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Studies on Adelestini (Hymenoptera, Tenthredinidae), particularly the long-tongued *Nipponorhynchus* Takeuchi of Japan

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Abstract

Nipponorhynchus brevis Smith & Naito, **sp. n.,** is described from Hokkaido, Japan. It is characterized by shorter mouthparts than those of the other two species of the genus, *N. bimaculatus* Naito and *N. mirabilis* Takeuchi. The previously unknown female of *N. bimaculatus* is described. Larvae of *N. bimaculatus* and *N. mirabilis* feed on *Chrysosplenium macrostemon* var. *shiobarense* (Saxifragaceae), and notes on the life history are given. *Nipponorhynchus* is compared with the Nearctic *Adelesta* Ross, the only other genus of Adelestini. A key to the genera and species of Adelestini is provided.

Keywords

Sawflies, Selandriinae, *Adelesta*, *Chrysosplenium*

Introduction

Nipponorhynchus was described by Takeuchi (1941) for a single unusual sawfly species, *N. mirabilis* Takeuchi, 1941, in which the maxillolabial complex is extremely elongated forming a proboscis-like structure. The mouthparts are so unique that Jervis and Vilhelmsen (2000) proposed an additional type, "Type 8," to the known seven

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functional types of elongated proboscises previously recognized among Hymenoptera. Type 8 was solely for *Nipponorhynchus*, and it differs from the other types by the greatly elongated prementum and stipes, together forming a structure with two food conduction channels.

A second species of *Nipponorhynchus*, *N. bimaculatus*, was added by Naito (1973), which, among other structural features, the mouthparts are elongated, but not quite as long as those of *N. mirabilis*. Here, we describe a third species with elongated mouthparts, but much shorter than the two previously described species, thus showing a gradient in length of the mouthparts from moderately to extremely long. Additionally, we also describe the female of *N. bimaculatus* for the first time.

Nipponorhynchus, known only from Japan, and the Nearctic *Adelesta* Ross are the only members of what is recognized as the tribe Adelestini in the Selandriinae. Though the two genera have a number of characters in common which distinguishes the tribe, we prefer to keep the two genera separate. A brief history of the tribe and key to the genera and species of the Adelestini is presented.

Materials and methods

Images for Figures 1–26 were acquired through an EntoVision micro-imaging system. This system included a Leica M16 or Leica DRMB compound microscope with an attached JVC KY-75U 3-CCD digital video camera or a GT-Vision Lw11057C-SCI digital camera, that fed image data to a notebook or desktop computer. The program Cartograph 6.6.0 was then used to merge an image series into a single in-focus image. Figures 27, 28, 30, and 31 were taken by TN using a Nikon D200 digital camera with AF Micro Nikon 200 mm lens. Figure 29 was taken by T. Saito using a Canon Power Shot S5 IS digital camera with a Canon Zoom 12XIS 6.0–72.0 mm lens.

Abbreviations used are: NSMT, National Museum of Nature and Science, Ibaraki, Japan; TN, collection of T. Naito, Himeji-shi, Hyogo Prefecture, Japan; USNM, National Museum of Natural History, Smithsonian Institution, Washington, DC, USA.

Results

***Nipponorhynchus bimaculatus* Naito**
Figs 2, 6, 10, 14, 19, 23, 24, 27–29

Nipponorhynchus bimaculatus Naito, 1973: 95, fig. 1.

Description. Female: Length, 5.0 mm. Antenna and head black; anterior half of clypeus dark brown, labrum and upper surface of maxillolabial complex whitish; palpi and undersurface of maxillolabial complex dark brown. Thorax black with tegula and posterior corners of pronotum whitish. Legs black with apices of coxae, trochanters,

Figures 1–4. Head, front view. **1** *Nipponorhynchus mirabilis* **2** *N. bimaculatus* **3** *N. brevis* **4** *Adelesta nova*.

apical quarter of femora, tibiae except apical quarter with black stripe on inner surface and basitarsomeres whitish. Abdomen black (terga 2 and 3 often with yellow mark in male); center of apical tergum and cercus whitish. Wings hyaline; veins and stigma black. Head very shiny, almost impunctate; inner orbits, gena and clypeus with fine irregular punctures. Thorax and abdomen very shiny, sometimes terga 3–9 finely reticulate; posterior margin of mesoscutellum with several large punctures.

Antenna length 1.7× head width, with scape and pedicel each longer than broad; 3rd antennomere length 1.3× 4th, 4th to 9th antennomeres gradually decreasing in length. Clypeus slightly broadly, circularly emarginated, about 3× broader than long. Malar space about equal to diameter of median ocellus. Lower interocular distance 1.3× eye height; eyes only slightly converging below. Maxillolabial complex about 1.0–1.1× head width and about 2.2× eye height; maxillary palpus about 0.6× length of proboscis, longer than distance between maxillary palpus and labial palpus. Distances between eye and lateral ocellus, between lateral ocelli, and between lateral ocellus and hind margin of head as 1.0:0.8:0.5. Interocellar furrow represented by small pit. Postocellar furrow defined. Postocellar area 1.5× broader than long. Posttergite distinct, length:width as1:4, triangular behind. Tarsal claws simple. Hind basitarsomere subequal to length of following 3 tarsomeres combined. Sheath in lateral view straight above, rounded at apex and below; from above, equally wide throughout. Lancet in Fig. 19; 10 or more annular spines in two or three rows.

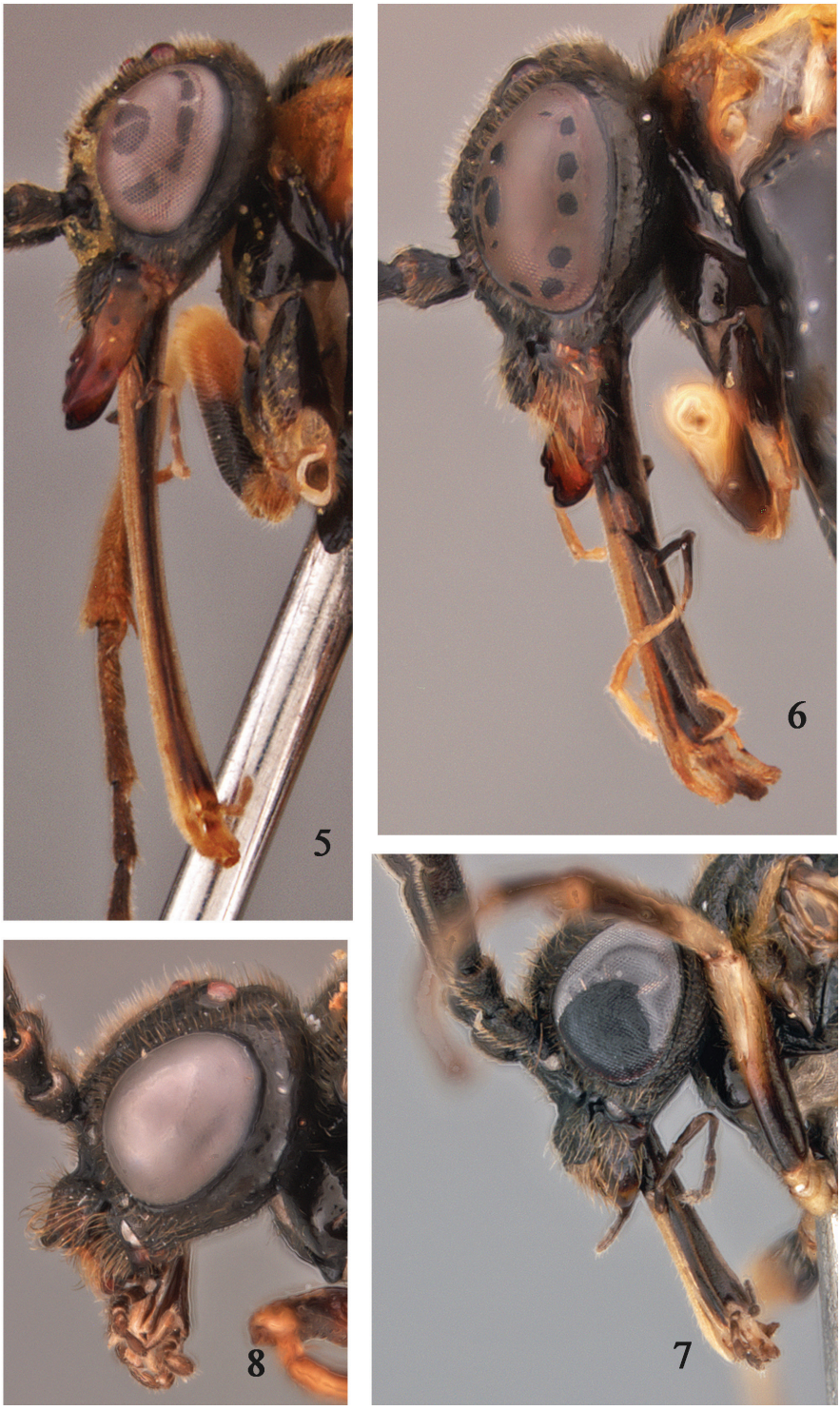
Male: Described by Naito (1973). Gentialia (Figs 23, 24), penis valve with valviceps almost round and apex somewhat flattened, dorsal spine slender.

Specimens examined. JAPAN: Honshu, Bicchuzawa, Bato, Tochigi Pref. 15.IV.2004, K. Katayama (1♀); same locality, 23.IV.2005, T. Naito (2♂); same locality, 24–30.IV.2005, S. Ibuki (4♀), same locality, 23, 29.IV.2005, A. Shinohara (2♀); same locality, 16–17.IV.2012, S. Ibuki (3♀); same locality, 29.III.2012, S. Ibuki (emerged from *Chrysosplenium macrostemon* Maxim var. *shiobarense* (Franch. Hara)) (2♀); Akazai-keikoku, Hyogo Pref. 20.V.1999, T. Okushima (1♀); Onzui-keikoku, Hyogo Pref., 21.IV.2008, T. Naito (1♀); Mt. Ooginosen, Hyogo Pref., 22.V.2006, T. Naito (1♀, 1 ♂); same locality, 7.V.2012, T. Naito; Mt. Hachibuseyama, Hyogo Pref., 5.V.2013, T. Naito (1♀); Honshu, Oodaigahara, Nara Pref., 7.VI.1976, T. Naito (1 ♂ paratype); Honshu, Bicchuzawa, Bato, Tochigi Pref., 23.IV.2005, T. Naito (2 ♀, 1 ♂); Hyogo Pref., Onzui-keikoka, 700 m, 21.IV.2008, T. Naito (1 ♀).

Distribution. Japan (Honshu).

Host and biological notes. TN observed adult habits on the host plant in April 2005 at Bicchuuzawa, Tochigi Pref., Japan. Later, Saito and Ibuki (2010) succeeded in rearing this sawfly. Adults appear in early spring and fly on the flowers of the host plant, *Chrysosplenium macrostemon* Maxim var. *shiobarense* (Franch. Hara) (Saxifragaceae). They insert the long proboscis into the flower and absorb the nectar (Fig. 27). Females cut the seed capsule of the host plant with the sawlike ovipositor and lay their eggs into the capsule (Fig. 28). Larvae mainly eat young seeds and bracts (Fig. 29). Mature larvae fall to the ground, enter it, and make a fragile cocoon of soil particles held together by saliva (similar to *N. mirabilis*, Fig. 31). They overwinter in the prepupal stage.

The life cycle of *N. mirabilis* is quite similar to *N. bimaculatus*, and the host plant is the same for both species. The two species coexist in Honshu, Japan, where *N. mirabilis* appears somewhat earlier than *N. bimaculatus*. The body of the larva is light brown in both species, but the head is light brown in *N. bimaculatus* (Fig. 29), whereas it is black in *N. mirabilis* (Fig. 30) (Saito and Ibuki 2010).



Figures 5–8. Head, lateral view. **5** *Nipponorhynchus mirabilis* **6** *N. bimaculatus* **7** *N. brevis* **8** *Adelesta nova*.

Nipponorhynchus brevis **Smith & Naito, sp. n.**
http://zoobank.org/937B73BC-65A3-4007-82D5-0942A3A95EC6
Figs 3, 7, 11, 15, 17, 20, 25, 26

Description. Female: Length 4.3 mm. Antenna and head black; anterior half of clypeus light brown, labrum and upper surface of maxillolabial complex white; palpi and undersurface of maxillolabial complex black. Thorax black with tegula and posterior corners of pronotum white. Legs black with apices of coxae, trochanters, apical quarter of femora, most of tibiae except about apical quarter with black stripe on inner surface; tarsi mostly black with inner surface of first two tarsomeres paler to white. Abdomen black; apical tergum and cercus white. Wings hyaline; veins and stigma black. Head shiny but roughened with scattered fine punctures, denser on genae, postocellar area, clypeus, and above toruli. Thorax and abdomen shiny; posterior margin of mesoscutellum with several large punctures.

Antennal length 1.3× head width, with scape and pedicel each longer than broad; 3rd antennomere slightly longer than 4th, 4th to 9th antennomeres gradually decreasing in length. Clypeus slightly broadly, circularly emarginated, about 3× broader than long. Malar space about equal to diameter of median ocellus. Lower interocular distance 1.3× eye height; eyes only slightly converging below. Maxillolabial complex about 0.6× head width and about 1.3× eye height; maxillary palpus subequal to length of proboscis, longer than distance between maxillary palpus and labial palpus. Distances between eye and lateral ocellus, between lateral ocelli, and between lateral ocellus and hind margin of head as 1.0:0.8:0.5. Postocellar area 1.5× broader than long. Posttergite distinct, long, rounded behind. Tarsal claws simple. Hind basitarsomere subequal to length of following 3 tarsomeres combined. Pulvilli minute on tarsomeres 1-4. Sheath in lateral view straight above, rounded at apex and below (Fig. 17); from above, equally wide throughout. Lancet (Fig. 20) with about 10 spines on basal two annuli and single row of about 6 spines on remaining annuli.

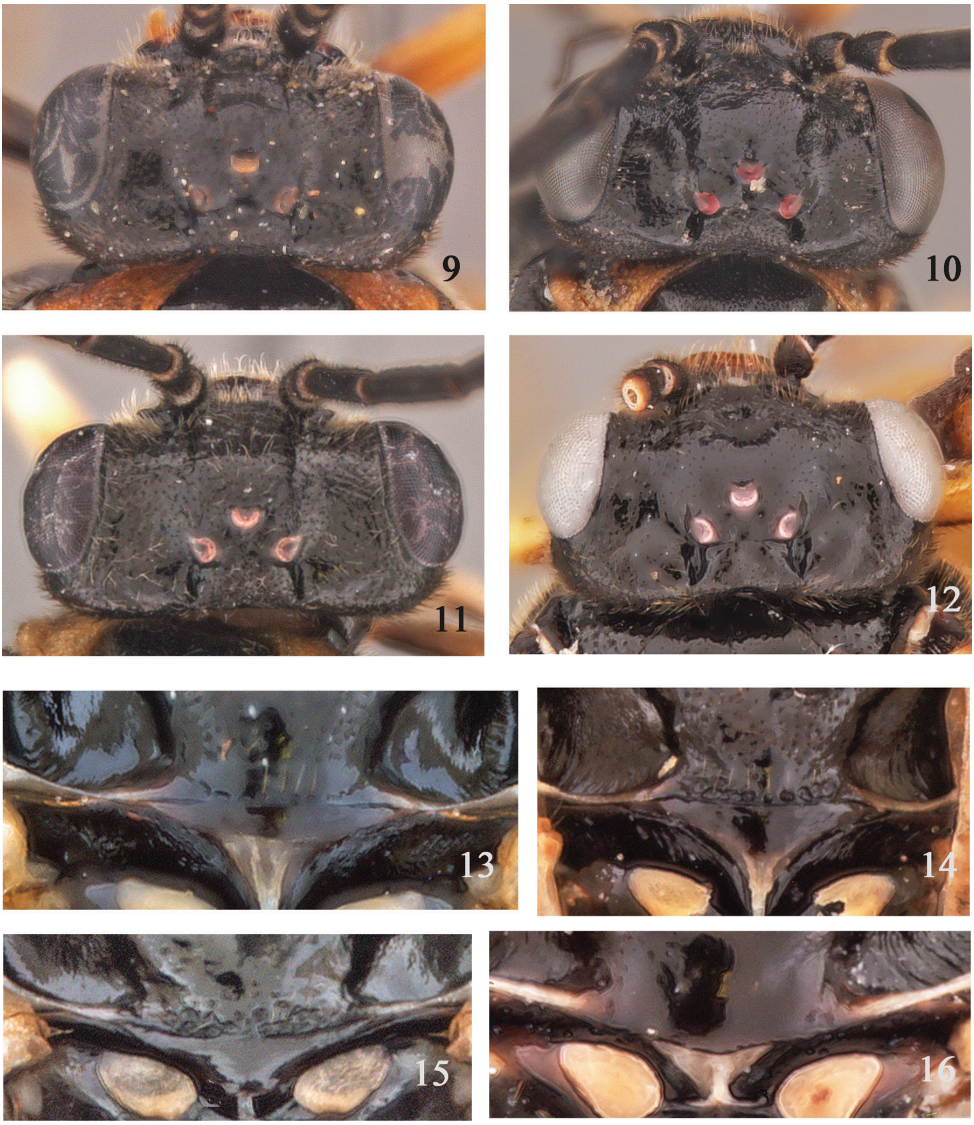
Male: Length 4.1 mm. Color and structure similar to female. Genitalia (Figs 25, 26) penis valve with valviceps elongate and rounded at apex, dorsal spine broad.

Type material. Holotype female "Japan: Hokkaido, Usubetsu, Sapporo, Ishikari, 42.9348°N, 141.1206°E, 29.IV–24.V.2012, small stream, Mal. trap, N. Kuhara" (NSMT). Paratypes: 4 ♀, 5 ♂, same data as holotype (NSMT, TN, USNM).

Distribution. Japan (Hokkaido).

Etymology. From the Latin *brevis*, meaning short, referring to the shorter mouthparts compared to the other species.

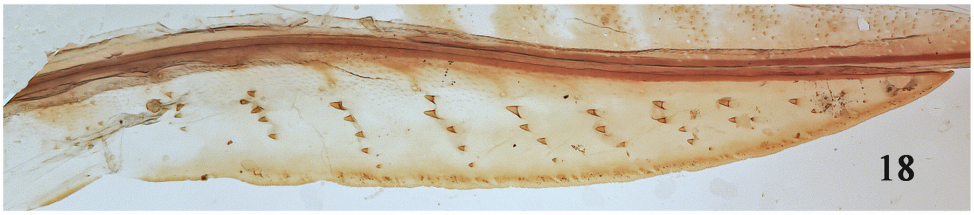
Comments. The new species is separated from both *N. mirabilis* and *N. bimaculatus* by its shorter mouthparts. In *N. mirabilis*, the mouthparts are about 1.3× head width and 3.0× eye height (Fig.1) and in *N. bimaculatus*, the mouthparts are about 1.0–1.1× head width and 2.2× eye height (Fig. 2). In *Adelesta nova*, the mouthparts are about 0.3× head width and 0.4× eye height (Fig. 4). It is also separated from *N. mirabilis* by the long maxillary palpus, which is longer than the distance between the maxillary palpus and labial palpus, and the longer more triangular posttergite, and

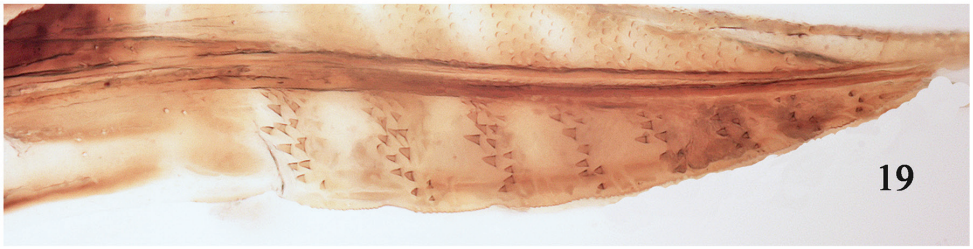


Figures 9–16. 9–12 Head, dorsal view. **13–16** Apex of mesonotum showing posttergite **9, 13** *Nipponorhynchus mirabilis* **10, 14** *N. bimaculatus* **11, 15** *N. brevis* **12, 16** *Adelesta nova*.

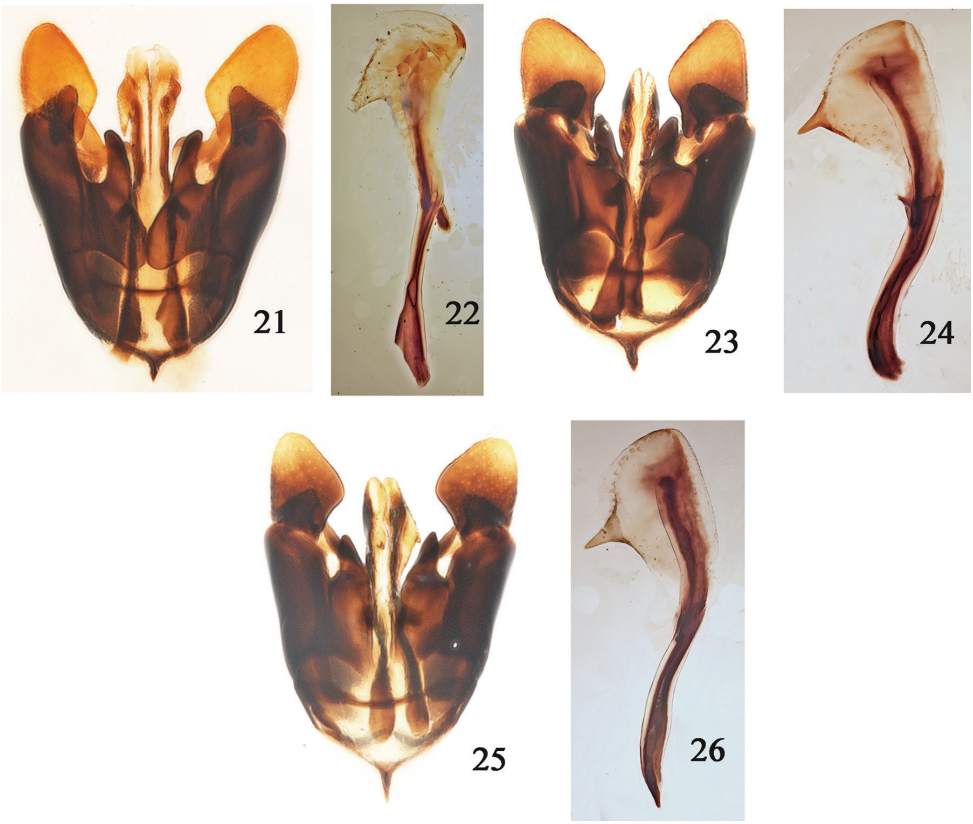
from *N. bimaculatus* by the finely punctate head, which is very shiny in *N. bimaculatus*. The female lancet and male genitalia appear close to *N. bimaculatus* (Figs. 19, 20, 23–26). In *N. brevis*, the lancet has the basal annuli more slanted and the annuli have fewer spines, and the male penis valve is more slender and has a broader dorsal spine. All females and males of *N. brevis* studied are of the same length.

This is the first record of *Nipponorhynchus* from Hokkaido. The host plant is unknown.





Figures 17–20. 17 *Nipponorhynchus brevis*, lateral view **18–20** Female lancets **18** *N. mirabilis* **19** *N. bimaculatus* **20** *N. brevis*.



Figures 21–26. Male genitalia. **21, 23, 25** Genital capsule, ventral view **22, 24, 26** Penis valve, lateral view **21, 22** *N. mirabilis* **23, 24** *N. bimaculatus* **25, 26** *N. brevis*.

Nipponorhynchus mirabilis Takeuchi

Figs 1, 5, 9, 13, 18, 21, 22, 30, 31

Nipponorhynchus mirabilis Takeuchi, 1941: 233; Takeuchi and Tokunaga 1941: figs 1–7; Malaise 1963: 169, 213, figs 138–140; Naito 1973: 96, fig. 2; Jervis and Vilhelmsen 2000: 134, fig. 5 (mouthparts).

