dorsum; inner sac of aedeagus with or without chitinized structures, with complex membranous pattern distally. Left paramere conchoid, without transverse apophysis, with small apical denticle on ventral margin. Right paramere falcate, attenuate at apex, broadened medially, with a hasp situated at subbasal position. *Female genitalia* (Figs 19–21), consisting of bipartite laterotergits and gonocoxae (latter clearly separated into basal gonocoxite 1 and apical gonocoxite 2). Laterotergite subtriangular, articulated to lateral base of gonocoxite 1, with protruding apophysis on anterior margin and 10–12 trichoid setae on posterior margin medially; gonocoxite 1 relatively narrow, elongate, with several long trichoid setae on ventral surface laterodistally; gonocoxite 2 not curved, with sides narrowed distally, apex not tapering, but widely rounded, two broad ensiform setae, one dorsomedial and one dorsolateral, preapical sensory furrow on ventral surface, with a furrow peg bearing two long and thin nematiform setae, and numerous pit pegs on both surfaces.

Etymology. *Apophylon* is a compound word, based on the Greek prefix ἀπό [apó] (away from, separate) and φύλον [fýlon] (tribe, clan), alluding to the putative systematic remoteness of this taxon concerning its relatives. It is treated as a Greek neuter.

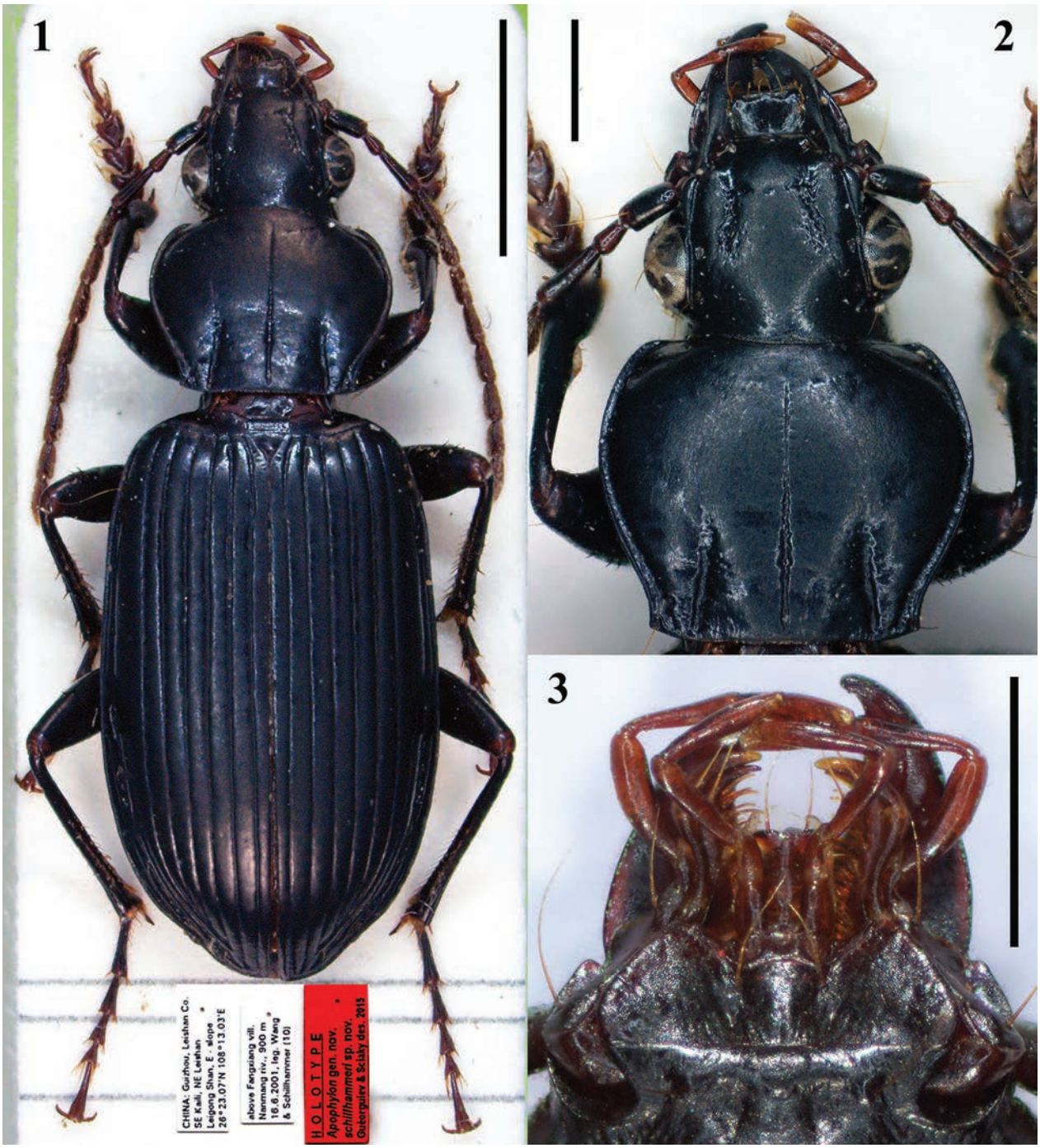
Apophylon schillhammeri Guéorguiev & Sciaky, sp. n.

http://zoobank.org/A13E950C-2BAC-43F4-A332-72A1FED0171A
Figs 1–10

Type material. Holotype ♂, well-preserved (metarsomeres 3 and 5 of the left hind leg were lost after taking Fig. 1), "CHINA, Guizhou, Leishan Co. SE Kali, NE Leishan Leigong Shan, E - slope 26°23.07'N 108°13.03'E" [printed, white] / "above Fangxiang vill. Nanmang riv., 900 m 16.6.2001, leg. Wang & Schillhammer (10)" [printed, white] / "HOLOTYPE *Apophylon* gen. nov. *schillhammeri* sp. nov. Guéorguiev & Sciaky des. 2015" [printed, red]. The holotype is preserved in NMW. The genitalia of the holotype are preserved in glycerine inside a plastic vial pinned under the card on which the specimen is mounted.

Diagnosis. See Table 1.

Description (based on male only). *Habitus* (Fig.1). Elongate, subparallel, moderately convex. *Tegument*. Dorsally smooth, largely impunctate, only head in frontal furrows and vertex laterally, as well as pronotum base between impressions coarsely punctate. *Measurements and ratios*. See Table 2. *Color*. Body anthracite black dorsally and ventrally, antennomeres 2–11, palpomeres and tarsomeres dark red to fire brick red. *Microsculpture*. Chiefly reduced (not visible); isodiametric on pronotal lateral margins and basal impressions, elytral basal border and striae, transverse-mesh on labrum and abdominal sterna in middle. *Lustre*. Dorsal and ventral surfaces moderately shiny, prosternal process, metasternum, and abdominal sterna shinier medially. *Head* (Fig. 2). Longer than wide, slightly narrower than pronotum; disc smooth; eyes as long as 1.2 times length of antennomere 3, tempora minute, ca. 1/5 of length of eye; frontal furrows wide, deep, roughly and coarsely punctate on inside and marginally; vertex with some large, scattered punctures on each side; clypeal suture partly obliterated; mandibles lightly pointed and hooked at apex. *Thorax*. Pronotal disc slightly convex, mostly smooth, only internal margin at each basal impression with a few coarse punctures; anterior angles rounded, hardly protruded; posterior angles obtuse, slightly protruded outside (Fig. 2). Elytra elongate, with sides narrowed towards base, widened towards apex; shoulders completely rounded; striae well-impressed, both grooved and wide; stria 7 with one preapical setiferous puncture (Fig. 4); intervals impunctate, smooth, 1–3 flat over most extent, 4–9 subconvex; intervals 2 and 8 fused apically; single apical puncture on lateral margin behind both end of stria 7 and junction of intervals 2 and 8 (Fig. 4); umbilicate series with 16 pores on left elytron and 18 pores on right elytron, humeral group of seven pores on both elytra, apical group consists of nine pores on left elytron and eleven pores on right elytron. Hind wings present. Prosternal process with posterior margin rounded. Legs moderately long and slender; metatarsomeres 1–2 setose medioventrally, in addition to lateroventral setae. *Abdomen*. Terminal sternite 6 distinctly sinuate and bordered on ex-



Figures 1–3. *Apophylon* gen. n. *schillhammeri* sp. n. from vil. Fangxiang, Guizhou, China, holotype. **1** Habitus; **2** Head and pronotum; **3** Head, ventral part of mouthparts. Scale lines: 3 mm (Fig. 1); 1 mm (Figs 2–3).

ternal margin, with two large marginal punctures (Fig. 7). *Male genitalia* (Figs 8–10). Median lobe of aedeagus long, ventrally bent at an angle of nearly 90˚, dorsally slightly curved to right apically, with apical lamella narrowed before tip, thereupon widened, subquadrate at tip, with a left-sided lobe prominent. Inner sac of aedeagus with a submedial lamella transversely situated, large and well chitinized. Left paramere conchoid, without transverse apophysis, with apical denticle on ventral margin (Figs 8–9, c–d). Right paramere falcate, with apical part protracted, medial part moderately broadened and a hasp at subbasal position (Figs 8–9, b, e).

Etymology. A noun in the genitive case for the collector of the holotype of this new species, the prominent specialist of Staphylinidae Harald Schillhammer.

Type locality and habitat. Harald Schillhammer (personal communication) kindly provided us detailed description for the site and time when the holotype of *A. schillhammeri* sp. n. was collected: “9) SE Kaili, Leishan Co., NE Leishan, E - slope of Leigong Shan, 26°26.59’N,

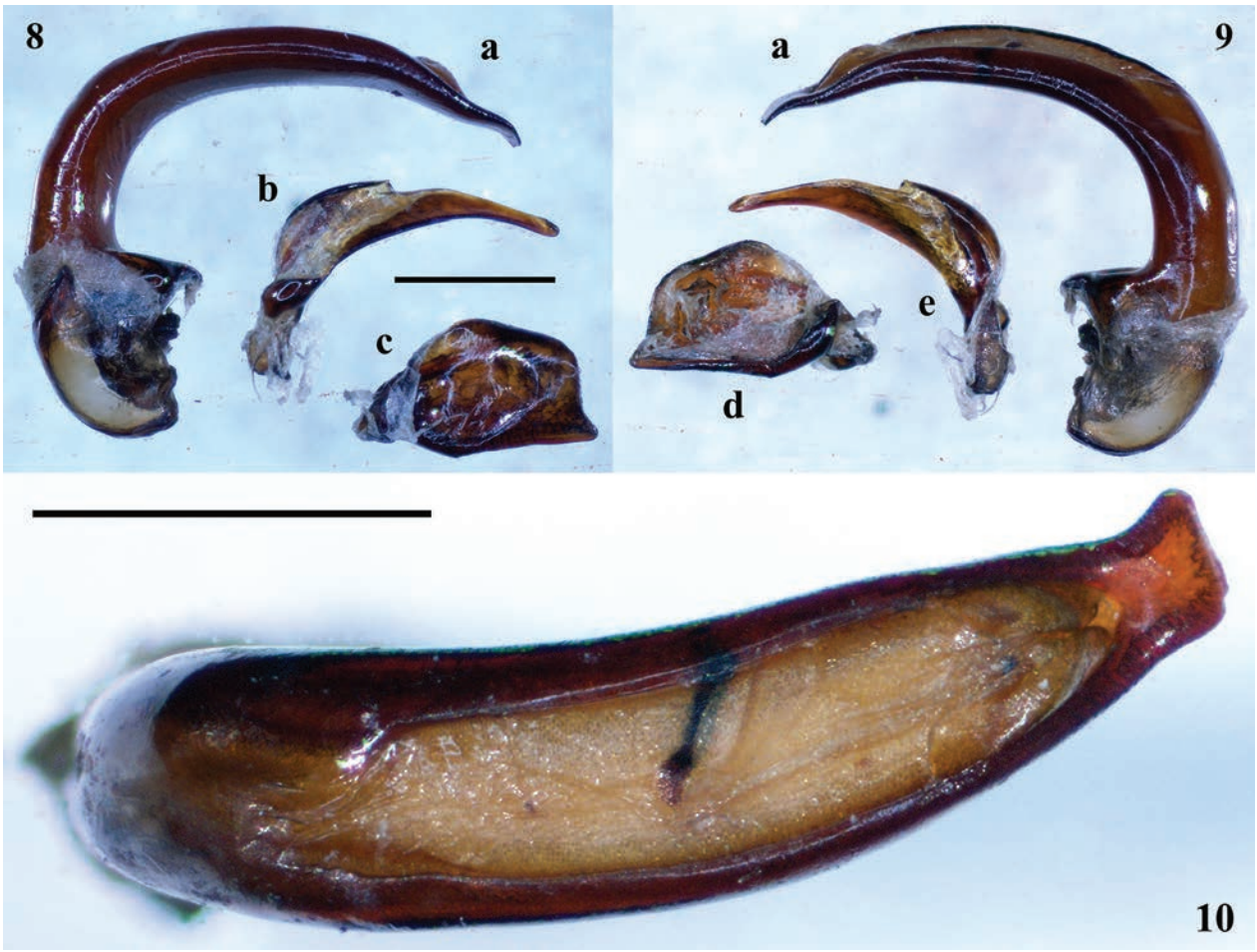
Table 1. Diagnostic features of *Apophylon* species.

Diagnostic feature	***A. schillhammeri* sp. n.**	***A. pangu* sp. n.**
A. Morphological features		
EL/EW	1.64	1.73–1.80
EL/PL	2.88	2.98–3.18
punctuation of tegument dorsally	largely impunctate (excl. head and base of pronotum)	largely with micropunctures
microsculpture dorsally	mostly reduced, distinct only on labrum, pronotum basal impressions and lateral margins, elytral basal border and striae	developed, distinct on head, pronotum and elytra
frontal furrows on head	wide, coarsely punctate (Fig. 2)	narrow, with micropunctures (Fig. 12)
vertex of head laterally	with several large punctures (Fig. 2)	with micropunctures (Fig. 12)
clypeal suture	partly obliterated (Fig. 2)	present, fine (Fig. 12)
punctuation of the pronotum basis, between the impressions	internal margin of each impression with a few coarse punctures (Fig. 2)	whole area with micropunctures and several longitudinal wrinkles (Fig. 12)
elytral intervals 1–3 anteriorly	flat	subconvex
elytral intervals 2 and 8	fused apically (Fig. 4)	divided apically by stria 7 (Fig. 13)
setiferous punctures within stria 7	one (Fig. 4)	two, as apical one on very end of stria (Fig. 13)
prosternal process posterior margin	rounded	nearly straight
median lobe of aedeagus in lateral view	more arcuate ventrally (Figs 8-9)	less arcuate ventrally (Figs 14–15)
apical lamella of aedeagus in dorsal view	subquadrate at tip, with a left sided lobe (Fig. 10)	nearly rounded at tip, without prominent lobe (Fig. 16)
internal sac of aedeagus	with a large, well chitinized lamella (Fig. 10)	without lamella (Fig. 16)
right paramere	more attenuate apically, moderately broadened medially (Figs 8–9)	shortly attenuate apically, strongly broadened medially (Figs 14–15)
B. Geographical features		
Area of distribution (river valley)	Yuan River Watershed: upper Qingshui River Basin (Fig. 22)	Lishui River Watershed: Suoxi River Basin (Fig. 22)

Figures 4–7. *Apophylon* gen. n. *schillhammeri* sp. n. from vil. Fangxiang, Guizhou, China, holotype. **4** Apex of elytra (**a** preapical puncture in stria 7; **b** apical setiferous puncture behind end of stria 7; **c** fused intervals 2 and 8); **5** Left metatarsus, ventral view; **6** Right mesotarsus, dorsal view; **7** Abdominal sternites 4–6, ventral view. Scale lines: 1 mm (Figs 4–7).

108°16.53'E, ca. 900 m, Nanmang river at and above Fangxiang village, ca. 15-20 m wide, variably fast flowing, slightly polluted by surrounding farmland. 16.6.2001, leg. Schillhammer & Wang; 10) as 9), gravel banks, large-sized stones (up to 50 cm diameter), with interstitial of fine sand and clay. 16.6.2001, leg. Schillhammer & Wang".

According to this information, the correct GPS coordinates of the type locality are 26°26.59'N, 108°16.53'E, which differ from the data written on the label pinned under the specimen (see "Type material"). In reality, it was an error in the process of printing the labels (Harald Schillhammer, personal communication).



Figures 8–10. *Apophylon* gen. n. *schillhammeri* sp. n. from vil. Fangxiang, Guizhou, China, holotype. **8–10.** Aedeagus (**8** left lateral view; **9** right lateral view; **10** dorsal view; **a** median lobe; **b** right paramere, internal face; **c** left paramere, external face; **d** left paramere, internal face; **e** right paramere, external face). Scale lines: 1 mm (Figs 4–10).

Table 2. Data about variation in measurements and ratios among the species of *Apophylon* gen. n.

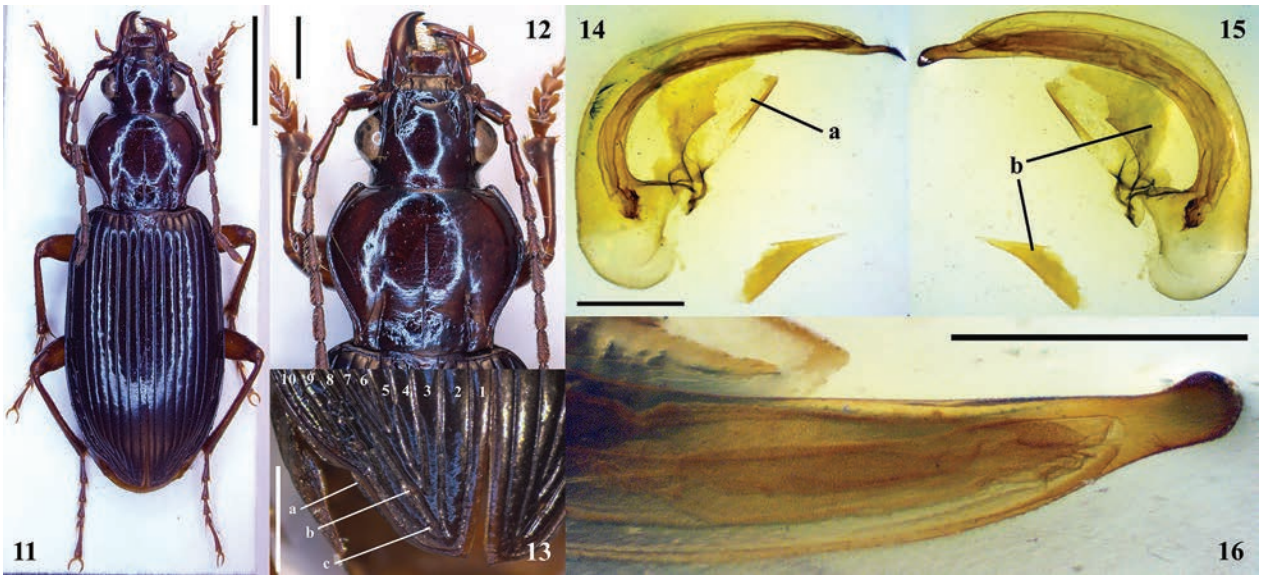
Measurement and ratios	***A. schillhammeri* sp. n.**	***A. pangu* sp. n.**					
	HT♂	HT♂	1PT♀	2PT♀	3PT♀	range	mean
BL (mm)	12.6	13.1	13.8	13.1	13.8	13.1–13.8	13.45
BW (mm)	4.4	4.4	4.5	4.4	4.4	4.4–4.5	4.43
PW/HW	1.37	1.39	1.4	1.45	1.38	1.38–1.45	1.41
PW/PL	1.29	1.25	1.26	1.29	1.25	1.25–1.29	1.26
PW/PaW	1.47	1.49	1.43	1.47	1.38	1.38–1.49	1.44
PW/PbW	1.4	1.42	1.37	1.43	1.38	1.37–1.43	1.4
PbW/PaW	1.05	1.05	1.04	1.02	1	1.00–1.05	1.03
EL/EW	1.64	1.73	1.8	1.77	1.77	1.73–1.80	1.77
EL/PL	2.88	2.98	3.06	3.18	3.08	2.98–3.18	3.08
EW/PW	1.4	1.38	1.34	1.4	1.38	1.34–1.40	1.38

The small river of Nanmang flows into the upper part of the basin of the Qingshui River. The Qingshui enters the Yuan River, which is one of the main tributaries of the Yangtze River in Hunan. Most probably, the species is a hygrophilous upland dweller that lives adjacent to water. Administratively, the type locality is in Leishan County, Qiandongnan Miao and Dong Autonomous Prefecture, south-eastern part of Guizhou Province, China (Fig. 22).

Apophylon pangu Guéorguiev & Sciaky, sp. n.

http://zoobank.org/0A24BF2E-E805-45DF-9FDF-6EF9FC1A1FE5
Figs 11–21

Type material. Holotype ♂, well-preserved, no part missing, “CHINA, NW-Hunan 1993 Wulingyuan, N Dayong Zangjiajie, 30.10., 450m leg. Schillhammer (4)” [printed, white] / “HOLOTYPE *Apophylon* gen. nov.