Diagnosis. Head roughened, with punctures. Maxillolabial process about 1.4× head width and 3× eye height (Figs 1, 5). Malar space longer than diameter of median ocellus. Posttergite short, narrow, of equal width throughout (Fig. 13). Lancet with single row of annular spines, not more than 4 or 5 spines on basal annuli (Fig. 18). Male genitalia (Figs 21, 22) with valviceps of penis valve round.

Specimens examined. JAPAN: Mt. Ooginosen, Hyogo Pref., 900 m, 22.V.2006, T. Naito (3 ♀, 1 ♂); Hyogo Pref., Akazai-keikoku, 600 m, 21.IV.2008, T. Naito (2 ♂).

Distribution. Japan (Honshu).

Host and biological notes. The host and life history are similar to those of *N. bimaculatus*. The larva (Fig. 31) also feeds on *Chrysosplenium macrostemon* Maxim var. *shiobarense*, but *N. mirabilis* occurs somewhat earlier in the season, and the head of the larva is black (Fig. 30). See notes under *N. bimaculatus*.

Adelestini

Ross (1937) first proposed the family-group name Adelestinae, including only *Adelesta* described at the same time, with the single species *A. nova* (Norton, 1867). He differentiated the subfamily by the absence of the epicnemium, the posttergite not differentiated, propleurae with the mesal margins narrow and pointed, the distal anal cell of the forewing almost as long as the proximal anal cell, and 1r-m joining Rs near separation from R in the hind wing.

Benson (1938) did not agree with Ross, indicating that the characters Ross used did not justify a separate category because of fluctuating morphological characters in the Selandriinae. However, his treatment as "?Adelestini" left the door open to accepting it as a possible tribe.

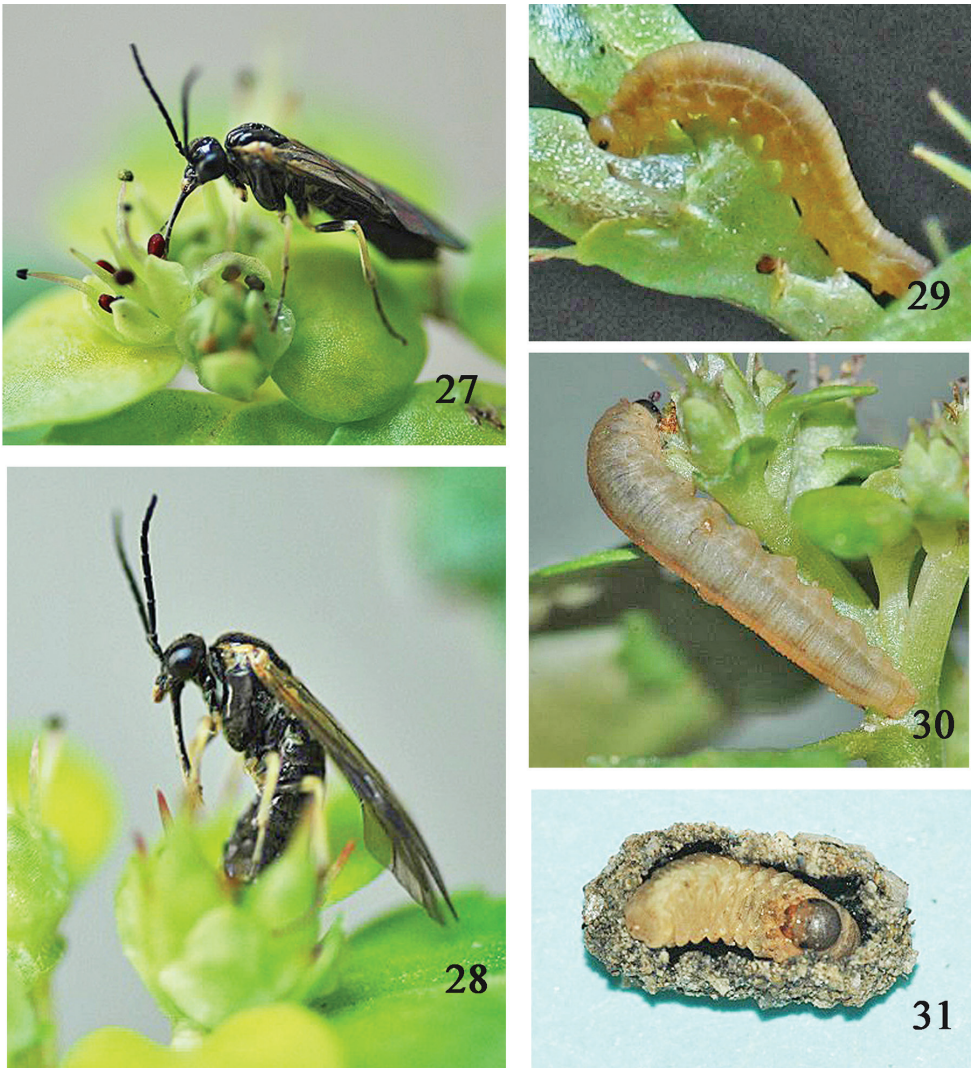
Takeuchi (1941) described *Nipponorhynchus* and Takeuchi and Tokunaga (1941) were the first to recognize that characters of *Adelesta* almost perfectly coincided with those of *Nipponorhynchus*. They placed both genera in Adelestini, one of three tribes in the Selandriinae. Their conclusion was based on Ross' (1937) description of *Adelesta* and not on comparison of actual specimens. The main character for the tribe was the absence of an epicnemium on the anterior part of the mesopleuron.

Ross (1951) and Smith (1969, 1979) continued to recognize the tribe Adelestini, mainly characterized by the subserrate antennae, forewing with an anal crossvein, long distal anal cell and constriction of the basal anal cell of the forewing, absence of an epicnemium, and indistinctly defined posttergite on the mesoscutellum. Both authors based their concept only on *Adelesta*.

Malaise (1963) did not recognize tribes, but keyed *Adelesta* and *Nipponorhynchus* to the same couplet, separated from other genera by the scutellar appendage (posttergite) not differentiated or very narrow, front wings with short anal crossvein at about the middle of the anal cell, labrum narrow and triangular, and antennae filiform or, slightly serrated. He recognized *Adelesta* as having a very short perpendicular anal crossvein in the forewing and antennae stout with the pedicel about as long as wide and *Nipponorhynchus* with an oblique anal crossvein in the forewing and antenna slender with pedicel longer than wide. In addition, though not mentioned for *Adelesta*, he gave the elongated mouthparts and broadly emarginated propodeum as additional characters for *Nipponohynchus*.

Naito (1975) proposed a phylogeny of some related genera in Selandriinae and concluded that *Nipponothynchus* and *Adelesta* belong to a distinct clade. However, he did not assign tribal names.

Sinonerva, with the single species *S. albipes*, was described by Wei (1998). He compared *Sinonerva* with *Adelesta* and *Nipponorhynchus* and mentioned that *Sinonerva* differs from the two by the bidentate mandibles, second segment of the antenna longer



Figures 27–31. *Nipponorhynchus* spp. and the host plant, *Chrysosplenium macrostemon* var. *shiobarense*. **27** *N. bimaculatus*, adult drinking honey of the host plant **28** *N. bimaculatus* adult female ovipositing into a seed capsule of the host plant. **29** *N. bim*aculatus larva eating young seeds of host plant **30** *N. mirabilis*, larva eating young seeds of host plant **31** *N. mirabilis* pupa in cocoon in soil.

than wide, developed epicnemium and posttergite, tarsal claws with a long inner tooth and small basal lobe, and the hind wing with cell Rs remote from vein Sc+R and the anal cell shortly petiolate. Later, Wei and Nie (1998) placed *Sinonerva* in the Adelestini with *Adelesta* and *Nipponorhynchus*. We have not seen *Sinonerva*, but it differs from *Adelesta* and *Nipponorhynchus* in several ways. The latter two genera have tridentate mandibles, antenna with flagellum gradually reduced towards apex, epicnemium absent, tarsal claws simple, and cell Rs in hind wing elongate and very near or touching vein Sc+R. Thus, we do not include *Sinonerva* in Adelestini.

We continue to recognize the Adelestini as a category in Selandriinae, separated from other Selandriinae by the presence of a short almost perpendicular anal cell in the forewing near the center of the anal cell, absence of an epicneium, an elongated maxillolabial process (the long proboscis), tridentate mandibles, lateral halves of first tergum widely separated on the meson thus exposing a broad membranous area, and simple tarsal claws. The indistinct posttergite, as mentioned by Ross (1937), Malaise (1963), and Smith (1969), is present only in *Adelesta*; it is well developed in *Nipponorhynchus*. Though not mentioned by previous authors, *Adelesta* does have somewhat elongated mouthparts, though not nearly as long as those in *Nipponorhynchus*. Though we see a gradient from the short proboscis in *Adelesta nova* to the unusually elongated proboscis in *Nipponorhynchus mirabilis*, and *Adelesta* and *Nipponorhynchus* share many characters in common, they can still be distinguished from each other by the shape of the posttergite, length of the mouthparts, antennae, placement of the anal crossvein in the forewing, and the shape of clypeus, and we choose to continue to keep them separate. The two genera and species can be separated by the following key.

Key to genera and species of Adelestini

1 Posttergite very narrow, of equal width throughout (Fig. 16); mouthparts short, less than eye length and about 0.3× head width (Figs 4, 8); apical labial palpomeres enlarged, palpi appear capitate; anal cell of forewing perpendicular, placed basally of the middle of the anal cell; antenna stout, antennomeres 4–9 at most 2× longer than broad; clypeus about 2× broader than long; eastern North America .....***Adelesta nova***

– Posttergite distinct, long, longer at center than at sides (Figs 13–15); mouthparts exceptionally developed, half or more head width and longer than eye height (Figs 1– 3, 5–7); labial palpomeres about equal in size; anal cell of forewing slightly slanted, placed at center of anal cell; antenna slender, antennomeres 4–9 more than 2× longer than broad; clypeus about 3× broader than long; Japan; *Nipponorhynchus*.....**2**

2 Maxillolabial complex short, about 0.6× head width and about 1.3× eye height (Figs 3, 7); maxillary palpus long, longer than distance between maxillary palpus and labial palpus ..... ***N. brevis***

– Maxillolabial complex longer, 1.1 to 1.4× head width and 2× or more eye height (Figs 1, 2, 5, 6); length of maxillary palpus various **3**

3 Posttergite long, triangular, longer at center than at sides (Fig. 14); head shiny; maxillolabial process subequal to head width and about 2× eye height (Figs 2, 6); malar space about equal to diameter of median ocellus.....***N. bimaculatus***

– Posttergite short, narrow, of equal width throughout (Fig. 13); head roughened, with punctures; maxillolabial complex about 1.4× head width and 3× eye height (Figs 1, 5); malar space longer than diameter of median ocellus..... ***N. mirabilis***

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References

Benson RB (1938) On the classification of sawflies (Hymenoptera: Symphyta). Transactions of the Royal Entomological Society of London 87: 353–384.

Jervis M, Vilhelmsen L (2000) Mouthpart evolution in adults of the basal, "symphytan", hymenopteran lineages. Biological Journal of the Linnean Society 70: 121–146.

Malaise R (1963) Hymenoptera Tenthredinoidea, subfamily Selandriinae, key to genera of the world. Entomologisk Tijdskrift 84: 159–216.

Naito T (1973) A new species of *Nipponorhynchus* Takeuchi from Japan (Hymenoptera: Tenthredinidae. Kontyû 41: 95–96.

Naito T (1975) Phylogeny and distribution of five related genera, *Eriocampidea*, *Hemitaxonus*, *Pseutohemitaxonus*, *Nipponorhynchus* and *Adelesta*, referred to the Selandriinae (Hymenoptera, Tenthredinidae). Kontyû 43: 330–342.

Norton E (1867) Catalog of the described Tenthredinidae and Uroceridae of North America. Transactions of the American Entomological Society 1: 193–280.

Ross HH (1937) A generic classification of the Nearctic sawflies (Hymenoptera: Symphyta). Illinois Biological Monographs 34, 173 pp.

Ross HH (1951) Tenthredinidae. In: Muesebeck CFW, Krombein KV, Townes HK (Eds) Hymenoptera of America North of Mexico, Synoptic Catalog. United States Department of Agriculture, Agriculture Monograph 2, 22–82.

Saito T, Ibuki S (2010) [Biological notes on the sawfly genus *Nipponorhynchus* at Bicchuzawa, Nakagwa-cho, and Yamaguchi, Nikko-shi, in Tochigi Pref.]. Insekuto 61: 101–107. [In Japanese]

Smith DR (1969) Nearctic sawflies II. Selandriinae: Adults (Hymenoptera: Tenthredinidae). United States Department of Agriculture, Technical Bulletin No. 1398, 48 pp., 10 pls.

Smith DR (1979) Symphyta. In: Krombein KV, Hurd PD Jr., Smith DR, Burks BD (Eds) Catalog of Hymenoptera in America north of Mexico, Volume 1, Symphyta and Apocrita (Parasitica). Smithsonian Institution Press, Washington, D.C., 3–137.

Takeuchi T (1941) A systematic study on the suborder Symphyta of the Japanese Empire (IV). Tenthredo 3: 230–274.

Takeuchi K, Tokunaga M (1941) Morphological study of head and mouthparts of a remarkable saw-fly, *Nipponorhynchus mirabilis* Takeuchi. Tenthredo 3: 275–291.

Wei M (1998) A new genus and species of Selandriidae of China (Hymenoptera: Tenthredinomorpha). Journal of Central South Forestry University 18: 1–3.

Wei M, Nie H (1998) Generic list of Tenthredinoidea s. str. (Hymenoptera) in new systematic arrangement with synonyms and distribution data. Journal of Central South Forestry University 18: 23–31.

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Phylogenetic relationships among the subfamilies of Dryinidae (Hymenoptera, Chrysidoidea) as reconstructed by molecular sequencing

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Abstract

Previously, the only published phylogenetic analysis of Dryinidae was a morphological analysis of just 32 characters. Herein, I present the first analysis of molecular sequence data examining the relationships among several of the major subfamilies of Dryinidae. A total of 77 specimens of Dryinidae from seven subfamilies, two specimens of *Chrysis* (Chrysididae), one specimen of *Cleptes* (Chrysididae), and one specimen of *Sclerogibba* (Sclerogibbidae) were examined utilizing molecular sequence data from nuclear 18S and 28S genes and mitochondrial Cytochrome Oxidase Subunit I (COI) and Cytochrome b (Cytb) genes. Dryininae were rendered nonmonophyletic due to the placement of *Thaumatodryinus*, which was sister to the remainder of Dryininae and Gonatopodinae. To establish monophyly of Dryininae, Thaumatodryininae were resurrected for *Thaumatodryinus*.

Keywords

Pincer Wasps, Molecular Systematics, Phylogeny, Phylogenetics

Introduction

Dryinidae are the third largest family within Chrysidoidea, containing 15 subfamilies, 50 genera, and over 1700 species found worldwide (Olmi 1994b, Olmi and Virla 2014, Olmi et al. 2014). These wasps are parasitoids and predators of Auchenorrhyncha and

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have huge potential as agricultural biocontrol agents, particularly for rice, fruit, and sugarcane pests (Sahragard et al. 1991, Olmi 1989, Mora-Kepfer and Espinoza 2009, Virla et al. 2011). In one species, *Gonatopus flavifemur* Esaki & Hashimoto, 1932, a single female was recorded as having attacked 466 planthoppers (as both food and hosts) over its 19-day adult life (Chua and Dyck 1982, Sahragard et al. 1991). Most dryinid species are host generalists that attack a wide variety of Auchenorrhyncha, often with host species belonging to different genera or even different families (Guglielmino and Olmi 1997, Guglielmino et al. 2013).

With only one or two world experts exclusively studying Dryinidae at any one time, the family has an interesting, but sparse, taxonomic history. Kieffer (1914) wrote the first world monograph of Dryinidae, with the first revisionary taxonomy for the family coming from Richards (1939, 1953). Outside of small agricultural studies and taxonomic descriptions, there was little focus on Dryinidae until the publication of Olmi (1984), a 1913-page world monograph that revised much of the taxonomy and provided keys throughout the family. Since then, there has been a growth in known dryinid diversity and host-records and the production of several large regional monographs (Olmi 1994a, b, Olmi 2005, Olmi 2007, Xu et al. 2013, Olmi and Virla 2014).

Currently, the fifteen subfamilies consist of four fossil subfamilies: Burmadryininae Olmi et al., 2014, Palaeoanteoninae Olmi & Bechly, 2001, Ponomarenkoinae Olmi 2010, and Protodryininae Olmi & Guglielmino, 2012 – and eleven extant subfamilies: Anteoninae Perkins, 1912, Aphelopinae Perkins, 1912, Apoaphelopinae Olmi, 2007, Apodryininae Olmi, 1984, Bocchinae Richards, 1939, Conganteoninae Olmi, 1984, Dryininae Haliday, 1833, Erwiniinae Olmi & Guglielmino, 2010, Gonatopodinae Kieffer, 1906, Plesiodryininae Olmi, 1987, and Transdryininae Olmi, 1984. The five largest subfamilies, Anteoninae, Gonatopodinae, Dryininae, Bocchinae, and Aphelopinae are found worldwide and comprise over ninety percent of the known diversity of Dryinidae (Olmi and Virla 2014, Xu et al. 2013). Conganteoninae contains about 15 species found in the Palearctic, Afrotropical, and Oriental regions, Plesiodryininae are known from a single species in the Nearctic region, Erwiniinae are known from a single species in the Neotropical region, Apoaphelopinae are known from two species in South Africa and Mozambique, Apodryininae are known from 13 species (with a Gondwanan distribution) and Transdryininae are known from two species from Australia (Olmi 1984, Olmi and Guglielmino 2010, Xu et al. 2013, Olmi and Virla 2014).

Over half of the described species of Dryinidae are found within three genera– *Anteon* Jurine, 1807, *Dryinus* Latreille, 1804, and *Gonatopus* Ljungh, 1810. A multiplicity of genera were synonymized within these three (refer to Olmi and Virla 2014 and Xu et al. 2013 for a complete list), but only within *Gonatopus* and *Dryinus* were the synonymized genera delimited amongst species groups. Olmi (1993) first synonymized *Chelothelius* Reinhard, 1863, *Mesodryinus* Kieffer, 1906, *Perodryinus* Perkins, 1907, *Tridryinus* Kieffer, 1913, *Bocchoides* Benoit, 1954, and *Alphadryinus* Olmi, 1984 within *Dryinus* and *Dicondylus* Haliday, 1830, *Pseudogonatopus* Perkins, 1905, *Agonatopoides* Perkins, 1907, *Apterodryinus* Perkins, 1907, *Donisthorpina* Richards, 1939, *Plectrogonatopoides* Ponomarenko, 1975, and *Acrodontochelys* Currado, 1976

within *Gonatopus* based on the lack of genus-level synapomorphies in the males of these synonymized genera. *Trichogonatopus* Kieffer, 1909 was also synonymized with *Gonatopus* upon the discovery of male specimens in Virla et al. (2010). Olmi (1993), Xu et al. (2013), and Olmi and Virla (2014), provided morphological keys to describe four species groups within *Dryinus* and 12 in *Gonatopus*.

Olmi (1993) also synonymized Thaumatodryininae Perkins, 1905 as a genus within Dryininae, *Thaumatodryinus* Perkins, 1905, along with moving a Gonatopodinae genus, *Pseudodryinus*, Olmi 1989, to Dryininae on the basis of mandibular character similarity in males. Currently, males of both *Pseudodryinus* and *Thaumatodryinus* are distinguishable from the other genera in Dryininae by having quadridentate mandibles, with *Thaumatodryinus* males presenting mandibular teeth that usually progress larger from anterior to posterior, whereas in *Pseudodryinus*, the four teeth of the mandible are irregularly sized. Females of *Thaumatodryinus* are easily distinguished from other Dryininae by the presence of long hairs on flagellomeres 3 – 8 (Mita 2009, Xu et al. 2013).

There is very little published on the phylogenetic relationships of the subfamilies within Dryinidae. Olmi (1994a) stated "we cannot discuss species affinities, because evolution has followed completely different paths in males and females, and female affinities are completely different from male affinities", and did not attempt to combine morphological data from both sexes to reconstruct a phylogeny. Olmi (1994a) presented a tree, but only included female specimens from four subfamilies found within Denmark and Fennoscandia and did not make clear how characters were coded and analyzed. In Carpenter (1999), a cladogram was reconstructed from 32 characters based on the taxonomic keys and descriptions of Massimo Olmi from both sexes. Given the growth in known dryinid diversity since then, neither study reflects the current subfamily classification and only addressed a small number of morphological features, although both placed Aphelopinae as the basal subfamily of Dryinidae and placed Gonatopodinae and Dryininae as sister groups (as in Olmi 1994a) or as closely associated in a polytomy that also contained Transdryininae and (Apodryininae + Plesiodryininae) (Carpenter 1999). There are no published molecular phylogenies, but DNA has been used to link the highly modified females of *Gonatopus javanus* Perkins, 1912 to males, which are similar looking throughout the genus, and to explore intraspecific genetic variation (Mita and Matsumoto 2012, Mita et al. 2013). Herein, I present the first analysis of molecular sequence data examining the relationships among several of the major subfamilies.

Methods

Materials

Phylogenetic relationships were inferred from 77 specimens of Dryinidae with one specimen of *Sclerogibba* Riggio & De Stefani-Perez, 1888 (Chrysidoidea: Sclerogibbidae), two species of *Chrysis* Linnaeus, 1761 (Chrysidoidea: Chrysididae), and *Cleptes seoulensis* Tsuneki, 1959 (Chrysidoidea: Chrysididae) as outgroup taxa. The majority

of specimens came from two sources: Instituto Nacional de Pesquisas da Amazônia (INPA) and Canadian National Collections (CNC). Materials from the CNC were sorted from bulk alcohol materials from a variety of institutions and collectors, as detailed in Suppl. material 1. Additionally, several specimens were provided courtesy of Massimo Olmi, Toshiharu Mita and Pierre Tripotin. Specimens were stored in 95 percent ethanol and refrigerated prior to extraction. As these materials were acquired from unsorted bulk Malaise, yellow pan trap, and sweep net samples, they have not been accessioned in collections. Materials will be returned to their original institutions following the completion of this work and subsequent description of new species.

Laboratory protocols

Genomic DNA was isolated using a QIAGEN DNeasy Tissue Kit following the manufacturer's protocols, with the exception of using non-destructive lysing techniques (Paquin and Vink 2009). This allowed for specimens to be pinned and identified after extraction protocols. PCR amplification was accomplished using General Electric PuReTaq Ready-To-Go beads with the following primers: the 18S region was amplified using 18SF2 (5'-CTA CCA CAT CCA AGG AAG GCA G-3') and 18SR2 (5'-AGA GTC TCG TTC GTT ATC GGA-3') (Rokas et al. 2002), 28S D2-D3 was amplified using For28Vesp (5' AGA GAG AGT TCA AGA GTA CGT G-3') and Rev28SVesp (5'-GGA ACC AGC TAC TAG ATG G-3') (Hines et al. 2007). Cytochrome Oxidase I (COI) was amplified for the Folmer/barcode region using LCO (5'- GGT CAA CAA ATC ATA AAG ATA TTG G-3') and HCO (5'-TAA ACT TCA GGG TGA CCA AAA AAT CA-3') (Vrijenhoek 1994). The Cytochrome b (Cytb) region was amplified using CB1 (5'-TAT GTA CTA CCA TGA GGA CAA ATA TC-3') and CB2 (5'-ATT ACA CCT CCT AAT TTA TTA GGA AT-3') (Simon et al. 1994). Thermocycler protocols are detailed in Suppl. material 2, with assistance from Jongok Lim. Sequencing was performed at the American Museum of Natural History (AMNH) in the Sackler Institute for Comparative Genomics on an ABI 3730.

Analyses

Sequences were assembled and edited in Geneious 5.4 (Kearse et al. 2012). Mitochondrial genes COI and Cytb were checked for stop codons and numts and aligned using the translation alignment algorithm within Geneious. 18S and 28S were aligned using MAAFT, using the E-INS-I algorithm as implemented in Geneious. This algorithm was chosen for its accuracy in difficult alignments (Morrison 2009) and its recent use in the Hymenoptera Tree of Life project, which provided sequences for outgroup taxon *Chrysis cembricola* Krombein, 1958 (Klopfstein et al. 2013) The concatenated matrix was assembled in SeqMatrix (Vaidya et al. 2011), resulting in a final matrix of 6594 characters, with 13 percent missing data.

Phylogenetic analyses were performed using parsimony, Bayesian and maximum likelihood approaches. For parsimony, TNT (Goloboff et al. 2008) was used with the new technology search algorithms with the following parameters modified from default: 200 ratchet iterations, upweighting percentage 8, downweighting 4; 50 cycles of drift; minimum length hit 25 times with gaps treated as missing data. Jackknife resampling (Farris et al. 1996) support values were calculated using GC-values from a symmetric resampling of 1000 replicates. Separate analyses were performed using equal weighting and implied weighting as implemented by the setK script in TNT (courtesy of J. Salvador Arias).

PartitionFinder (Lanfear et al. 2012) was used to select models of molecular evolution for the RAxML (Stamatakis 2014) and MrBayes (Ronquist et al. 2012) analyses for each ribosomal gene, and each codon for COI and Cytb. For the models available for implementation in RAxML, each partition was returned as GTR+I+G. Using RAxML 8.1.11 XSEDE on the Cipres server, 20 independent analyses were performed with different starting seed values and 1000 rapid bootstrapping (BS) replicates, choosing the tree with the best known likelihood (BKL) score amongst those independent searches (method adapted from Munro et al. 2011). Additionally, Garli 2.1 (Bazinet et al. 2014) on www.molecularevolution.org was utilized to see if the same topology was returned as the best tree, with 1000 bootstrap replicates.

For Bayesian analyses, Mr Bayes 3.2.3 (Ronquist et al. 2012) XSEDE was utilized with the following partitions: K80+I+G for 18S and GTR+I+G for 28S, HKY+I+G for the 1st positions in COI and Cytb, and GTR+I+G for the 2nd and 3rd positions in COI and Cytb.

In MrBayes, default parameters were used, with the exception of allowing enough time for 15,000,000 generations.

Trees were visualized in Figtree v.1.3.1 (Rambaut 2007)

Results

The topologies of the equal weighting and implied weighting analyses in TNT (parsimony) were the same, with the equal weighting analysis recovering nine trees with a best score of 8562 steps (CI 0.287 RI 0.641) and the implied weighting (K = 20.527) analysis recovering nine trees with a best score of 200. The best RAxML tree from 20 separate analyses had a final optimization likelihood of -44251.166938 (Fig. 2), and had the same topology as the tree produced by Garli, and the MrBayes analysis produced an average standard deviation of split frequencies (ASDSF) of 0.010179, with 25 percent of samples discarded as burn-in (Fig. 3).

Results were largely congruent for parsimony, likelihood, and Bayesian approaches in terms of higher-level topology (Figs 1–3), while species-level topologies were more variable. Apodryininae (as represented by *Madecadryinus politus* Olmi, 2007) were the sister taxon to all other Dryinidae in every analysis. The greatest difference among analyses were among Aphelopinae, Bocchinae and

Conganteoninae. In all three trees, Aphelopinae and Conganteoninae were recovered as monophyletic, but since Bocchinae were represented by one species, its monophyly could not be tested. In the Bayesian analysis, Bocchinae were the sister group to the remainder of Dryinidae excluding Apodryininae, with Aphelopinae and Conganteoninae as sister groups. In the parsimony and likelihood analyses, Bocchinae were the sister group to Conganteoninae, with Aphelopinae sister to (Conganteoninae + Bocchinae). The remaining subfamily topologies were the same in all three analyses – Anteoninae, Aphelopinae, and Gonatopodinae were monophyletic, with Anteoninae as the sister subfamily to ((*Thaumatodryinus* + (Dryininae *partim* + Gonatopodinae). Dryininae were paraphyletic due to the placement of *Thaumatodryinus merinus* Olmi, 2004 and *Thaumatodryinus macilentus* De Santis & Vidal Sarmiento, 1974, which were sister to a monophyletic Gonatopodinae and the remainder of Dryininae.

Many of the genera tested were found to be nonmonophyletic. Within Anteoninae, *Lonchodryinus* Kieffer, 1905 was the only genus found as monophyletic, as was *Epigonatopus* Perkins, 1905 in Gonatopodinae. *Dryinus* and *Thaumatodryinus* were the only genera from Dryininae tested, although all four of the *Dryinus* 'species groups' defined by Olmi (1993), were examined. Species groups were only defined for females, so undescribed male dryinid specimens could not be assessed. However, *Dryinus* Group 1 was found nonmonophyletic due to the placement of *Dryinus striatus* Fenton, 1927, although *Dryinus* Group 2 and *Dryinus* Group 4 were monophyletic. *Dryinus* Group 3 could not be assessed due to the sampling of a single specimen. *Gonatopus* was not monophyletic, nor were any of its species groups.

Discussion

The validity of Thaumatodryininae

Olmi (1993) synonymized Thaumatodryininae with Dryininae, placing *Thaumatodryinus* close to the Dryininae genus *Pseudodryinus.* Olmi (1989) had originally attributed *Pseudodryinus* to Gonatopodinae on the basis of lacking a spur (1, 0, 2 tibial formula), but later examination of *Pseudodryinus* specimens by Olmi revealed a tibial formula of 1, 1, 2, allowing for the genus to be moved to Dryininae. At that time, previously unknown males of *Pseudodryinus* were discovered, and were shown to have quadridentate mandibles, as opposed to the tridentate mandibles found in all other male Dryininae (Olmi 1993). Olmi proposed that these males belonged to Thaumatodryininae, and then further noted that it would be unfeasible to have the females of *Pseudodryinus* within Dryininae and the males of *Pseudodryinus* within Thaumatodryininae. To preserve *Pseudodryinus* as a valid genus, *Thaumatodryinus* (the only genus within Thaumatodryininae) was synonymized within Dryininae.

In the molecular analyses presented here, the two different species of *Thaumatodryinus* were monophyletic and sister to Gonatopodinae + Dryininae. Molecular

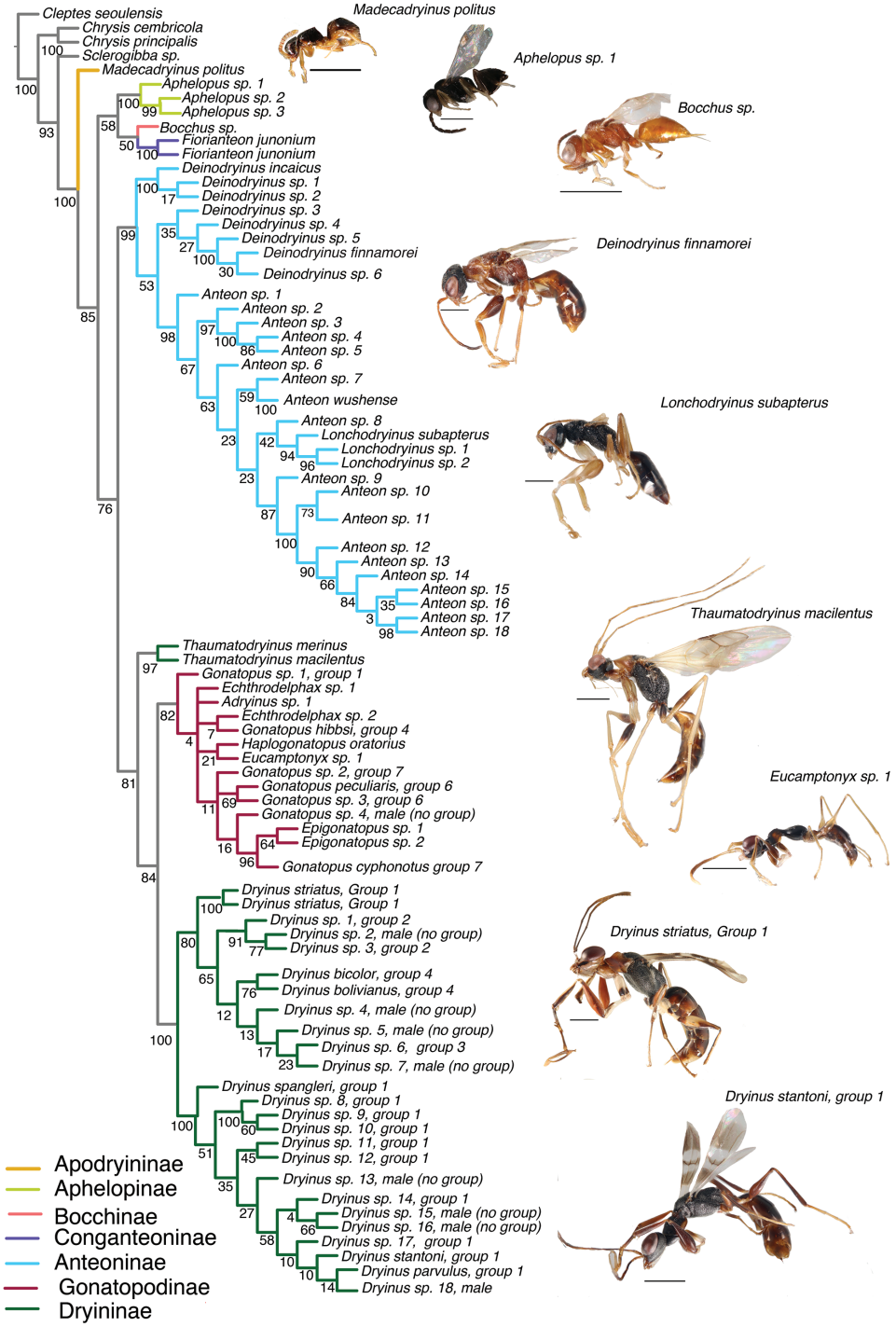

Figure 1. Parsimony support tree. Jackknife support for nodes given in GC-values (frequency differences) from 1000 replicates. CI 0.287 RI 0.641. Scale bar in all images is 1.0 mm.

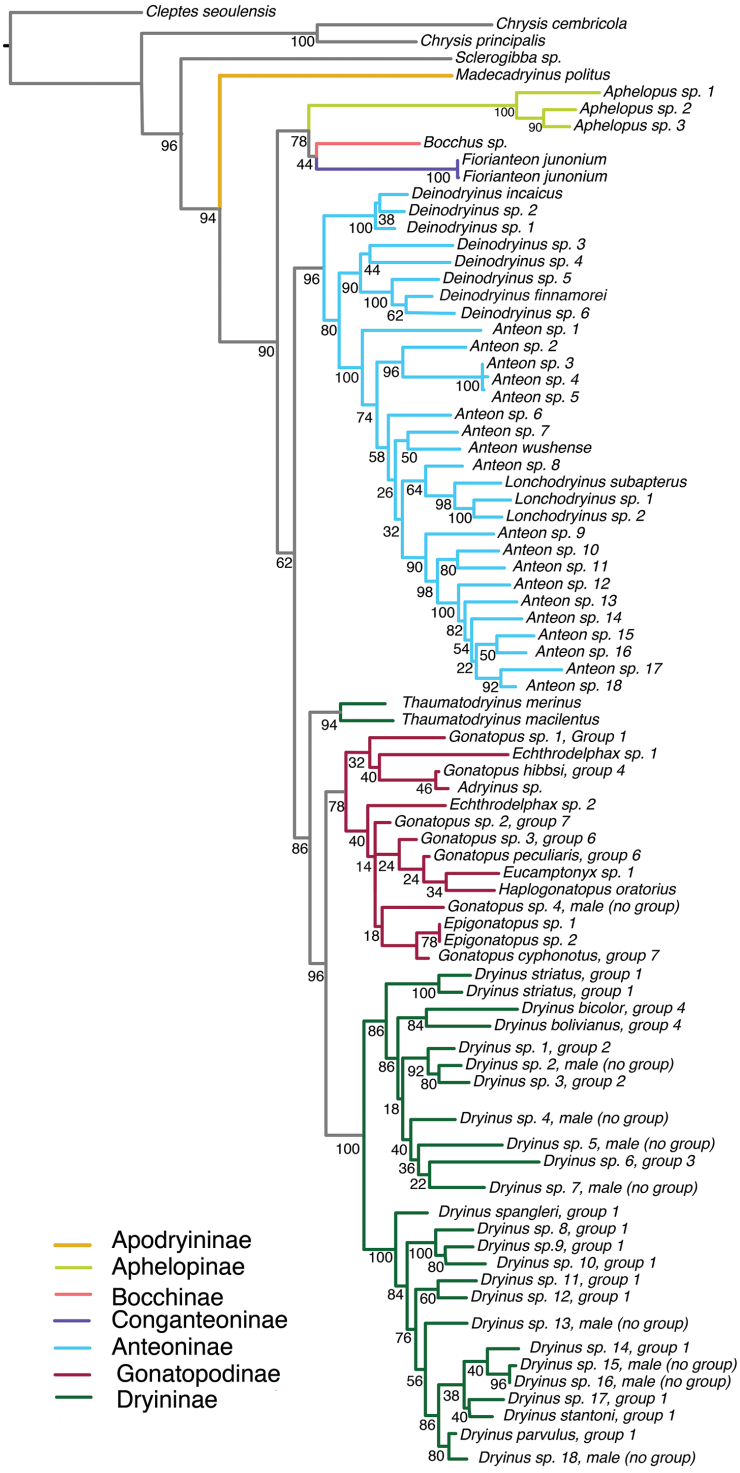

Figure 2. Likelihood support tree. Rapid Bootstrap support values shown at nodes.

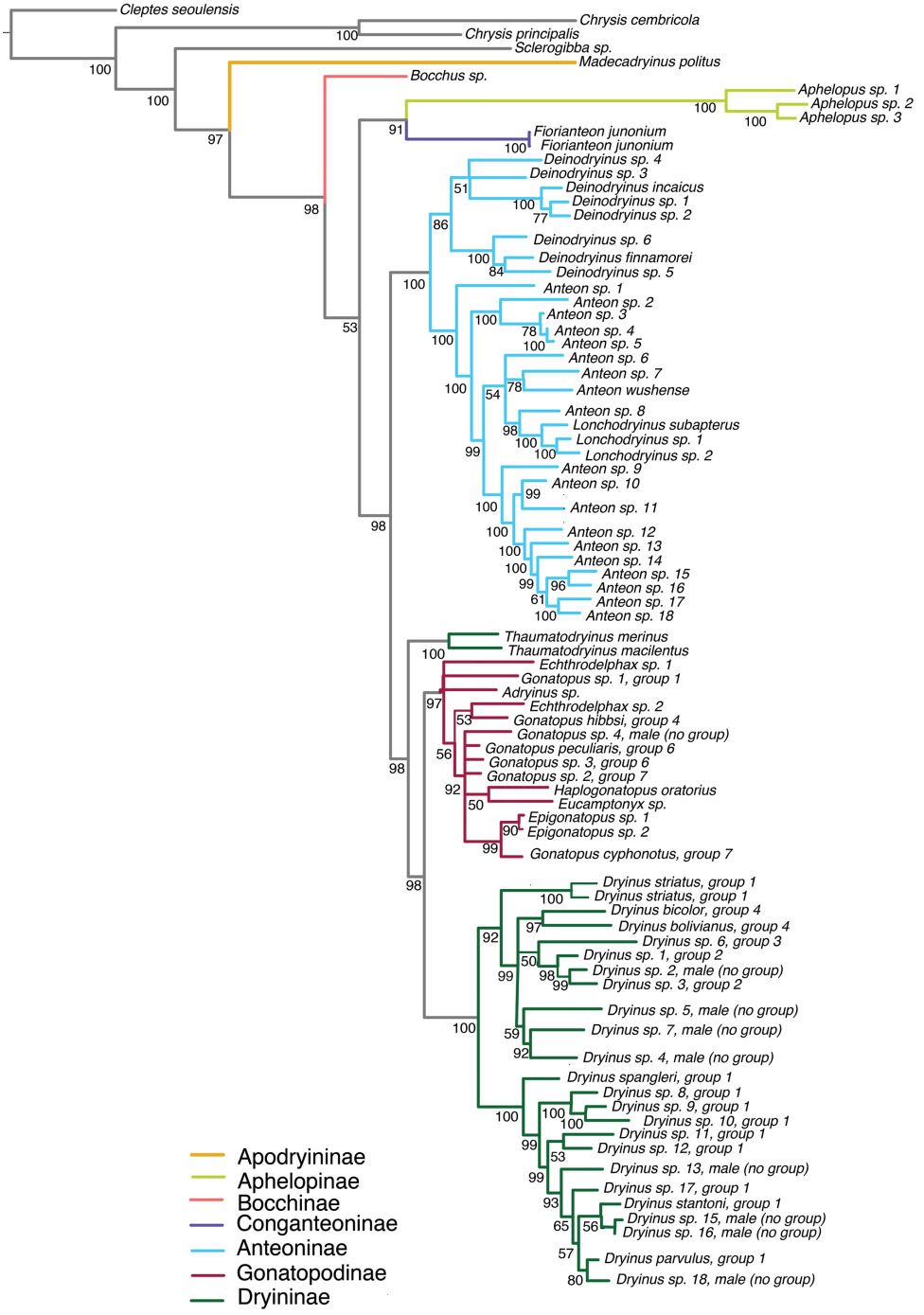

Figure 3. Bayesian support tree. Support probabilities shown at nodes as a percent.

data from *Thaumatodryinus macilentus* were taken from a female specimen, while molecular data from *Thaumatodryinus merinus* come from a male. Unfortunately, neither male nor female specimens of *Pseudodryinus* with viable DNA were available to test their placement within Dryininae or Thaumatodryininae. To establish the monophyly of Dryininae, and retain Gonatopodinae as a separate subfamily, I resurrect Thaumatodryininae, containing the genus *Thaumatodryinus*. The defining synapomorphy of Thaumatodryininae is the presence of long hairs on flagellomeres 3 – 8 in females (Xu et al. 2013).

Evolution of the chela

The tree produced by Olmi only treated Aphelopinae, Anteoninae, Dryininae, and Gonatopodinae from Fennoscandia and Denmark (Olmi 1994a), and similarly found Dryininae and Gonatopodinae as sister groups (*Thaumatodryinus* was not included in the cladogram). Olmi (1994a) placed Anteoninae as sister to (Dryininae + Gonatopodinae), which was found in this study. Carpenter (1999) also found Anteoninae as the sister group to the clade that contained Dryininae and Gonatopodinae. This study diverges from these past two trees in the basal lineage of Dryinidae. In both Olmi (1994a) and Carpenter (1999), Aphelopinae were considered the basal lineage of Dryinidae on the basis of the lack of the characteristic pincer-like chela. Here, Apodryininae were found as the basal lineage of Dryinidae and while not all subfamilies of Dryinidae were considered, this suggests that the loss of the chela is a derived trait of Aphelopinae. Erwiniinae (known only from the type species) are also achelate, but were not included in this study.

Sampling of genera and species groups of Dryinus and Gonatopus

Several of the smaller subfamilies were not represented in this study because of their scarcity – Apoaphelopinae are known from two species, Erwiniinae from one species, Plesiodryininae from one species, and Transdryininae from two species.

Sampling of the genera of the subfamilies was also incomplete. Within Dryininae, only *Dryinus* was treated, although all four of the species groups were included. *Megadryinus* Richards, 1953 (known from three species), *Gonadryinus* Olmi, 1991 (known from one species), and *Pseudodryinus* (known from ten species) were absent. Given the shared characteristic of having quadridentate mandibles in males, *Thaumatodryinus* and *Pseudodryinus* might be related, but without a specimen from which viable DNA could be sequenced, the placement of *Pseudodryinus* could not be assessed.

Within Gonatopodinae, only five of the twelve species groups of *Gonatopus* were assessed. *Epigonatopus* Perkins, 1905, which is only known from Australia, was found

monophyletic, and *Echthrodelphax* Perkins, 1903 was nonmonophyletic. All other genera assessed (*Adryinus* Olmi, 1984, *Haplogonatopus* Perkins, 1905, and *Eucamptonyx* Perkins, 1907) were only represented by a single specimen. DNA-viable specimens from *Pentagonatopus* Olmi, 1984 (known from three species), *Pareucamptonyx* Olmi, 1991 (known from two species) *Esagonatopus* Olmi, 1984, (known from six species), *Gynochelys* Brues, 1906 (known from two species), and *Neodryinus* Perkins, 1905 (known from 49 species) were unavailable.

Within Anteoninae, three out of four extant genera were included, with *Metanteon* Olmi, 1984 (known only from the type species) not included. Conganteoninae were only represented by one genus, *Fiorianteon* Olmi, 1984, and did not include the other genus, *Conganteon* Benoit, 1951. Bocchinae were only represented by *Bocchus* Ashmead, 1893, and did not include *Mirodryinus* Ponomarenko, 1972 and *Mystrophorus* Förster, 1856. Aphelopinae were only represented by *Aphelopus* Dalman, 1823, and did not include *Crovettia* Olmi, 1984. Apodryininae were only represented by *Madecadryinus* Olmi, 2007, and did not include the six other genera.

Conclusion

In all analyses, *Thaumatodryinus* was well-supported and Thaumatodryininae were resurrected here, bringing the total subfamilies of Dryinidae to 16.

The validity of species groups within *Dryinus* and *Gonatopus* remains questionable. Some species groups, like *Dryinus* Group 4, which was originally a separate genus, *Perodryinus*, were easily recovered as monophyletic while *Dryinus* Group 1, which contains several synonymized genera, was not recovered as monophyletic. This may be because the larger species groups share synonymized genera – for example, *Dryinus* species groups 1, 2, and 3 all contain synonymized species from *Mesodryinus*. Shared synonymized genera are found within the *Gonatopus* species groups as well.

In continuing molecular studies, specimens from each of the species groups of *Gonatopus* and *Dryinus* should be included, as well as all of the genera of the subfamilies, where sampling permits. In particular interest would be to find morphological synapomorphies at the generic level for male Dryinidae.

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References

Bazinet AL, Zwickl DJ, Cummings MP (2014) A gateway for phylogenetic analysis powered by grid computing featuring Garli 2.0. Systematic Biology 63: 812–818. doi: 10.1093/sysbio/syu031

Carpenter JM (1999) What do we know about chrysidoid (Hymenoptera) relationships? Zoologica Scripta 28: 215–231. doi: 10.1046/j.1463-6409.1999.00011.x

Chua TH, Dyck VA (1982) Assessment of *Pseudogonatopus flavifemur* E. & H. (Dryinidae: Hymenoptera) as a biocontrol agent of the rice brown planthopper. Proceedings of the International Congress in Tropics 1–4: 253–265.

Farris JS, Albert V, Källersjö M, Lipscomb D, Kluge AG (1996) Parsimony jackknifing outperforms neighbor-joining. Cladistics 12: 99–124. doi: 10.1111/j.1096-0031.1996.tb00196.x

Goloboff PA, Farris JS, Nixon KC (2008) TNT, a free program for phylogenetic analysis. Cladistics 24: 774–786. doi: 10.1111/j.1096-0031.2008.00217.x

Guglielmino A, Olmi M (1997) A host-parasite catalog of world Dryinidae (Hymenoptera: Chrysidoidea). Contributions on Entomology, International 2: 165–298.

Guglielmino A, Olmi M, Bückle C (2013) An updated host-parasite catalogue of world Dryinidae (Hymenoptera: Chrysidoidea). Zootaxa 3740: 1–113. doi: 10.11646/zootaxa.3740.1.1

Hines HM, Hunt JH, O'Connor TK, Gillespie JJ, Cameron SA (2007) Multigene phylogeny reveals eusociality evolved twice in vespid wasps. Proceedings of the National Academy of Sciences 104: 3295–3299. doi: 10.1073/pnas.0610140104

Kearse M, Moir R, Wilson A, Stones-Havas S, Cheung M, Sturrock S, Buxton S, Cooper A, Markowitz S, Duran C, Thierer T, Ashton B, Mentjies P, Drummond A (2012) Geneious Basic: an integrated and extendable desktop software platform for the organization and analysis of sequence data. Bioinformatics 28: 1647–1649. doi: 10.1093/bioinformatics/bts199

Kieffer JJ (1914) Bethylidae. Das Tierreich, 41. R. Friedlander und Sohn, Berlin, 595 pp.