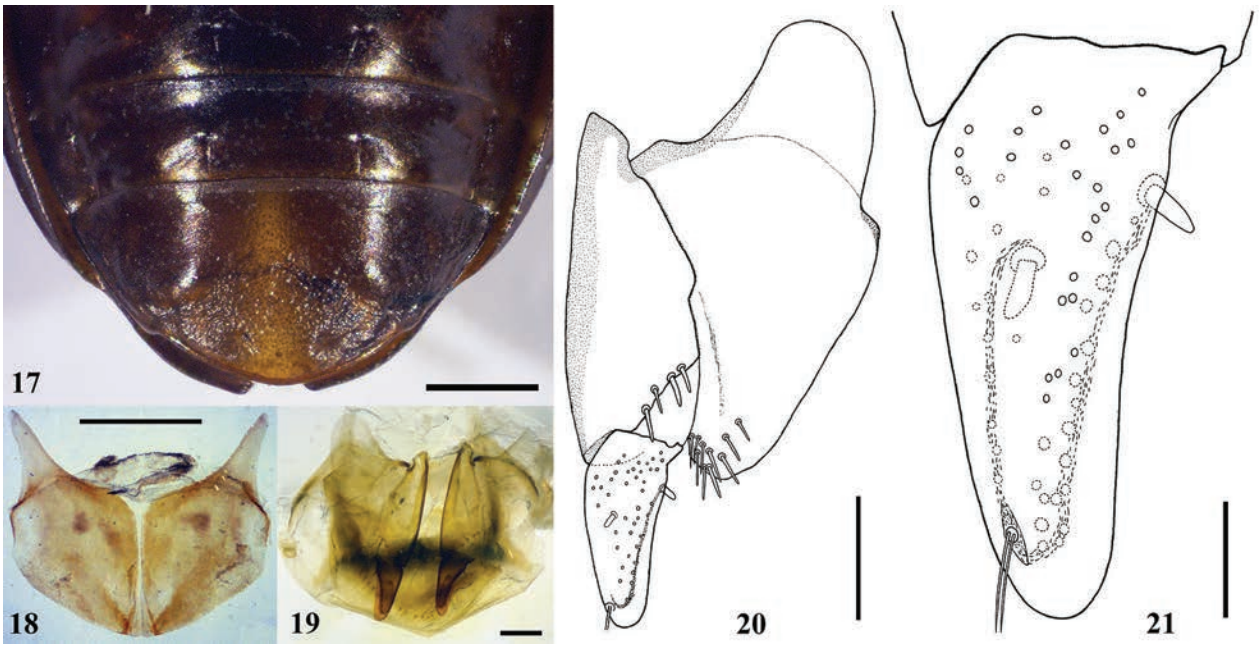


Figures 11–16. *Apophylon* gen. n. *pangu* sp. n. from Zhangjiajie national Forest Park, Hunan, China, holotype. **11** Habitus; **12** Head and pronotum; **13** Apex of left elytron (**a** apicolateral plica; **b** preapical puncture in stria 7; **c** apical setiferous puncture at end of stria 7; **1–10** numeration of intervals); **14–16**. Aedeagus with attached parameres (**14** left lateral view; **15** right lateral view; **16** dorsal view; **a** left paramere; **b** right paramere). Scale lines: 3 mm (Fig. 11); 1 mm (Figs 12–16).

pangu sp. nov. Guéorguiev & Sciaky des. 2015" [printed, red]. Paratypes 3♀♀, each one supplied with a first label as that of the holotype, and with a second label: "PARATYPE *Apophylon* gen. nov. *pangu* sp. nov. Guéorguiev & Sciaky des. 2015" [printed, red]. The holotype and one paratype are preserved in NMW, while the other two paratypes are deposited in NMNHS and cRS, respectivelly. The genitalia of the holotype are preserved in Euparal on a separate piece of plastic pinned under the card on which the specimen is mounted.

Diagnosis. See Table 1.

Description. *Habitus* (Fig. 11). Elongate, subparallel, slightly convex. *Tegument*. Dorsally smooth, but head, pronotum and elytra with micropunctures visible at higher magnification. *Measurements and ratios*. See Table 2. *Color*. Body rufous to black dorsally and ventraly, antennomeres 2–11, palpomeres and tarsomeres lighter. *Microsculpture*. Isodiametric to slightly transverse-mesh on head and pronotum, distinctly transverse-mesh on elytra and abdominal sterna. *Lustre*. Body throughout moderately shiny. *Head* (Fig. 12). Longer than wide, narrower than pronotum; disc moderately convex; eyes as long as 1.1 times length of antennomere 3, tempora minute, ca. 1/4 of length of eye; frontal furrows narrow, with micropunctures; vertex without large punctures; clypeal suture present, fine; mandibles pointed and hooked at apex. *Thorax*. Pronotal disc slightly convex, with micropunctation throughout and several longitudinal wrinkles between basal impressions; anterior angles rounded, slightly protruded; posterior angles obtuse, slightly protruded outside (Fig. 12). Elytra with sides narrowed towards base, widened towards apex; shoulders completely rounded; striae well-impressed, wide and somewhat grooved; stria 7 with two setiferous punctures, a larger preapical and a smaller apical, as latter on very end of stria (Fig. 13); intervals smooth, with scattered micropunctation, subconvex; intervals 2 and 8 divided apically by stria 7; umbilicate series mostly with 16 pores (sometimes 15 or 17), humeral group of seven pores, apical group of nine pores. Hind wings present. Prosternal process with posterior margin nearly straight. Legs moderately long and slender; metatarsomeres 1–2, and sometimes metatarsomere 3, setose medioventrally, in addition to lateroventral setae. *Abdomen*. Sternite 6 in both sexes bisinuate and bordered marginally, in males flat and smooth with two large marginal setiferous punctures, in females impressed and rugose apically with four punctures (Fig. 17); postabdominal sternite 7 of female short, consisting of two chitinized plates closely connected with a tight membrane each to other, each plate proximally with well-developed ramus (Fig. 18). *Male genitalia* (Figs. 14–16). Median lobe of aedeagus long, ventrally bent at an angle lesser than 90˚, dorsally slightly curved to right apically, with apical lamella somewhat narrowed before tip, thereupon widened and rounded at tip. Inner sac of aedeagus without chitinized structures. Left paramere conchoid, without transverse apophysis, with apical denticle on ventral margin (Figs 14–15, a). Right paramere broken, but clearly falcate, with apical part shortly attenuate, medial part strongly broadened and a hasp at subbasal position (Figs 14–15, b). *Female genitalia* (Figs 19–21). Laterotergite subtriangular, with round, protruding apophysis anteriorly and group of 10–12 trichoid setae posteromedially; gonocoxite 1 relatively narrow, elongate, nearly twice as long as gonocoxite 2, with four long trichoid setae on ventral surface; gonocoxite 2 rather wide, about two and a half times longer than wide, with sides narrowed distally, apex widely rounded, two broad ensiform setae, one



Figures 17–21. *Apophylon* gen. n. *pangu* sp. n. from Zhangjiajie national Forest Park, Hunan, China, female paratype. **17** Abdominal sternites 5–6, ventral view; **18** Postabdominal sternite 7, dorsal view; **19** Gonocoxae, ventral view; **20** Left gonocoxa and left laterotergite, ventral view; **21** Left gonocoxite 2, ventral view. Scale lines: 1 mm (Figs 17–18); 0.3 mm (Figs 19–20); 0.1 mm (Fig. 21).

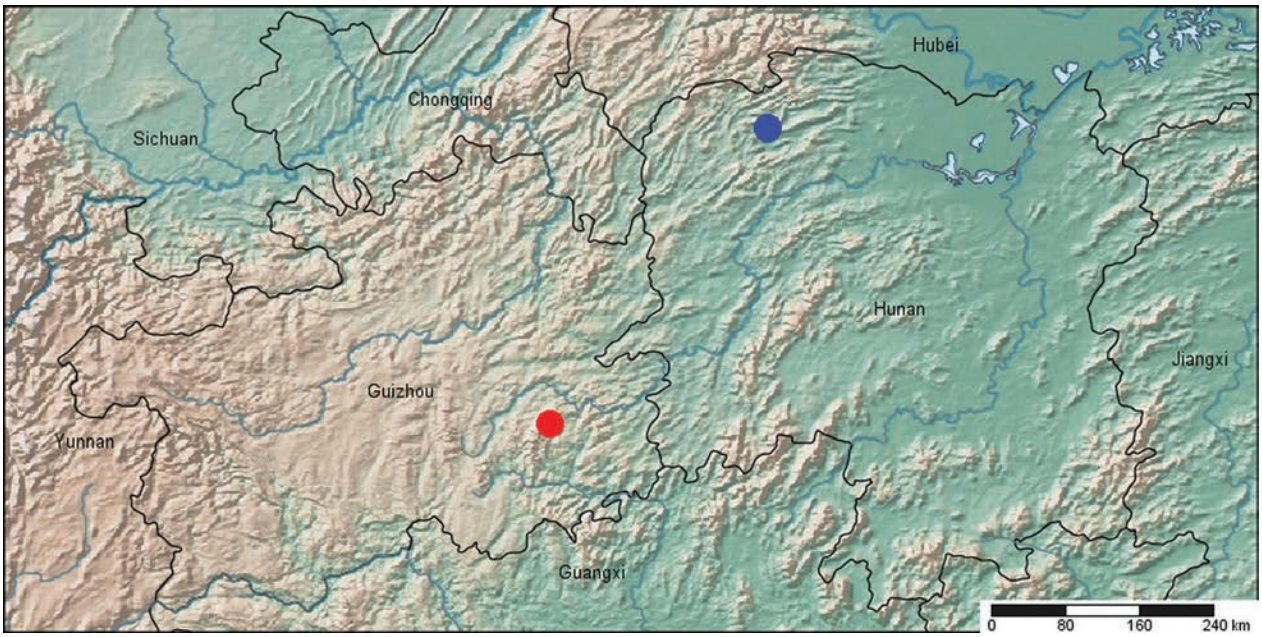


Figure 22. Map of the provinces of Guizhou and Hunan with localities (**red circe** type locality of *Apophylon* gen. n. *schillhammeri* sp. n.; **blue circle** type locality of *Apophylon* gen. n. *pangu* sp. n.).

dorsomedial and one dorsolateral, ensiform setae slightly shorther than both nematiform setae and trichoid setae of laterotergite and basal gonocoxite, preapical sensory furrow on ventral surface, with furrow peg bearing two very long and thin nematiform setae, and numerous pit pegs on both surfaces (some larger pit pegs more or less regularly arranged along dorsal edge spreading between two ensiform setae).

Etymology. A noun in the nominative for the Chinese deity Pangu or Pan Gu, who is the first living being and the creator of everything in some versions of Chinese mythology.

Type locality and habitat. The field notebook of Harald Schillhammer (personal communication) indicates the following data about the site and time when the type series of *A. pangu* sp. n. was collected: “Zhangjiajie For-

est National Park, Suoxiyu Nature Reserve, Wulingyuan section (ca. 30 km N Zhangjiajie City); ca. 2 km downstream of Shuiraosimen; small branch of Jinbian Xi, ca. 1–2 m wide, slowly flowing, with riffle areas and pools; 30.X.1993; leg. Schönmann, Schillhammer & Ji; [4]". According to Harald Schillhammer (personal communication), the altitude of the site of collecting is ca. 450 m and approximate GPS coordinates are 29°21.10'N, 110°29.06'E. This site is located near Wulingyuan Town, Wulingyuan District, Zhangjiajie Prefecture, north-western part of Hunan Province, China (Fig. 22).

The rivers of Shuiraosimen and Jin Bian Xi flow into the basin of the Lishui River (or Li River), which is one of the main tributaries of Yangtze River in Hunan. Most probably, as its congener, the species is a hygrophilous lowland dweller that lives adjacent to water.

Note. We note that the description of *A. pangu* is based on teneral specimens. Hence, some observations, such as micropunctation, microsculpture, color and luster, structure of internal sac of aedeagus, may differ in fully sclerotized adults.

Discussion

The two new species exhibit several peculiar characters which are described below according to their phylogenetic significance. At least the last two of them are suggested to be apomorphic.

1) *Left paramere without transverse apophysis, with apical denticle on ventral margin.*

According to Bousquet (1999), all the genera from the "pterostichite complex" have, or have lost as a second adaptation, a left paramere with transverse apophysis. Based on derived larval characters shared, this author also recognized a "molopite complex" of genera within the "pterostichite complex". He stated that, among the genera of the "molopite complex", only *Abax*, *Molops* and *Percus* possess a left paramere without transverse apophysis. Based on the aforementioned derived character shared by the species of the last three genera, Bousquet considered the lack of transverse apophysis on the left paramere as a result of reversal rather than in a plesiomorphic state. We compared the left parameres of species from *Abax* and *Molops* with that of the new species, and established that the European taxa exhibit a rather modified conchoid type of paramere: more elongate, with a more prominent basal bulge on external face, without apical denticle on the ventral margin. The left parameres in the two species of *Apophylon* gen. n. represents a distinct, maybe archetypal conchoid pattern, i.e. with less prominent basal bulge on the external face and a clear apical denticle on ventral margin (the latter state occurs also in species from subtribe Sphodrina Laporte, 1834, see Casale 1988: 383: Fig. 541, 409: Fig. 581), compared with the left parameres in most Pterostichini. On this ground, taking into account also two characters states shared by the species of *Abax*, *Molops* and *Percus*, i.e. mesotrochanter without seta and highly reduced right paramere, we exclude a relationship between the genera of the "molopite complex" and the new genus from China.

2) *Right paramere falcate, with styloid apex, medial part broadened and hasp situated subbasaly on the internal face.*

This specific shape of right paramere is unknown among the Holarctic and Oriental Pterostichini, though a few species are somewhat similar. *Pterostichus* (*Neohaptoderus*) *kleinfeldianus* Sciaky & Wrase, 1997 (Sciaky and Wrase 1997: 1124, Fig 4c) has a right paramere similarly widened medially, but with a hasp situated medially and a basal part different in form. The medial position of the hasp in most *Pterostichus* Bonelli, 1810 species is presumably the result of a reduction of the apical part of the paramere, while the basal situation of the hasp is a probable plesiomorphic condition. *Pterostichus* (*Petrophilus*) *melanarius* (Illiger, 1798) also possesses a similarly curved right paramere, but it is less broadened medially and thinner apically. These two examples show a convergence in the shape of the right paramere, since the species of this genus differ greatly in other traits (median lobe of aedeagus with ostium situated on the left site, left paramere with transverse apophysis, etc.) that are completely different from those in the new species. Completely different shaped is the right paramere in the species from the large Holarctic genus *Poecilus* Bonelli, 1810, which is short, not elongate apically (cfr. Jeannel 1942, Fig. 256 a, c, e, g and Fig. 257 a, b, d, e f, i).

It is worth noting that the form of the right paramere of *Apophylon* gen. n. greatly resembles right parameres of some species belonging to Sphodrina (see Casale 1988: 188: Fig. 196, 311: Fig. 438).

3) *Median lobe of aedeagus with ostium situated on the dorsal side.*

The dorsal position of the ostium is hypothesized as the plesiomorphic state for pterostichines (Bousquet 1999: 33) in contrast with the hypothesized apomorphic condition of having the ostium displaced on left side, as in many presumably more derived groups of *Pterostichus*. Related to the huge genus *Pterostichus*, there are several pterostichine genera with the aedeagus with a dorsal ostium; e.g. *Gastrellarius* Casey, 1918, *Stereocerus* Kirby, 1837, and the monotypic *Aristochroodes* Marcilhac, 1993. However, the species from the first two genera possess a left paramere with transverse apophysis. *Aristochroodes reginae* Marcilhac, 1993 has differently shaped right paramere, heterodynamic elytral striation, and discal setiferous punctures in interval 3 (Sciaky 1996).

Moore (1965) and Sciaky (1994) discussed the position of the ostium in reference to the Pterostichini and noted that it is not an "absolute" feature as Jeannel (1942) stated. The value of this feature should be carefully assessed in the Pterostichini and always in the context of a set of important characters, though it is useful to delimit natural phyletic groups. For example, a left-sided

ostium is observed in two not related norther hemisphere clades, the small Nearctic genus *Lophoglossus* Le Conte, 1852 and a huge cluster of subgenera of *Pterostichus* (Bousquet 1999: 39, Will 1999, Sasakawa and Kubota 2007: 102, Fig. 1). Each of these two groups is suggested monophyletic. Likewise, a distinct right-sided ostium has appeared at least twice independently in two lines of tribe. Once Moore (1965: 2) announced this state for the Australasian *Trichosternus* series of genera (now the *Omalosoma* series, cfr. Will 2006a), and secondly, Sciaky (1994) noticed it for the East Asian genus *Straneostichus* Sciaky, 1994. Phylogenetically, these two groups have no direct relationship with each other, since the former is Gondwanaland ancestry, and the latter belongs to the Laurasian "pterostichite complex" (see above).

4) *Metatarsomeres 1–2 (and sometimes metatarsomere 3) setose on medioventral surface, in addition to the lateroventral setae.*

We did not find this feature in the Pterostichini examined, except for two genera of the Mediterranean subtribe Euchroina and a single species of "Trigonotomini". All examined species of *Orthomus* Chaudoir, 1838, and the only species of *Parorthomus* Guéorguiev, Wrase, Farkač, 2014 possess mesotarsomere 1 and metatarsomeres 1-2 setose on ventral surface beside the lateroventral setae. *Trigonotoma lewisii* Bates, 1873, also possesses this character and its distribution is like in *Orthomus*, while other two species of "Trigonotomi", *Lesticus serraticollis* (Chaudoir, 1868) and *Lesticus beroni* Dubault, Lassale, Roux, 2012, do not exhibit this character.

This feature is widespread among taxa of the tribe Platynini Bonelli, 1810, a group which is not closely related to the Pterostichini. Barr (1973) noted this feature for the monotypic genus *Speocolpodes* Barr, 1973 from Guatemala, and we observed it in different phyletic lineages, as *Mexisphodrus profundus* Barr, 1966 from Mexico; *Platynus fracrtilinea* (Darlington, 1934) and *P. biramosus* (Darlington, 1939) from the Caribbean; *Altagonum sphodrum* Darlington, 1952 and *Notagonum altum ibele* Darlington, 1952 from New Guinea. Some species of the Sphodrini Laporte, 1834, among them *Laemostenus oblongus* s.l. (Dejean, 1828), *L. cavicola* (Schaum, 1858), *L. plasoni* s.l. (Reitter, 1885), and *L. derventicus* B. Guéorguiev, 2003, possess the first two segments of the mesotarsomes and mesotarsomeres setose medioventrally. However, this condition in the last taxa is depending on the pubescence on the dorsal surface of the tarsomeres (a generic feature for *Laemostenus* Bonelli, 1810). Actually, the disposition and density of the medioventral setae of the tasomeres in taxa from different carabid tribes suppose this character state evolved independently in different carabid tribes.

5) *Meso- and metatarsomeres 1–4 with two dorsolateral grooves divergent distally.*

This condition occurs in the two species of *Apophylon* gen. n. and seems to be an autapomorphy in regard to Pterostichini. Many Eurasian pterostichines that we have examined possess a groove only on the external side of metatarsomeres 1–3 or 1–4. Usually a groove is wanting on the inner side of the metatarsomeres. However, some taxa, among them the Western Mediterranean species *Poecilus purpurascens* s.l. (Dejean, 1828), *P. decipiens* s.l. Waltl, 1835 and *P. pantanellii* (A. Fiori, 1903), from the subgenera *Carenostylus* Chaudoir, 1838, *Parapedius* Seidlitz, 1887 and *Metapedius* A. Fiori, 1903 of genus *Poecilus*, respectively, possess nearly the same character state as that observed in the new genus. Interestingly, this condition is not present in species from the remaining subgenera of *Poecilus*, so it may be a mark of close relationships between the aforementioned three subgenera. On the other hand, it is not indication for relation between the last and the new genus for reasons below discussed.

Six Palearctic species of *Argutor* Dejean, 1821 (Bousquet 2004: 648) also possess a groove on the inner side of meso- and metatarsomeres 1-5. Moreover, the same species of *Argutor* have a dorsal groove on tarsomeres 1–5 in all legs. Bousquet (ibid.) suggested that the last state is: "unusual in the genus *Pterostichus* and is probably apomorphic. It suggests that these species form a monophyletic group within the subgenus". There are some striking differences between the tarsal grooves in *Argutor* and those in *Apophylon* gen. n., thus this does not provide any evidence for a relationship between these taxa. The meso- and metatarsal grooves in *Argutor* are: a/ three; b/ lateral grooves are situated each to other at 180˚ regarding the tarsal axis, so they are parallel. The grooves in *Apophylon* are: a/ only two; b/ situated laterally on the dorsal surface; d/ convergent towards the base of each tarsal segment and divergent towards its apex. In addition, a dorsal groove is absent on the tarsomeres in the new species.

According to Moore (1965), the Australian species of *Loxandrus* Leconte, 1852, and *Cerabilia* Laporte de Castelnau, 1867 (= *Feronista* Moore, 1965), genera of tribe Abacetini Chaudoir, 1873, as well as the New Zealand *Aulacopodus* Britton, 1949, a genus currently positioned within the "*Notonomus* series" (Will 2006b), have meso- and metatarsomeres sulcate on each side. Allen and Ball (1979: 491) observed the same character state in many of the Mexican taxa from the subtribe Loxandrina Erwin and Sims, 1984 (tribe Abacetini). As we have not seen material from the three genera, we cannot compare the states of these genera and the new genus. However, it is evident that similar character states arose independently in different phyletic lines, thus we treat the character in question as an autapomorphy in *Apophylon* gen. n.

6) *Elytral striae with shining isodiametric microreticulation, in contrast to less shining, transverse-mesh reticulation on elytral intervals.*

This pattern and distribution of the microreticulation on the tegument is unknown to us and it is likely a result of a microevolution peculiar only to this lineage.

The lack of knowledge about both the female genital tract and the larval characters prevent us from making

more precise conclusions about the systematic position of the new genus. There are only a few facts that might be interpreted with certainty. The lack of transverse apophysis on the left paramere in the new species is a plesiomorphic character state rather than apomorphic (Bousquet 1999: 33, 35), taking into consideration that it is joined to an aedeagus with dorsal ostium and to a rather plesiomorphic right paramere, with a styloid apex. Therefore, we propose that the new genus should be placed as incertae sedis within Pterostichini, since it does not show any character states that we consider as shared and derived with any of the following: ("pterostichite complex", incl. the "molopite complex", sensu Bousquet 1999: 37) + ("myadines" + *Stereocerus* Kirby, 1837, sensu Bousquet 1999: 85 and Bousquet 2012: 50–51) + ("Trigonotomi", sensu Dubault et al. 2008 and Will and Kavanaugh 2012). Out of this grouping, the position of the new genus is obscure.

A close affinity between the new genus from China and the genus *Poecilus* is unlikely because of the lack of the parascutelar striola and seta on the metatrochanter in the former (both features present in the latter), as well as for the lack of medioventral pubescence on the metatarsomeres 1–3 and the shallow frontal furrows on the head in the latter (both features differently stated in the former). In addition, the taxa of *Poecilus* s.str. have antennomeres 1–3 or at least some of them carinate medially; this state is not present in the genus herewith described.

At the moment there is no solid evidence to bring *Apophylon* gen. n. closer to any of the Gondwanaland branches of the Pterostichini. The new genus is distinct from the genera of subtribe Euchroina (sensu Will 2006c, Guéorguiev et al. 2014; contrasting characters for Euchroina in parentheses) in: right paramere elongate styloid (right paramere reduced, peg-like); lacking parascutellar stria (parascutellar stria present in most taxa); sternites 4–6 without transverse sulci (sternites 4–6 with transverse sulci in most taxa). However, the last two groups share the following significant character states which deserve further consideration to decide if reliable evidence for a relationship between them exists: 1/ large and prominent eyes compared to the size of the head; 2/ well-impressed frontal furrows of head, not or hardly attaining the level of anterior supra-orbital punctures; 3/ submentum without lateral setae; 4/ metacoxa with arcuate anterior marginal sulcus; 5/ metatrochanter without seta; 6/ tarsomere 5 in all legs setose beneath; and 7/ median lobe of aedeagus with dorsal ostium.

Further, there are some important similarities which are worth mentioning between the genus from Guizhou and Hunan and several other pterostichine genera from the Australasian and American continents. The most striking morphological resemblance that we found is with the American *Hybothecus* Chaudoir, 1874, realizing that it could be partly due to the detailed generic characteristics given by Bousquet (1999: 51–53, Fig. 33). This is due to a lack of detailed characteristics for many pterostichine groups. Except the three characters of the male genitalia (see points 1–3), *Hybothecus* and *Apophylon* gen. n. share: 1/ mentum tooth emarginate at apex; 2/ lateral setae of submentum absent; 3/ basal impression of pronotum single (from each side) and linear; 4/ elytral striae impressed, impunctate; 5/ no parascutellar striola; 6/ no discal punctures in interval 3; 7/ apicolateral plica distinct; 8/ seta of mesotrochanter present; 9/ seta of metatrochanter absent; 10/ metatarsomeres 1-3 pubescent ventrally; and 11/ gonocoxite 2 elongate, with nematiform setae.

Some Australian genera (*Rhytisternus* Chaudoir, 1865, *Rhytiferonia* Darlington, 1962, *Liopasa* Tschitschérine, 1901, and *Cratogaster* Blanchard, 1843, Moore 1965, Baehr 2001), the New Caledonian *Platysmodes* Fauvel, 1903, and *Abacophrastus* Will, 2011 (Will 2011a), that are currently arranged within at least three different phyletic lines (Will 2006d), as well as the Chilean *Chaetauchenium* Tschitschérine, 1900 (Will 2011b), share with the new genus: 1/ median lobe of aedeagus with dorsal ostium; 2/ left paramere primitively conchoid, with an apical denticle on the ventral margin; 3/ right paramere falcate, with styloid apex, medial part broadened and hasp situated subbasaly on the internal face; 4/ mentum tooth weakly emarginate; 5/ elytron without both parascutellar striola (present in the New Caledonian genera, present or lacking in the Chilean genus) and setiferous punctures in interval 3 (present or lacking in the Chilean genus). As stated above, each of the first three character states are plesiomorphic (see points 1–3), and therefore cannot be used as an indication of close relationships. In spite of this, we think that these characters taken together, in view of their phyletic weight, could be important in the search for an older affinity and a further investigation based on substantial character analysis could be productive.

At the present status of knowledge, it is impossible to propose what may be the adelphotaxon of *Apophylon* gen. n. and thereby determine its close relatives. Therefore, we treat this genus as *incertae sedis* within the Pterostichini. On the other hand, it seems that the genus may be the only relict of an early taxonomic branch of the "Angarian" (Asiatic-European) provenance. Whether or not this branch has other extant descendants is not clear. Finally, we note that its systematic position cannot be examined in more depth until a major phylogenetic analysis can be undertaken either by a more detailed morphological analysis, by a molecular analysis, or desirably, by both.

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References

Allen, Ball (1980) Synopsis of Mexican taxa of the *Loxandrus* series (Coleoptera: Carabidae: Pterostichini). Transactions of the American Entomological Society 105: 481–576. http://www.jstor.org/stable/25078248?seq=1#page_scan_tab_contents

Baehr M (2001) The genus *Rhytiferonia* Darlington in New Guinea (Carabidae: Pterostichinae). Coleoptera 5: 41–55.

Ball GE, Shpeley D (2013) Western Hemisphere Zuphiini: descriptions of *Coarazuphium whiteheadi*, new species, and *Zuphioides*, new genus, and classification of the genera (Coleoptera, Carabidae). ZooKeys 315: 17–54. doi: 10.3897/zookeys.315.5293

Barr TC Jr. (1973) *Speocolpodes*, a New Genus of Troglobitic Beetles from Guatemala (Coleoptera, Carabidae). Psyche 80(4): 271–276. doi: 10.1155/1973/83417

Bousquet Y (1999) Supraspecific classification of the Nearctic Pterostichini (Coleoptera: Carabidae). Fabreries, Supplément 9, 292 pp.

Bousquet Y, Webster RP (2004) Review of the Nearctic species of the Holarctic subgenus *Argutor* (Coleoptera: Carabidae). The Canadian Entomologist 136: 645–660. doi: 10.4039/n04-030

Bousquet Y (2012) Catalogue of Geadephaga (Coleoptera, Adephaga) of America, north of Mexico. ZooKeys 245: 1–1722. doi: 10.3897/zookeys.245.3416

Casale A (1988) Revisione degli Sphodrina (Coleoptera, Carabidae, Sphodrini). Museo Regionale di Scienze Naturali Monografie V, Torino, 1024 pp.

Dubault G, Lassalle B, Roux P (2008) Les genres des "Trigonotomi" : *Pareuyaptus* n. gen. et révision des *Euryaptus* Bates, 1892 (Coleoptera, Pterostichidae). Bulletin de la Société entomologique de France 113(2): 239–248.

Guéorguiev B, Wrase DW, Farkač J (2014) Revision of the East Mediterranean *Orthomus* (Coleoptera, Carabidae, Pterostichini), with description of *Parorthomus* gen. n. *socotranus* sp. n. from Socotra Island and key to the Old World genera of subtribe Euchroina. ZooKeys 427: 21–57. doi: 10.3897/zookeys.427.7618

Jeannel R (1942) Coléoptères carabiques. Deuxième partie. Faune de France 40. Paul Lechevalier et Fils, Paris, 573–1173. http://www.faunedefrance.org/bibliotheque/docs/R.%20JEANNEL%28Fde-Fr40%29%20Carab%20vol%202%20.pdf

Liebherr JK, Will KW (1998) Inferring phylogenetic relationships within the Carabidae (Insecta, Coleoptera) from characters of the female reproductive tract. In: Ball GE, Casale A, Vigna Taglianti A (Eds) Phylogeny and Classification of Caraboidea (Coleoptera: Adephaga). Atti, Museo Regionali di Scienze Naturali, Torino, 107–170. http://nature.berkeley.edu/~kipwill/FULLPAPERS/9.pdf

Moore BP (1965) Studies on Australian Carabidae (Coleoptera) 4.- The Pterostichinae. Transactions of the Royal Entomological Society of London 117: 1–32. doi: 10.1111/j.1365-2311.1965.tb00042.x

Sasakawa K, Kubota K (2007) Phylogeny and Genital Evolution of Carabid Beetles in the Genus *Pterostichus* and Its Allied Genera (Coleoptera: Carabidae) Inferred from Two Nuclear Gene Sequences. Annals of the Entomological Society of America 100: 100–109. http://www.bioone.org/doi/abs/10.1603/0013-8746%282007%2910 0%5B100%3APAGEOC%5D2.0.CO%3B2

Sciaky R (1994) *Straneostichus* gen.n., a new genus and four new species from China (Coleoptera: Carabidae: Pterostichinae). Annalen des Naturhistorischen Museums in Wien Serie B für Botanik und Zoologie 96: 189–198. http://www.landesmuseum.at/pdf_frei_remote/ANNA_96B_0189-0198.pdf

Sciaky R (1996) New taxa and new synonyms among Pterostichinae from Asia (Coleoptera, Carabidae). Entomofauna, Zeitschrift für Entomologie 17(29): 429–439. http://www.landesmuseum.at/pdf_frei_remote/ENT_17_0429-0440.pdf

Sciaky R, Wrase DW (1997) Twenty-nine new taxa of Pterostichinae from Shaanxi (Coleoptera, Carabidae). Linzer biologische Beiträge 29(2): 1087–1139. http://www.landesmuseum.at/pdf_frei_remote/LBB_0029_2_1087-1139.pdf

Will KW (1999) Systematics and zoogeography of the genus *Lophoglossus* Leconte (Coleoptera Carabidae Pterostichini). In: Zamotajlov A, Sciaky R (Eds) Advances in carabidology. Papers dedicated to the memory of Prof. Dr. Oleg L. Kryzhanovskij. MUISO Publishers, Krasnodar, 259–276. http://nature.berkeley.edu/~kipwill/FULLPAPERS/12.pdf

Will K (2006a) *Omalosoma* series. Version 07 July 2006 (temporary). http://tolweb.org/Omalosoma_series/51497/2006.07.07 [The Tree of Life Web Project, http://tolweb.org/]

Will K (2006b) *Notonomus* series. Version 07 July 2006 (temporary). http://tolweb.org/Notonomus_series/51528/2006.07.07 [The Tree of Life Web Project, http://tolweb.org/]

Will K (2006c) Euchroina. Version 21 October 2006 (temporary). http://tolweb.org/Euchroina/51298/2006.10.21 [The Tree of Life Web Project, http://tolweb.org/]

Will K (2006d) Pterostichini. Version 21 October 2006 (temporary). http://tolweb.org/Pterostichini/102/2006.10.21 [The Tree of Life Web Project, http://tolweb.org/]

Will KW (2011a) Taxonomic review of the Pterostichini and Loxandrini fauna of New Caledonia (Coleoptera, Carabidae). In: Erwin T (Ed.) Proceedings of a symposium honoring the careers of Ross and Joyce Bell and their contributions to scientific work. Burlington, Vermont, 12–15 June 2010. ZooKeys 147: 337–397. doi: 10.3897/zookeys.147.1943

Will KW (2011b) *Chaetauchenium* Tschitchérine, 1900 (Carabidae: Pterostichini) a new species and new status for a lineage from the Valdivian temperate rainforest. Gayana 75(2): 192–197. doi: 10.4067/S0717-65382011000200009

Will K, Kavanaugh DH (2012) A new species of *Lesticus* Dejean, 1828 (Coleoptera, Carabidae) from the Finisterre Range, Papua New Guinea and a key to the genera of pterostichine-like Harpalinae of New Guinea. ZooKeys 246: 27–37. doi: 10.3897/zookeys.246.4112

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Larval muscle attachment site (MAS) patterns are a conserved character among Piophilini flies (Diptera, Piophilidae)

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Abstract

The dorsoventral muscle attachment sites (MAS) patterns are described for six species of the tribe Piophilini (Diptera: Piophilidae): *Centrophlebomyia furcata* (Fabricius), *Liopiophila varipes* (Meigen), *Piophila casei* (Linnaeus), *Piophila megastigmata* McAlpine, *Prochyliza nigrimana* (Meigen) and *Stearibia nigriceps* (Meigen). Comparison between the MAS patterns of Piophilini and previous descriptions for Calliphoridae (Diptera) revealed differences in the muscle equipment between the larvae of both taxa. Among the Piophilini, the MAS patterns were highly conserved and only a genus-specific pattern for *Piophila* species and a species-specific pattern for *C. furcata* were found. Nevertheless, these differences in MAS patterns were subtle and some intraspecific variability was observed; hence, the MAS patterns do not appear to be suitable as diagnostic characters allowing for species determination of Piophilini larvae.

Key Words

Larval morphology
Forensic entomology
Phylogeny
Identification
Centrophlebomyia furcata
Liopiophila varipes
Piophila casei
Piophila megastigmata
Prochyliza nigrimana
Stearibia nigriceps

Introduction

Lacking legs or prolegs, the larvae of Diptera Cyclorrhapha move by the contraction of longitudinal and dorsoventral muscles, increasing the haemolymph hydrostatic pressure (Roberts 1971). However, in spite of its importance, the anatomy of these muscles has only been described for some cyclorrhaphous species; see for example the works of Hooper (1986), Bate (1990) and Wipfler et al. (2013) on *Drosophila melanogaster* Meigen, Hewitt (1908) on *Musca domestica* Linnaeus, and Crossley (1965) and Hanslik et al. (2010) on *Calliphora vicina* Robineau-Desvoidy. All of those studies described a great number of longitudinal muscles usually extending between two segmental borders, and a small number of dorsoventral muscles in the lateral, ventrolateral and dorsolateral regions of each segment (Wipfler et al. 2013).

Recently, Niederegger and Spieβ (2012), and Niederegger et al. (2013, 2015) studied the larval dorsoventral muscles and their cuticular attachments in forensically important blow fly species (Diptera: Calliphoridae). These muscular attachment sites (MAS) are easily visualized as clusters of dots in the larval cuticle and form distinct and both genus- and species-specific patterns in blow fly larvae, allowing for species identification (Niederegger and Spieβ 2012; Niederegger et al. 2013, 2015). Furthermore, the MAS patterns are constant throughout larval development and the length of the MAS rows is linearly correlated with the larval body length (Niederegger et al. 2013). Reliable identification of the material collected is particularly crucial in forensic

investigations as the immature stages of necrophagous insects are usually the only entomological evidence collected at autopsies and crime scenes (Amendt et al. 2007). However, the identification of immature stages remains a difficult task for some forensically important insect groups like the commonly named 'skipper flies' (Diptera: Piophilidae). This common name is due to the skipping behaviour showed by the third-instar larvae, which is mediated by contraction of the musculature. According to the phylogeny proposed by McAlpine (1977), the family Piophilidae includes two subfamilies: Neottiophilinae, which includes ectoparasite species of nestling birds, and Piophilinae, which includes two tribes: the Mycetaulini, whose larvae develop mainly on rotten fungi, and the Piophilini, whose larvae develop mainly on decaying organic matter and which is divided in two subtribes: Piophilina and Thyreophorina. Both subtribes Piophilina and Thyreophorina are typically associated with cadavers in advanced stages of decay and can be potentially useful as forensic indicators; moreover, some Piophilina species can also be major pests for the food industry and agents of human myiasis (Martín-Vega 2011). Given this forensic, economic and medical importance, methods for the identification of piophilid immature stages are strongly needed. However, barcode sequences for molecular identification are still only available for a few species (e.g. Boehme et al. 2012) and, although several recent studies have yielded new insights into the morphology of the immature stages of the Piophilidae (e.g. Martín-Vega et al. 2012, 2014; Paños et al. 2013; Martín-Vega and Baz 2014), the larval morphology of most piophilid genera and species remains undescribed. As a consequence, some diagnostic characters within existing identification keys must be used with caution (Martín-Vega et al. 2014). It is therefore desirable to explore additional morphological characters which may increase not only the accuracy and reliability of the species identification (which is particularly essential for a correct use of insects as forensic indicators), but also may support the reconstruction of phylogenetic relationships.

The aims of the current study were (i) to describe the dorsoventral muscle equipment in a representative set of piophilid species from the tribe Piophilini, comparing them with previous data on the anatomy of Cyclorrhapha larval muscles; and (ii) to determine if those patterns are genus- or species-specific and can thus be used as an additional tool for Piophilidae species determination.

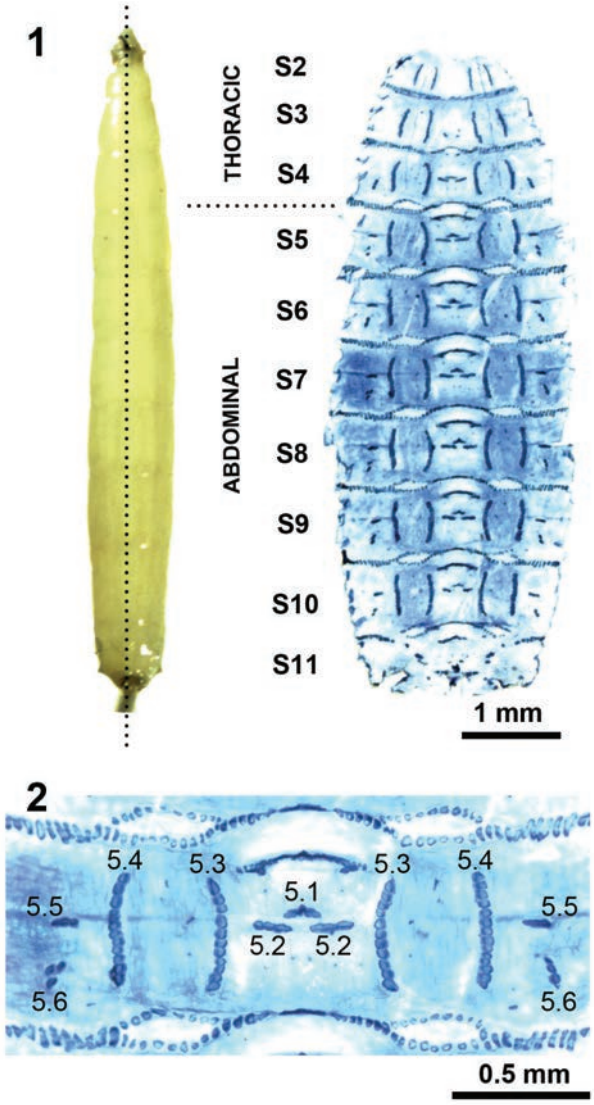
Material and methods

Six target species were selected for the current study: five species belonging to subtribe Piophilina—*Liopiophila varipes* (Meigen), *Piophila casei* (Linnaeus), *Piophila megastigmata* McAlpine, *Prochyliza nigrimana* (Meigen) and *Stearibia nigriceps* (Meigen); and one species belonging to subtribe Thyreophorina—*Centrophlebomyia furcata* (Fabricius). These six species are among the most common piophilid species occurring on carrion and show wide geographical distributions (Martín-Vega 2011).

Adult males and females of *C. furcata*, *L. varipes*, *P. casei*, *P. megastigmata* and *P. nigrimana* were collected on animal carcasses and carrion baits in different habitats of central Spain, identified using published taxonomical keys (McAlpine 1977, 1978) and subsequently used to start laboratory cultures. Details on collection sites and on the conditions and maintenance of the laboratory colonies for each species can be found in Martín-Vega et al. (2012, 2014) and Martín-Vega and Baz (2014). For each species, larvae were reared to the third-instar, killed in near-boiling water and then preserved in 70% ethanol for more than 24 hours to allow the muscles to detach from the cuticle (see Niederegger and Spieβ 2012). This fixation and storage method is also recommended to achieve best preservation of larval samples (Amendt et al. 2007). Furthermore, larvae of *S. nigriceps* were obtained from a human corpse being object of a current investigation in the Institute of Legal Medicine of the Friedrich-Schiller-University of Jena (Germany). Additional larvae of *S. nigriceps* were kindly supplied by Dr Krzysztof Szpila (Nicolaus Copernicus University, Poland). Several third-instar larvae were killed and preserved following the aforementioned method, while the remaining larvae were placed in a plastic container containing minced meat and reared to adulthood. Ten third-instar larvae of each target species were randomly collected and dissected for the study. Before dissection, the length and diameter of the larvae were measured (accuracy ± 0.1 mm) using a calibrated ocular micrometre.