Klopfstein S, Vilhelmsen L, Heraty JM, Sharkey M, Ronquist F (2013) The hymenopteran tree of life: Evidence from protein-coding genes and objectively aligned ribosomal data. PLoS ONE 8. doi: 10.1371/journal.pone.0069344

Lanfear R, Calcott B, Ho SYW, Guindon S (2012) PartitionFinder: combined selection of partitioning schemes and substitution models for phylogenetic analyses. Molecular biology and Evolution 29: 1695–1701. doi: 10.1093/molbev/mss020

Mita T (2009) A taxonomic study of the Dryininae (Hymenoptera: Dryinidae) of Japan, with description of a new species of *Pseudodryinus*. Zootaxa 2168: 45–56.

Mita T, Matsumoto Y (2012) First description of the male of *Gonatopus javanus* (RCL Perkins) determined by mitochondrial COI sequence (Hymenoptera: Dryinidae). Entomological Science 15: 214–218. doi: 10.1111/j.1479-8298.2011.00502.x

Mita T, Sanada-Morimura S, Matsumura M, Matsumoto Y (2013) Genetic variation of two apterous wasps *Haplogonatopus apicalis* and *H. oratorius* (Hymenoptera: Dryinidae) in East Asia. Applied Entomology and Zoology 48: 119–124. doi: 10.1007/s13355-012-0160-4

Mora-Kepfer F, Espinoza AM (2009) Parasitism and predation of the planthopper *Tagosodes orizicolus* (Homoptera: Delphacidae) by a dryinid parasitoid in Costa Rica. Revista de Biologia Tropical 57: 203–211.

Morrison DA (2009) Why would phylogeneticists ignore computerized sequence alignment? Systematic biology 58: 150–158. doi: 10.1093/sysbio/syp009

Munro J, Heraty JM, Burks RA, Hawks D, Jottern J, Cruaud A, Rasplus J (2011) A Molecular phylogeny of the Chalcidoidea (Hymenoptera). PLoS ONE 6. doi: 10.1371/journal.pone.0027023

Olmi M (1984) A revision of the Dryinidae (Hymenoptera). Memoirs of the American Entomological Institute 37: 1–1913.

Olmi M (1989) Supplement to the revision of the world Dryinidae (Hymenoptera, Chrysidoidea). Frustula Entomologica (Nuova Serie) 12: 109–395.

Olmi M (1993) A new generic classification for Thaumatodryininae, Dryininae, and Gonatopodinae, with descriptions of new species (Hymenoptera Dryinidae). Bollettino di Zoologia agraria e di Bachicoltura, Ser. II, 25: 57–89.

Olmi M (1994a) The Dryinidae and Embolemidae (Hymenoptera: Chrysidoidea) of Fennoscandia and Denmark. Fauna Entomologica Scandinavica 30: 1–100.

Olmi M (1994b) Taxonomic studies on the Dryinidae of Mozambique (Hymenoptera: Chrysidoidea). Oriental Insects 28: 67–80. doi: 10.1080/00305316.1994.10432296

Olmi M (2005) A new fossil dryinid in amber from the Dominican Republic: *Harpactosphecion scheveni* n. sp. (Hymenoptera Dryinidae). Frustula entomologica (Nuova Serie) 26: 15–19.

Olmi M (2007) New species of Afrotropical Dryinidae (Hymenoptera: Chrysidoidea), with description of a new genus and a new subfamily. African Invertebrates 48: 199–232.

Olmi M, Guglielmino A (2010) Description of Erwiniinae, new subfamily of Dryinidae from Ecuador (Hymenoptera: Chrysidoidea). Zootaxa 2605: 56–62.

Olmi M, Xu Z, Guglielmino A (2014) Descriptions of new fossil taxa of Dryinidae (Hymenoptera: Chrysidoidea) from Burmese amber (Myanmar). Acta Entomologica Musei Nationalis Pragae 54: 703–714.

Olmi M, Virla EG (2014) Dryinidae of the Neotropical Region (Hymenoptera: Chrysidoidea). Zootaxa 3792: 1–534. doi: 10.11646/zootaxa.3792.2.1

Paquin P, Vink CJ (2009) Testing compatibility between molecular and morphological techniques for arthropod systematics: a minimally destructive DNA extraction method that preserves morphological integrity, and the effect of lactic acid on DNA quality. Journal of Insect Conservation 13: 453–457. doi: 10.1007/s10841-008-9183-0

Rambaut A (2007) FigTree, a graphical viewer of phylogenetic trees. http://tree.bio.ed.ac.uk/software/figtree

Richards OW (1939) The British Bethylidae (Hymenoptera). The Transactions of the Royal entomological Society of London 89: 185–344. doi: 10.1111/j.1365-2311.1939.tb00740.x

Richards OW (1953) The classification of the Dryinidae (Hymenoptera), with descriptions of new species. Transactions of the Royal entomological Society of London 104: 51–70. doi: 10.1111/j.1365-2311.1953.tb01250.x

Rokas A, Nylander JAA, Ronquist F, Stone GN (2002) A maximum-likelihood analysis of eight phylogenetic markers in gallwasps (Hymenoptera: Cynipidae): implications for insect phylogenetic studies. Molecular Phylogenetics and Evolution 22: 206–219. doi: 10.1006/mpev.2001.1032

Ronquist F, Teslenko M, van der Mark P, Ayres DL, Darling A, Höhna S, Larget B, Liu L, Suchard MA, Huelsenbeck JP (2012) MrBayes 3.2: efficient Bayesian phylogenetic inference and model choice across a large model space. Systematic biology 61: 539–542. doi: 10.1093/sysbio/sys029

Sahragard A, Jervis MA, Kidd NAC (1991) Influence of host availability on rates of oviposition and host-feeding, and on longevity in *Dicondylus indianus* Olmi (Hym., Dryinidae), a parasitoid of the Rice Brown Planthopper, *Nilaparvata lugens* Stål (Hemiptera: Delphacidae). Journal of Applied Entomology 112: 153–162. doi: 10.1111/j.1439-0418.1991.tb01041.x

Simon C, Fratti F, Beckenbach A, Crespi B, Liu H, Flook P (1994) Evolution, weighting, and phylogenetic utility of mitochondrial gene sequences and a compilation of conserved polymerase chain reaction primers. Annals of the Entomological Society of America 87: 651–701. doi: 10.1093/aesa/87.6.651

Stamatakis A (2014) RaxML Version 8: A tool for phylogenetic analysis and post-analysis of large phylogenetic. Bioinformatics 30: 1312–1313. doi: 10.1093/bioinformatics/btu033

Vaidya G, Lohman DJ, Meier R (2011) SequenceMatrix: concatenation software for the fast assembly of multi-gene datasets with character set and codon information. Cladistics 27: 171–180. doi: 10.1111/j.1096-0031.2010.00329.x

Virla EG, Espinosa MS, Olmi M (2010) A contribution to the knowledge of Dryinidae of Argentina: descriptions of the hitherto unknown males of *Gonatopus argentinus* Olmi and *Trichogonatopus richardsi* Olmi (Hymenoptera: Chrysidoidea). Frustula entomologica (Nuova Serie)31: 124–134.

Virla EG, Espinosa MS, Moya-Raygoza G (2011) First host record for *Anteon pilicorne* (Ogloblin) (Hymenoptera: Dryinidae), a parasitoid of Cicadellidae, including the corn leafhopper (Hemiptera: Cicadellidae). Neotropical Entomology 40: 285–287. doi: 10.1590/S1519-566X2011000200021

Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294–299.

Xu Z, Olmi M, He J (2013) Dryinidae of the Oriental region (Hymenoptera: Chrysidoidea). Zootaxa 3614: 001–460. doi: 10.11646/zootaxa.3900.1.1

Supplementary material 1

Specimen information and gene coverage

Authors: C. M. Tribull

Data type: specimens data

Explanation note: Locality, museum collection, collector, and sex listed for each specimen in study. Genbank accession numbers provided for sequences sourced from genbank. Success of sequencing for each specimen is indicated by a filled green box.

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Supplementary material 2

Primer protocols

Authors: C. M. Tribull

Data type: primer data

Explanation note: Primer names and thermocycler conditions for each gene. Provided courtesy of Jongok Lim.

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RESEARCH ARTICLE

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Discovery of a new species belonging to the genus *Heinrichiellus* Tereshkin (Ichneumonidae, Ichneumoninae, Platylabini)

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Abstract

Herein, we describe a new species of the distinctive ichneumonine genus *Heinrichiellus* Tereshkin, *H. nambui* **sp. n.** from Japan. To our knowledge, this is the first record of the genus from Japan. A key to the species of *Heinrichiellus* is provided.

Keywords

Taxonomy, new species, Japan

Introduction

Heinrichiellus Tereshkin is a monotypic genus of the subfamily Ichneumoninae (Tereshkin 1996, 2009). The type locality of the type species *Heinrichiellus hildegardae* (Tereshkin) is Russian Far East, eastern Palearctic region. Because of its unique morphological features, such as the absence of an antennal cavity, extremely long and thin maxillary palpus, presence of sharp starnauli on the mesonotum, extremely slender and long legs, and long but not flattened metasomal petiole, the systematic position of

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Heinrichiellus had remained ambiguous (Tereshkin 1996). Recently, Tereshkin (2009) conducted a large study on the genera of the tribe Platylabini and placed *Heinrichiellus* in Platylabini, because of the following common characteristics: convex clypeus, slim and narrow mandibles, highly elevated scutellum, and amblypygous metasoma.

Platylabini includes 38 genera worldwide, 13 of which have been recorded from the eastern Palearctic region (Tereshkin 2009, Yu et al. 2012). Because Ichneumoninae is the most species rich subfamily of Japanese Ichneumonidae, faunistic and taxonomic studies of this subfamily are still insufficient. Although only 4 genera and 13 species of Platylabini have been recorded from Japan, considerably more species and genera are expected to exist in this country than those known previously.

In this study, we found a few Japanese specimens of the genus *Heinrichiellus* belonging to Platylabini. They exhibited some distinct differences compared to *H. hildegardae*; thus, we described another species of this peculiar genus.

Materials and methods

This study was conducted using the materials deposited at the National Institute for Agro-Environmental Sciences, Tsukuba (NIAES), and Ehime University Museum, Matsuyama (EUMJ). We also investigated the ichneumonid specimens from the collections of Hokkaido University, Osaka Museum of Natural History, Kanagawa Prefectural Museum of Natural History, and Tokyo Metropolitan University; however, no additional specimens of *Heinrichiellus* were found. The specimens were observed using a stereomicroscope (Olympus SZ60). Photographs were obtained at the Laboratory of Environmental Entomology, Ehime University, using a Nikon Digital Sight DS-Fi1 camera attached to a Leica S8APO stereomicroscope. Several partially focused images were combined using CombineZP© (Hadley 2009). Morphological terminology is as per Gauld (1991). Microsculpture descriptions follow Eady (1968).

Taxonomy

Genus *Heinrichiellus* Tereshkin, 2009

Heinrichia Tereshkin, 1996: 86. Preoccupied by *Heinrichia* Stresemann, 1931.
Type species: *Heinrichia hildegardae* Tereshkin; monobasic.
Heinrichiella Tereshkin, 2000: 232. New name for *Heinrichia* Tereshkin, 1996. Preoccupied by *Heinrichiella* Hedwig, 1949.
Heinrichiellus Tereshkin, 2009: 1535. New name for *Heinrichiella* Tereshkin, 2000.
Heinrichiola Kocak & Kemal, 2009: 1. New name for *Heinrichiella* Tereshkin, 2000.

Diagnosis. This genus can be distinguished from other genera of Ichneumoninae on the basis of the following characteristics: head slightly transverse in dorsal view, ab-

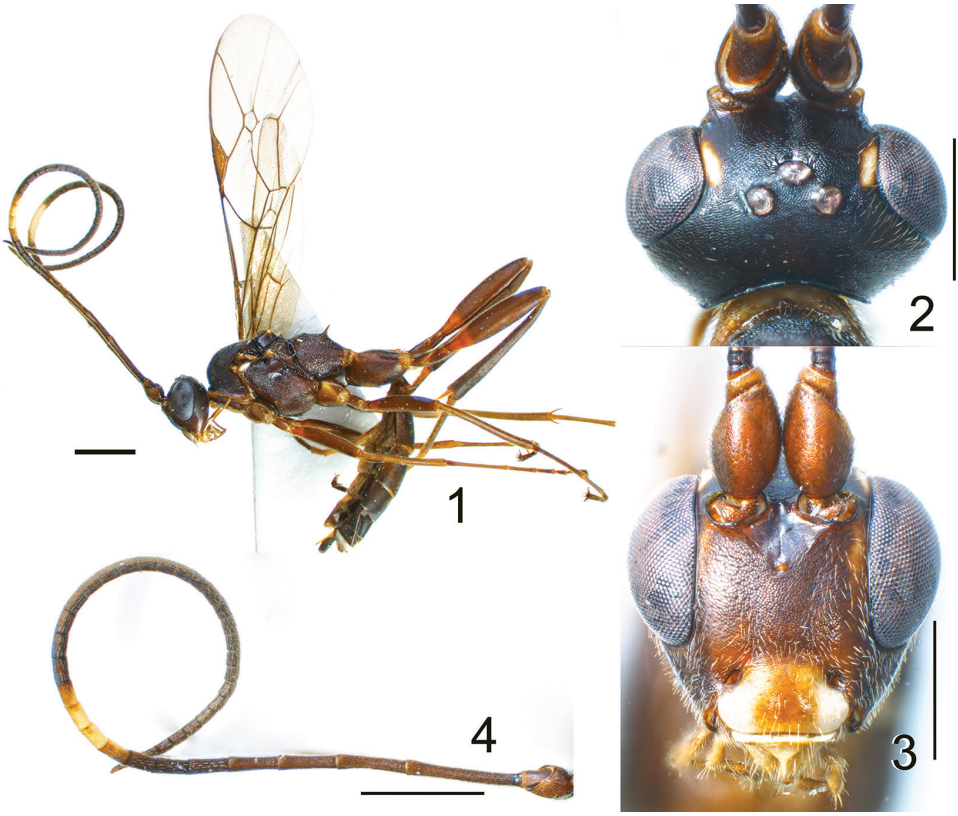
sence of antennal cavity, clypeus convex, sternaulus reaching base of mid coxa, highly elevated scutellum, propodeum with strongly developed and sharp apophysis, fore wing with large pentagonal areolet, all legs longer than fore wings, petiole long and not flattened, rounded in cross-section, gastrocoelus in the form of a longitudinal furrow with thyridium in the form of a small circle, metasoma amblypygous.

***Heinrichiellus nambui* Kikuchi & Konishi, sp. n.**
http://zoobank.org/A468C72C-792B-47BA-9348-4254FF355937
Figs 1–12

Holotype. ♀, 35°56'N 138°54'E, Chichibu City, Saitama Prefecture, Honshu, Japan. Data on the label: "Green School, Ootaki, Saitama, Japan 10. VII. 1999 T. Nambu leg. [YPT & MT]". Deposited in the collection of NIAES. **Paratypes.** 1♀, "43°00'N, 141°24'E, Hitsujigaoka, Sapporo, Hokkaido, Japan, 20–27. viii. 2003, Malaise trap, K. Konishi", EUMJ; 1♂, "43°00'N, 141°24'E, Hitsujigaoka, Sapporo, Hokkaido, Japan, 4-11. viii. 2008, Malaise trap, K. Konishi", EUMJ.

Description of female. *Head.* Head 1.5 times as wide as long in dorsal view and coriaceous except area between polished antennal sockets (Figs 2, 3); ocellar-ocular length (OOL)/postero-ocellar length (POL) = 1.05 (Fig. 2). Frons not concave above each antennal socket; frons with small and distinct tubercle between antennal sockets; antennal sockets large and protruding anteriorly in dorsal view; face 1.2 times as wide as high; inner margins of compound eyes parallel; clypeus strongly convex and transverse, 1.7 times as wide as high, with straight apical margin; anterior tentorial pits large; labrum very wide, 0.8 times as wide as clypeus, with straight apical margin, protruding from under clypeus (Fig. 3). Mandible slender, 3.6 times as long as wide at base, gradually narrowed from base to apex, with lower tooth 0.3 times as long as upper tooth. Malar space 2.2 times as wide as base of mandible. Occipital carina complete and separated from hypostomal carina above base of mandible by 1.4 times width of mandibular base; dorso-median part of occipital carina evenly arched. Maxillary palpus extremely long, reaching epicnemial carina; fifth segment 4.0 times as long as mandibular base (Fig. 1). Flagellum bristle-shaped, very long and slender; apical flagellomere conical; first flagellomere 8.5 times as long as apical width and 1.7 times as long as second one (Fig. 4).

Mesosoma. Collar of pronotum long. Pronotum strigose on coriaceous surface. Mesonotum strongly convex, with notaulus developed to middle of mesonotum; surface of mesonotum granulate with scattered punctures except densely punctate postero-median portion (Fig. 5). Epicnemial carina complete; subalar prominence not sharp; impression below speculum not strong; sternaulus distinct, sharp, almost reaching base of middle coxa; postpectal carina absent; surface of mesopleuron obliquely strigose, except speculum slightly polished (Fig. 6). Scutellum highly elevated above postscutellum, with lateral carina reaching apex and dorsal surface almost flat; hind margin of metanotum with a triangular projection on each side of postscutellum (Figs 5, 7). Propodeum in profile with area basalis flat and evenly slanted from base of area superomedia; regular carinae



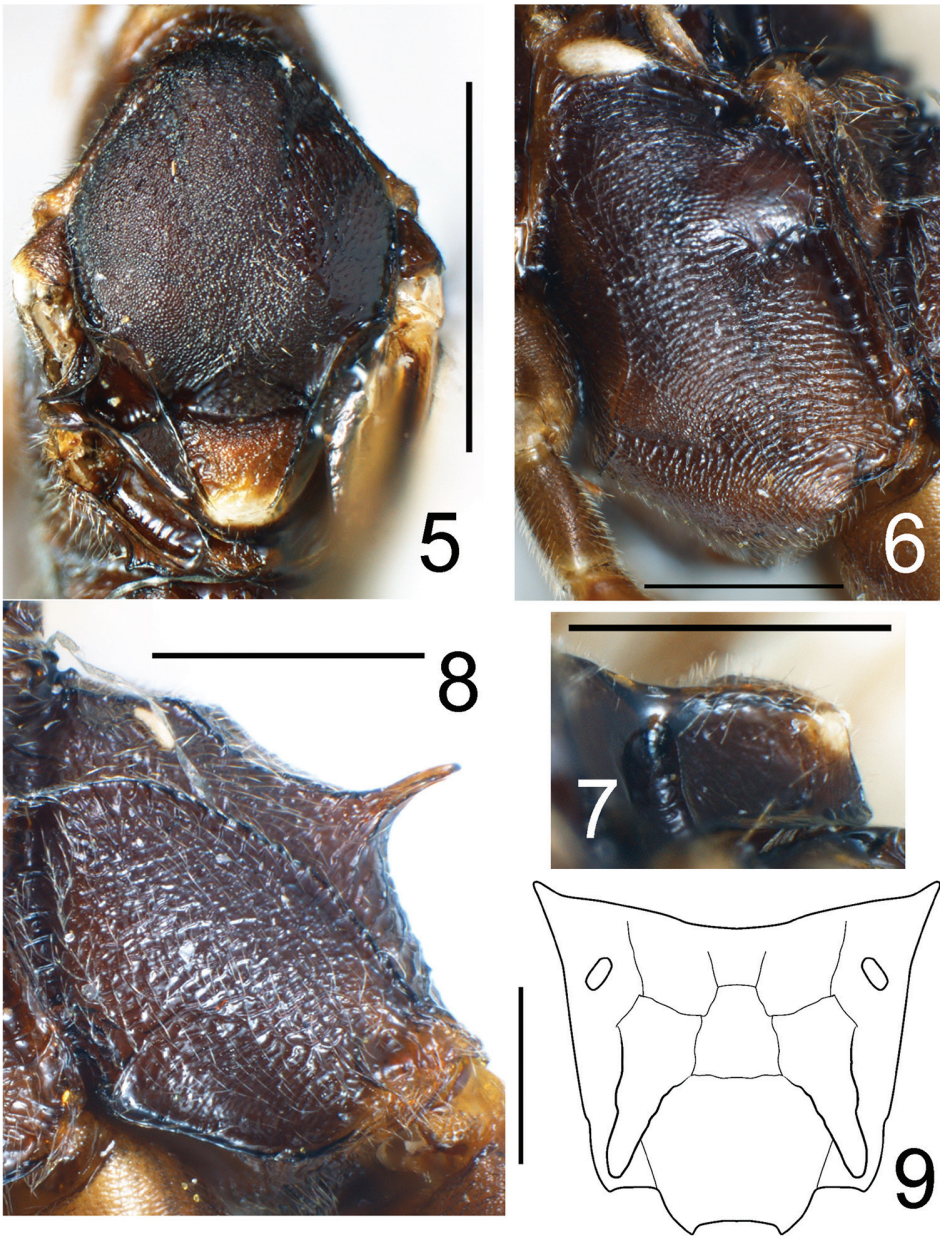
Figures 1–4. *Heinrichiellus nambui* sp. n., Holotype. **1** habitus **2** head in dorsal view **3** head in frontal view **4** antenna. Scale bars = 1 mm.

of propodeum complete; basal one-third of juxtacoxal carina distinct; area superomedia pentagonal, 1.1 times as long as wide; apex of area dentiparae with very strongly developed and sharp apophysis, almost perpendicular to surface of propodeum, and the apophysis slightly curved downward or almost straight; surface of propodeum rugose; area metapleuralis strigose (Figs 8, 9). Propodeal spiracle 2.5 times as long as wide.

Legs. Legs very slender and long; all legs longer than fore wing. Hind tibia 9.0 times as long as apical width; ratio of length of tibiae fore:mid:hind = 1.0:1.3:1.8. Tarsal claws not pectinate.

Wings (Fig. 10). Fore wing 5.9 mm long; areolet 1.8 times as long as *3rs-m*, 0.7 times as high as *2m-cu*, pentagonal and almost symmetrical; *1m-cu*, *2m-cu*, and *3rs-m* each with single bulla; *Cu-a* opposite *Rs & M*; ramulus absent. Hind wing with *cu-a* one-fourth as long as first abscissa of *Cu1*.

Metasoma. Metasoma coriaceous (Figs 11, 12). First tergite in profile almost straight, slightly bent downward at base of postpetiole; in dorsal view 4.6 times as long as wide at base; petiole very long, rounded in cross-section, not flattened, of approximately equal width and height; in dorsal view petiole slightly broadened posteriorly;



Figures 5–9. *Heinrichiellus nambui* sp. n., Holotype. **5** mesonotum to postscutellum in dorsal view **6** mesopleuron **7** scutellum in lateral view **8** propodeum in lateral view **9** carinae of propodeum. Scale bars = 1 mm.

dorso-median carina present only on apical portion of postpetiole (Fig. 11). Second tergite in dorsal view 2.8 times as long as wide at base. Gastrocoelus slightly impressed, in form of longitudinal groove. Thyridium oval, distant from base of second tergite

Figure 10. *Heinrichiellus nambui* sp. n., Holotype, wings. Scale bar = 1 mm.

Figures 11–12. *Heinrichiellus nambui* sp. n., Holotype. **11** tergite 1 in dorsal view **12** apex of abdomen in lateral view. Scale bars = 1 mm.

by 0.7 times its length. Tergites 3–6 with laterotergites separated by distinct crease. Sternites 2–5 laterally sclerotized and middle part not sclerotized. Hypopygium with apical margin rounded and longitudinally folded in middle. Ovipositor sheath with apex truncate, protruding beyond apex of metasoma (Fig. 12).