Preparation of larvae and evaluation of the MAS patterns followed the methodology described in Niederegger and Spieβ (2012) and Niederegger et al. (2013, 2015). The dorsally dissected cuticle was cleaned and stained with Coomassie brilliant blue solution (Sigma, 1% in tap water), cutting off the first segment (Fig. 1). The stained cuticles were flattened and covered with a glass slide cover and mounted onto the dissecting microscope. After study, the cuticles were stored in 70% ethanol at the Institute of Legal Medicine of the Friedrich-Schiller-University of Jena.

Each MAS is visible on the cuticle as a 'dot'. The dots are grouped in distinct clusters which are arranged symmetrically along the ventral midline (Figs 1, 2). Following Niederegger and Spieβ (2012), a cluster of dots is called 'row' and the term 'pattern' refers to the shape of a row. All rows in segments 2–11 were documented and labelled following Niederegger et al. (2015): rows were numbered according to the segment and the position within the segment, starting at the centre (Fig. 2). The individual rows were photographed for each segment using a digital camera (BeyTec, Moticam 1000) attached to the dissecting microscope, using identical magnification in every preparation. Then, on the computer, each MAS dot was covered with a semitransparent coloured circle using graphic software (Adobe Photoshop CS). The resulting rows of circles were stacked, using the most anterior circle (in longitudinal rows) or the left circle (in transverse rows) as reference point. The resulting areas with a high degree of overlap were marked as 'condensed pattern' to allow the direct comparison between species. Moreover,



Figures 1–2. *Liopiophila varipes* (Meigen), third-instar larva. **1.** Dorsal view of a pinned larva before dissection (left) and stained larval cuticle (right), showing the symmetrical muscular attachment sites on segments S2 to S11; **2.** Detail of the abdominal segment S5 showing the label for each muscular attachment site pattern.

the number of MAS per row was documented for each specimen, and the average number of MAS per row and the standard deviation were computed for each species (see Suppl. material 1).

Results

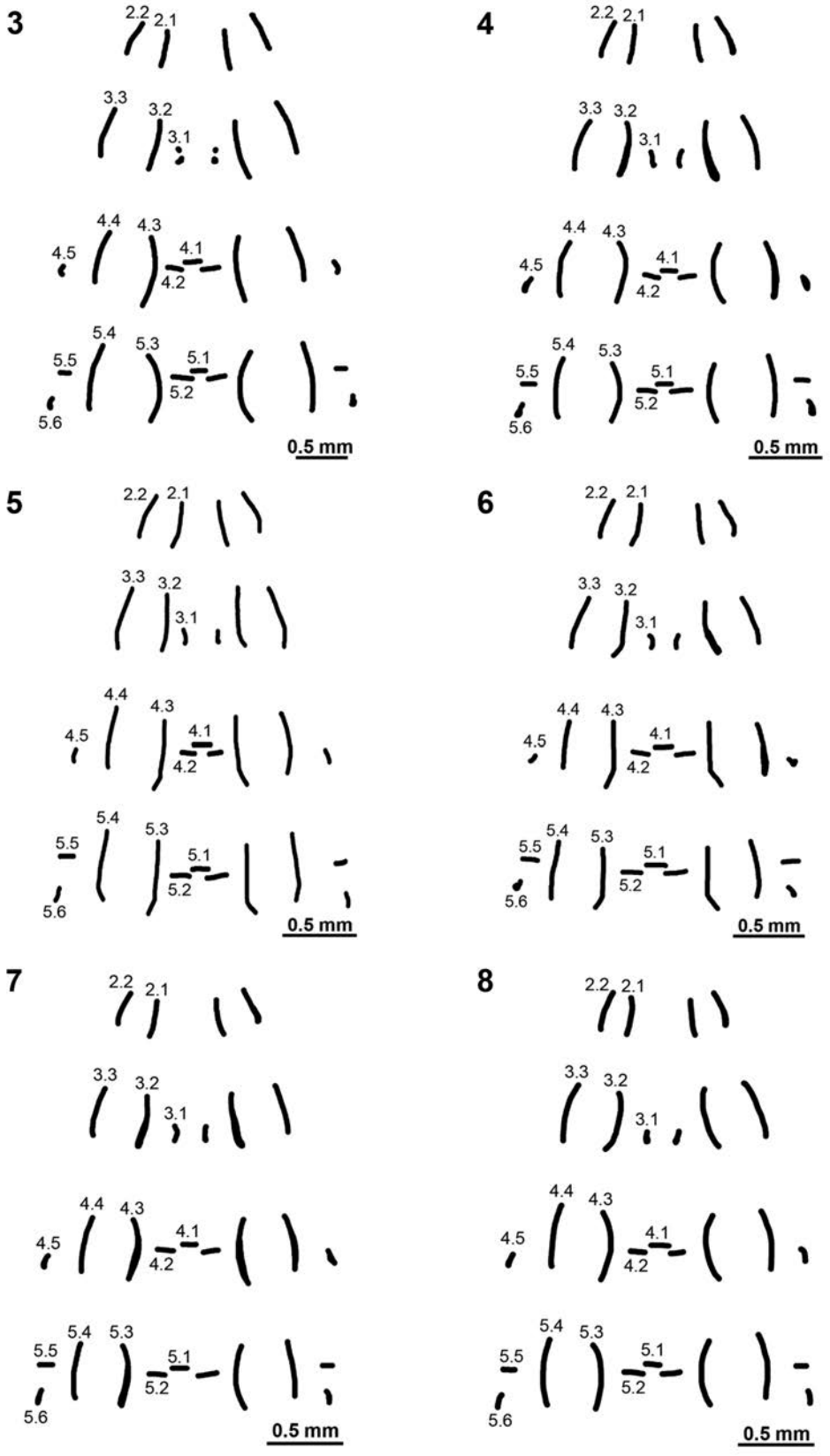
Larval muscle equipment

The MAS patterns followed the same general model in the six target species (Figs 3–8). The three thoracic segments (S2 to S4) and the last abdominal segment (S11) showed different muscle equipment (i.e. number of MAS rows) than abdominal segments S5 to S10, where the muscle equipment was identical (Fig 1). Thoracic segment S2 was equipped with only two pairs of symmetrical, longitudinal rows, labelled 2.1 and 2.2 (Figs 3–8). Thoracic segment S3 showed two small, usually symmetrical, oblique rows, labelled 3.1; and two pairs of symmetrical, longitudinal rows, labelled 3.2 and 3.3 (Figs 3–8). Thoracic segment S4 showed a single transverse row, perpendicular to the ventral midline, labelled as 4.1; two symmetrical, transverse rows placed under row 4.1, labelled 4.2; two pairs of symmetrical, longitudinal rows 4.3 and 4.4; and two small, distal symmetrical oblique rows, labelled 4.5 (Figs 3–8). Abdominal segments S5 to S10 showed the same muscle equipment than thoracic segment S4, plus two additional symmetrical, transverse rows, labelled 5.5–10.5, depending on the segment number. No significant differences were found between abdominal segments S5–S10 within the same individual (Fig. 1), so only the MAS patterns from abdominal segment S5 are shown (Figs 3–8). Finally, the last abdominal segment S11 showed only two irregular, asymmetrical clusters with a varying number of dots (Fig. 1). These clusters of dots did not follow any distinct pattern between individuals within any species. Moreover, because of the pinning for dissection (see Material and Methods), the abdominal segment S11 was usually broken and the sample size was below ten for every species. Therefore, no stacked or condensed patterns for segment S11 are shown.

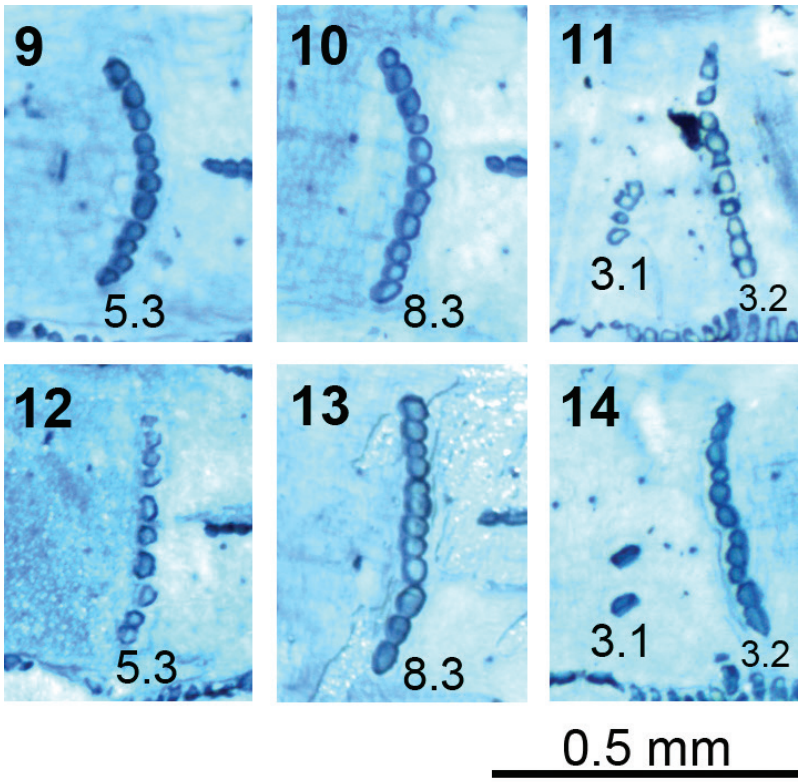
MAS patterns as an identification tool in the Piophilini

Only subtle differences were found in the MAS patterns between some species. The condensed patterns for the longer, longitudinal rows 4.3 and 5.3–10.3 were generally curved in their middle, parentheses-shaped in *C. furcata*, *L. varipes*, *P. nigrimana* and *S. nigriceps* (Figs 3, 4, 7–10). However, the same longitudinal rows 4.3 and 5.3–10.3 were straight but markedly bended on its final third, J-shaped in both *P. casei* and *P. megastigmata* (Figs 4, 5, 12, 13). The longitudinal row 3.2 also showed this pattern, although not so markedly in every individual (Figs 3–8). It must be highlighted that, in some specimens, some individual rows did not show a clear parentheses-shape (in *C. furcata*, *L. varipes*, *P. nigrimana* and *S. nigriceps*) or J-shape (in *P. casei* and *P. megastigmata*), but the correspondent pattern could be clearly observed in other longitudinal rows of the same individual. On the other hand, the oblique row 3.1 showed a clear disruption in every *C. furcata* individual (Fig. 3, 14), but no disruptions were observed in the other species (Figs 4–8, 11). No clear differences were observed in the other rows between species (Figs 3–8). Moreover, the oblique rows 4.5 and 5.6–10.6 showed variable angles within the same segment and within the same species, so no clear condensed patterns can be determined (Figs 3–8).

Suppl. material 1 shows the average number of MAS per row within each segment. More dots were generally found in the longitudinal rows 4.3–10.3 in *C. furcata*, *L. varipes* and *S. nigriceps*, but the observed range overlapped in any case in the six target species.



Figures 3–8. Condensed larval muscular attachment site patterns for six species of Piophilini. **3.** *Centrophlebomyia furcata* (Fabricius). Larval length = 11.91±1.03 mm; diameter = 1.45±0.12 mm; n = 10; **4.** *Liopiophila varipes* (Meigen). Larval length = 7.34±0.3 mm; diameter = 0.75±0.03 mm; n = 10; **5.** *Piophila casei* (Linnaeus). Larval length = 7.43±0.42 mm; diameter = 0.87±0.05 mm; n = 10; **6.** *Piophila megastigmata* McAlpine. Larval length = 7.69±0.28 mm; diameter = 0.82±0.03 mm; n = 10; **7.** *Prochyliza nigrimana* (Meigen). Larval length = 6.61±0.24 mm; diameter = 0.72±0.02 mm; n = 10; **8.** *Stearibia nigriceps* (Meigen). Larval length = 7.28±0.37 mm; diameter = 0.76±0.06 mm; n = 10.



Figures 9–14. Muscular attachment sites in Piophilini larvae. **9.** *Liopiophila varipes* (Meigen), third-instar larva, detail of abdominal row 5.3; **10.** *Prochyliza nigrimana* (Meigen), third-instar larva, detail of abdominal row 8.3; **11.** *Stearibia nigriceps* (Meigen), third-instar larva, detail of thoracic row 3.1; **12.** *Piophila casei* (Linnaeus), third-instar larva, detail of abdominal row 5.3; **13.** *Piophila megastigmata* McAlpine, third-instar larva, detail of abdominal row 8.3; **14.** *Centrophlebomyia furcata* (Fabricius), third-instar larva, detail of thoracic row 3.1.

Discussion

Larval muscle equipment

Previous studies had described a variation in the muscle equipment (i.e. variation in the number of MAS rows) between the larval segments of the same individual in different cyclorrhaphous species (Hewitt 1908; Niederegger and Spieβ 2012; Niederegger et al. 2013, 2015; Wipfler et al. 2013). As described by Wipfler et al. (2013) for *D. melanogaster*, the thoracic segments and the first and last abdominal segments of the Piophilini show a varying muscle equipment, whereas the abdominal segments S5–S10 appear uniform (Fig. 1). There is a progressive increase in the muscle equipment from segment S2 to segments S5–S10, but the number of muscles decreases drastically in the last abdominal segment (Fig. 1); this is also in accordance with the observations of Wipfler et al. (2013) on *D. melanogaster*.

On the other hand, the current study of the larval MAS patterns of the Piophilini shows that their muscle equipment is clearly different from the Calliphoridae (Niederegger and Spieβ 2012; Niederegger et al. 2013, 2015). The thoracic segments of Calliphoridae larvae show more MAS rows and contain a higher number of MAS (Niederegger and Spieβ 2012; Niederegger et al. 2013, 2015; MAS patterns of the abdominal segments were not described). The higher number of muscles in blowfly larvae in comparison to the smaller larvae of Piophilini is very likely due to the difference in larval size between both families, but it also suggest variation in the muscle equipment among different Diptera families. The preparation of larval specimens for the study of the MAS patterns is fast and simple (Niederegger and Spieβ 2012), so it may provide a potential useful tool for comparative anatomy studies on cyclorrhaphous Diptera. In the current study, the similar MAS patterns observed between both closely related Piophilina genera (Figs 4–8) and a more distantly related genus of Thyreophorina (Fig. 3) suggest that the larval MAS patterns may be highly conserved among the Piophilini. Hence, it would be desirable to describe the larval MAS patterns in species of the piophilid tribe Mycetaulini and subfamily Neottiophilinae, as well as in species of related families (see McAlpine 1977, for a phylogeny of the Piophilidae and related families), in order to know either if the general pattern described here is apomorphous in the Piophilini or if it is a conserved character among more taxa.

MAS patterns as an identification tool in the Piophilini

Both genus- and species-specific MAS patterns have been described in Calliphoridae larvae (Niederegger and Spieβ 2012; Niederegger et al. 2013, 2015). It provides a

simple identification method which may be particularly useful in the analysis of blow fly larvae collected in a forensic case. However, the current results show that larval MAS patterns show no significant differences among a set of different Piophilini genera, and therefore cannot provide a reliable identification at a species level. Indeed, the current results suggest that the larval MAS patterns may be also conserved among other species of the subtribe Piophilini, as mentioned.

At a genus level, the two *Piophila* species showed a distinctive, J-shaped pattern in longitudinal rows 4.3 and 5.3–10.3 (Figs 5, 6, 12, 13), in comparison to the parentheses-shaped pattern of the other species (Figs 3, 4, 7–10). This genus-specific character should be taken with caution as some intraspecific variability was observed, although the analysis of several segments in the same individual may provide additional support in order to determine the pattern of the longitudinal rows of muscle attachments in a particular specimen. Nevertheless, it is recommended to use alternative morphological characters for the identification of *Piophila* larvae, like the shape of the cephalopharyngeal skeleton or the arrangement of the spines of ventral creeping welts (Martín-Vega et al. 2012; Paños et al. 2013). Similarly, the distinctive disruption observed in the oblique row 3.1 of *C. furcata* larvae (Figs 3, 14) may also be present in the larvae of the other *Centrophlebomyia* species or in other Thyreophorina genera, so it is not possible to confirm if it is a species-, genus- or subtribe-specific pattern. The larvae of *C. furcata* are highly distinctive and easily distinguishable from the larvae of Piophilini (Martín-Vega and Baz 2014); however, the larval morphology of most Thyreophorina genera remains undescribed.

Even though it is true that the larval MAS patterns have not been shown to be a valid tool for species identification in the Piophilini, the conserved pattern among species of this tribe and the observed differences in comparison to Calliphoridae larvae raise interesting questions on the larval muscle anatomy and functioning. How do these muscles operate in the typical skipping behaviour of piophilid larvae? Is the conservation of the MAS patterns related to the performance of that kind of movement? Further studies on the mechanics of the piophilid skipping behaviour may answer these questions. Moreover, given the paucity of anatomical descriptions of the muscular system of Diptera larvae, the current study also suggests the potential use of this simple method in comparative studies. As MAS patterns have shown to be highly conserved among the Piophilini but significantly different from those described for a relatively distant family (Niederegger and Spieβ 2012; Niederegger et al. 2013, 2015), they might represent a valuable tool in the reconstruction of phylogenetic relationships.

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References

Amendt J, Campobasso CP, Gaudry E, Reiter C, LeBLanc HN, Hall MJR (2007) Best practice in forensic entomology—standards and guidelines. International Journal of Legal Medicine 12: 90–104. doi: 10.1007/s00414-006-0086-x

Bate M (1990) The embryonic development of larval muscles in *Drosophila*. Development 110: 791–804.

Boehme P, Amendt J, Zehner R (2012) The use of COI barcodes for molecular identification of forensically important fly species in Germany. Parasitology Research 110: 2325–2332. doi: 10.1007/s00436-011-2767-8

Crossley AC (1965) Transformations in the abdominal muscles of the blow-fly, *Calliphora erythrocephala* (Meig.), during metamorphosis. Journal of Embryology and Experimental Morphology 14: 89–110.

Hanslik U, Schoofs A, Niederegger S, Heinzel HG, Spieβ R (2010) The thoracic muscular system and its innervation in third instar *Calliphora vicina* larvae. I. Muscles of the pro- and mesothorax and the pharyngeal complex. Journal of Morphology 271: 960–968. doi: 10.1002/jmor.10848

Hewitt CG (1908) The structure, development, and bionomics of the house-fly, *Musca domestica*, Linn. Part II – The breeding habits, development, and the anatomy of the larva. Quarterly Journal of Microscopical Science 208: 395–448.

Hooper JE (1986) Homeotic gene function in the muscles of *Drosophila* larvae. EMBO Journal 5: 2321–2329.

Martín-Vega D (2011) Skipping clues: Forensic importance of the family Piophilidae (Diptera). Forensic Science International 212: 1–5. doi: 10.1016/j.forsciint.2011.06.016

Martín-Vega D, Baz A (2014) Comparative larval morphology of the European bone-skippers, *Thyreophora cynophila* (Panzer, 1798) and *Centrophlebomyia furcata* (Fabricius, 1794) (Diptera: Piophilidae), with notes on their coexistence and natural history. Journal of Natural History 48: 285–299. doi: 10.1080/00222933.2013.791938

Martín-Vega D, Baz A, Díaz-Aranda LM (2012) The immature stages of the necrophagous fly, *Prochyliza nigrimana*: comparison with *Piophila casei* and medicolegal considerations (Diptera: Piophilidae). Parasitology Research 111: 1127–1135. doi: 10.1007/s00436-012-2943-5

Martín-Vega D, Díaz-Aranda LM, Baz A (2014) The immature stages of the necrophagous fly Liopiophila varipes and considerations on the genus Liopiophila (Diptera: Piophilidae). Deutsche Entomologische Zeitschrift 61: 37–42. doi: 10.3897/dez.61.7534

McAlpine JF (1977) A revised classification of the Piophilidae, including 'Neottiophilidae' and 'Thyreophoridae' (Diptera: Schizophora).

Memoirs of the Entomological Society of Canada 103: 1–66. doi: 10.4039/entm109103fv

McAlpine JF (1978) A new species of *Piophila* from South Africa (Diptera: Piophilidae). Annals of the Natal Museum 23: 455–459.

Niederegger S, Miroschnikow A, Spieβ R (2013) Marked for life: muscle attachment site patterns in blowfly larvae are constant throughout development. Parasitology Research 112: 347–355. doi: 10.1007/s00436-012-3142-0

Niederegger S, Spieβ R (2012) Cuticular muscle attachment sites as a tool for species determination in blowfly larvae. Parasitology Research 110: 1903–1909. doi: 10.1007/s00436-011-2716-6

Niederegger S, Szpila K, Mall G (2015) Muscle attachment site (MAS) patterns for species determination in European species of *Lucilia* (Diptera: Calliphoridae). Parasitology Research 114: 851–859. doi: 10.1007/s00436-014-4248-3

Paños A, Arnaldos MI, García MD, Ubero-Pascual N (2013) Ultrastructure of preimaginal stages of *Piophila megastigmata* McAlpine, 1978 (Diptera, Piophilidae): a fly of forensic importance. Parasitology Research 112: 3771–3788. doi: 10.1007/s00436-013-3567-0

Roberts MJ (1971) On the locomotion of Cyclorrhaphan maggots (Diptera). Journal of Natural History 5: 583–590. doi: 10.1080/00222937100770421

Wipfler B, Schneeberg K, Löffler A, Hünefeld F, Meier R, Beutel RG (2013) The skeletomuscular system of the larvae of *Drosophila melanogaster* (Drosophilidae, Diptera) – A contribution to the morphology of a model organism. Arthropod Structure & Development 42: 47–68. doi: 10.1016/j.asd.2012.09.005

Supplementary material 1

Average number of muscular attachment sites (±STD) per row for six species of subtribe Piophilini

Authors: Daniel Martín-Vega, Senta Niederegger

Data type: dataset

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‘The *adikeshavus*-group’: A new species group of *Idris* Förster (Hymenoptera, Platygastridae) from India, with descriptions of five new species

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Idris
Scelioninae
spiders

Abstract

Idris Förster is a megagenus in the tribe Baeini comprising species that exclusively parasitize the eggs of spiders dwelling in vegetation and leaf litter. This is the only tribe in Platygastridae capable of using spider eggs for their development. Constructing species groups will facilitate studies of highly speciose genera like *Idris.* So far only one species group ‘the *melleus*-group’ has been proposed in this genus. A new species group ‘the *adikeshavus*-group’ from India is proposed. Five new species in this genus – *I. adikeshavus*, *I. deergakombus*, *I. brevicornis*, *I. lopamudra* and *I. teestai* – are described from India. All five species are imaged and a key to them is provided.

Introduction

Platygastroidea, the third largest superfamily of Parasitic Hymenoptera, are ubiquitous. They parasitize the eggs of most orders of insects and are host group specific. For instance, Gryonini use heteropteran eggs, Teleasinae and Xenomerini use carabid eggs, Embidobiini use embiid eggs, and so on (Masner 1976; Austin et al. 2005, Austin and Field 1997). The tribe Baeini under subfamily Scelioninae (one of the five subfamilies in Platygastridae) is worldwide in distribution. All species in Baeini are known to be specialist parasitoids on the eggs of spiders (Austin 1985, Austin and Field 1997). This high level of host specificity is the result of their having speciated along with spiders over an extended period of time (Iqbal and Austin 2000a, Stevens and Austin 2007). They also exhibit high levels of sexual dimorphism that varies between genera. Clava with four compact fused clavomeres, A1 not extending beyond level of anterior ocellus and a tridentate mandible with convex outer surface serve to distinguish this from all other tribes in the subfamily (Austin and Field 1997).

In spite of their ubiquity and species richness, the taxonomy of the Baeini remains in its infancy with the fauna in most regions remaining to be worked. Australia, however, is the exception since intensive studies have been carried out on this tribe (Austin 1986, 1988, Iqbal and Austin 2000b). Nevertheless, it has been estimated that 80% of the species remain to be discovered and described even in Australia (Stevens and Austin 2007). Additionally, Iqbal and Austin (1997) feel that Baeini exhibit high levels of endemism and are confined to small geographic localities. Areas that have not yet been surveyed are therefore likely to yield many new species.

The genus *Idris* (Tribe: Baeini) was erected by Förster in 1856 with *I. flavicornis* as the type species (Förster 1856). Masner and Denis (1996) state that very small or very large eggs of spiders are not parasitized by this genus, as a result of which all species are generally of uniform size varying from 1–2 mm. So far 154 species of *Idris* have been described worldwide (Johnson 2015), of which 24 are from India (Mani 1939, 1973, 1975; Mani and Mukerjee 1976, Mani and Sharma 1982, Mukerjee 1978, 1981, 1994).

Idris and *Ceratobaeus* were considered two distinct genera by Masner (1976). Later Huggert (1979) treated *Ceratobaeus* as a subgenus of *Idris*. Austin (1984, 1995) and Galloway and Austin (1984) retained them as two separate genera. In 1996 Masner and Denis in their work on the '*melleus*-group' of *Idris* treated *Ceratobaeus* as a junior synonym of *Idris*. Iqbal and Austin (2000a) state that both *Ceratobaeus* and *Idris* are polyphyletic and were of the opinion that they be treated as distinct till the Baeini as a whole are studied to resolve the confusion. This was later resolved by molecular studies conducted by Carey et al. (2006) and Murphy et al. (2007) based on combined analysis of the nuclear 28s rRNA and mitochondrial CO1 genes both of which indicated that Baeini is not monophyletic. Three definitive clades were found *viz.* clade A consisting of *Idris* + *Ceratobaeus* Ashmead + *Hickmanella* Austin + *Odontacolus* Kieffer; clade B with *Baeus* and clade C with *Mirobaeoides* Dodd + *Neobaeus* Austin. *Mirobaeoides* and *Neobaeus* were more closely related to other platygastrids that do not parasitize spider eggs. Analysis of highly species rich genera like *Idris* and *Ceratobaeus* indicated that they were not monophyletic and that the horn on T1 housing the long ovipositor (when not in use) has evolved many times within the tribe. The reduction in wings was inferred to be an adaptation to enhance the efficiency of locating spider eggs in leaf litter and for penetrating the silk walls of the egg sacs of spiders. It was also concluded that macroptery is most likely an ancestral condition in Scelionidae, with no evidence that this character state had been regained as functional wings post wing reduction. The results of these molecular phylogenetic studies were at odds with the phylogenies constructed using morphological characters alone (Carey et al. 2006, Murphy et al. 2007).

As *Idris* is highly speciose with the possibility of over a thousand species being present (Valerio et al. 2013), the clustering of species into groups will aid in the study of this genus. Only one species group, the '*melleus*-group', has so far been proposed by Masner and Denis (1996) for Nearctic species of *Idris*. India being a subtropical country will without doubt harbour a large fauna of Baeini. This initial study of Indian species of *Idris* reveals a closely knit group of five species for which a new species group, 'the *adikeshavus*-group' has been proposed. The females of the species in this group possess a horn on T1 which is absent in males and the propodeum present as lateral lamellae anterior to the horn. Other diagnostic characters of this species group have been mentioned under results.

Materials and methods

Morphological terminology is after Masner (1976, 1980) and Mikó et al. (2007, 2010). Specimens were mounted on point-card tips. The descriptions and imaging were carried out employing Leica M205A stereomicroscope, with 1× objective and Leica DFC-450 digital camera.

The holotypes and paratypes of all the five new species are deposited in the ICAR-National Bureau of Agricultural Insect Resources, Bangalore, India.

We have used the following abbreviations in the description of the taxa. All the measurements taken are as per Miko (2010). HL – Head Length; HW – Head width; HH – Head height; FCI (Frontal cephalic index) = HW/HH; LCI (Lateral cephalic index) = HH/HL; A1–A12 – Antennomeres 1–12 (A1 = Scape, A2 = pedicel); L – Length; W – Width; H – Height; OOL – Ocellar-ocular length; POL – Posterior ocellar length; IOS – Interorbital space; T1–T7 – Metasomal tergites 1 to 7. Width of all metasomal tergites taken anteriorly.

All the specimens were collected by using sweep nets (SN), yellow pan traps (YPT) and pitfall traps (PFT). In addition to these, spider egg sacs were collected for obtaining adults of Baeini. The 151 parasitized spider egg sacs collected over a period of time were attacked by *Idris s.l.* (74.83%), *Baeus* (1.98%), *Ceratobaeus s.l.* (3.97%), *Odontacolus* (1.32%), Eupelmidae (0.66%), Eulophidae *viz*., ?*Pediobius* sp. (9.27%), Ichneumonidae (0.66%), Mantispidae (5.29%) and Diptera (1.98%). In 49% of the cases *Idris s.l.* occurred as the sole parasitoid in the egg sacs while *Ceratobaeus s.l.* and other non-platygastrid parasitoids were the only ones that emerged from 3% and 11% of the parasitized egg sacs respectively. Spiderlings emerged along with the parasitoids from 37 % of the parasitized egg sacs. The number of adult *Idris* emerging from an individual spider egg sac varied from 5–677. However no species in 'the *adikeshavus* species-group' dealt in this paper were reared from spider eggs.

Results

'The adikeshavus species-group'

Diagnosis. This species group is very unique as compared to all other *Idris* spp. in the following combination of character states:

1. T2 is either 1.7–2.0× longer than T3 or equal to T3
2. Both fore wing and hind wing with extremely long marginal cilia; hind wing curved inwards beyond submarginalis
3. Both wing shape and density of microtrichia on wings vary between males and females
4. Presence of propodeum as lateral lamellae anterior to horn
5. T7 and S6 very large and elongate
6. Densely setose vertex
7. Male antenna twelve segmented, constriction between A11 and A12 distinct

Description. Body convex; head transverse, wider than mesosoma in dorsal view; eyes small, densely setose; lateral ocelli adjacent to eyes; temples not visible when viewed laterally; head wider than high, higher than long; IOS larger than eye height; vertex with dense setae; facial striae present, striae reaching lower orbit of eye; lower frons smooth, upper frons setigerous punctate; central keel well developed, not reaching anterior ocellus; occipital carina sharp; radicle elongate, > 1/4th length of A1; female clava broad; length of clava 1.0–1.4× length of A2–A6; male antenna with clear constriction between A11–A12.

Mesosoma: Notauli well developed posteriorly, ranging in length from 0.27–0.32× length of mesoscutum; mesoscutum and mesoscutellum densely setose; mesoscutellum semicircular; metascutellum narrow in females and well defined in males; propodeum present as lateral triangular lamellae; lateral pronotal area rugose or with weak transverse ridges; mesopleuron with or without several transverse ridges beneath tegula; mesopleural depression distinct; metapleuron almost smooth; in females fore wing spatulate and with extremely long marginal cilia 1.7–2.2× width of wing; hind wing with a typical inward curve at the end of submarginal vein; hind wing marginal cilia 2.18–2.9× width of wing; in males the wings are narrow, densely covered with microtrichia, and hind wing less curved beyond the submarginal vein.

Metasoma: T1 with a short or long horn, horn with or without costae; T1 costate; T2 either subequal (as in *I. adikeshavus*) or 1.7–2.0× longer than T3; T7 and S6 very large and elongate, ovipositor extruded; laterotergites wide and well incised into sternites.

Discussion. The character states, ocelli adjacent to eye; female with seven antennomeres and an unsegmented clava; male antenna with 12 antennomeres; skaphion absent; hind wing with complete submarginal vein reaching frenal hooks and presence of horn on T1 (though not found in many species of *Idris*) (Masner, personal communication) place this group under *Idris*.

The members of 'the *adikeshavus*-group' however can be distinguished from other species of *Idris* by the combined occurrence of seven character states as mentioned under diagnosis. However the presence of three key character states, *viz.* T2 either 1.7–2.0× longer or equal to T3; T7 and S6 very large and elongate; fore wing and hind wing with extremely long marginal cilia with hind wing curved inwards beyond submarginalis readily distinguishes this species group from other species of *Idris*. As of now 'the *adikeshavus*-group' is restricted to India with five species. Since all species in the Baeini are parasitoids of spider eggs, members of 'the *adikeshavus*-group' too in all likelihood parasitize the eggs of spiders. The members of this group are rare as only 52 specimens were collected during six years of intensive collecting.

The males and females are sexually dimorphic, varying in the presence and absence of horn on T1, shape of wings and density of microtrichia on wings. The presence of a horn (of variable length between species) indicates the presence of a long ovipositor housed within it when not in use as is the case in *Odontacolus* and *Ceratobaeus s.l.*

Key to 'the *adikeshavus* species-group' of *Idris* (based on females)

1 Horn on T1 smooth (Figs 3 & 4) or with weak striae (Fig. 41); microtrichia on fore wings long (Figs 7, 36) 2
· Horn on T1 costate (Figs 30, 32); fore wing almost smooth and shiny (Fig. 33) 4
2 Mesoscutum fully reticulate (Fig. 40) ..... *I. teestai* sp. n.
· Mesoscutum sculptured otherwise (Fig. 2) 3
3 T2 equal to T3 (Fig. 6); T3 weakly striate antero-medially (Fig. 7); forewing marginal cilia 1.7× width of wing (Fig. 7) ..... *I. adikeshavus* sp. n.
· T2 1.7–2.0 longer than T3 (Fig. 23); T3 smooth (Fig. 23); forewing marginal cilia 2.1× width of wing (Fig. 27) ..... *I. deergakombus* sp. n.
4 Propodeum medially produced as a rectangular costate plate (Figs 11 &14); horn short, weakly transversely costate laterally and almost smooth posteriorly (Figs 12 & 17); posterior margin of horn round ..... *I. brevicornis* sp. n.
– Propodeum not produced medially (Fig. 31); horn long, strongly transversely costate laterally and posteriorly (Fig. 30); posterior margin of horn almost wedge shaped (Fig. 31) ..... *I. lopamudra* sp. n.

Idris adikeshavus Veenakumari, sp. n.

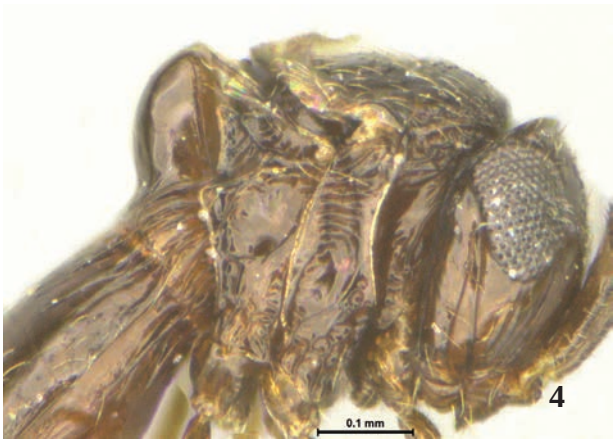
http://zoobank.org/57DE4BAC-CC39-4C2F-8A50-F33AF8CA6FEC
Figures 1–7

Holotype (Female). (ICAR/NBAIR/P371) INDIA: Sikkim, Gangtok, Hanuman Tok, SN, 15.x.2008. **Paratypes**: (ICAR/NBAIR/372), 1 female same data as holotype; (ICAR/NBAIR/P373), 1 female Sikkim, Gangtok, Ranipul, 04.vi.2008, SN; (ICAR/NBAIR/P374), 1 female Sikkim: Pakyong, MT, 02.11.2014; (ICAR/NBAIR/P375), 1 male Sikkim, Tadong, ICAR complex for North Eastern Hill Region, YPT, 29.x. 2014.

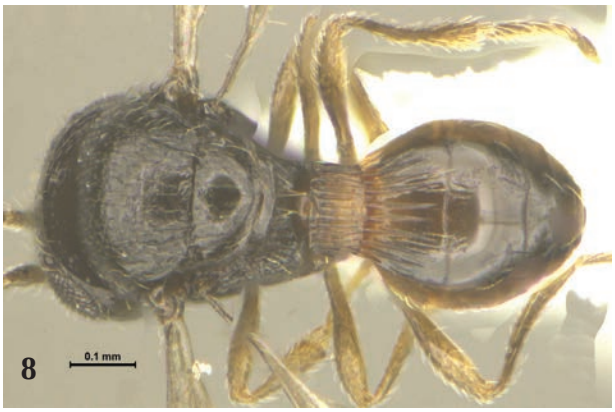
Type locality. INDIA: Sikkim

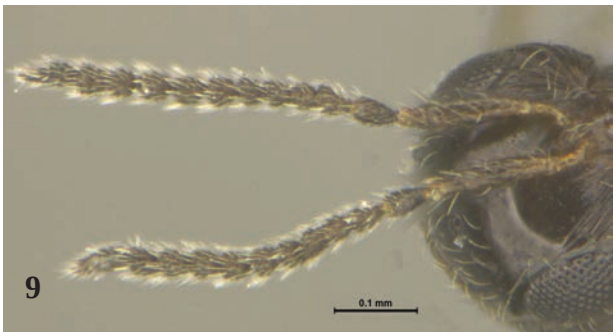
Description of female. Color and size (Figs 1, 3)**.** Head and mesosoma blackish brown, metasoma brown, shining; T7 anteriorly yellow and posteriorly brownish yellow; legs including coxae brown; radicle light brown; A1 brownish black with extremities light brown; A2 dark brown with apex light brown; A3–A6 light brown; clava brownish black. Body length=1.194 mm.

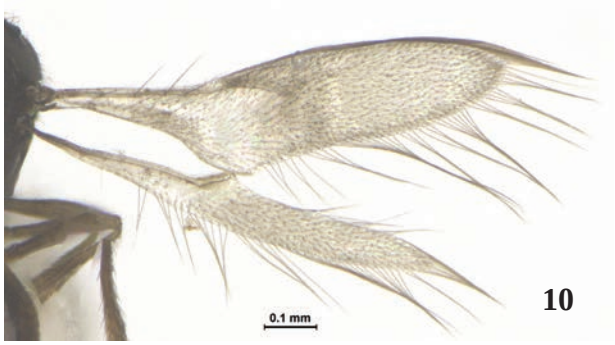
Head (Figs 2, 5). FCI = 1.37; LCI = 1.7; IOS 0.56× width of head; POL > LOL in ratio of 19.7:10.2; lateral ocelli contiguous with eye; compound eyes small (L:W = 14.7:12.7) densely setose; orbital carina sharp, well developed; temples



Figures 1–7. *Idris adikeshavus* sp. n. (female) **1**. Habitus (dorsal); **2.** Head and mesosoma; **3.** Habitus (lateral); **4.** Pleuron; **5.** Head (frontal view) and antennae; **6.** Metasoma; **7.** Wings.







Figures 8–10. *Idris adikeshavus* sp. n. (male). **8.** Habitus; **9.** Antennae; **10.** Wings.

not visible in lateral view; lower frons smooth and shining with strong facial striae; upper frons and vertex setigerous punctate; gena smooth; central keel 0.37× head height; length and width of antennomeres A1–A7 in ratio of 15.1:3.3, 5.1:2.8, 2.0:2.1, 1.9:1.8, 1.8:20, 1.9:2.3, 17.2:7.7, respectively; radicle 0.27× length of A1.

Mesosoma (Figs 2, 4). Mesoscutum (L:W = 18.5:27.6) setose, anteriorly reticulate, posteriorly punctate; notauli (L:W = 6.0:1.5) present; internotular distance 0.45× width of mesoscutum; mesoscutellum (L:W = 7.6:22.7) sparsely setigerous punctate; scutoscutellar sulcus laterally foveate and medially non-foveate; metascutellum smooth, narrow medially, increasing in size laterally; metanotal trough foveate; lateral pronotal area smooth, foveate on posterior margin; mesopleuron with 8 transverse ridges beneath tegula; mesopleural carina, femoral depression and mesopleural pit distinct; metapleuron smooth, metapleural pit distinct; paracoxal sulcus foveate basally; propodeum present as two carinate lamellae anterior to horn.

Fore wing (Fig. 7) (L:W = 63.1:18.0) spatulate, apically stipulate; apical half of fore wing with extremely long marginal cilia, 1.7× width of wing; five long, thick bristles present on submarginalis; entire wing covered with long thin microtrichia; length of submarginalis : marginalis : stigmalis in ratio of 28.2:3.5:10.4; hind wing (L:W = 62.7:10.7) deeply curved inwards beyond submarginal vein; long marginal cilia, 2.65× width of wing present apically; marginal cilia on the incurved anterior margin of wing, 0.26× width of wing, while those on posterior margin of wing 0.81× width of wing; microtrichia on hind wing small and sparse.

Metasoma (Fig. 6). (L:W = 69.1:31.4); T1 finely costate with a long smooth horn; length of horn 1.28× length of T1; posterior margin of T1 beyond horn smooth with a single costa in between ; T2 costate, costae broad, tapering posteriorly, almost reaching posterior margin of T2; length of T2 equal to T3; T3 weakly costate antero-medially; costae reaching 0.63× length of T3; rest of T3 smooth; T4–T7 smooth; T7 acuminate; long setae present on lateral margin of T2, sublateral and lateral margin T3–T6; ovipositor extruded 0.35× length of T7; length and width of tergites T1–T7 in ratio of 11.2:18.1, 13.8:19.1, 13.8:30.9, 6.0:26.1, 3.2:20.1, 2.1:14.6, 19.2:10.6, respectively.

Variability (n=4)**.** Female body length: 1.158–1.198 mm (m=1.176, SD=0.03); FCI=1.30–1.38 (m=1.34; SD=0.04); LCI=1.68–1.8 (m=1.69; SD=0.01); mesoscutum length=0.183–0.205 mm (m=0.188; SD=0.07); mesoscutum width=0.25–0.282 mm (m=0.269; SD=0.09); mesoscutellum length=0.074–0.080 mm (m=0.075; SD=0.08); mesoscutellum width=0.188–0.229 mm (m=0.206; SD=0.01); fore wing length=0.621–0.653 mm (m=0.643; SD=0.03); fore wing width=0.170-0.185 mm (m=0.183; SD=0.09); length of fore wing marginal cilia=0.396–0.426 mm (m=0.406; SD=0.08); hind wing length=0.62–0.638 mm (m=0.632; SD=0.03); hind wing width=0.084-0.11 mm (m=0.092; SD=0.04); length of hind wing marginal cilia=0.283–0.302 mm (m=0.286; SD=0.08); length of T1=0.104–0.112 mm (m=0.109; SD=0.07); length of T2=0.136–0.139 mm (m=0.137; SD=0.07); length of T3=0.134–0.138 mm (m=0.135; SD=0.03).

Description of male (Figs 8, 9, 10). Body length = 1.14 mm. Similar to female except for the following character states.