Coloration. Body ground color reddish to blackish brown (Fig. 1). Vertex with a pair of white spots along eye margins (Fig. 2); clypeus whitish brown medially and

Figures 13–16. *Heinrichiellus nambui* sp. n., Paratype (male). **13** habitus **14** head in dorsal view **15** head in frontal view; 16, apex of abdomen in lateral view. Scale bars = 1 mm.

white on lateral quarter; maxillary and labial palpi whitish brown; labrum and flagellar annulus (eighth–eleventh flagellomeres) white. Subalar prominence white; scutellum whitish brown on anterior two-third and white on posterior one-third. Metasoma with seventh tergite white. Ovipositor sheath black; basal quarter and apical portion white.

Description of male (Figs 13–17). As in female except for the following characters. *Head.* OOL/POL = 1.33 (Fig. 14); face 1.5 times as wide as high; clypeus 2.0 times as wide as high (Fig. 15). First flagellomere 7.1 times as long as apical width and 1.5 times as long as the second one.

Mesosoma. Apophysis of propodeum shorter than that in female, almost straight; area superomedia 1.2 times as wide as long.

Metasoma. Genitalia as in Figures 16–17; apex of gonosquama rather narrow and curved downwards. Basal apodeme of aedeagus broadened and curved downwards.

Coloration. Body ground color black to dark brown (Fig. 13). Vertex with a pair of white spots along eye margins (Fig. 14); clypeus and lateral parts of face white; malar space white (Fig. 15); maxillary and labial palpi whitish brown; labrum and flagellar annulus (14th–17th flagellomeres) white. Collar of pronotum, subalar prominence and

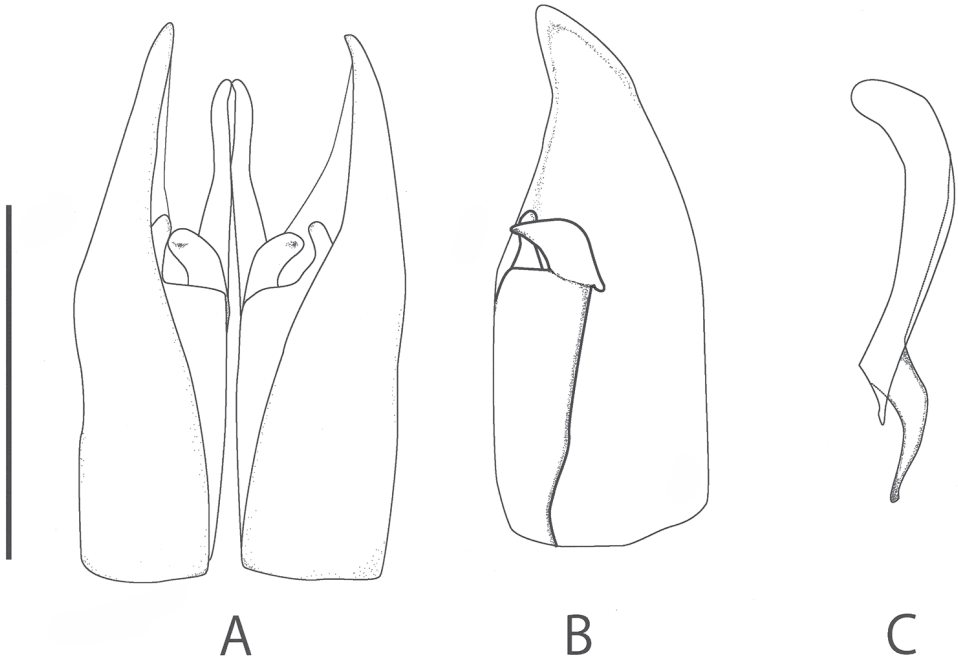


Figure 17. *Heinrichiellus nambui* sp. n., Paratype (male) genitalia (**A** ventral view **B** gonoforceps in mesal view **C** aedeagus in lateral view). Scale bar = 0.5 mm.

posterior one-third of scutellum white. Fore- and mid-coxae and trochanters white; fore- and mid-femora and tibiae reddish brown; second–fourth hind tarsomeres whitish brown. Metasoma with seventh tergite and genital capsule white (Fig. 17).

Distribution. Japan (Hokkaido, Honshû).

Etymology. This species is named after Mr. Toshiaki Nambu who collected the holotype.

Remarks. When this new species is compared with the descriptions of another congener, *H. hildegardae*, by Tereshkin (1996, 2009), they can be distinguished on the basis of the following key.

Key to species of the genus *Heinrichiellus*

1 Body punctate; mesopleura microsculptured; area superomedia of propodeum long and hexagonal in female, almost square in male; spiracles of propodeum 3 times as long as wide; areolet of fore wing asymmetrical..... ..... ***H. hildegardae*** **Tereshkin**

– Body coriaceous with rugosity; mesopleura obliquely strigose; area superomedia of propodeum pentagonal in both sex; spiracles of propodeum 2.5 times as long as wide; areolet of fore wing almost symmetrical ... ***H. nambui*** **sp. n.**

Discussion

Heinrichiellus nambui sp. n. is the second species of the genus *Heinrichiellus*. While the type species of the genus, *H. hildegardae*, was reported from Primorski Krai of Russia, *H. nambui* was found in Hokkaido and Honshu, Japan. Vegetation of the type locality (Chichibu, Saitama Prefecture) and the locality of the paratypes comprises deciduous broad-leaved forests in the mainland of Japan. *Heinrichiellus hildegardae* was described based on the characteristics of one female and two males. Similarly, only two females and one male of *H. nambui* could be found; nevertheless, we examined the principal collections of Ichneumoninae in Japan, and these collections included many specimens collected from similar environments as the type locality. The following possibilities might explain the rarity of this genus in collections.

Specimens of *Heinrichiellus* might often be overlooked as belonging to Cryptinae. Because this genus has a distinct sternaulus similar to that in Cryptinae, this character leads to misidentification. In fact, the paratypes were found in a box of Cryptinae in EUMJ. A well-developed sternaulus is a characteristic of Cryptinae and unusual in Ichneumoninae. Other characteristics such as the form of the clypeus and wing venation can be used for correct identification.

The habitat of *Heinrichiellus* is not suitable for using the usual methods of collecting wasps, such as sweeping and placement of ground Malaise traps. Recorded hosts of Platylabini mainly belong to Geometridae (Yu et al. 2012) and members of the tribe are known as larval-pupal parasitoids (van Veen 1981, Tereshkin 2009). The metasoma morphology is either amblypygous, which is adapted for attacking larvae, or oxypygous, which is adapted for attacking pupae (Heinrich 1960, Hinz 1983, Sime and Wahl 2002). Although Sime and Wahl (2002) suggested that oxypygous species do not strictly attack pupae, none of the species with an amblypygous metasoma were recorded as pupal parasitoids; this indicates that *Heinrichiellus* is also a larval-pupal parasitoid. A study on *Ichneumon* suggested that species with a slender body and long antenna tend to attack hosts pupating above the ground (Tschopp et al. 2013); *Heinrichiellus* also probably attacks hosts pupating above the ground. Further, many Geometridae species use arboreous plants; to attack the larvae, the habitat of *Heinrichiellus* might be forest canopy. Thus, canopy Malaise traps might need to be used for collecting such parasitoid wasps.

These findings suggest that *Heinrichiellus* are more likely to be distributed in a wider area, including other Islands of Japan as well as other Asian countries. Additional studies are warranted to elucidate the distribution pattern of species belonging to this genus.

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References

Eady RD (1968) Some illustrations of microsculpture in the Hymenoptera. Proceedings of the Royal Entomological Society of London 43: 66–72.

Gauld ID (1991) The Ichneumonidae of Costa Rica, 1. Memoirs of the American Entomological Institute 47: 1–589.

Hinz R (1983) The biology of the European species of the genus *Ichneumon* and related species (Hymenoptera: Ichneumonidae). Contributions of the American Entomological Institute 20: 151–152.

Koçak AÖ, Kemal M (2008) On the nomenclature of a pre-occupied generic name in the family Ichneumonidae (Hymenoptera). Centre for Entomological Studies Ankara. Miscellaneous Papers 150: 1.

Sime KR, Wahl DB (2002) The cladistics and biology of the *Callajoppa* genus-group (Hymenoptera: Ichneumonidae, Ichneumoninae). Zoological Journal of the Linnean Society 134: 1–56. doi: 10.1046/j.1096-3642.2002.00006.x

Tereshkin A (1996) A new Ichneumoninae Stenopneusticae genus, *Heinrichia*, from the Far East(Hymenoptera, Ichneumonidae). Entomofauna 17: 89–96.

Tereshkin A (2000) Description of the males of *Ulesta nigroscutellata* Tereshkin, 1993 and *Rhadinodonta rufidens*(Wesmael, 1844) and a new name for the genus *Heinrichia* Tereshkin, 1996 (Hymenoptera, Ichneumonidae, Ichneumoninae Stenopneusticae). Entomofauna 21: 229–234.

Tereshkin AM (2009) Illustrated key to the tribes of subfamilia Ichneumoninae and genera of the tribe Platylabini of World fauna (Hymenoptera, Ichneumonidae). Linzer biologische Beiträge 41(2): 1317–1608.

Tschopp A, Riedel M, Kropf C, Nentwig W, Klopfstein S (2013) The evolution of host associations in the parasitic wasp genus *Ichneumon* (Hymenoptera: Ichneumonidae): convergent adaptations to host pupation sites. BMC Evolutionary Biology 13: 74. doi: 10.1186/1471-2148-13-74

van Veen JC (1981) The biology of *Poecilostictus cothurnatus* (Hymenoptera: Ichneumonidae) an endoparasite of *Bupalus piniarius* (Lepidoptera: Geometridae). Annales Entomologici Fennici 47: 77–93.

Yu DSK, van Achterberg C, Horstmann K (2012) Taxapad 2012, Ichneumonoidea 2011. Ottawa, Ontario. http://www.taxapad.com [database on flash-drive]

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RESEARCH ARTICLE

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Pediobius cajanus sp. n. (Hymenoptera, Eulophidae), an important natural enemy of the Asian fly (*Melanagromyza obtusa* (Malloch)) (Diptera, Agromyzidae) in the Dominican Republic

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Abstract

Pediobius cajanus **sp. n.** is described based on material from the Dominican Republic, where it is widespread, and it is anticipated to have a much larger distribution in tropical America. It is compared to other species of *Pediobius* from the New World, and is also compared to *P. vignae* (Risbec), a similar species from Africa with similar biology. The new species is a gregarious endoparasitoid of the pupae of the Asian fly, *Melanagromyza obtusa* (Malloch), an agromyzid that causes major damage to pigeon pea, *Cajanus cajan* (L). Millspauh. In the Dominican Republic *P. cajanus* **sp. n.** is the most important parasitoid of this pest. Details on its biology are provided.

Keywords

Guandul, potential biocontrol agent, Neotropics

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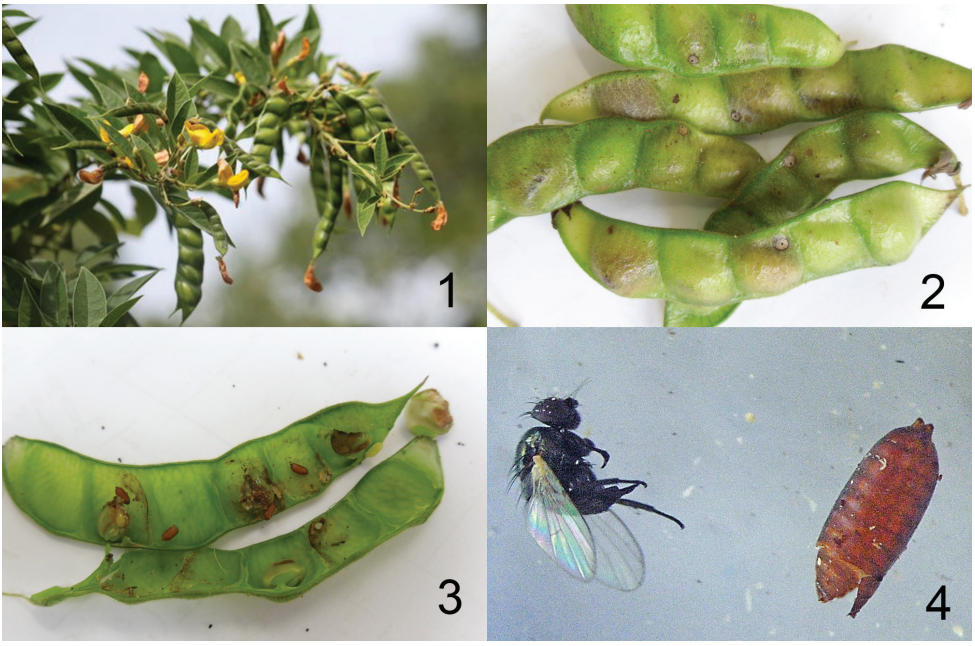
Introduction

Pediobius is a cosmopolitan genus with 217 described species (Noyes 2015), 25 of which have been recorded from the Neotropical region (Hansson 2002). Species of *Pediobius* develop as primary or secondary endoparasitoids in eggs, larvae or pupae of other insects, and the host range is extensive (Bouček 1988). The host species belong mainly to Coleoptera, Diptera, Hymenoptera and Lepidoptera. Some species have been reared from egg sacks of spiders, but then act as secondary parasitoids of ichneumonid larvae (Hymenoptera) feeding on the spider eggs. In the Neotropical region *Pediobius* species have been recorded from Coleoptera, Hymenoptera, and Lepidoptera but not from Diptera (Hansson 2002). Some *Pediobius* species have been used in biological control, most notable is perhaps *P. foveolatus* (Crawford), which has been used successfully to control populations of the Mexican bean beetle, *Epilachna varivestis* Mulsant, 1850 (Coleoptera: Coccinellidae) in North America (Barrows and Hooker 1981). Here we describe a new species of *Pediobius* that is the main enemy and a potential biocontrol agent of the Asian fly, *Melanagromyza obtusa* (Malloch, 1914) (Diptera: Agromyzidae). The Asian fly is an invasive pest in tropical America that causes extensive damage to pigeon pea, *Cajanus cajan* (L) Millspauh. Pigeon pea is an important source of food in tropical America, and as processed food is an important source of income from export.

The components of the tritrophic system including *Pediobius cajanus* sp. n.

The pigeon pea, "guandúl" in Spanish (Fig. 1), is a legume native to tropical India, and it has been grown in the Dominican Republic and other countries in tropical America since the late 15th century, when the Spanish came to the Americas. It is a very important source of nutrition: Miquilena and Higuera Moros (2012) gave a protein value of 17.52%, and compared it to lentil and soy, with 18 and 35% protein values respectively. The plant is very tolerant to heat and drought and in dry areas without access to irrigation, it is a valuable alternative to less tolerant crops. In addition to its usefulness as food for humans the plant fixates nitrogen and thus contributes to the fertilization of the soil; the empty seedpods are an important food source for livestock, the remaining plant parts can be used as firewood, and it also has some medicinal properties (Cedano 2006).

In the Dominican Republic, the study area for this paper, the pigeon pea is grown in approximately 25,000 hectares, by nearly 3,000 farmers (statistics from the Ministry of Agriculture 2013). However, this figure is underestimated because much of the production is in small lots, along paths and road edges, and it is used as property borders, and these areas are not included in the statistics. Thus, the total area of cultivation is unknown, but the unrecorded areas are significant and contribute to the diet of some of the country's population. In the Dominican Republic its cultivation has also been developed as a source of income for farmers who process the bean as canned or freshly



Figures 1–4. 1 pigeon pea, *Cajanus cajan* (L). Millspauh **2** seed pods of pigeon pea with marks indicating windows created by larvae of the Asian fly, *Melanagromyza obtusa* (Malloch), prior to pupation, a window that facilitates the emergence of the adult fly from the pod **3** opened seed pods of pigeon pea with pupae of the Asian fly **4** imago of the Asian fly with pupa.

frozen beans for export. The export of pigeon pea has diversified and today it is being exported to many countries, including countries in Europe, but the largest importers are in the arc of the Antilles.

The pigeon pea is attacked by a complex of insect pests, mainly from the orders Lepidoptera, Diptera, Hemiptera and Coleoptera (Schmutterer 1990). One of the major pests is the Asian fly (Fig. 4) which causes great damage to the crops of pigeon pea, considerably reducing the production and export volumes.

Studies in India have shown that the damage caused by the Asian fly affects 25.5 to 36% of the crop (Sharma et al. 2011). These data are in accordance with those found in the Dominican Republic, where the Asian fly was detected in 2000 (Phytosanitary Alert system 2004, and Etienne et al. 2004). An investigation in the Dominican Republic by Guzman et al. (2010) indicated that the percentage of damage, even though the crops were treated with insecticides every 21 days, reached a level of 27%. However, the amount of damage varies considerably between different localities and the state of crop development in the Dominican Republic. In 2012 the level of damage was evaluated in 122 localities and in the town of Rancho Los Vargas, Puerto Plata, it reached 76% (Taveras and Guzman 2013).

Yadaf and Yadaf (2011) conducted a review of the parasitoids of the Asian fly in India and listed 21 Hymenoptera parasitoids in 10 genera. They found that *Euderus*

lividus (Ashmead, 1886) (Eulophidae) and *Ormyrus orientalis* Walker, 1871 (Ormyridae) were the main parasitoids, and these two species were also the most studied parasitoids for control of the fly. Species of *Pediobius* have, prior to this paper, not been recorded from the Asian fly.

In the Dominican Republic *Ormyrus orientalis* and an unidentified species of *Pediobius* have been reared from the Asian fly on pigeon pea. In a paper by Taveras and Guzman (2013) the presence of these beneficial parasitoids was recorded from 103 sites that included 25 of the 31 provinces in the country. The level of parasitism was 27.8%, with the *Pediobius* species responsible for 25.8%, and *Ormyrus orientalis* for 2%. This information clearly indicates that these parasitoids are distributed throughout the country, which is also supported by this investigation, and very probably have a far larger distribution outside the Dominican Republic. It also indicates that the *Pediobius* species is an important natural enemy of the Asian fly, and as such might be considered as a biocontrol agent against this invasive pest.

Because of the economic importance of the pigeon pea, and because the unidentified *Pediobius* species obviously is an eminent natural enemy of its main pest, the Asian fly, in the Dominican Republic, it is important to identify this *Pediobius* species. After a close examination of several specimens of *Pediobius* we found that it belongs to an undescribed species. To facilitate the identification of this new species it is described and diagnosed here, and given a scientific name so that future information can be linked to it.

Methods

The color photos were made with a Nikon SMZ 1000 stereomicroscope and a Nikon DS-5M camera. To eliminate reflections from the metallic and shiny body, a dome light manufactured as described by Kerr et al. (2008), was used as the light source for photography. Photos were taken at different focus levels and Helicon Focus Pro version 4.75 was used to merge them into a single image. The SEM photos were made from uncoated specimens on their original cardboard mounts. These were taken in low vacuum mode on a JEOL® JSM 5600LV scanning electron microscope.

Pods of pigeon pea were collected in several different parts of the Dominican Republic and were placed in plastic bags with holes for ventilation and prevention of condensation inside the bags. The samples were brought to the laboratory where the pods were opened and fly larvae, pupae and adults were counted. The larvae and pupae were placed in plastic containers (9 × 9 cm) with a piece of cloth at the opening to facilitate aeration. The emerging parasitoids and imagines of the Asian fly were killed and stored in vials with ethanol.

Measurements were taken using the Nikon stereomicroscope mentioned above, using a eyepiece micrometer at 80 times magnification. The female holotype and ten paratypes of each sex were measured.

Morphological terms follow Gibson (1997). For illustrations of the morphological terms see also Hansson (2015).

Results

***Pediobius cajanus* sp. n.**
http://zoobank.org/72DC9BF3-90AD-4964-981B-0B30F5FD3EBA
Figures 6–19

Material examined. Type material: HOLOTYPE ♀ labelled "DOMINICAN REPUBLIC: San Juan Province, San Juan de la Maguana, 20.x.2014, Rosina Taveras", "Ex pupae of *Melanagromyza obtusa* on pigeon pea (*Cajanus cajan*)" (in the Natural History Museum, London, United Kingdom). PARATYPES: 42♀ 15♂ with same label data as holotype (in the Natural History Museum, London, United Kingdom; Canadian National Collection of Insects and Arachnids, Ottawa, Canada; Museo Nacional de Historia Natural, Dominican Republic; Museum of Biology (Entomology), Lund, Sweden; United States National Museum of Natural History, Washington, D.C., USA). Additional material: 42♀ 12♂ from the Dominican Republic: Luperon Province, Puerto Plata, v.2013 (in the Museum of Biology (Entomology), Lund, Sweden).

Diagnosis. Hind leg with tibial spur 0.4 times as long as length of hind tarsus; propodeum with strong submedian carinae that diverge towards posterior part (Fig. 18); propodeal callus with four setae; female gaster elongate (Figs 13, 19), 2 times as long as wide; small species (0.9–1.5 mm).

In the most recent keys to the Neotropical species of *Pediobius* (see Hansson 2002) and in the key to Nearctic species (Peck 1985), *P. cajanus* runs to *P. pyrgo* (Walker, 1839). It differs from *P. pyrgo* in having median third of scutellum smooth (Fig. 17) (completely reticulate in *P. pyrgo*), posterior margin of dorsellum tridentate (Fig. 18) (rounded in *P. pyrgo*), and petiole in female 0.7 times as long as wide (1.0 times as long as wide in *P. pyrgo*).

Pediobius cajanus sp. n. also appears to be morphologically similar to *P. vignae* (Risbec, 1951) from Nigeria, as described in Kerrich (1973). The host of *P. vignae*, *Melanagromyza vignalis* Spencer, 1959 in seeds of *Vigna unguiculata* (L.) Walp. (Fabaceae), is also similar to the host of *P. cajanus*. When Kerrich (1973) revised the tropical and subtropical species of *Pediobius* he was unable to find the type material of *P. vignae* and designated a neotype for the species, to be deposited in BMNH. However, this neotype, or the series it was pulled from, cannot be located in BMNH (Natalie Dale-Skey, pers. comm.). Thus we rely totally on the redescription of *P. vignae* in Kerrich (1973) for the interpretation of this species. *Pediobius cajanus* sp. n. differs from *P. vignae* in having eyes bare (Figs 15, 16) (setose in *P. vignae*), scutellum smooth in median third (Fig. 17) (reticulate throughout in *P. vignae*), female first gastral tergite 0.5 times as long as length of gaster (Figs 13, 19) (well over half the length of gaster in *P. vignae*), female with first gastral tergite with very weak and superficial reticulation posteromedially (Figs 13, 19) (this part with strong and very distinct reticulation in *P. vignae*).

Description. Female: length of body 1.1–1.5 mm.