1. Absence of horn on T1
2. Metascutellum broad and distinct when viewed dorsally
3. Male antenna twelve segmented, constriction between A11 and A12 distinct; length and width of antennomeres A1–A12 in ratio of 15.0:4.3, 5.5:3.5, 4.5:3.8, 3.5:3.3, 3.3:3.8, 3.5:3.8, 3.5:3.8, 4.3:3.8, 4.1:3.8, 4.1:4.3, 3.8:4.3, 8.0:4.3
4. Shape of wings different. Fore wing (L:W = 87.1:20.0) narrow, elongate and densely setose; hind wing (L:W = 79.1:10.3) less curved, densely setose; fore wing marginal cilia 1.34× width of wing; hind wing marginal cilia 1.73× width of wing; wings 1.39× longer than in female

Etymology. The species is named '*adikeshavus*' meaning first one to have long hairs in Sanskrit, alluding to the long marginal setae on both pairs of wings in this species as well as the species group.

Diagnosis. *I. adikeshavus* differs from *I. brevicornis*, *I. deergakombus* and *I. lopamudra* by having T2 equal to T3 while in all others T2 > 1.7× length of T3; T3 faintly costate in *I. adikeshavus* while T3 smooth in other three species; *I. adikeshavus* differs from *I. brevicornis* and *I. lopamudra* in having longer and denser microtrichia on fore wings, while it is almost smooth in the latter two. In *I. adikeshavus*, A4 and A5 subequal to A3 while in others A4 and A5 0.6–0.7× length of A3. *I. teestai* differs from *I. adikeshavus* in having a fully reticulate mesoscutum and mesoscutellum.

Idris brevicornis Veenakumari, sp. n.

http://zoobank.org/551EA7B3-358D-4012-90FD-7191CCD0832C
Figures 11–17

Holotype (Female). (ICAR/NBAIR/P381) INDIA: Karnataka: Bengaluru, Attur, PFT, 24.xii.2012. **Paratypes**: (ICAR/NBAIR/P382), 1 male, same data as holotype, YPT, 08.viii.2013; (ICAR/NBAIR/P383), 1 female, Karnataka: Chikkaballapur, Nandi Hills, SN, 16.xi.2009; (ICAR/NBAIR/P384, P385, P386), 3 females, Karnataka: Bengaluru, Jarakabande Kaval, MT, 22.xi.2013; (ICAR/NBAIR/P387), 1 female, same data as P386, 31.xii.2013; (ICAR/NBAIR/P388), 1 female, same data as P386, 18.x.2013; (ICAR/NBAIR/P389), 1 female, same data as P386, 09.xii.2013; (ICAR/NBAIR/P390), 1 male, Tamil Nadu: Hosur, Uddanapalli, YPT, 31.i.2015; (ICAR/NBAIR/P408, P409), 2 females, Karnataka: Bengaluru, Gandhi Krishi Vigyana Kendra, YPT, 22.xii.2014; (ICAR/NBAIR/P410), 1 female, same data as P390; (ICAR/NBAIR/P411), 1 female, same data as P384, 30.xii.2014.

Type locality. INDIA: Karnataka, Tamil Nadu

Description of female. Color and size (Figs 11, 12)**.** Entire body dark brownish black except yellow T7; legs brown. Body length = 0.716 mm.

Head (Figs 13, 14, 16)**.** FCI=1.37; LCI=1.70; IOS 0.62× width of head; POL > LOL in ratio of 16.5:10.4; length and width of compound eye in ratio of 11.1:8.0; lower frons smooth with facial striae; upper frons and vertex with setigerous punctae; length and width of antennomeres A1–A7 in ratio of 11.6:2.8, 4.5:2.5, 1.8:1.5, 1.3:1.5, 1.3:1.5, 1.8:2.0, 11.5:6.5 respectively; radicle 0.26× length of A1.

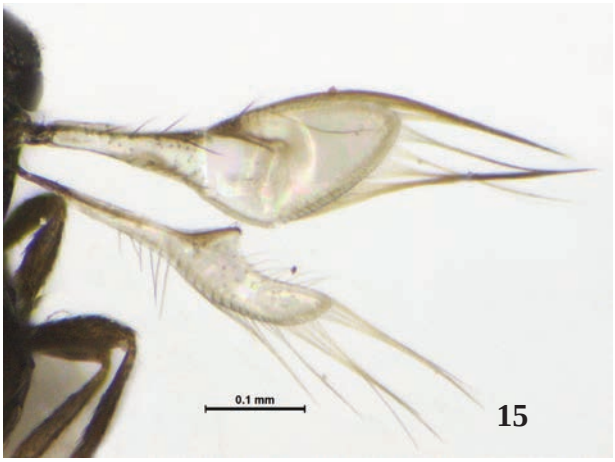
Mesosoma (Fig. 14). Mesoscutum (L:W = 14.3:22.5) anteriorly weakly reticulate, rest smooth, sparsely setose; mesoscutellum (L:W = 5.6:16.9) smooth, sparsely covered with setigerous punctae; notauli short (L:W = 3.9:0.8); internal notular distance 0.54× width of mesoscutum; lateral pronotal area smooth with few foveae ventrally; mesopleuron with six transverse carinae beneath tegula and two short transverse carinae beneath these elongate carinae; femoral depression distinct with foveae posteriorly; mesepimeral sulcus distinct; metapleuron smooth with few foveae ventrally; metapleural pit distinct; scutoscutellar sulcus not foveate except for a single fovea laterally; metascutellum narrow, rectangular; metanotal trough anteriorly smooth and posteriorly with longitudinal foveae; propodeum medially produced as a rectangular costate plate; lateral propodeal area weakly costate.

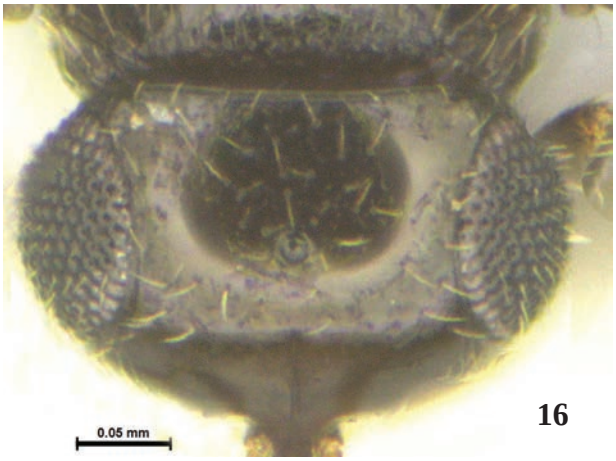
Fore wing (Fig. 15) (L:W = 34.9:12.7) totally devoid of microtrichia in apical half; a few short microtrichia found basally; hind wing (L:W = 34.3:7.9) with a few short microtrichia; fore wing marginal cilia 2× width of wing while hind wing marginal cilia 2.14× width of wing; submarginalis: marginalis: stigmalis in ratio of 16.1:3.1:5.3.

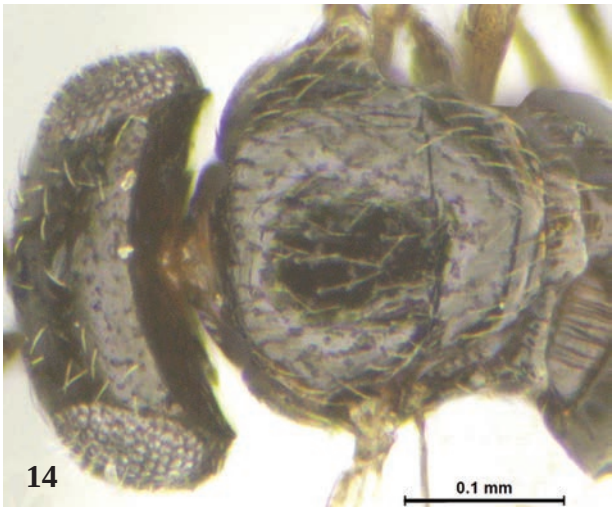
Metasoma (Fig. 17). (L:W = 41.3:25.1); T1 finely costate, with a short round medial horn; horn with a few weak transverse costae laterally and almost smooth posteriorly; height of horn 0.39× length of T1; T2 with basal foveae; T2 costate, costae not reaching posterior margin; rest of tergites smooth; T2, 1.95× longer than T3; sparse long setae found laterally and sublaterally on T2–T4; length and width of tergites T1–T7 in ratio of 7.7:17.5, 13.7:19.4, 7.0:23.8, 2.6:19.5, 1.5:14.2, 1.5:11.8, 6.7:8.3, respectively; ovipositor 0.65× length of T1.

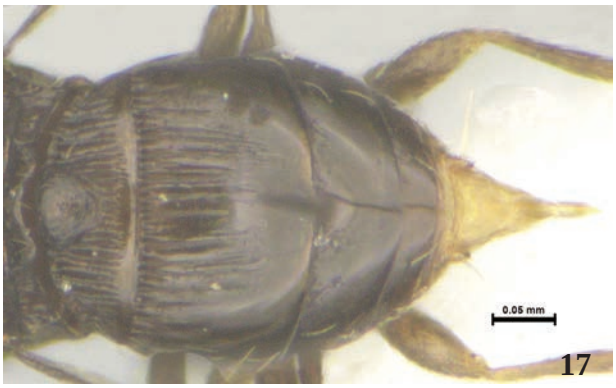
Variability (n=12)**.** Female body length: 0.677–0.782 mm (m=0.72; SD=0.04). FCI=1.31–1.41 (m=1.38; SD=0.02); LCI=1.65–1.71 (m=1.68; SD=0.01); mesoscutum length=0.122–0.149 mm (m=0.138; SD=0.07); mesoscutum width=0.213–0.239 mm (m=0.227; SD=0.01); mesoscutellum length=0.046–0.065 mm (m=0.054; SD=0.06); mesoscutellum width=0.16–0.192 (m=0.183; SD=0.01); fore wing length=0.297–0.398 mm (m=0.352; SD=0.03); fore wing width=0.113–0.135 mm (m=0.12; SD=0.01); length of fore wing marginal cilia=0.212–0.239 mm (m=0.221; SD=0.01); hind wing length=0.288–0.346 mm (m=0.331; SD=0.03); hind wing width=0.075–0.089 mm (m=0.08; SD=0.04); length of hind wing marginal cilia=0.148–0.189 mm (m=0.172; SD=0.01); length of T1=0.071–0.079 mm (m=0.076; SD=0.04); length of T2=0.123–0.139 mm (m=0.131; SD=0.06); length of T3=0.051–0.071 mm (m=0.062; SD=0.08).

Description of male (Figs 18, 19, 20)**.** Similar to female; Body length=0.758 mm; length and width of antenno-

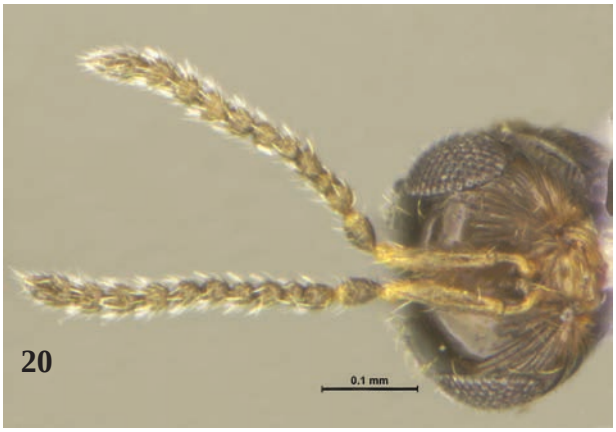








Figures 11–17. *Idris brevicornis* sp. n. (female). **11.** Habitus (dorsal); **12.** Habitus (lateral) and pleuron; **13.** Head (frontal view) and antennae; **14.** Head and mesosoma; **15.** Wings; **16.** Head showing ocelli; **17.** Metasoma.



Figures 18–20. *Idris brevicornis* sp. n. (male) **18.** Habitus; **19.** Wings; **20.** Antennae.

meres A1–A12 in ratio of 11.8:3.3, 5.3:3.3, 3.5:3.3, 2.3:2.8, 2.5:3.3, 2.3:2.8, 2.8:3.0, 3.0:3.3, 3.0:3.5, 3.0:3.5, 3.5:3.5, 5.8:3.5 respectively; fore wing (L:W = 60.7:14.2) and hind wing (L:W = 52.7:7.3) densely covered with long microtrichia; fore wing marginal cilia equal to width of wing; hind wing marginal cilia 1.81× width of wing.

Etymology. The species is named '*brevicornis*' referring to the short horn on T1.

Diagnosis. *I. brevicornis* differs from *I. lopamudra* in having a short horn, with the latter having a longer horn which is distinctly costate laterally and posteriorly; T2 in *I. brevicornis* is 1.95× longer than T3 while in *I. lopamudra* T2 1.7× longer than T3; propodeum is extended as median costate plate in *I. brevicornis* which is not so in other species of *Idris* described here.

Idris deergakombus Veenakumari, sp. n.

http://zoobank.org/C4EDBF3E-E01C-4342-A665-D9F6FD7FE428
Figures 21–27

Holotype (Female) (ICAR/NBAIR/P376) INDIA: Arunachal Pradesh, Pasighat, College of Horticulture and Forestry, YPT, 05.v.2014. **Paratypes:** (ICAR/NBAIR/P377, P378), 2 females, same data as that of holotype; (ICAR/NBAIR/P379), same data as holotype, SN, 03.v.2014; (ICAR/NBAIR/P380), same data as holotype, YPT, 03.v.2014.

Type locality. INDIA: Arunachal Pradesh, Pasighat.

Description of female. Color and size (Figs 21, 25). Head, mesosoma, horn on T1 dark brown; metasomal tergites T1–T6 paler than mesosoma; T7 yellowish brown; legs same color as metasoma except paler tarsi; antennae brown except dark brown T2 and clava. Body length=0.989 mm.

Head (Figs 24, 26)**.** FCI=1.25; LCI=1.60; IOS 0.6× width of head; lower frons smooth, upper frons setigerous punctate; facial striae present reaching lower orbit; gena smooth; POL>OOL in ratio of 17.9:9.9; eyes (L:W = 12.7:9.8) densely setose; length and width of antennomeres A1–A7 in ratio of 12.6:2.7, 4.6:3.0, 1.8:1.8, 1.1:1.7, 1.1:1.8, 1.9:2.5, 13.6:7.8, respectively; radicle 0.27× length of A1.

Mesosoma (Figs 22, 25)**.** Mesoscutum (L:W = 15.4:23.7) anteriorly reticulate, posteriorly setigerous punctate; mesoscutellum (L:W = 6.0:15.0) with similar sculpture as that of mesoscutum anteriorly, posteriorly almost smooth; notauli (L:W = 4.0:1.2) present; internotular distance 0.43× width of mesoscutum; lateral pronotal area almost smooth with weak transverse ridges; mesopleuron with eight transverse ridges beneath tegula, femoral depression, mesopleural carina distinct; posterior margin of femoral depression crenulate; metapleuron smooth, with distinct metapleural sulcus and metapleural pit; scutoscutellar sulcus weakly foveate; metascutellum medially narrow and laterally broad; propodeum present as lateral lamellae anterior to horn.

Figures 21–27. *Idris deergakombus* sp. n. (female) **21.** Habitus (dorsal); **22.** Pleuron; **23.** Metasoma **24.** Head (frontal view) and antennae; **25.** Habitus (lateral); **26.** Head and mesosoma; **27.** Wings.

Fore wing (Figs 26, 27) (L:W = 46.3:13.9) transparent with long microtrichia; hind wing (L:W = 45.7:8.4) with sparse short microtrichia; submarginalis : marginalis: stigmalis of fore wing in ratio of 20.7:3.0:6.4 respectively; fore wing marginal cilia 2.1× width of wing while hind wing marginal cilia 2.94× width of wing.

Metasoma (Fig. 23) (L:W = 60.3:25.0); anterior margin of T1 crenulate; T1 strongly costate; horn on T1 long, smooth except for few weak costae posteriorly; length of horn 1.41× length of T1; T1 with two lateral setae; T2 anteriorly smooth beneath which a row of basal foveae present; T2 costate beneath basal foveae, costae not reaching posterior margin; T2, 2× length of T3; T2 with dense short lateral setae; T3–T7 smooth; T3 with long sublateral setae; T4 and T5 with single sublateral seta; ovipositor extruded 0.25× length of T7; T7 acuminate; length and width of tergites in ratio of 7.4:17.3, 16.7:15.7, 8.0:24.5, 5.0:23.0, 3.3:17.4, 2.0:13.9, 17.8:10.9, respectively.

Variability (n=5)**.** Female body length=0.929–1.128 mm (m=1.07; SD=0.07); FCI=1.21–1.36 (m=1.3; SD=0.02); LCI=1.58–1.69 (m=1.63; SD=0.03); mesoscutum length=0.141–0.159 mm (m=0.15; SD=0.07); mesoscutum width=0.22–0.239 mm (m=0.227; SD=0.07); mesoscutellum length=0.056–0.073 (m=0.066; SD=0.07); mesoscutellum width=0.135–0.161 mm (m=0.157; SD=0.015); fore wing length=0.407–0.468 mm (m=0.426; SD=0.03); fore wing width=0.124–0.150 mm (m=0.133; SD=0.01); length of fore wing marginal cilia=0.284–0.385 mm (m=0.332; SD=0.03);hind wing length=0.432–0.483 mm (m=0.445; SD=0.04); hind wing width=0.071–0.087 mm (m=0.077, SD=0.04); length of hind wing marginal cilia=0.221–0.251 (m=0.232; SD=0.04); length of T1=0.068-0.084 mm (m=0.073; S. D.=0.09); length of T2=0.148–0.174 mm (m=0.16; SD=0.09); length of T3=0.078–0.092 mm (m=0.085; SD=0.05).

Male. Unknown

Etymology. The species is named '*deergakombus*' which means 'long horn' in Sanskrit.

Diagnosis. *I. deergakombus* differs from *I. brevicornis* and *I. lopamudra* in having long and denser microtrichia on fore wing while in the latter two the wings are almost smooth; horn on T1 is longer and smooth in *I. deergakombus* while it is costate in *I. brevicornis* and *I. lopamudra*. *I. deergakombus* has a long horn while it is short in *I. brevicornis*; In *I. deergakombus* T2 2× length of T3 while in *I. lopamudra* T2 1.7× length of T3.

Idris lopamudra Veenakumari, sp. n.

http://zoobank.org/359E61DA-8A59-4501-8A28-4CBF3758191A
Figures 28–34

Holotype (Female). (ICAR/NBAIR/P391) INDIA: Karnataka: Bengaluru, Hebbal, YPT, 12.iv.2010. **Paratypes**: (ICAR/NBAIR/P392), 1 female, same data as holotype, PFT, 18.i.2010; (ICAR/NBAIR/P393), 1 female, same data as P392, 11.i.2010; (ICAR/NBAIR/P394), 1 female, same data as P392, 04.i.2010; (ICAR/NBAIR/P395), 1 female, same data as P392, YPT, 03.iii.2010; (ICAR/NBAIR/P396), 1 female, same data as P392, PFT, 20.ii.2010; (ICAR/NBAIR/P397, P398), 2 females, Bengaluru, Malleshwaram, Aranyabhavan, PFT, 17.ii.2010; (ICAR/NBAIR/P399), 1 female, Bengaluru, Attur, YPT, 27.vii.2013; (ICAR/NBAIR/P400), 1 female, Karnataka: Tumkur, Ranganathswamy Betta, SN, 20.ix.2011; (ICAR/NBAIR/P401), 1 female, Karnataka: Bengaluru, Jarakabande Kaval, MT, 23.i.2015; (ICAR/NBAIR/P402), 1 female, same data as P401, YPT, 13.i.2014; (ICAR/NBAIR/P403), 1 female, same data as P401, MT, 29.i.2014; (ICAR/NBAIR/P404), 1 female, same data as P401, MT, 31.xii.2013; (ICAR/NBAIR/P405), 1 female, Tamil Nadu: Hosur, Uddanapalli, MT, 31.1.2015; (ICAR/NBAIR/P406), 1 female, same data as P405, YPT, 31.i.2015; (ICAR/NBAIR/P407), 1 female, same data as P405, YPT, 02.xii.2014.

Type locality. INDIA, Karnataka, Tamil Nadu

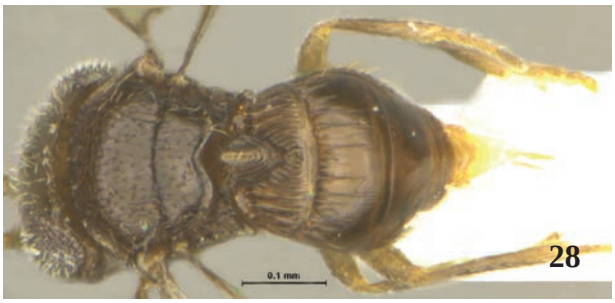
Description of female. Color and size (Fig. 28)**.** Head, mesosoma brown, metasoma paler than mesosoma; posterior tergites yellowish brown; legs same color as metasoma; antennae brown to dark brown with patches of yellow on apical A1, anterior and posterior margin of A2 and lateral clava. Body length=0.725 mm.