Antenna dark and metallic (Figs 6, 11). Frons dark golden-purple with bluish tinges (Fig. 8). Vertex shiny with dark golden and blue tinges (Fig. 10). Pronotum

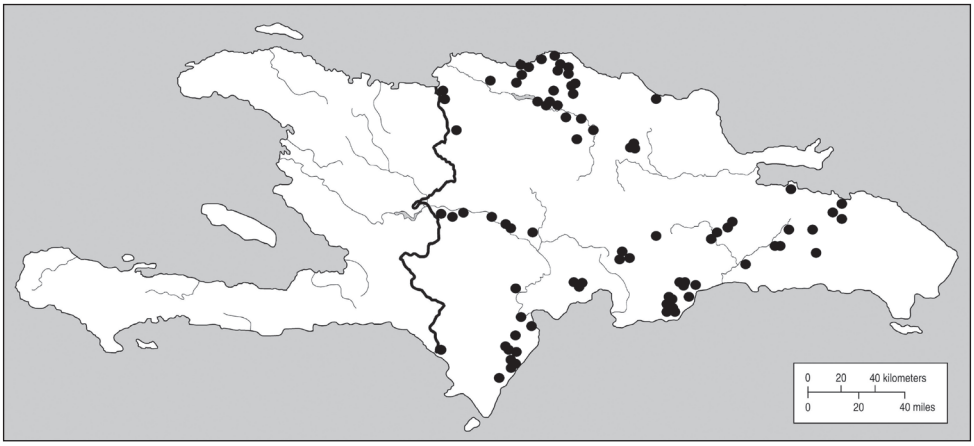
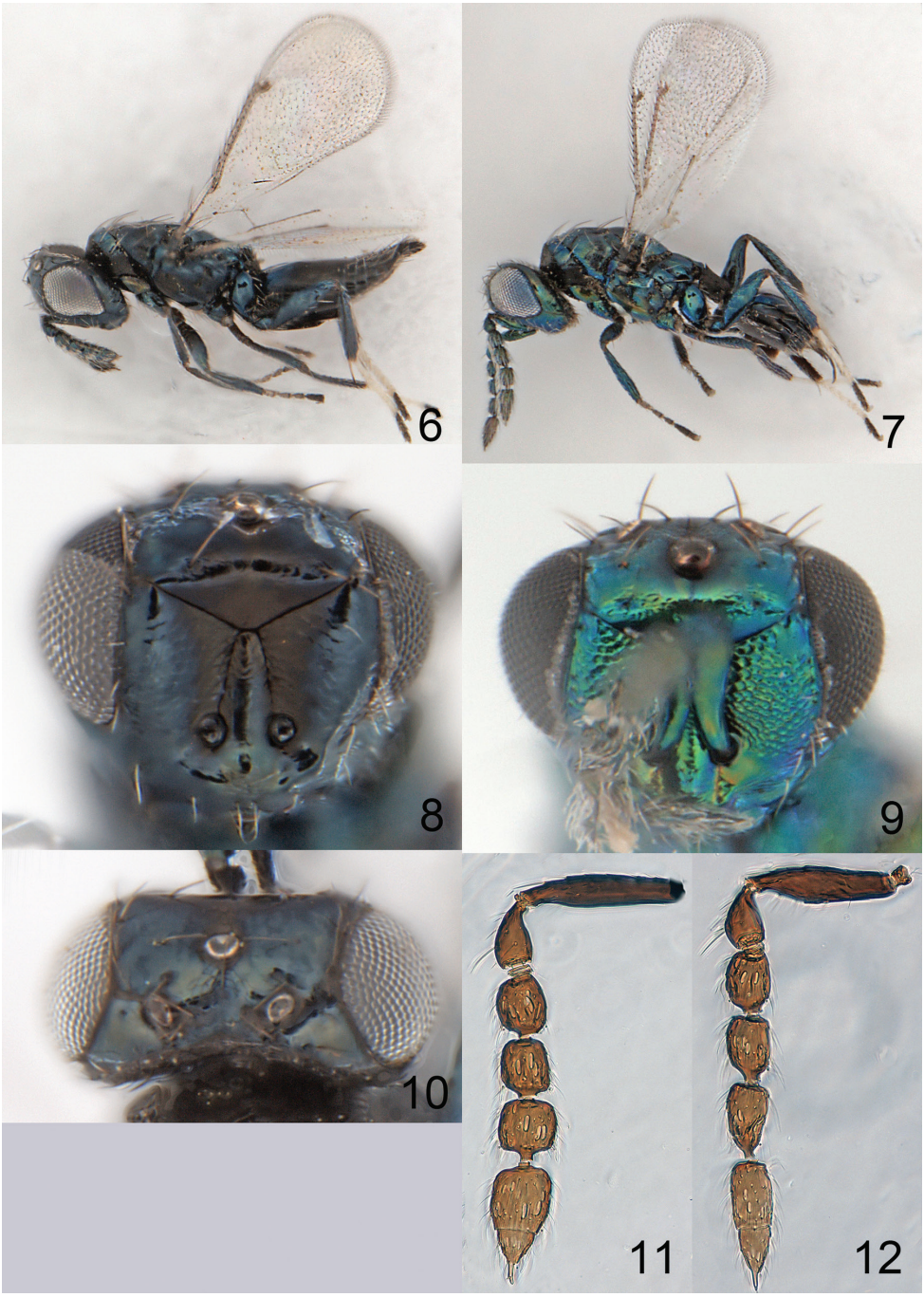


Figure 5. Map of the island of Hispaniola showing localities in the Dominican Republic where *Pediobius cajanus* sp. n. has been reared from *Melanagromyza obtusa* during this investigation. Specific names of localities and coordinates are provided in Table 1.

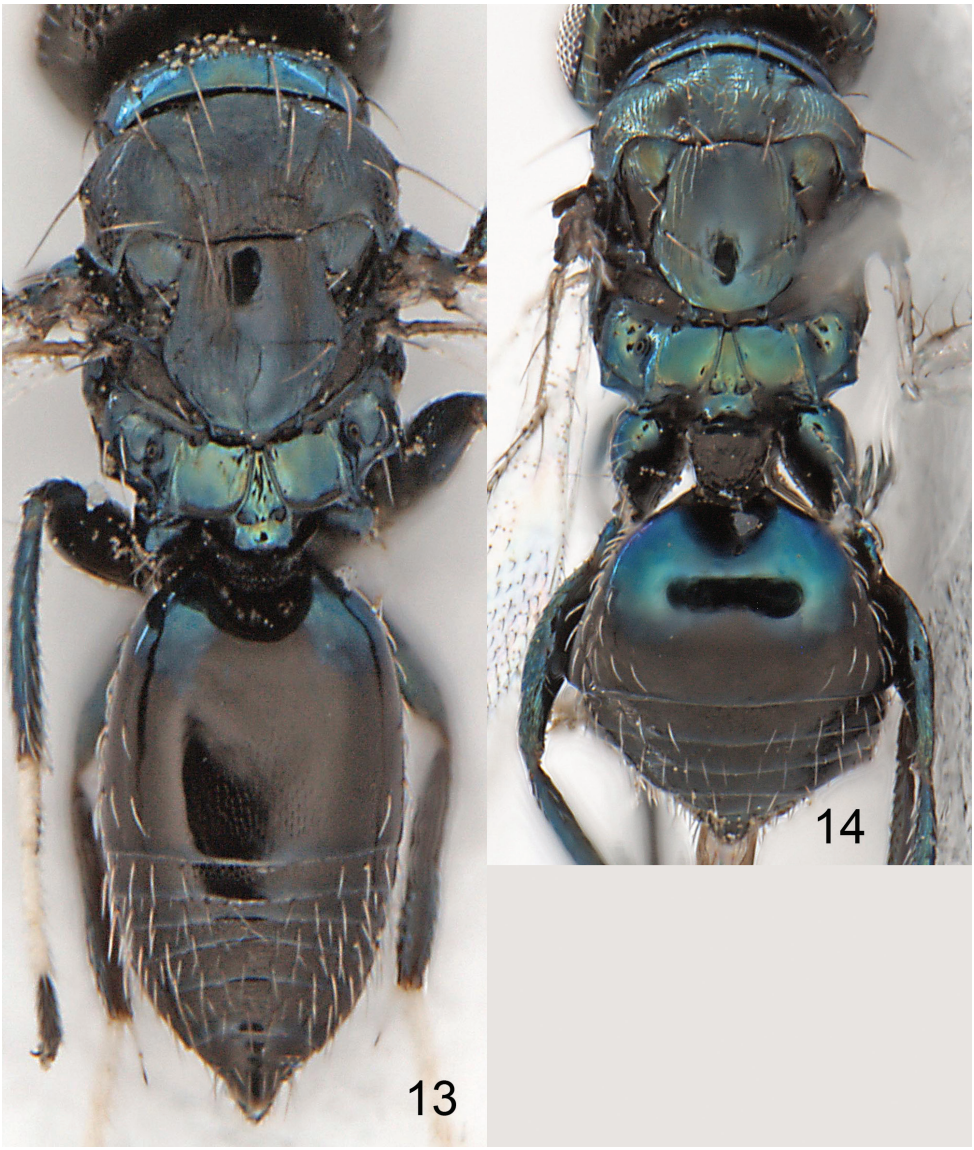
with part in front of transverse carina dark golden-purple, part behind transverse carina metallic bluish-green (Fig. 13). Mesoscutum dark golden-purple (Fig. 13). Scutellum dark golden-purple with lateral and posterior parts with greenish tinges (Fig. 13). Propodeum golden-green (Fig. 13). Coxae, femora and tibiae dark and metallic (Fig. 6); tarsal segments 1–3 dusky on fore leg and white on mid and hind legs, fourth segment dark brown on all legs. Wings hyaline. Petiole dark golden-purple. Gaster with first tergite metallic bluish-green in anterior fourth, posterior three quarters and remaining tergites dark golden-purple (Fig. 13).

Antenna as in Figs 6, 11. Frons smooth and shiny below level of toruli and above frontal suture, between these parts with very weak reticulation (Fig. 16); antennal scrobes join frontal suture separately (Fig. 8). Vertex inside and behind ocellar triangle with weak, small-meshed reticulation, outside ocellar triangle smooth (Fig. 15). Occipital margin with a weak carina behind posterior ocelli, otherwise rounded (Fig. 15). Eyes bare (Figs 15, 16). Ratios: length of head (in dorsal view)/width of head (measured at widest part): holotype 0.49, paratypes 0.46–0.52; height of eye in frontal view/malar space: holotype 2.06, paratypes 1.87–2.33; height of eye in frontal view/width of mouth opening: holotype 1.45, paratypes 1.29–1.46; distance between posterior ocelli/distance between eye and posterior ocellus: holotype 2.38, paratypes 1.75–2.40

Mesoscutum with weak reticulation (Fig. 17), meshes isodiametric in anteromedian part but otherwise elongate; notauli distinct and narrow in anterior two thirds, indistinct in posterior third. Scutellum convex with median third smooth, lateral parts to either side of smooth, median part reticulate with elongate meshes (Fig. 17). Posterior margin of dorsellum with a prominent medial projection and with weak and blunt lateral projections (Fig. 18). Transepimeral sulcus strongly curved. Fore wing speculum closed below; 12 admarginal setae. Hind leg with tibial spur 0.4 times as long as length of hind tarsus. Propodeum with strong submedian carinae that diverge towards



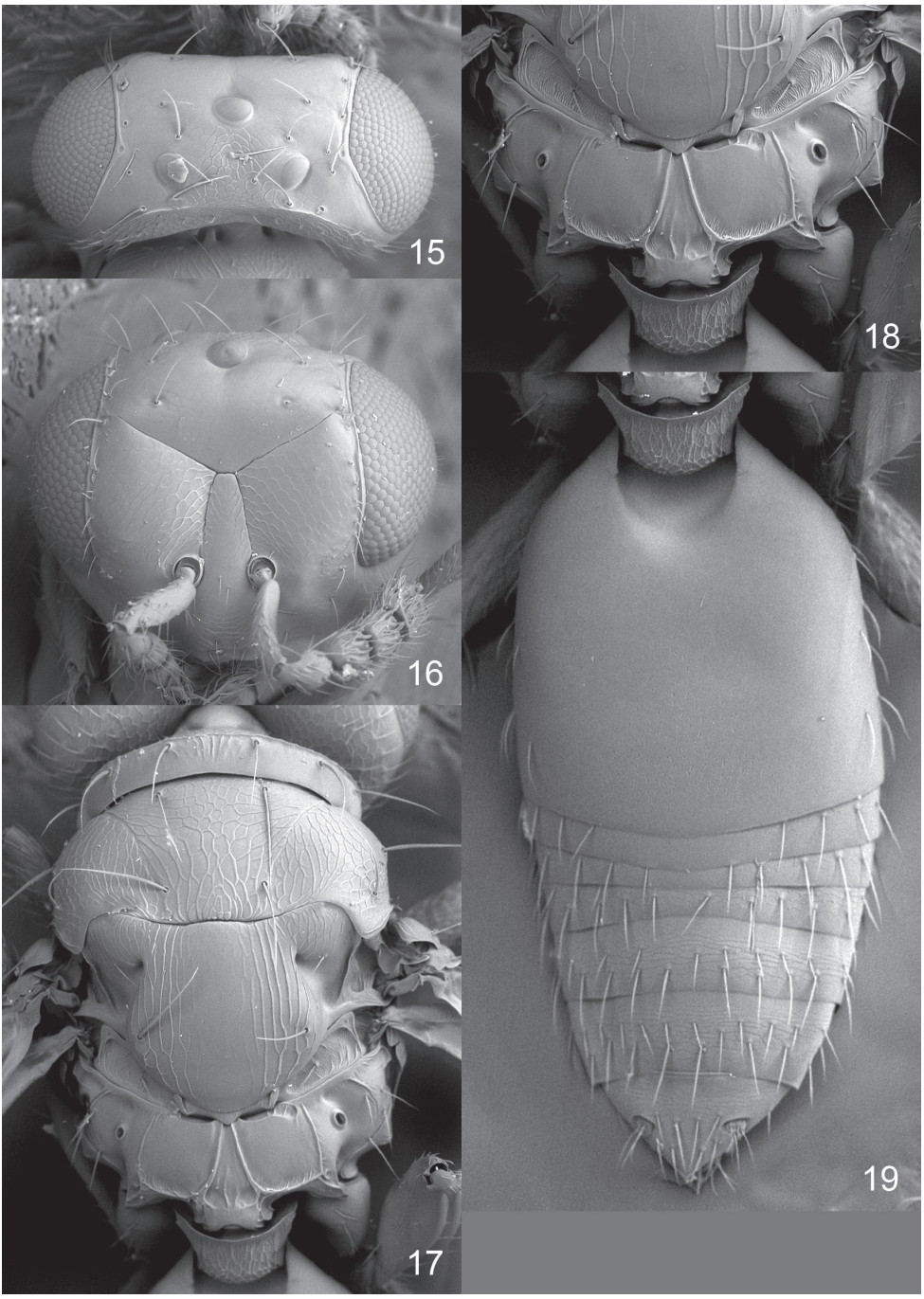
Figures 6–12. *Pediobius cajanus* sp. n. **6–7** habitus in lateral view **6** female **7** male **8–9** head in frontal view **8** female **9** male **10** vertex, female **11–12** antenna in lateral view **11** female **12** male.



Figures 13–14. *Pediobius cajanus* sp. n., habitus in dorsal view **13** female **14** male.

posterior part (Fig. 18); with a short but distinct nucha; callus with four setae. Petiolar foramen rounded. Ratios: length of fore wing/length of marginal vein: holotype 1.98, paratypes 1.85–2.04; length of fore wing/height of fore wing: holotype 1.67, paratypes 1.63–1.75; length of postmarginal vein/length of the stigmal vein: holotype 0.96, paratypes 0.63–1.00.

Petiole 0.7 times as long as wide, with strong irregular sculpture (Fig. 19). Gaster with first tergite smooth (Fig. 19), posteromedially with very weak and superficial reticulation, meshes incomplete; first tergite covers 0.5 times the length of gaster in both



Figures 15–19. *Pediobius cajanus* sp. n., female **15** vertex **16** head in frontal view **17** thoracic dorsum **18** propodeum in dorsal view **19** petiole and gaster in dorsal view.

sexes (Figs 13, 14, 19). Ratio length of the mesosoma (measured along the median mesosoma from the pronotal collar carina to posterior margin of the propodeum)/ length of gaster: holotype 0.88, paratypes 0.81–0.93.

Male: length of body 0.9–1.3 mm.

Similar to female except as follows. Frons bright metallic bluish-green (Fig. 9). Mesoscutum golden-green (Fig. 14). Scutellum golden-green (Fig. 14). Gaster with first tergite metallic bluish-green in anterior half, posterior half and remaining tergites dark golden-purple (Fig. 14).

Antenna as in Figs 7, 12. Ratios: height of eye in frontal view/malar space: 1.75–1.94; height of eye in frontal view/width of mouth opening: 1.30–1.60.

Petiole 1.1 times as long as wide. Gaster with first tergite completely smooth. Ratio length of the mesosoma (measured along the median mesosoma from the pronotal collar carina to posterior margin of the propodeum)/length of gaster: 1.09–1.58.

Etymology. Named after the host plant.

Distribution. The Dominican Republic. The first author of this paper has reared this new species from its host from 90 sites (Fig. 5, Table 1).

Biology. *Pediobius cajanus* sp. n. is a gregarious endoparasitoid in pupae of *Melanagromyza obtusa*. The female wasps lay 3–15 eggs per fly pupa (mean = 7.6, n = 50). In laboratory conditions, with 25 °C, the development time from egg to pupa of the parasitoid was 21 days. Without food the female wasps lived for four days and males for two days. The sex ratio female to male is 5:1 (n = 50).

Biology of the Asian fly. The female fly lays eggs on immature pods, and the emerging larvae feed in the developing seeds, initially feeding externally but after the first molt feed inside the seed, which they eventually destroy (Fig. 3). A single seed may be enough for a larva to complete its development, but usually more than one seed is devoured. The larva goes through three stages prior to pupation. Before pupating in the seed pod the larva emerges from the seed and opens a window in the wall of the pod (Fig. 2).

Conclusions. *Pediobius cajanus* sp. n. is so far known only from the Dominican Republic, but its distribution throughout this country suggests a larger distribution. It is certainly found over the entire island of Hispaniola, of which the Dominican Republic constitutes the larger part. It is possibly also found on neighboring islands in the Caribbean, e.g. Cuba, and perhaps also in tropical parts of the mainland in the Americas. Some *Pediobius* species have a very large distribution (Kerrich 1973, Hansson 2002), thus indicating a strong dispersal ability. If this ability is present also in *P. cajanus* sp. n. future investigations must establish.

In the Dominican Republic *P. cajanus* sp. n. is an important natural enemy of the Asian fly, killing on average 25% of the fly larvae in investigated areas. The fly is found in many tropical countries, in Asia, its native area, as well as in other tropical parts of the World, and is a serious pest on economically valuable crops in these areas. The record of parasitism of *P. cajanus* sp. n. in the Dominican Republic makes it worthwhile to investigate the potential of this parasitoid as a biocontrol agent of the Asian fly.

Table 1. List of localities in the Dominican Republic where *Pediobius cajanus* sp. n. has been reared from *Melanagromyza obtusa*.

Locality	Province	Decimals	Degrees
13 de Azua	Azua	18.459420, -70.853738	18°27'33.9"N, 70°51'13.5"W
Guanábano, Azua	Azua	18.447210, -70.790729	18°26'50.0"N, 70°47'26.6"W
Los Jovillos	Azua	18.449151, -70.801853	18°26'56.9"N, 70°48'06.7"W
Santana	Bahoruco	18.417995, -71.193348	18°25'04.8"N, 71°11'36.0"W
Pizarrete, Bani	Peravia	18.290396, -70.229342	18°17'25.4"N, 70°13'45.6"W
Barahona	Barahona	18.201356, -71.093906	18°12'04.9"N, 71°05'38.1"W
Caballero, Cachón	Barahona	18.248869, -71.195371	18°14'55.9"N, 71°11'43.3"W
Caletón, Enriquillo	Barahona	17.960965, -71.266760	17°57'39.5"N, 71°16'00.3"W
Charco Prieto, Higuero	Barahona	18.024770, -71.210300	18°01'29.2"N, 71°12'37.1"W
El Puerto, Polo	Barahona	18.052038, -71.280082	18°03'07.3"N, 71°16'48.3"W
Enriquillo	Barahona	17.895977, -71.238366	17°53'45.5"N, 71°14'18.1"W
Higuero,	Barahona	18.055723, -71.287129	18°03'20.6"N, 71°17'13.7"W
La Cueva, Polo	Barahona	18.159054, -71.251670	18°09'32.6"N, 71°15'06.0"W
Naranjal, Enriquillo	Barahona	17.902976, -71.237133	17°54'10.7"N, 71°14'13.7"W
Paraíso	Barahona	18.031771, -71.198618	18°01'54.4"N, 71°11'55.0"W
Polo	Barahona	18.093777, -71.283545	18°05'37.6"N, 71°17'00.8"W
San Rafael de Los Patos	Barahona	17.956199, -71.190141	17°57'22.3"N, 71°11'24.5"W
Cañongo,	Dajabón	19.623469, -71.692030	19°37'24.5"N, 71°41'31.3"W
Monte Grande, Loma de C.	Dajabón	19.395277, -71.617351	19°23'43.0"N, 71°37'02.5"W
Sangre Linda, La Ceiba	Dajabón	19.589494, -71.703911	19°35'22.2"N, 71°42'14.1"W
El Seibo	El Seibo	18.770027, -69.059393	18°46'12.1"N, 69°03'33.8"W
Miches	El Seibo	18.980588, -69.051765	18°58'50.1"N, 69°03'06.3"W
Pedro Sánchez	El Seibo	18.865925, -69.111536	18°51'57.3"N, 69°06'41.5"W
Corozito	Elías Piña	18.845685, -71.712592	18°50'44.5"N, 71°42'45.3"W
Km 5	Elías Piña	18.878255, -71.663325	18°52'41.7"N, 71°39'48.0"W
Matayaya	Elías Piña	18.888584, -71.590058	18°53'18.9"N, 71°35'24.2"W
Gaspar Hernández	Espaillat	19.633862, -70.284616	19°38'01.9"N, 70°17'04.6"W
Hoyoncito	Hato mayor	18.743150, -69.413553	18°44'35.3"N, 69°24'48.8"W
Las Cañas	Hato mayor	19.013698, -69.382548	19°00'49.3"N, 69°22'57.2"W
Los Cocos de Los López	Hato mayor	18.764635, -69.264540	18°45'52.7"N, 69°15'52.3"W
Villa Tapia,	Hermanas Mirabal	19.304531, -70.423018	19°18'16.3"N, 70°25'22.9"W
Barranca Sección Jamo	La Vega	19.265503, -70.462317	19°15'55.8"N, 70°27'44.3"W
Toro Cenizo,	La Vega	19.267749, -70.435889	19°16'03.9"N, 70°26'09.2"W
Guanuma	Monte Plata	18.695502, -69.923678	18°41'43.8"N, 69°55'25.2"W
La luisa Blanca	Monte Plata	18.741184, -69.897959	18°44'28.3"N, 69°53'52.6"W
Monte Plata	Monte Plata	18.795157, -69.775756	18°47'42.6"N, 69°46'32.7"W
Monte Plata	Monte Plata	18.811407, -69.772323	18°48'41.1"N, 69°46'20.4"W
Doña Antonia	Montecristi	19.673590, -71.230963	19°40'24.9"N, 71°13'51.5"W
El Cerro Gordo	Montecristi	19.758288, -71.211732	19°45'29.8"N, 71°12'42.2"W
Juan Gómez	Montecristi	19.702509, -71.409304	19°42'09.0"N, 71°24'33.5"W
Juancho, Oviedo	Pedernales	17.859494, -71.290455	17°51'34.2"N, 71°17'25.6"W
La Colonia, Villa Esperanza	Pedernales	17.851947, -71.331894	17°51'07.0"N, 71°19'54.8"W