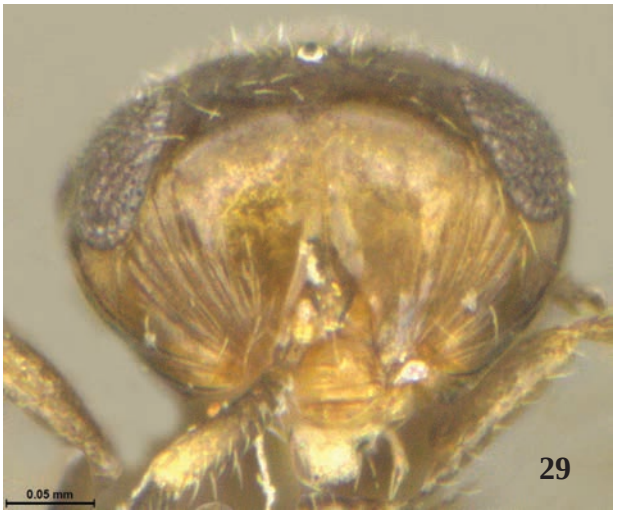
Head (Figs 29, 31, 34)**.** FCI=1.24; LCI=1.65; IOS 0.57× width of head; lower frons smooth, upper frons and vertex with setigerous punctae; eyes (L:W = 11.1:10.1) densely setose; strong facial striae present; central keel present; gena smooth. POL>LOL in ratio of 15.4:8.5; length and width of antennomeres A1–A7 in ratio of 11.2:3.8, 5.0:3.3, 1.8:2.3, 1.1:2.0, 1.2:2.3, 1.7:2.3, 11.5:7.5, respectively; radicle 0.24× length of A1.

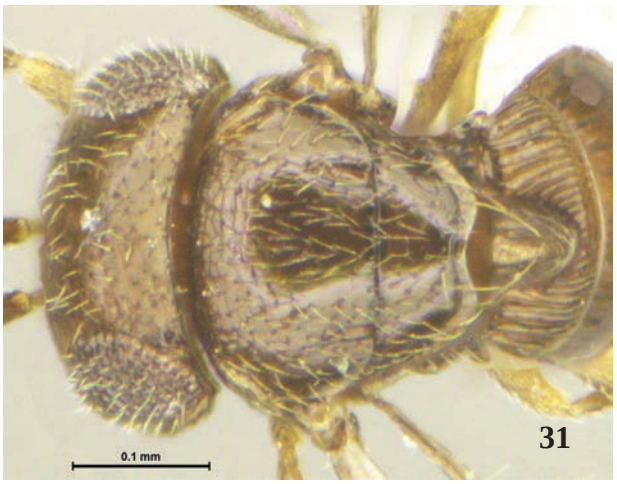
Mesosoma (Figs 30, 31)**.** Mesoscutum (L:W = 13.6:22.9) anteriorly reticulate and posteriorly setigerous punctate; notauli (L:W = 4.1:1.4) present; internotular distance 0.44× width of mesoscutum; mesoscutellum (L:W = 5.2:18.8) with setigerous punctae; metascutellum smooth, narrow and medially indented; metanotal trough weakly foveate; scutoscutellar sulcus not foveate medially, foveate laterally; lateral pronotal area almost smooth except for a few faint transverse carinae anteriorly; mesopleuron with eight transverse carinae beneath tegula; femoral depression and mesopleural carina distinct; metapleuron almost smooth except for some uneven sculpture dorsally; propodeum present as lateral lamellae anterior to horn.

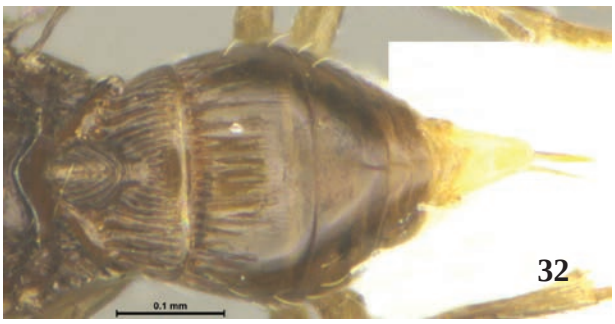
Fore wing (Fig. 33) (L:W = 34.8:12.6) transparent with very sparse microtrichia in basal half; hind wing (L:W = 32.3:7.6) less curved, with sparse microtrichia; fore wing marginal cilia 2.12× width of wing; hind wing marginal cilia 2.46× width of wing; submarginalis: marginalis: stigmalis in ratio of 16.7:2.6:6.6 respectively.

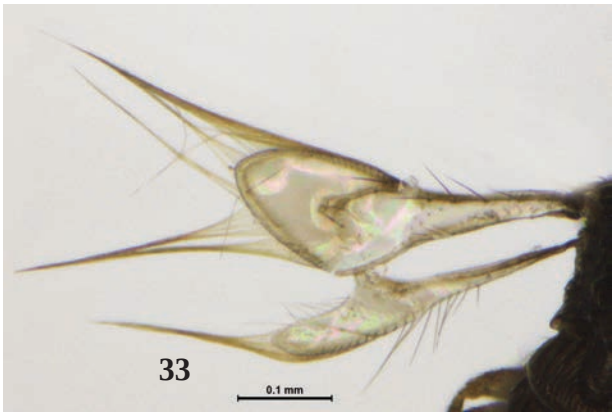
Metasoma (Fig. 32)**.** (L:W = 40.5:24.8); T1 strongly costate, costae extending up to posterior margin; T1 with median horn, horn transversely costate laterally and posteriorly; horn almost wedge shaped posteriorly; T2 basally foveate, costate, costae wide apart; T2 1.7× longer than T3; T3–T7 smooth; sparse long setae present sublaterally on T2 and T3; length and width of tergites T1–T7 in



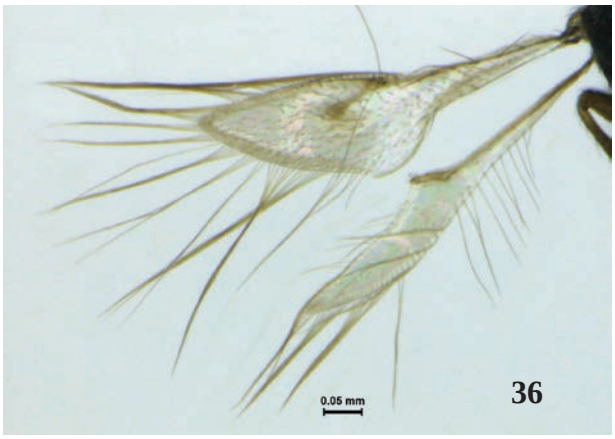


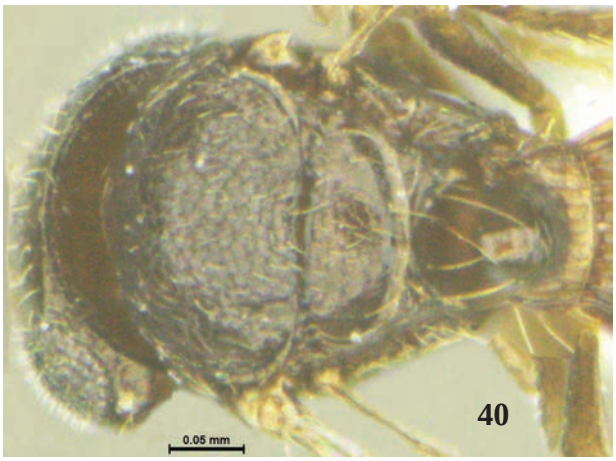


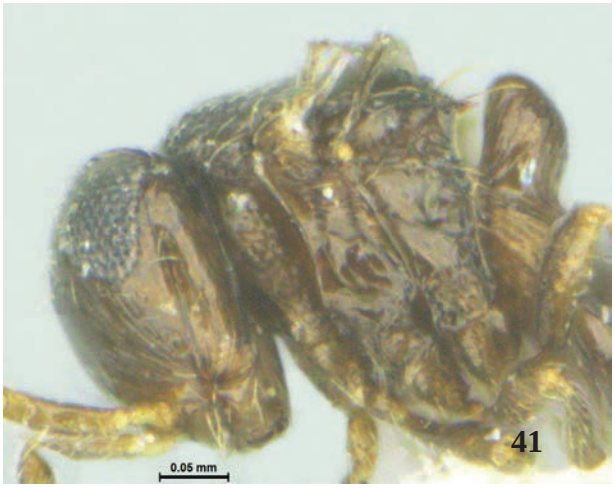




Figures 28–34. *Idris lopamudra* sp. n. (female) **28.** Habitus; **29.** Head (frontal view); **30.** Pleuron; **31.** Head and mesosoma; **32.** Metasoma; **33.** Wings; **34.** Head and antennae.







Figures 35–41. *Idris teestai* sp. n. (female) **35** Habitus (dorsal); **36** Wings; **37** Metasoma (dorsal); **38** Metasoma (lateral); **39** Head and antennae; **40** Mesoscutum and mesoscutellum showing reticulations; **41** Pleuron.

ratio of 8.6:18.5, 11.4:20.1, 6.7:24.3, 2.0:16.9, 1.8:13.6, 0.9:9.2, 8.6:8.0, respectively.

Variability (n=15)**.** Female body length=0.745–0.837 mm (m=0.8; SD=0.03); FCI=1.15–1.30 (m=1.25; SD=0.06); LCI=1.63–1.72 (m=1.68; SD=0.09); mesoscutum length=0.123–0.149 mm (m=0.136; SD=0.09); mesoscutum width=0.192–0.239 mm (m=0.219; SD=0.04); mesoscutellum length=0.05–0.065 mm (m=0.058; SD=0.09);

mesoscutellum width=0.18–0.193 mm (m=0.189; SD=0.01); fore wing length=0.341–0.391 mm (m=0.353; SD=0.09); fore wing width=0.121–0.141 mm (m=0.132; SD=0.05); length of fore wing marginal cilia=0.273–0.318 mm (m=0.291;SD=0.01); hind wing length=0.315–0.342 mm (m=0.329;SD=0.03); hind wing width=0.07–0.081 mm (m=0.079; SD=0.09); length of hind wing marginal cilia=0.17–0.205 (m=0.186; SD=0.01); length of T1=0.08–0.092 mm (m=0.087; SD=0.01); length of T2=0.113–0.121 mm (m=0.117; SD=0.05); length of T3=0.057–0.071 mm (m=0.067; SD=0.07).

Male. Not known.

Etymology. The species is named '*lopamudra*' after the wife of the Vedic sage Agastya, who was one of the few women philosophers of ancient India; used here as a noun in apposition.

Diagnosis. The distinguishing characters for this species are mentioned under other species of *Idris*.

Idris teestai Veenakumari, sp. n.

http://zoobank.org/8CAB4371-84C2-4F2B-A733-5100F8106172
Figures 35-41

Holotype (Female). (ICAR/NBAIR/P856) INDIA: Sikkim, Gangtok, Hanuman Tok, SN, 12.x.2008.

Type locality. INDIA: Sikkim.

Description of female. Color and size (Fig. 35). Head, mesosoma dark brown with lateral margin of mesoscutum and metanotum greyish-brown; metasoma brown except T7 which is a shade paler, horn dark brown, legs dark brown; radicle yellowish brown, rest of antennomeres brown except dark brown clava. Body length = 0.834 mm. (n=1).

Head (Figs 39, 41)**.** FCI=1.23; LCI=1.68; IOS 0.61× width of head; lower frons smooth; upper frons and vertex setigerous punctate; eyes (L:W = 10.6:8.5) densely setose; facial striae strong; central keel long, 0.5× height of head; POL>LOL in ratio of 15.8:8.6; interantennal process projecting; length and width of antennomeres A1–A7 in ratio of 10.8:2.6, 3.9:2.9, 1.8:1.8, 1.2:1.9, 1.3:1.5, 1.8:2.2, 11.0:5.3, respectively; radicle long 0.37× length of A1.

Mesosoma (Figs 40, 41)**.** Mesoscutum (L:W = 14.4:22.2) fully reticulate, sparsely setose, setae short; notauli short (L:W = 3.2:1.1); internotular distance 0.67× width of mesoscutum; mesoscutellum (L:W = 6.4:14.6), with same sculpture as that of mesoscutum; metascutellum smooth, narrow, uniformly rounded posteriorly; metanotal trough with weak foveae; scutoscutellar sulcus not foveate medially, weakly foveate laterally; lateral pronotal area weakly rugose; mesopleuron with weak transverse striae beneath tegula; mesopleural pit with deep foveae ventrally; metapleuron almost smooth with uneven sculpture ventrally; metapleural pit present; propodeum present as lateral lamellae anterior to horn; anterior and posterior margin of propodeum projecting as a small spine.

Forewing (Fig. 36.) (L:W = 47.9:14.6) with long marginal cilia 2.1× width of wing; entire wing with long microtrichia; length of submarginalis: marginalis: stigmalis in ratio of 23.7:4.6:8.6 respectively; hind wing (L:W = 47.3:7.9) with short, sparse microtrichia; hind wing marginal cilia 2.18× width of wing.

Metasoma (Figs 37, 38)**.** (L:W = 49.8:21.8); T1 strongly costate the entire length; horn (L:W = 8.6:6.3) on T1 smooth with weak striae; striae longitudinal laterally and transverse posteriorly; T2 basally foveate, strong costae arising from these foveae; costae on T2 not reaching posterior margin; T2 posteriorly smooth; anterior margin of T3 convex as a result of which length of T2 is longer laterally; T2 subequal to T3; T3 weakly striate in anterior half, setose sublaterally; T4–T7 smooth; length and width of tergites T1–T7 in ratio of 7.5:10.1, 12.8:11.0, 12.6:21.6, 4.5:18.2, 1.7:14.2, 1.2:10.1, 9.7:8.1, respectively.

Male. Not known.

Etymology. The species is named '*teestai*' after the river Teesta in the state of Sikkim, from where the type specimen was collected.

Diagnosis. This species can be easily distinguished from the other four species described here by reticulate sculpture on mesoscutum and mesoscutellum.

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References

Austin AD (1984) The fecundity, development and host relationship of *Ceratobaeus* spp. (Hymenoptera: Scelionidae), parasites of spider eggs. Ecological Entomology 9: 125–138. doi: 10.1111/j.1365-2311.1984.tb00707.x

Austin AD (1985) The function of spider egg sacs in relation to parasitoids and predators, with special reference to the Australian fauna. Journal of Natural History 19: 359–376. doi: 10.1080/00222938500770261

Austin AD (1986) A taxonomic revision of the genus *Mirobaeoides* Dodd (Hymenoptera: Scelionidae). Australian Journal of Zoology 34: 315–337. doi: 10.1071/ZO9860315

Austin AD (1988) A new genus of baeine wasp (Hymenoptera: Scelionidae) from New Zealand associated with moss. New Zealand Journal of Zoology 15: 173–183. doi: 10.1080/03014223.1988.10422612

Austin AD (1995) New species of baeine parasitoids of spider eggs (Hymenoptera: Scelionidae) from Western Australia. Records of the Western Australian Museum, Supplement No. 52: 253–263.

Austin AD, Field SA (1997) The ovipositor system of scelionid and platygastrid wasps (Hymenoptera: Platygastroidea): comparative morphology and phylogenetic implications. Invertebrate Taxonomy 11: 1–87. doi: 10.1071/IT95048

Austin AD, Johnson NF, Dowton M (2005) Systematics, evolution and biology of scelionid and platygastrid wasps. Annual Review of Entomology 50: 552–583. doi: 10.1146/annurev.ento.50.071803.130500

Carey D, Murphy NP, Austin AD (2006) Molecular phylogenetics and the evolution of wing reduction in a tribe of parasitoid wasps (Hymenoptera: Scelionidae: Baeini). Invertebrate Systematics 20: 489–501. doi: 10.1071/IS06011

Förster A (1856) Hymenopterologische Studien. II. Heft. Chalcidae und Proctotrupii. Ernst ter Meer, Aachen, 152 pp.

Galloway ID, Austin AD (1984) Revision of the Scelioninae (Hymenoptera: Scelionidae) in Australia. Australian Journal of Zoology, Supplementary Series 99: 1–138.

Huggert L (1979) Revision of the west Palaearctic species of the genus *Idris* Foerster *s.l.* (Hymenoptera, Proctotrupoidea, Scelionidae). Entomologica Scandinavia Suppl. No. 12, 60 pp.

Iqbal M, Austin AD (1997) Species richness and endemism of baeine wasps (Hymenoptera: Scelionidae) in Australia. Memoirs of Museum Victoria 56: 455–459.

Iqbal M, Austin AD (2000a) Systematics of the wasp genus *Ceratobaeus* Ashmead (Hymenoptera: Scelionidae) from Australasia: parasitoids of spider eggs. Records of the South Australian Museum, Monograph Series 6: 1–164.

Iqbal M, Austin AD (2000b) A preliminary phylogeny for the Baeini (Hymenoptera: Scelionidae): Endoparasitoids of spiders eggs. In: Austin AD, Dowton M (Eds) The Hymenoptera; Evolution, Biodiversity and Biological control. CSIRO Publishing, Melbourne, 178–191.

Johnson NF (2015) Platygastroidea. http://osuc.biosci.ohio-state.edu/hymDB/eol_scelionidae.home [accessed on 14.6.2014]

Mani MS (1939) Descriptions of new and records of some known chalcidoid and other hymenopterous parasites from India. Indian Journal of Entomology 1: 69–99.

Mani MS (1973) On a new scelionid parasite (Hymenoptera: Serphoidea). Oriental Insects 7: 353–354. doi: 10.1080/00305316.1973.10434097

Mani MS (1975) On a collection of Scelionidae and Platygasteridae (Hymenoptera: Proctotrypoidea) from India. Memoirs of the School of Entomology, St. John's College 4: 63–80.

Mani MS, Mukerjee MK (1976) On some Baeinae (Proctotrupoidea: Scelionidae) from India. Oriental Insects 10: 497–526. doi: 10.1080/00305316.1976.10434520

Mani MS, Sharma SK (1982) Proctotrupoidea (Hymenoptera) from India. A review. Oriental Insects 16: 135–258. doi: 10.1080/00305316.1982.10434314

Masner L (1976) Revisionary notes and keys to world genera of Scelionidae (Hymenoptera: Proctotrupoidea). Memoirs of the Entomological Society of Canada 108: 1–87. doi: 10.4039/entm10897fv

Masner L (1980) Key to genera of Scelionidae of the Holarctic region, with descriptions of new genera and species (Hymenoptera: Proctotrupoidea). Memoirs of the Entomological Society of Canada 112: 1–54. doi: 10.4039/entm112113fv

Masner L, Denis J (1996) The Nearctic species of *Idris* Foerster. Part I: the *melleus*-group (Hymenoptera: Scelionidae). The Canadian Entomologist 128: 85–114. doi: 10.4039/Ent12885-1

Mikó I, Masner L, Deans AR (2010) World revision of *Xenomerus* Walker (Hymenoptera: Platygastroidea, Platygastridae). Zootaxa 2708: 1–73.

Mikó I, Vilhelmsen L, Johnson NF, Masner L, Pénzes Z (2007) Skeleto-musculature of Scelionidae (Hymenoptera: Platygastroidea) head and mesosoma. Zootaxa 1571: 1–78.

Mukerjee MK (1978) Descriptions of some Baeinae-complex (Hymenoptera: Proctotrupoidea: Scelionidae) from India. Memoirs of the School of Entomology, St. John's College 5: 47–66.

Mukerjee MK (1981) On a collection of Scelionidae and Platygastridae (Hymenoptera: Proctotrupoidea) from India. Records of the Zoological Survey of India, Miscellaneous Publication, Occasional Papers. No. 2, 78 pp.

Mukerjee MK (1994) Descriptions of some new and records of some known Proctotrupoidea (Hymenoptera) from Garhwal Himalayas, India. Records of the Zoological Survey of India, Occasional Papers 163: 1–73.

Murphy NP, Carey D, Castro LR, Dowton M, Austin AD (2007) Phylogeny of the platygastroid wasps (Hymenoptera) based on sequences from the 18srRNA, 28S rRNA and cytochrome oxidase *I* genes: implications for the evolution of the ovipositor system and host relationships. Biological Journal of the Linnaean Society 91: 653–669. doi: 10.1111/j.1095-8312.2007.00825.x

Stevens NB, Austin AD (2007) Systematics, distribution and biology of the Australian ‚micro-flea' wasps, *Baeus* spp. (Hymenoptera: Scelionidae): parasitoids of spider eggs. Zootaxa 1499: 1–45.

Valerio AA, Austin AD, Masner L, Johnson NF (2013) Systematics of Old World *Odontacolus* Kieffer *s.l.* (Hymenoptera, Platygastridae *s.l.*): parasitoids of spider eggs. ZooKeys 314: 1–151. doi: 10.3897/zookeys.314.3475

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On foreign land: the conquest of Europe by *Cinara curvipes* (Patch, 1912)

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http://zoobank.org/042F2C13-2C7E-433C-BE06-BA26D5DCDCC3

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Abstract

Cinara curvipes (Patch, 1912), a Nearctic aphid species first recorded in Europe at the turn of the millenium, has invaded almost one quarter of the continent during the past 15 years. This communication gives information about the first reports from Poland, summarises the species' conquest of Europe and gives forecasts and possible explanations for such a rapid expansion. An identification key to aphid species on *Abies* is provided to help monitor its further expansion, as well as for the benefit of forestry and phytosanitary services.

Key Words

biocapacity
climatic changes
Aphidoidea
invasiveness forecast
species acclimatization
zoogeography

Introduction

About 200 aphid species of the genus *Cinara* (Lachnidae) are known worldwide: 21 of them infest *Abies* spp. (Blackman and Eastop 2015), but only three species have so far been reported from Europe (Holman 2009).