Locality	Province	Decimals	Degrees
Pedernales	Pedernales	18.042637, -71.740322	18°02'33.5"N, 71°44'25.2"W
Altamira Puerto Plata	Puerto Plata	19.667481, -70.831862	19°40'02.9"N, 70°49'54.7"W
Canada Bonita	Puerto Plata	19.623430, -70.841566	19°37'24.4"N, 70°50'29.6"W
Cruce Guanabano-Navarrete	Puerto Plata	19.645546, -70.831922	19°38'44.0"N, 70°49'54.9"W
El Clavo, Altamira	Puerto Plata	19.688241, -70.838275	19°41'17.7"N, 70°50'17.8"W
El Corral, La Isabella	Puerto Plata	19.889946, -71.078641	19°53'23.8"N, 71°04'43.1"W
El estrecho de Luperon	Puerto Plata	19.811370, -70.927220	19°48'40.9"N, 70°55'38.0"W
Llano de Perez	Puerto Plata	19.735383, -70.836076	19°44'07.4"N, 70°50'09.9"W
Los pilones Estero Hondo	Puerto Plata	19.850299, -71.194336	19°51'01.1"N, 71°11'39.6"W
Los Saballos	Puerto Plata	19.762564, -70.852450	19°45'45.2"N, 70°51'08.8"W
Luperón, Puerto Plata	Puerto Plata	19.888215, -70.965599	19°53'17.6"N, 70°57'56.2"W
Ranchito de los Vargas	Puerto Plata	19.800079, -70.951472	19°48'00.3"N, 70°57'05.3"W
Tiburcio, Estero Hondo	Puerto Plata	19.824297, -71.169407	19°49'27.5"N, 71°10'09.9"W
Boruga	San Cristobal	18.467846, -70.111334	18°28'04.2"N, 70°06'40.8"W
Dona Ana	San Cristobal	18.367099, -70.172548	18°22'01.6"N, 70°10'21.2"W
Hato Viejo, Nigua	San Cristobal	18.375388, -70.054718	18°22'31.4"N, 70°03'17.0"W
Juan Barón	San Cristobal	18.254917, -70.178947	18°15'17.7"N, 70°10'44.2"W
La Pared Haina	San Cristobal	18.459363, -70.050263	18°27'33.7"N, 70°03'00.9"W
Limón Dulce	San Cristobal	18.476587, -70.102365	18°28'35.7"N, 70°06'08.5"W
Najayo Arriba	San Cristobal	18.393321, -70.167548	18°23'36.0"N, 70°10'03.2"W
Nizao	San Cristobal	18.251518, -70.215143	18°15'05.5"N, 70°12'54.5"W
Palenque	San Cristobal	18.259212, -70.146696	18°15'33.2"N, 70°08'48.1"W
Pedro Caballero	San Cristobal	18.486706, -70.085832	18°29'12.1"N, 70°05'09.0"W
Santana, Nizao	San Cristobal	18.277117, -70.216288	18°16'37.6"N, 70°12'58.6"W
Yaguate	San Cristobal	18.340808, -70.189547	18°20'26.9"N, 70°11'22.4"W
IDIAF, Sabana Larga	San Jose de Ocoa	18.592277, -70.492133	18°35'32.2"N, 70°29'31.7"W
La ciénaga	San Jose de Ocoa	18.605390, -70.461812	18°36'19.4"N, 70°27'42.5"W
Los Naranjos	San Jose de Ocoa	18.582174, -70.424650	18°34'55.8"N, 70°25'28.7"W
Arroyo Loro	San Juan de la Maguana	18.815161, -71.274463	18°48'54.6"N, 71°16'28.1"W
El llanito, Pedro Corto	San Juan de la Maguana	18.843386, -71.411901	18°50'36.2"N, 71°24'42.8"W
Perfecto Socorro, Santomé	San Juan de la Maguana	18.813673, -71.268493	18°48'49.2"N, 71°16'06.6"W
Sabana Alta	San Juan de la Maguana	18.729593, -71.111594	18°43'46.5"N, 71°06'41.7"W
Batey Los Chicharrones	San Pedro de Macorís	18.619355, -69.265162	18°37'09.7"N, 69°15'54.6"W
San José de los llanos	San Pedro de Macorís	18.630262, -69.488109	18°37'48.9"N, 69°29'17.2"W
San José de los llanos	San Pedro de Macorís	18.632422, -69.487457	18°37'56.7"N, 69°29'14.8"W
Gurabo Abajo	Santiago	19.487863, -70.671401	19°29'16.3"N, 70°40'17.0"W
Navarrete	Santiago	19.563186, -70.892973	19°33'47.5"N, 70°53'34.7"W
Villa González	Santiago	19.535330, -70.788074	19°32'07.2"N, 70°47'17.1"W
El Toro, Guerra	Santo Domingo	18.550604, -69.697820	18°33'02.2"N, 69°41'52.1"W
Engombe	Santo Domingo	18.457893, -70.006814	18°27'28.4"N, 70°00'24.5"W

Locality	Province	Decimals	Degrees
Engombe	Santo Domingo	18.458875, -70.005151	18°27'31.9"N, 70°00'18.5"W
Batey Libertad, Mao	Valverde	19.622122, -70.988046	19°37'19.6"N, 70°59'17.0"W
Boca de Mao	Valverde	19.588610, -71.042608	19°35'19.0"N, 71°02'33.4"W
Damajagua, Mao	Valverde	19.650145, -70.994961	19°39'00.5"N, 70°59'41.9"W
Damajagua, Mao	Valverde	19.651787, -70.995733	19°39'06.4"N, 70°59'44.6"W
Jicomé	Valverde	19.629866, -70.953735	19°37'47.5"N, 70°57'13.4"W
Mao	Valverde	19.562764, -71.087287	19°33'46.0"N, 71°05'14.2"W
Los Mogotes, Villa Altagracia	San Cristobal	18.738189, -70.245321	18°44'17.5"N, 70°14'43.2"W
Navarrete	Santiago	19.563186, -70.892973	19°33'47.5"N, 70°53'34.7"W
Villa González	Santiago	19.535330, -70.788074	19°32'07.2"N, 70°47'17.1"W
El Toro, Guerra	Santo Domingo	18.550604, -69.697820	18°33'02.2"N, 69°41'52.1"W
Engombe	Santo Domingo	18.457893, -70.006814	18°27'28.4"N, 70°00'24.5"W
Engombe	Santo Domingo	18.458875, -70.005151	18°27'31.9"N, 70°00'18.5"W
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Damajagua, Mao	Valverde	19.650145, -70.994961	19°39'00.5"N, 70°59'41.9"W
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Los Mogotes, Villa Altagracia	San Cristobal	18.738189, -70.245321	18°44'17.5"N, 70°14'43.2"W

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References

Barrows EM, Hooker ME (1981) Parasitization of the Mexican bean beetle by *Pediobius foveolatus* in urban vegetable gardens. Environmental Entomology 10: 782–786. doi: 10.1093/ee/10.5.782

Bouček Z (1988) Australasian Chalcidoidea (Hymenoptera): A biosystematic revision of fourteen families, with a reclassification of species. CAB International, Wallingford, UK, 832 pp.

Cedano J (2006) Guia Tecnica Cultivo de Guandul. Centro para el Desallorro Agropecuario y Forestal CEDAF, Santo Domingo, Republica Dominicana, 84 pp.

Etienne J, Martinez M, Boëcasse G (2004) Première signalisation avérée du ravageur *Melanagromyza obtusa* (Malloch) dans la région néotropicale (Dipt., Agromyzidae). Bulletin de la Société Entomologique de France 109(1): 105–106.

Gibson GAP (1997) Morphology and terminology. In: Gibson GAP, Huber JT, Woolley JB (Eds) Annotated Keys to the Genera of Nearctic Chalcidoidea (Hymenoptera). National Research Council Research Press, Ottawa, 16–44.

Guzman R, Lopez L, Taveras R (2008) Dinámica Poblacional de la Mosca Asiática del Guandúl *Melanagromyza obtusa* (Malloch) y sus Enemigos Naturales en República Dominicana. (Consideraciones Económicas del Control Químico Utilizado por los Productores durante el Estudio). Informe final de proyecto CONIAF, 60 pp.

Hansson C (2002) Eulophidae of Costa Rica (Hymenoptera: Chalcidoidea), 1. Memoirs of the American Entomological Institute 67: 1–290.

Hansson C (2015) Neotropical Eulophidae. http://www.neotropicaleulophidae.com [accessed January 2015]

Kerr PH, Fisher EM, Buffington M (2008) Dome lighting for insect imaging under a microscope. American Entomologist 54: 198–200. doi: 10.1093/ae/54.4.198

Kerrich GJ (1973) A revision of the tropical and subtropical species of the Eulophid genus *Pediobius* Walker (Hymenoptera: Chalcidoidea). Bulletin of the British Museum (Natural History) 29: 115–199.

Ministerio de agricultura (2013) Estadísticas, Siembra Cosecha y Producción Agropecuaria. http://www.agricultura.gob.do/media/SyncCMSMedia/5054/2.1--Superf-sembrada-y-cosecha,-Volumen-de-produccion--y-Rendimiento,%202013.xls

Miquilena E, Higuera Moros A (2012) Evaluation of protein content, mineral content and amino acid profile of *Cajanus cajan*, *Vigna unguiculata* and *Vigna radiata* flours as alternative in human feeding. Departamento de Química y Departamento de Agronomía, Facultad de Agronomía, La Universidad del Zulia. Venezuela. Revista Científica UDO Agrícola 12 (3): 730–740.

Noyes JS (2015) Universal Chalcidoidea Database. World Wide Web electronic publication. http://www.nhm.ac.uk/chalcidoids [accessed January 2015]

Peck O (1985) The taxonomy of the Nearctic species of *Pediobius* (Hymenoptera: Eulophidae), especially Canadian and Alaskan forms. The Canadian Entomologist 117: 647–704. doi: 10.4039/Ent117647-6

Phytosanitary Alert System (2004) *Melanagromyza obtusa* (Malloch) new detection in South Florida. Pest Alert. http://www.pestalert.org/Detail.CFM?recordID=1 [accessed January 2015]

Sharma O, Bhosle B, Kamble K, Bhede B, Seeras N (2011) Management of pigeon pea pod borers with special reference to pod fly (*Melanagromyza obtusa*). Indian Journal of Agricultural Sciences 81(6): 539–43.

Schmutterer H (1990) Crop Pests in the Caribbean. Plagas de las plantas cultivadas en el Caribe. Technical Cooperation – Federal Republic of Germany, Eschborn, 345 pp.

Taveras R, Guzman R (2013) Control biológico de *Melanagromyza obtusa*, mosca asiática del Guandúl con la producción y liberación del parasitoide *Ormyrus* sp. Informe final de proyecto CONIAF, 35 pp.

Yadaf A, Yadaf S (2011) Review of the Parasitoid-Complex of *Melanagromyza obtusa* (Diptera: Agromyzidae). Indian Journal of Biological Studies and Research 1(2): 1–37.

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Variability and fluctuating asymmetry of mid tibial spurs in *Eucremastus* Szépligeti (Hymenoptera, Ichneumonidae, Cremastinae)

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Abstract

The presence of one or two spurs on the mid tibia has been widely used as a diagnostic character in many taxa, but it has been discovered to be a highly variable character in the Cremastinae genus *Eucremastus*. Variation in the number of mid tibial spurs and occurrence of asymmetry in this genus was studied. The anomalies observed in this character are classified into three categories. Other non-cremastine genera traditionally characterized by having a single mid tibial spur were studied, but no anomalies were found. The taxonomic implications of this variation are discussed.

Keywords

Eucremastus, spurs, morphological traits, fluctuating asymmetry

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Introduction

Fluctuating asymmetry refers to the random deviation from perfect symmetry in bilateral traits (Van Halen 1962, Parsons 1990). It is more frequent in sexually selected traits, and it has been proposed as an important force for sexual selection (Moller and Pomiankowski 1993). Fluctuating asymmetry in morphological traits has been suggested to be the result of environmental (Silva et al. 2009) or genetic stress (Smith et al. 1997) during ontogeny, although this relationship remains unclear (Bjorksten et al. 2000).

When asymmetry affects morphological characters with taxonomic importance, its diagnostic value is reduced since it gives rise to different states of that character, sometimes in the same individual, and contributes to potentially misleading taxonomic descriptions and identifications.

The number and relative size of mid tibial spurs in Ichneumonidae has been considered a relatively invariant taxonomic character. The presence of a single mid tibial spur has been used in the diagnostic description of a tribe, Exenterini, of the subfamily Tryphoninae (Townes 1969a), but mostly at the generic level, e.g. *Metopius* Panzer (Townes 1971, Gauld et al. 2002), *Acerataspis* Uchida (males) (Townes 1971) (Metopiinae); *Anomalon* Panzer (Gauld 1997), *Liopterna* Townes, *Calcaneum* Townes and *Ophionellus* Westwood (Townes 1971) (Anomaloninae), or even at species level in Ophioninae (Gauld and Mitchell 1978).

As a general rule, the Cremastinae, a cosmopolitan group rather common in dry open areas (Gauld 2000) have two spurs on both the mid and hind tibiae. However, there is one genus, *Eucremastus* Szépligeti, which is characterized by having only one mid tibial spur (Fig. 1) (Townes 1971). Some authors (Ceballos 1921, Sedivy and Narolsky 2001) pointed out the presence of two spurs in several specimens of *E. manni* (Tschek). Moreover, *E. villiersi* (Benoit) form *turkmeniensis* was described as having two distinct mid tibial spurs in the female (Narolsky 2001), which highlights how variable the presence of one or two spurs is in this genus. Nevertheless, the occurrence of asymmetry in this character has not been reported, but it was found in some specimens of *E. manni* and *E. collaris* Narolsky from different collections.

These circumstances suggest not only that the presence of one or two spurs on the mid tibiae of *Eucremastus* may be a more variable feature that was considered until now, but also that this genus may present fluctuating asymmetry associated with this character. The aim of this paper is to demonstrate the variability of this character particularly in *Eucremastus* but also in other genera characterized by having a single mid tibial spur, and to investigate the occurrence of fluctuating asymmetry in this genus.

Material and methods

Studied material of this genus belongs to the following institutions:

CEUA University of Alicante, Alicante, Spain.

ZISP Zoological Institute of Russian Academy of Sciences, Saint Petersburg, Russia.
BMNH Natural History Museum, London, United Kingdom.
HNHM Hungarian Natural History Museum in Budapest, Hungary.
MNCN Museo Nacional de Ciencias Naturales, Madrid, Spain.

In order to establish the importance of variability, we also studied some material belonging to other Ichneumonidae genera which traditionally have been separated by having a single mid tibial spur. This material is preserved in the following institutions:

1) University of Alicante, Alicante, Spain (CEUA).
2) Zoological Museum of University of Turku, Turku, Finland (ZMUT).
3) Colección Entomológica Regional of Universidad Autónoma de Yucatán, Mérida, Mexico (CER-UADY).
4) Smithsonian Institution, Washington D.C., USA (USNM).

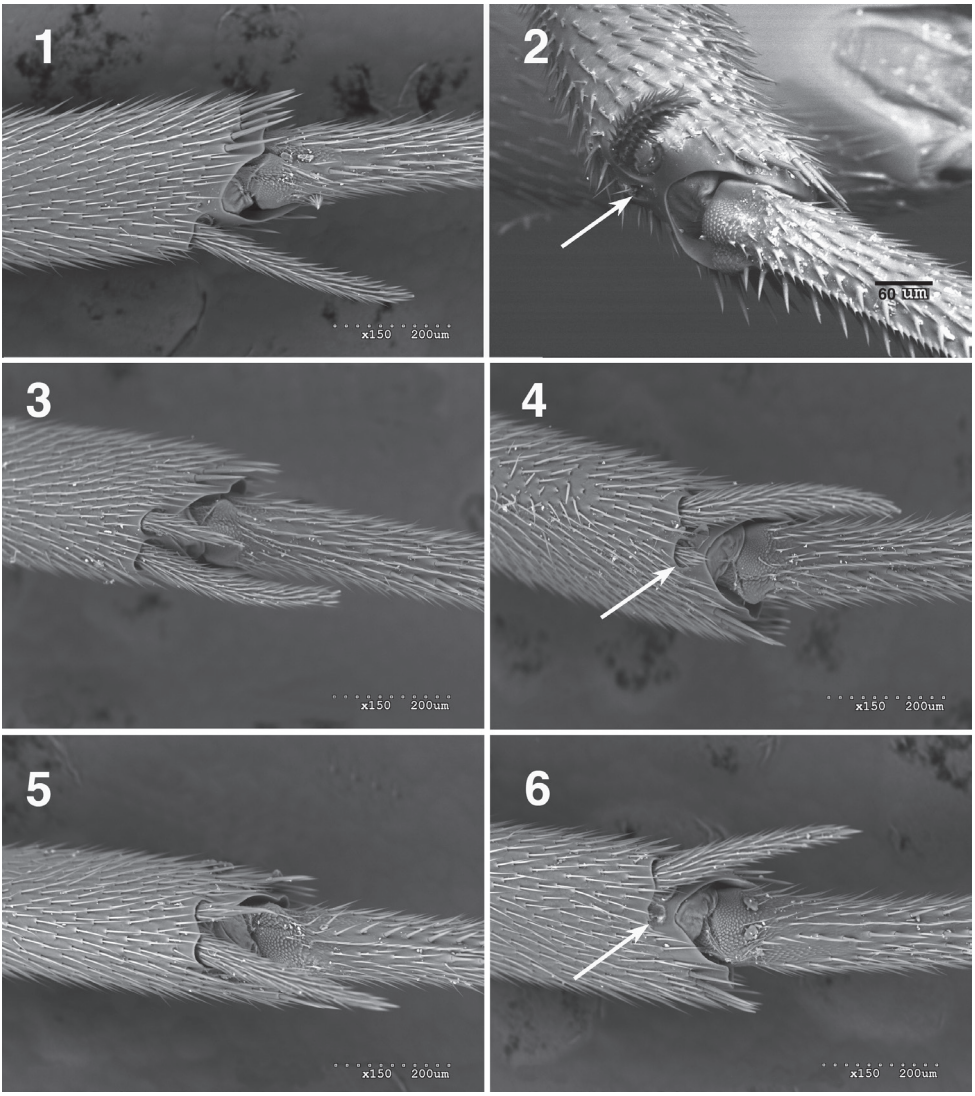
We considered the morphological structure to be anomalous when deviations from normality occurred in any specimens belonging to one species, which usually did not possess these anomalies. Normality is the commonest state of the character, and is defined as Type 0, as follows:
Type 0: both mid tibiae with a single long spur.

The variability of anomalies found in the studied material was classified into 3 categories, as follows:
Type 1: both mid tibiae with two unequal spurs.
Type 2: one single spur on a mid tibia and a long spur clearly developed jointly with a very small stump on the other mid tibia (Fig. 2).
Type 3: two distinct spurs on a mid tibia (Figs 3 and 5) and a long spur clearly developed jointly with a short stump on the other mid tibia (Figs 4 and 6).

Type 1 is a symmetric anomaly, while types 2 and 3 are asymmetric anomalies.

Since anomalies have been found only in two species (i. e. *E. manni* and *E. collaris*), we will report only the material belonging to these two species, although some individuals of *E. villiersi* (Benoit) (11 specimens, including holotype, ZISP) and *E. parvipes* (Morley) (holotype, BMNH) were also checked. *Eucremastus villiersi* form *turkmeniensis* may be considered to represent an anomaly type 1; however, we did not see any material belonging to this form, thus it is not included in the material studied. As for the other non-cremastine genera, we only report data from specimens at the genus level, since most of the material we examined was only sorted to genera.

Fluctuating asymmetry is usually measured as the mean difference between right and left sides (Palmer and Strobeck 1986). However, since we measured the mid tibia spurs asymmetries qualitatively (i.e., type 2 and 3 anomalies), we present the frequency distribution of asymmetry by considering type 2 and 3 anomalies as both sides' asymmetries, respectively, and both type 1 and type 0 anomalies as bilateral symmetries.



Figures 1–6. Mid tibial spurs of *Eucremastus manni*: **1** mid tibia without anomalies **2** type 2 anomaly in specimen from Turkey, right leg **3–6** type 3 anomalies in specimens from Spain: **3–4** right leg and left leg, respectively, of specimen from Fresneda **5–6** right leg and left leg, respectively, of specimen from Raña del Pocico. The white arrows point to the stump of the spur.

Scanning Electron Microscopy studies were done using a Hitachi S-3000N (University of Alicante, Spain) and a LEO 1455VPL (Natural History Museum, United Kingdom), both in low vacuum mode.

Results

In this paper we examined a total of 60 specimens belonging to *Eucremastus manni* and *E. collaris*. We found mid tibial spur anomalies in seven specimens. These are detailed below and summarized in Table 1. We also examined 347 specimens belonging to other genera with a single mid tibial spur, but no anomalies were found.

Asymmetries (i.e. type 2 and 3 anomalies) were only found in *E. manni*. About 90% of *E. manni* individuals were symmetrical, and asymmetries occurred at very low frequency (Fig. 7).

Material studied belonging to *Eucremastus*

Eucremastus manni: Spain (HNHM): Genotype, "Murcia", Staud., 1895, *Eucremastus brevicornis* Szépligeti 1905, 1 ♀. Spain (CEUA): Alicante: Sierra Mariola, Foia Ampla, 4-17/VI-2002, 1 ♀, Malaise trap; Font Roja, Mas de Sant Ignaci, 17-VI/2-VII-2002, 1 ♀, Malaise trap. Ciudad Real: Fresneda, 29-V/17-VI-2004, 1 ♀, TM; 17-VI/5-VII-2004, 1 ♀, Malaise trap (**anomaly type 3**); Raña del Pocico, 18-V-2004, in *Thapsia villosa*, 1 ♂ (**anomaly type 3**). Spain (MNCN): Ávila: Navalperal (no date), 1 ♀. Alicante: Alicante (no date), 1 ♂; Orihuela / Arneva, VI-1925, 1 ♀. Asturias: Villaviciosa (no date), 1 ♀ (**anomaly type 3**). Ciudad Real: Pozuelo, 1897, 1 ♀. Madrid: Buitrago, 24-VI-1984, 2 ♂♂; El Pardo, 16-VI-1941, 2 ♀♀; El Escorial (no date), 2 ♀♀ 2 ♂♂; 6-VII-1914, 1 ♀; 17-VI-1915, 1 ♀ 2 ♂♂; 14-VI-1916, 1 ♂; 19-VI-1918, 1 ♀; 14-VI-1922, 1 ♀; 8-IV-1929, 1 ♂; 8-VI-1929, 1 ♀ 2 ♂♂; Alcalá (no date), 1 ♀ (**anomaly type 1**); Madrid (no date), 8 ♀♀ 1 ♂; VI-1993, 1 ♂; San Agustín, 8-VI-1912, 1 ♀; Sierra de Guadarrama, 25-VI-1910, 1 ♀; 21-VI-1911, 1 ♀; 25-VI-1916, 1 ♂; 23-VI-1932, 1 ♂; Torrelaguna, 3-VI-1986, 2 ♂♂. Segovia: La Granja (no date), 1 ♀. Valladolid: Tordesillas, 26-VI-1930, 1 ♀ (left leg missing, right leg with two unequal spurs). Turkey (BMNH): Adana, Ciftehan, 26-V-1960, Guichard & Harvey, 1 ♀ (**anomaly type 2**); Amasya, 31-V-1959, K.M. Guichard, 1 ♀ (**anomaly type 2**), 1 ♀; Erzurum, Kandil, 11-VI-1962, Guichard & Harvey, 1 ♀. Greece (BMNH): near Keffsia, 18/VI/1957, G. Mavromoustakis, 2 ♀♀. One specimen (ZISP) labeled "Escorial, Dusmet", 1 ♀.

Eucremastus collaris: Arm. CCP (ZISP): Paratype, "Hosrovskii zap-k, Bediiskii uzh. arzhovoe redkolesye", A. Kotenko, 29-VI-1981, 1 ♀ (**anomaly type 1**); Paratypes, 2 ♀♀.

Material studied belonging to other genera

Anomaloninae

Anomalon spp.: Ecuador (USNM, currently on loan to ZMUT): Dept. Orellana: Tiputini, 1998, 22 ♀♀ 9 ♂♂, Leg. T. Erwin; Onkone Gare, 1998, 1 ♀, Leg. T.

Erwin. Dept. Zamora-Chinchipe: Reserva Biológica San Francisco, 2009, 13 ♀♀ 1 ♂, Leg. M. Pollet & A. Braekeleer. Peru (ZMUT): Dept. Madre de Dios: Los Amigos, 2008, 37 ♀♀, Leg. Gómez; Iquitos, 1998-2000, 73 ♀♀, Leg. Ilari Sääksjärvi et al. Peru (USNM, currently on loan to ZMUT):Tambopata River, 1998, 2 ♀♀, Leg. T. Erwin; Manu River, 1998, 2 ♀♀ 1 ♂, Leg. T. Erwin. Dept. Loreto: Napo River, 1998, 1 ♀, Leg. T. Erwin; Spain (CEUA): Alicante: Mariola Mountain, 2001-2002, 15 ♀♀, Leg. CIBIO; Carrasqueta Mountain, 2001-2002, 7 ♀♀, Leg. CIBIO. Ciudad Real: Cabañeros National Park, 2004, 64 ♀♀, Leg. CIBIO.