Numerous reports have been recently published on harmful aphid species – both native (e.g. Hałaj and Osiadacz 2015, Martin 2010, Osiadacz and Hałaj 2014, Vučetić et al. 2014) and alien (e.g. Cœur d'acier et al. 2010, Hałaj et al. 2011, Pérez Hidalgo and Mier Durante 2012, Rakauskas et al. 2015) – expanding their distribution ranges in Europe. *Cinara curvipes* (Patch) – the bow-legged fir aphid – is one such alien species, originally from North America, where it is widespread (Maw et al. 2000; Voegtlin and Bridges 1988). The first reports of *C. curvipes* in Europe date back to the late 1990s, and interestingly, relate almost simultaneously to three disjunct regions of the continent: the United Kingdom (Martin 2000), Germany (Gottschalk 2001, Scheurer 2001) and Serbia (Poljaković-Pajnik and Petrović-Obradović 2002). Further reports, after a period without any, come from 2007-2009, when *C. curvipes* was still expanding its distribution in the United Kingdom (Baker 2009) and Germany (Scheurer 2009), but in the meantime it was found in Switzerland (Angst et al. 2007), the Czech Republic (Olbrechtová 2007), Slovakia (Nakládal et al. 2007) and Slovenia (Jurc et al. 2009). There were no further reports of a significant expansion of its range until 2013-2014, when it was found in Hungary (Bodor 2013) and Austria (Perny 2014), and there is a recent report from Turkey (Görür et al. 2015). In 2014 it was found in Poland for the first time (Gliwice, 11.04.2014; Zabrze, 26.04.2014). The following year, as well as in further localities in Upper Silesia (Bytom, 16.05.2015; Ruda Śląska, 24.05.2015), it was found in the Wielkopolska-Kujawy Lowland (Białe

Błota near Bydgoszcz, 03.05.2014; Konin, 01.06.2015; Bukówiec Górny near Leszno, 09.05.2015; Poznań, 21.05.2015) (Fig. 1). Aphid samples (wingless and winged morphs) were collected from colonies of several hundred individuals that were feeding on the lower trunk parts or older branches of *Abies concolor* (Fig. 2) and *A. alba* (Upper Silesia: Ruda Śląska, 24.05.2015).

The information on the sightings of this species, although not 'hard evidence', may suggest an explanation for this aphid expansion, namely, that it is happening by natural dispersal rather than by trade in infested plants (although this possibility cannot be ruled out). Winged females (migrants) disperse not only through active flight; above all, given the significant distances between sightings, they appear to move passively with the aerial plankton. It is reasonable to assume that this could be the way in which the species has invaded Europe. It must be pointed that large scale dispersion happens occasionally. Irruptions sometimes occur, especially when warmer winters are favourable to the species' development. This aphid can undergo not only a complete life cycle with sexual morphs and overwintering eggs (holocyclic development), but also permanent parthenogenesis (anholocyclic development) with overwintering wingless adults and larvae. During mild winters the survival rate of these morphs increases significantly and in early spring very large colonies appear, in which the proportion of winged morphs can reach 30%, and later as much as 90% (Scheurer and Binazzi 2004). The potential to infest new host plants in new areas is therefore very considerable. One can therefor speculate that local and global climate changes leading to warming (Spencer et al. 2015), and boosting the activity of sucking insects (Rouault et al. 2006), constitute one of the factors governing the expansion of the bow-legged fir aphid. Moreover, only a few predators that naturally control its abundance have been found (Olbrechtová 2007, Scheurer and Binazzi 2004), and no parasitoids have been reported (Starý and Havelka 2008). During this study larvae of *Harmonia axyridis* (Pallas) (a ladybird, also invasive) were for the first time

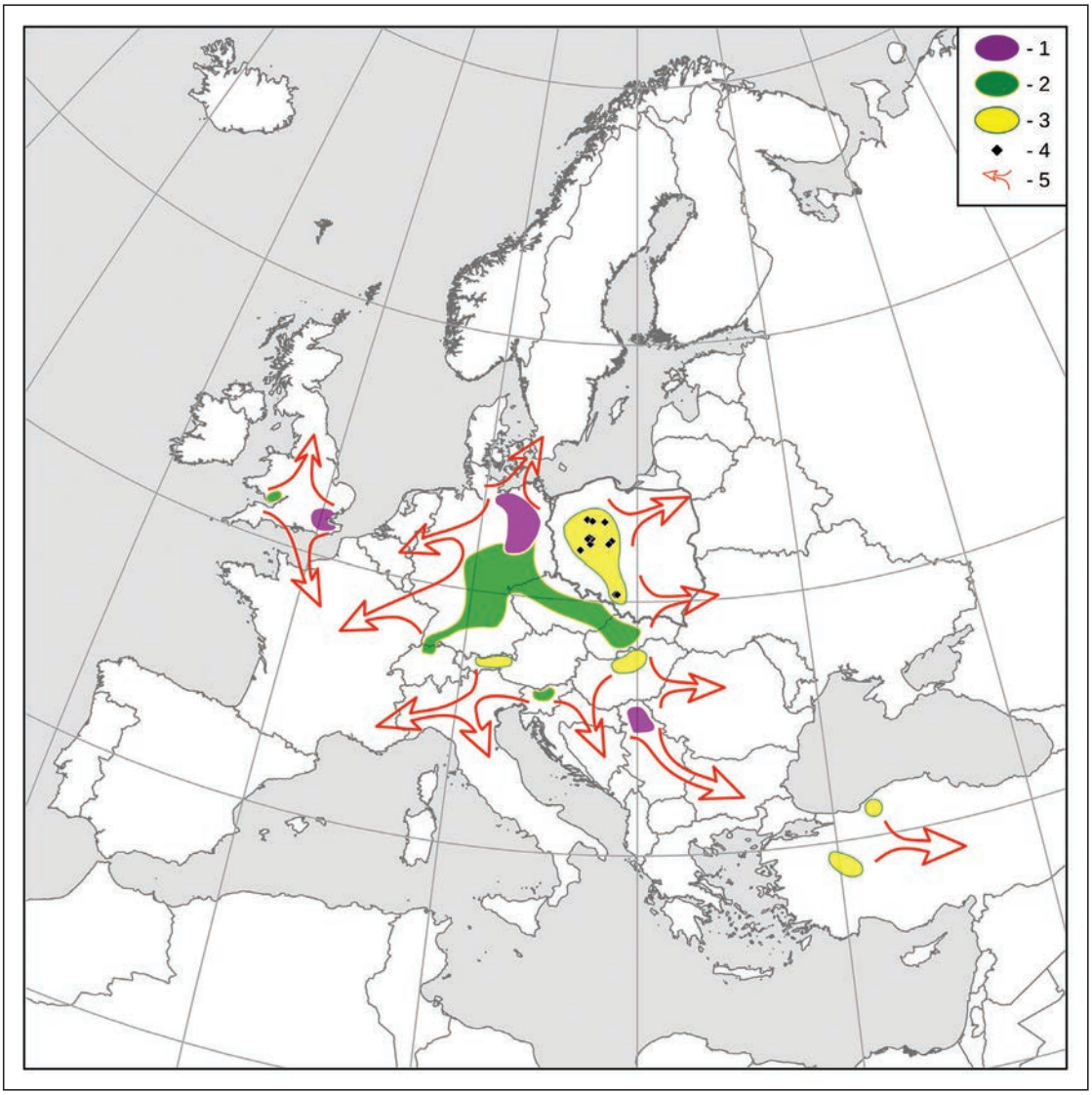

Figure 1. Distribution of *Cinara curvipes* in Europe – records in particular periods and predicted expansion. **1.** recorded in 1999–2001; **2.** recorded in 2007-2009; **3.** recorded in 2013-2015; **4.** 1st records in Poland; **5.** probable expansion routes.

Figure 2. *Cinara curvipes* on the trunk of *Abies concolor* (29 May 2015) [photo by M. Kręciała].

found in these aphid colonies, but only at two sites, in small numbers, and not during the peak abundance of the aphid population (± 3 larvae / 200 aphids). As observed by others (Jurc et al. 2009, Scheurer 2009, Scheurer and Binazzi 2004) ants (*Lasius niger* L., *Myrmica rubra* L.) were present in some aphid colonies, but only at one quarter of the sites examined by us.

C. curvipes is an oligophagous species which in its original area infests many coniferous trees (*Abies balsamea*, *A. concolor*, *A. grandis*, *A. lasiocarpa*, *A. magnifica*, *A. religiosa*, *Picea engelmannii*, *P. glauca*, *Pinus contorta*). Most of these plants are grown in Europe as decorative trees and here, too, they were found to have been attacked by the bow-legged fir aphid. However, its first sighting was on the Mediterranean *Cedrus atlantica* (Martin 2000), and later ones were on coniferous trees from Asia (*Abies koreana*, *A. nordmanniana*, *A. veitchii*, *Cedrus deodara*, *C. libani*) (Bodor 2013, Gottschalk 2001, Scheurer 2009). Interestingly, in Europe bow-legged fir aphids were found to be infesting American conifer species (*Abies procera, Picea pungens*, *Pseudotsuga menziesii*, *Tsuga canadensis*) that they have not been recorded from in North America. However, it should be noted that there are no European records from *Pinus*, and only one record of it occuring on North American *Pinus* (Voegtlin 1976, cited in Blackman and Eastop 2015).

This constant increase in the number of host species confirms the expansive nature of this species. In addition, being an acclimatised alien species, it can pose a significant threat to native plants (Hałaj et al. 2011). Earlier reports (Jurc et al. 2009, Scheurer 2009) and our current observations confirm that native European coniferous trees (*Abies alba* and *Picea omorika*) are being attacked. Although at present the threat posed by this pestiferous aphid is deemed low (EPPO 2015), it did lead to the death of the *A. concolor* trees it invaded in Serbia (Poljaković-Pajnik and Petrović-Obradović 2002). Our observations from this year (2015) suggest that the infestation by *C. curvipes* of one of the two *A. alba* that it colonised (about 15-year-old, 3.5 m tall trees, in a private garden in Ruda Śląska) caused its condition to deteriorate (signs of drying out). In addition, the enormous quantities of honeydew produced by the vast colonies of these aphids decrease the aesthetic value of the attacked plants (also because they then attract large numbers of wasps and ants), and the possible growth of mould can lead to economic losses (Furniss and Carolin 1978), which is of importance to growers of ornamental conifers (Bodor 2013, Perny 2014). During its peak production time (in late summer and autumn), honeydew was collected by bees. This was not a frequent or widespread phenomenon in Poland, although it has been observed by other workers (Scheurer and Binazzi 2004). For an unexplained reason (possibly related to chemical composition?), bees seem to prefer the honeydew of indigenous Lachnidae species.

C. curvipes has a high biological potential: holo- and anholocyclic development, oliogophagism leading to

polyphagism, vast colonies with a large proportion of winged morphs and their dispersal with the aerial plankton, and a small number of natural enemies. Consequently, we expect the species' range to expand further and the number of host plant species to increase. Since this aphid species has been reported from European coniferous trees, natural fir forests need to be monitored for the presence of *C. curvipes*, especially in montane and submontane areas, which are especially vulnerable to change.

Fir trees, both native and introduced, are infested by several other aphid species besides *Cinara* spp. (Aphidoidea). A key is appended to facilitate their identification by entomologists and other interested parties (*e.g.* forest and phytosanitary services).

Key to aphids (Aphidoidea) feeding on *Abies* in Europe

1 Aphids feed on underground parts of firs 2
– Aphids feed on ground parts of firs 3
2 Siphunculi absent, aphids live in colonies densely covered with wax ..... *Prociphilus* spp. [Two species whose wingless generation morphs on the fir roots are nearly indistinguishable. In *P. bumeliae* (Schrank, 1801) the posterior pair of wax gland plates on head is better developed than the anterior pair, while in *P. fraxini* (Fabricius, 1777) the posterior pair of these plates is not better developed or is absent].
– Siphunculi present, aphids live in colonies not covered with a dense wax..... *Cinara confinis* (Koch) (see below)
3 Siphunculi very long, many times longer than the diameter of their base (up to about a quarter of the length of the body) 4
– Siphunculi as broad hairy cones, not longer than their diameter at the base, or absent 5
4 Processus terminalis of last antennal segment at most 1.6 times as long as the base of this segment (from 1.1 to 1.6). Life wingless pale green, with two darker green longitudinal stripes: green spruce aphid ..... *Elatobium abietinum* (Walker, 1849)
– Processus terminalis of last antennal segment at least 1.7 times as long as the base of this segment (from 1.7 to 2.5). Life wingless greenish, similar in colour to their host's needles ..... *Elatobium blackmani* Binazzi & Barbagallo, 1997
5 Head of wingless adults fused to pronotum. On dorsum of abdomen there are well developed glandular plates and therefore the living aphids are densely covered with wax wool. Winged morphs with the characteristic long (extending to the tip of the wing), narrow and pointed (sickle-shaped) pterostigma: balsam twig aphid ..... *Mindarus abietinus* Koch, 1857
– Head of wingless adults not fused to pronotum. Dorsum of abdomen devoid of glandular plates and therefore the living aphids are not densely covered with wax wool. Winged morphs with a pterostigma of another shape 6
6 Live wingless aphids green (very rarely pale brown), and feeding solely on young shoots and small branches, where they stay on the needles. Eyes are very clear and red. Siphuncular cones pale. Maximum diameter of the base of the siphuncular cone less than 3 times the diameter of the siphuncular aperture (less than 0.3 mm): green-striped fir aphid..... ..... *Cinara pectinatae* (Nördlinger, 1880)
– Live wingless aphids dark (brown or greenish-black to black), feeding in colonies on the trunk or branches. Eyes are not very clear, darkish. Siphuncular cones dark. Maximum diameter of the base of the siphuncular cone more than 3 times the diameter of the siphuncular aperture (more than 0.3 mm) 7
7 Siphuncular cones with hairs of two types: thicker and long – about 1.5-2 times as long as the diameter of the siphuncular aperture; thin and short – about as long as the diameter of the siphuncular aperture, usually shorter. Live wingless aphids dark brown or greenish-black, with a double row of blackish, slightly shining speckles and small flecks of fine wax in transverse rows. Hind tibiae are straight. Aphids feed on ground plant parts, but during the summer they have also been found on the roots: black-stem aphid ..... *Cinara confinis* (Koch, 1856)
– Siphuncular cones only with long hairs, usually about 1.5 times as long as the diameter of the siphuncular aperture, sometimes longer. Live wingless aphids shiny or dull grey-black, sometimes developing a covering of pale grey wax, especially on the thorax and along each side of the dorsum. Hind tibiae are distinctly curved: bow-legged fir aphid..... ..... *Cinara curvipes* (Patch, 1912)

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References

Angst A, Scheurer S, Forster B (2007) First record of *Cinara curvipes* (Patch) (Homoptera, Aphidina, Lachnidae) on *Abies concolor* in Switzerland. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 80: 247–252.

Baker EA (2009) Observations of aphids (Aphidoidea) new to Wales. British Journal of Entomology and Natural History 22(4): 235–246.

Blackman RL, Eastop VF (2015) Aphids on the world's plants. An online identification and information guide. http://www.aphidsonworldsplants.info [accessed 07 June 2015]

Bodor J (2013) Damage of bow-legged fir aphid (*Cinara curvipes* Patch, 1912) in Hungary. Növényvédelem 49(6): 273–275.

Cœur d'acier A, Pérez Hidalgo N, Petrović-Obradović O (2010) Aphids (Hemiptera, Aphididae). Chapter 9.2. In: Roques A et al. (Eds) Alien terrestrial arthropods of Europe. BioRisk 4(1): 435–474. doi: 10.3897/biorisk.4.57

EPPO (2015) EPPO Global Database. https://gd.eppo.int [accessed 17 June 2015]

Gottschalk HJ (2001) *Cinara curvipes* (Patch), Erstfund in Mecklenburg-Vorpommern, ein potentieller Forstschädling. Mitteilungsblatt des Entomologischen Vereins Mecklenburg 1: 36.

Furniss RL, Carolin VM (1978) Western forest insects. Miscellaneous Publications, 1339. U.S. Department of Agriculture, Forest Service, Washington D.C.

Görür G, Toper Kaygin A, Şenol A, Akyildirim Beğen H (2015) *Cinara curvipes* (Patch, 1912) (Hemiptera; Aphididae) as new aphid species for Turkish aphidofauna. Artvin Coruh University Journal of Forestry Faculty 16(41): 37–39.

Hałaj R, Osiadacz B (2015) Note: *Aphis vitalbae* Ferrari, 1872 (Hemiptera: Aphididae): new finding on ornamental *Clematis* spp. in Poland. Phytoparasitica 43(1): 103–106. doi: 10.1007/s12600-014-0417-2

Hałaj R, Osiadacz B, Klejdysz T, Strażyński P (2011) *Viteus vitifoliae* (Fitch, 1885) a new species of aphid (Hemiptera: Aphidomorpha: Phylloxeridae) in Poland. Polish Journal of Entomology 80: 457–464. doi: 10.2478/v10200-011-0033-0

Holman J (2009) Host plant catalog of aphids. Palearctic Region. Springer, Dordrecht, 1140 pp. doi: 10.1007/978-1-4020-8286-3

Jurc M, Poljaković-Pajnik L, Jurc D (2009) The first record of *Cinara curvipes* (Patch, 1912) (Homoptera, Aphididae) in Slovenia and its possible economic impact. Zbornik gozdarstva in lesarstva 88: 21–29.

Martin JH (2000) Two new British aphid introductions in 1999, in the context of other additions over the preceding thirty years (Sternorrhyncha: Aphidoidea). Entomologist's Gazette 51(2): 97–105.

Maw HEL, Foottit RG, Hamilton KGA, Scudder GGE (2000) Checklist of the Hemiptera of Canada and Alaska. NRC Research Press, Ottawa.

Nakládal O, Turčáni M, Šrůtka P (2007) First record of *Cinara curvipes* (Hemiptera: Aphididae) from Slovakia. Klapalekiana 43: 201–202.

Olbrechtová J (2007) First occurrence of *Cinara curvipes* Patch 1912 on white fir (*Abies concolor* (Gordon et Glendinning) Hildebrand 1861) in the Czech Republic. Aphids and other Hemipterous Insects 13: 43–49.

Osiadacz B, Hałaj R (2014) First records of gall-inducing aphid *Pemphigus populi* (Hemiptera: Aphidoidea, Eriosomatidae) in Poland with gall-based key to Central and North European species of the genus. Entomologica Fennica 25: 16–26.

Pérez Hidalgo N, Mier Durante MP (2012) First record of *Prociphilus* (*Meliarhizophagus*) *fraxinifolii* (Riley) [*Hemiptera*: *Aphididae*] in the Iberian Peninsula. Bulletin OEPP/EPPO Bulletin 42(1): 142–145. doi: 10.1111/j.1365-2338.2012.02531.x

Perny B (2014) Die Coloradotannen-Rindenlaus, *Cinara curvipes* – Ein harmloser Einwanderer aus Nordamerika in Österreichs Christbaumkulturen und Gärten? Forstschutz Aktuell 60/61: 28–30.

Poljaković-Pajnik L, Petrović-Obradović O (2002) Bowlegged fir aphid *Cinara curvipes* (Patch) (Aphididae, Homoptera) new pest of *Abies concolor* in Serbia. Acta entomologica serbica 7: 147–150.

Rakauskas R, Havelka J, Zaremba A (2015) Plum (*Prunus* spp.) aphid guild (Hemiptera: Sternorrhyncha, Aphididae) structure in Lithuania: any impact of an alien aphid species? Zemdirbyste-Agriculture 102(1): 81−86. doi: 10.13080/z-a.2015.102.010

Rouault G, Candau JN, Lieutier F, Nageleisen LM, Martin JC, Warzée N (2006) Effects of drought and heat on forest insect populations in relation to the 2003 drought in Western Europe. Annals of Forest Science 63: 613–624. doi: 10.1051/forest:2006044

Scheurer S (2001) *Cinara curvipes* (Patch) Aktualisierung und Berichtigung unseres bisherigen Wissens über die Rindenlaus. Ameisenschutz aktuell 2: 1.

Scheurer S (2009) „Mattschwarze Tannenrindenläuse" erobern Wälder, Parks und Gärten. LWF aktuell 73: 24–25.

Scheurer S, Binazzi A (2004) Notes on bio-ecology and ethology of *Cinara curvipes* (Patch), a newly introduced species into Europe (Aphididae Lachninae). Redia 87: 61–65.

Spencer RW, Christy JR, Braswell WD (2015) Version 6.0 of the UAH Temperature Dataset Released: New LT Trend = +0.11 C/decade. http://www.drroyspencer.com/2015/04/version-6-0-of-the-uah-temperature-dataset-released-new-lt-trend-0-11-cdecade [accessed 15 June 2015]

Starý P, Havelka J (2008) Fauna and associations of aphid parasitoids in an up-dated farmland area (Czech Republic). Bulletin of Insectology 61(2): 251–276.

Voegtlin DJ (1976) A biosystematic study of *Cinara* spp. on the conifers of the west-side Sierra forests. PhD thesis, University of California, Berkeley.

Voegtlin DJ, Bridges CA (1988) Catalogue of the *Cinara* Species of North America (Homoptera: Aphidida). Illinois Natural History Survey, Special Publication 8: 1–55.

Vučetić A, Jovičić I, Petrović-Obradović O (2014) Several new and one invasive aphid species (Aphididae, Hemiptera) caught by yellow water traps in Serbia. Phytoparasitica 42(2): 247–257. doi: 10.1007/s12600-013-0357-2