Ophionellus sp.: Ecuador (USNM, currently on loan to ZMUT): Dept. Orellana: Onkone Gare, 2005-2006, 8 ♀♀ 7 ♂♂, Leg. T. Erwin. Peru (ZMUT): Dept. Loreto: Iquitos, 2000, 1 ♀, Leg. Ilari Sääksjärvi. Dept. Madre de Dios: Los Amigos, 2008, 30 ♀♀, Leg. Gómez.

Metopiinae

Metopius sp.: Ecuador (USNM, currently on loan to ZMUT): Dept. Orellana: Tiputini, 1998, 1 ♀ 1 ♂, Leg. T. Erwin. Mexico (CER-UADY): Yucatán: El Cuyo, 2009, 3 ♂♂, Leg. A. González. Peru (ZMUT): Dept. Loreto: Iquitos, Alpahuayo I, 2000, 12 ♀♀ 4 ♂♂, Leg. Ilari Sääksjärvi et al. Dept. Madre de Dios: Los Amigos, 2008, 3 ♀♀ 1 ♂, Leg. Gómez.

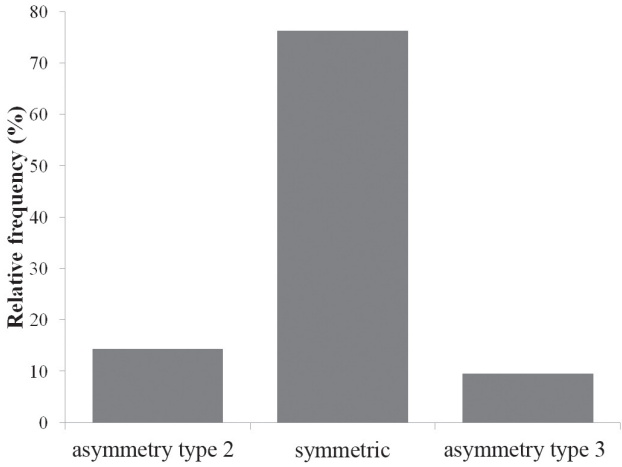


Figure 7. Frequency distribution of fluctuating asymmetries of mid tibial spurs in *E. manni*. Symmetric means both type 0 and anomaly type 1.

Table 1. Sample size of examined material and proportions of anomaly occurrence (between brackets), by species and by sex.

	Sex	Individuals	Anomaly occurrence
E. manni	Female	41	5 (12.2%)
	Male	16	1 (6.3%)
E. collaris	Female	3	1 (33.3%)

Tryphoninae

Cycasis sp.: Spain (CEUA): Alicante: Carrasqueta Mountain, 2002, 6 ♂♂, Leg. CIBIO; Mariola Mountain, 2002, 4 ♀♀ 4 ♂♂, Leg. CIBIO. Ciudad Real: Cabañeros National Park, 2004, 10 ♂♂, Leg. CIBIO.

Exyston sp.: Greece (CEUA): Lesbos Island, Vatoussa, 2001, 1 ♂, Leg. Rojo & Pérez.

Kristotomus sp.: Spain (CEUA): Ciudad Real: Cabañeros National Park, 2004, 10 ♂♂, Leg. CIBIO.

Discussion

About one in 10 individuals of *E. manni* had asymmetric spurs, more frequently in females. Since we measured a discrete variable, fluctuating asymmetry could not be tested, but the occurrence of asymmetry at this relatively high proportion would suggest this genus would be particularly sensitive to environmental or genetic stress. Therefore, given the growing interest in the use of fluctuating asymmetry as a measure of developmental instability, and hence of environmental stress during development (Hogg et al. 2001, Silva et al. 2009, amongst others), this character may be used for this purpose by measuring the relative size of each spur on each mid tibia. Despite the apparently low sample size of our study, we must underline that this frequency of anomalies is noteworthy considering that the genus *Eucremastus* is rather rare in collections. Fluctuating asymmetry has not been measured in Ichneumonidae, although isolated teratologies have been reported (Kerrich 1934, Bordera and Tormos 1986).

Not only asymmetry but the overall high rate of variation in the presence of one or two mid tibial spurs in some species of *Eucremastus* invalidates this character for taxonomic diagnosis of this genus, although not in other taxa, since anomalies were absent in other genera that usually have a single mid tibial spur. According to this, we redefine the diagnostic characters of *Eucremastus*, and provide some features that separate it from related genera (Table 2).

Table 2. Diagnostic characters to distinguish amongst some related genera in Cremastinae.

	Temelucha	***Eucremastus***	***Eucremastoides***	***Noxocremastus***
Median longitudinal carina of pronotum	Weak	Absent	Strong	Absent
Mandibles	Relative size of teeth variable	Lower tooth twice as long as upper tooth	Teeth of equal length	Lower tooth clearly longer than upper tooth
Lateral carina of scutellum	Absent or weak	Reaching the apex	Absent or weak	Absent
Ovipositor tip	Straight to downcurved	Straight	Downcurved	Downcurved
Ventral edges of first tergite	Touching along a distance longer than the width of petiole	Touching along a distance longer than the width of petiole	Touching or running parallel very close along a distance longer than the width of petiole	Touching or approaching along a distance shorter than the width of petiole
Glymma	Shallow	Shallow	Distinct	Shallow

Eucremastus Szépligeti, 1905

Wings moderately darkened. Occipital carina interrupted above. Frons concave. Genal carina joining oral carina very close to base of mandible. Lower tooth of mandible nearly twice as long as upper tooth. Pronotum slightly convex, without a median longitudinal carina. Scutellum rather convex, with a strong lateral carina reaching its apex. Hind femur without tooth beneath. Mid tibia with one or two spurs, when two spurs are present they are of unequal length. Ventral edges of first tergite touching each other, enclosing sternite in its middle. Glymma present, short and oblique. Ovipositor sheath about 1.5 × longer than hind tibia. Ovipositor tip almost straight.

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References

Bjorksten T, David P, Pomiankowski A, Fowler K (2000) Fluctuating asymmetry of sexual and nonsexual traits in stalk-eyed flies: a poor indicator of developmental stress and genetic quality. Journal of Evolutionary Biology 13(1): 89–97. doi: 10.1046/j.1420-9101.2000.00146.x

Bordera S, Tormos J (1986) Un bracónido y tres ichneumónidos teratológicos (Hym., Ichneumonoidea). Boletín de la Asociación española de Entomología 10: 335–338.

Gauld I (1997) The Ichneumonidae of Costa Rica, 2. Memoirs of the American Entomological Institute 57: 1–485.

Gauld I (2000) The Ichneumonidae of Costa Rica, 3. Memoirs of the American Entomological Institute 63: 1–453.

Gauld I, Mitchell PA (1978) The taxonomy, distribution and host preferences of African parasitic wasps of the subfamily Ophioninae. CAB: Slough. Commonwealth Institute of Entomology, London, 1–287.

Gauld I, Sithole R, Ugalde G, Godoy C (2002) The Ichneumonidae of Costa Rica, 4. Memoirs of the American Entomological Institute 66: 1–768.

Kerrich GJ (1934) A new case of teratology in Ichneumonidae. Entomologist's Monthly Magazine 70: 61–62.

Kolarov JA (1980) A new Cremastinae genus and species from Bulgaria (Hymenoptera, Ichneumonidae). Acta Zoologica Bulgarica 16: 90–92.

Kolarov JA (1992) New and little known Cremastinae species in Bulgarian fauna and a key for identification of the Western Palearctic genera (Hymenoptera, Ichneumonidae). Acta Zoologica Bulgarica 44: 75–78.

Moller AP, Pomiankowski A (1993) Fluctuating asymmetry and sexual selection. Genetica 89: 267–279. doi: 10.1007/BF02424520

Narolsky NB (1990) New data on the Cremastinae wasps (Hymenoptera: Ichneumonidae) from Kazakhstan and Central Asia. Zoologicheskii Zhurnal 69(7): 63–68.

Narolsky NB (1993) Ichneumonid wasps of *Noxocremastus* genus (Hymenoptera: Ichneumonidae, Cremastinae) from Palaearctic. Zhurnal Ukrayins'kogo Entmologichnogo Tovaristva 1(1): 19–26.

Narolsky NB (2001) A review of world species of the genus *Eucremastus* (Hymenoptera, Ichneumonidae, Cremastinae). Vestnik Zoologii 35(3): 23–29.

Palmer AR, Strobeck C (1986) Fluctuating asymmetry: measurement, analysis, patterns. Annual Review of Ecology and Systematics 17: 391–421. doi: 10.1146/annurev.es.17.110186.002135

Parsons PA (1990) Fluctuating asymmetry: an epigenetic measure of stress. Biological reviews 65: 131–145. doi: 10.1111/j.1469-185X.1990.tb01186.x

Smith DR, Crespi BJ, Bookstein FL (1997) Fluctuating asymmetry in the honey bee, *Apis melifera*: effects of ploidy and hybridization. Journal of Evolutionary Biology 10: 551–574. doi: 10.1007/s000360050041

Townes HK (1969a) The genera of Ichneumonidae, Part 1. Memoirs of the American Entomological Institute 11: 1–300. doi: 10.1007/BF02027741

Townes HK (1969b) The genera of Ichneumonidae, Part 3. Memoirs of the American Entomological Institute 13: 1–307.

Townes HK (1971) The genera of Ichneumonidae, Part 4. Memoirs of the American Entomological Institute 17: 1–372.

Van Halen L (1962) A study of fluctuating asymmetry. Evolution 16: 125–142. doi: 10.2307/2406192

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The highest known euglossine bee community from a garden in the Bolivian Andes (Hymenoptera, Apidae, Euglossini)

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Abstract

In this contribution, the first observations of euglossine bee species from the Bolivian Prepuna are reported. *Euglossa melanotricha* Moure, *Eufriesea mariana* (Mocsáry) and *Exaerete dentata* (L.) were observed at an elevation of 2640 m in a garden located in San Joaquin, Salancachi (Chuquisaca department, annual precipitation 400–500 mm). This is the highest known record for a population of *Euglossa* and *Eufriesea* to date. All of the euglossine bees were observed exclusively on introduced plants. The distributional patterns, biological associations and ecological significance of the observed euglossine bees are discussed.

Keywords

Bolivia, orchid bees, Prepuna, inter-Andean dry valleys

Introduction

Euglossine bees, also known as orchid bees, are a mainly Neotropical tribe of the Apidae that comprises approximately 232 species in five genera (Nemésio and Rasmussen 2011). They have received significant attention in the past century, in particular because they are one of the most important groups of pollinators (e.g. Dressler 1982; Roubik 1989) and the exclusive pollinators of nearly 700 orchid species (Pemberton and Wheeler 2006).

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Euglossine bee species are most diverse in tropical evergreen forests (up to 53 spp., see Nemésio and Rasmussen 2014), which is likely because the high precipitation, favorable temperatures, and low seasonality in these forests serve to facilitate a continuous supply of nectar and pollen as well as a generous supply of varied odor substances for courtship displays (see Rebêlo 2001; Roubik and Hanson 2004; Aguiar et al. 2014). The species richness of euglossine bees in Brazil decreases in semi-deciduous Atlantic Forest (~1200 mm/yr) (11 to 19 spp., reviewed by Aguiar and Gaglianone 2012), open habitats such as Cerrado (700–1200 mm/yr) (8 spp., reviewed by Faria and Silveira 2011) and the semi-arid, deciduous Caatinga (500–700 mm/yr) (5 spp., see Lopes et al. 2007). In the sub-Andean areas of Peru and Bolivia, Abrahamczyk et al. (2013) found a negative relationship between euglossine bee species richness and climatic seasonality, which was most pronounced between tropical evergreen rainforests (3710 mm/yr) (26 spp.) and subtropical deciduous dry forests in Bolivia (733 mm/yr) (2 spp.).

In mountainous terrain, little is known about the factors limiting the upper distribution of euglossine bees, although available data suggests that such patterns are influenced by the same factors that shape the latitudinal distribution (see Nemésio 2008; Aguiar et al. 2014). In the higher elevations, commonly found in the Andes (often reaching over 5000 m a.s.l., Fig. 1A), sub-humid and humid mountain forests are replaced by shrub and grasslands in which plant diversity and productivity are restricted by aridity, high radiation, low temperatures, and alkaline and saline soils (Ibisch and Merida 2003). While euglossine bees commonly occur from sea level up to 1700 meters of elevation (Dressler 1982; Dick et al. 2004; Nates-Parra et al. 2006), only four of the 232 known euglossine bee species have been observed at an elevation higher than 2640 m (*Exaerete smaragdina* (Guérin-Méneville): 2650 m; *Eulaema cingulata* (F.): 2800 m; *El. polychroma* (Mocsáry): 3400 m; *El. boliviensis* (Friese): 3900 m) (reviewed by Ramírez et al. 2002; Gonzalez and Engel 2004). Species of the genus *Eufriesea* have not been reported from elevations higher than 2050 m (reviewed by Ramirez et al. 2002) and the highest elevations that have been recorded for species of the genus *Euglossa* are 2050 m (*Euglossa nigropilosa* Moure) (see Ramírez et al. 2002) and 2560 m (*Euglossa ioprosopa* Dressler) (Parra-H and Nates-Parra 2007).

Observations of a euglossine bee community are reported herein, including species of *Euglossa* and *Eufriesea*, from a garden at an elevation of 2640 m in the semi-arid Prepuna of the Bolivian Andes.

Material and methods

The observation of orchid bees were made on a private estate, named "San Joaquin" (19°10'30S; 65°13'25W) in Salancachi, close to the village of Yotala in the department of Chuquisaca in an elevation of 2640 m (Fig. 1). Because the eastern cordillera blocks moisture-bearing winds originating in the Amazon basin and the Atlantic (Strecker et al. 2007), the average annual precipitation in the study area ranges only between 400–500 mm (López et al. 2013). Rainfall is concentrated in a rainy season and there is a pronounced

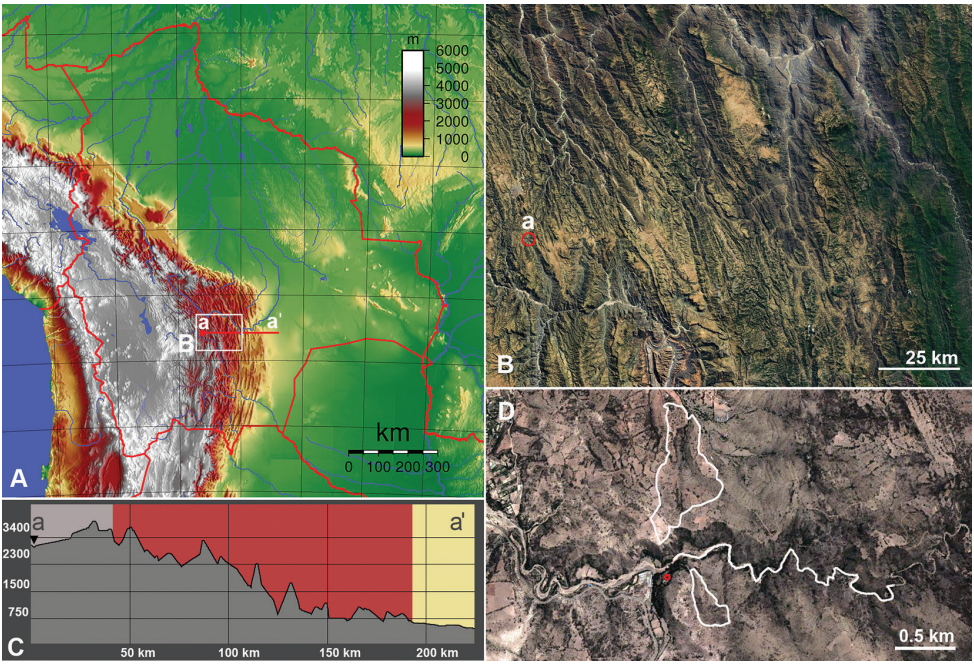

Figure 1. A map of Bolivia (**a** study area, **a'** lowland Chaco, relief profile of a–a' shown in **D**) **B** Andean slope of Chuquisaca department (**a** study area), green area to the east is subhumid mid-elevation Tucuman Bolivian forest, to the north the Rio Grande **C** relief profile (a study area, a' lowland Chaco; ecosystems (according to Navarro and Ferreira 2011), grey: Inter-Andean xerophytic shrub Prepuna; brown: Bolivian-Tucuman pluviseasonal mountain shrubland, xerophytic and subhumid forest; cream: Preandine transitional Chaco-forest) **D** Salancachi, surveyed transects indicated by white line, the garden of San Joaquin by red point.

dry season with 6–8 arid months (Ibisch and Mérida 2003). The average temperature is about 12–16 °C, with high temperatures that may exceed 30 °C and low temperatures falling below 0 °C (Ibisch and Mérida 2003). In this contribution, the ecoregion classification proposed by Navarro (2002) has been followed and the vegetation of the altitudinal zone of the inter-Andean valleys situated between 2.100 to 3.200 m a.s.l. is considered as Prepuna (see also Thomas et al. 2010). The vegetation in the Prepuna is characterized by xerophytic shrubs and cacti with a low number of xeric tree species (Thomas et al. 2010).

The tree vegetation in San Joaquin consists mainly of non-native *Eucalyptus* (Myrtaceae) trees (a commonly planted tree throughout the high Andes, see Thomas et al. 2010), *Persea americana* Mill. (Avocado) (Lauraceae), and *Pinus* sp. (Pinaceae). A garden of vascular plants (~260 m^2) (Fig. 2B) is maintained with water from a subterranean spring. Among the flowering plants in this garden, *Ismene narcissiflora* (Jacq.) M. Roem. (Amaryllidaceae) is the only vascular species native to Bolivia. *Euphorbia pulcherrima* Willd. ex Klotzsch (Euphorbiaceae) is native to Mexico and Central America (Lee 2000), *Duranta erecta* L. (Verbenaceae) is possibly native to the West Indies, Central America, and/or the Florida Keys, *Pelargonium* sp. (Geraniaceae) and *Agapan-*

Figure 2. A San Joaquin close to Yotala in Chuquisaca department, surrounded by *Eucalyptus* (Myrtaceae) trees **B** garden in San Joaquin **C** *Euglossa melanotricha* Moure on flowers of *Hibiscus rosa-sinensis* L. (Malvaceae) **D** *Exaerete dentata* (L.) on flowers of *Agapanthus praecox* Willd. (Amaryllidaceae).

thus praecox Willd. (Amaryllidaceae) originate from South Africa (Mor et al. 1984) and *Hibiscus rosa-sinensis* L. (Malvaceae) is introduced from Asia.

The garden of San Joaquin and three transects of about 14 km length were surveyed (Fig. 1D) on three days in September 2012, and in April and December of 2013. The humidity and temperature were measured in December of 2013 with a digital handheld hygrometer in locations where orchid bees were observed. The species were identified following the references in Abrahamczyk et al. (2012). In addition, the taxonomists André Nemésio (Universidade Federal de Uberlândia, Brazil) and Benjamin Bembé (Zoologische Staatssammlung München, Germany) were consulted for the confirmation of the identification of *Euglossa melanotricha* Moure.

Results

No euglossine bees were observed in the three transects outside of the garden during any of the three surveys. Flowers of *Acacia* (Fabaceae) trees, shrubs, and vascular plants in these transects were exclusively visited by *Apis mellifera* L. or other flower visitors.

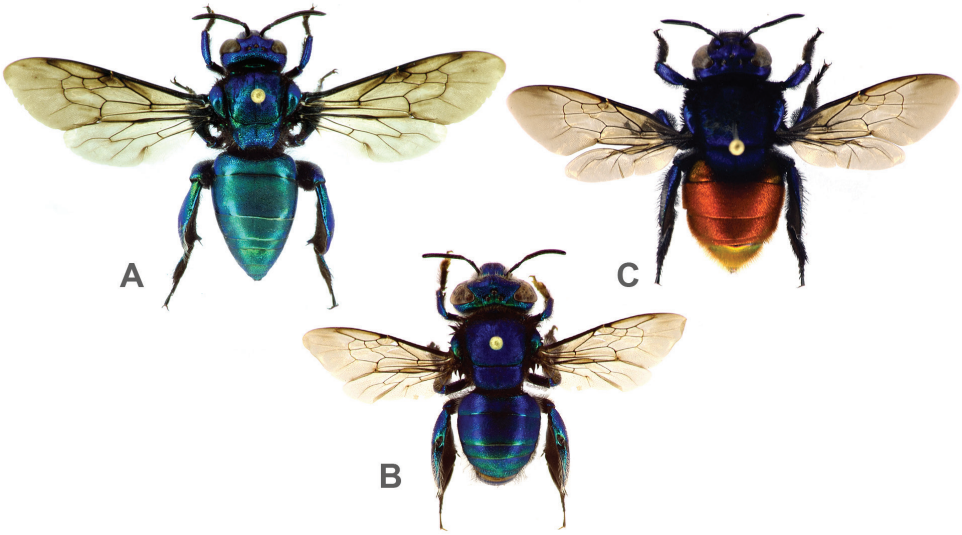

Figure 3. Euglossine bee species collected in San Joaquin: **A** *Exaerete dentata* (L.) **B** *Euglossa melanotricha* Moure **C** *Eufriesea mariana* (Mocsáry).

In September of 2012 a male of *Euglossa melanotricha* (Fig. 3B) was observed hovering over a barbecue in the garden during noon and the next morning a female was found on the back of a chair inside the house. In April of 2013, *E. melanotricha* was abundant (not counted) on flowers of *Hibiscus rosa-sinensis* (Fig. 2C) and *Duranta erecta.*

In December of 2013, individuals of three euglossine bee species (*Euglossa melanotricha* (46♂; 19♀) (Fig. 3B), *Exaerete dentata* (L.) (12♂; 3♀) (Fig. 3A) and *Eufriesea mariana* (Mocsáry) (6♀) (Fig. 3C), were captured in the garden. The bees were active between 0900–1700 h, in temperatures between 21.7–24.3 °C and at relative humidities of 52.7–28.5% (humidity decreasing towards noon).

All three euglossine species were observed foraging in the flowers of *Agapanthus praecox*. *Exaerete dentata* and *Euglossa melanotricha* were also observed in the flowers of *Hibiscus rosa-sinensis,* and *E. melanotricha* additionally in the flowers of *Duranta erecta*. Euglossine bees were the only hymenopteran floral visitors that were recognized in these plants.

No euglossine bees were observed on the flowers of *Ismene narcissiflora*, the only native flowering plant in the garden. The flowers of *Euphorbia pulcherrima* were visited by *Apis mellifera* and several wasp species, but not by euglossine bees.

Discussion

The observations reported here are the first published records for euglossine bee species from the Prepuna and the inter-Andean dry valleys in Bolivia, and the elevation of 2640 m is the highest known record for a population of *Euglossa* and *Eufriesea* to date (see Ramírez et al. 2002).

Euglossine species richness in San Joaquin (400-500 mm/yr) is comparable with that of the semi-deciduous lowland forest in Santa Cruz department about 180 km east of the actual study area (733 mm/yr, 2 spp., see Abrahamczyk et al. 2013) and single sites in the Caatinga (500–700 mm/yr, 1-3 spp., Lopes et al. 2007). The euglossine fauna of the Bolivian Prepuna may contain species of the genus *Eulaema* as well: e.g. *El. cingulata* (F.) and *El. nigrita* Lepeletier are the two most common and ubiquitous *Eulaema* species and they are widely distributed in relatively arid areas south of the Amazon basin (Zucchi et al. 1969). Both species have been reported in Bolivia at an elevation of ~2600 m (see Ramírez et al. 2002).

Eufriesea mariana has been previously reported in similar habitats (Kimsey 1982; Ramírez et al. 2010; pers. obs., see Perger and Guerra 2013 for data) and co-occurs in several locations in the Argentinean Andes with *Ex. dentata* (Ascher and Pickering 2014). Since species of *Exaerete* are considered obligate nest parasites of species of the euglossine genera *Eulaema* and *Eufriesea* (see Garofalo and Rozen 2001 for references), the presence of *Ex. dentata* in the Andes may be facilitated by parasitizing *Ef. mariana*.

Euglossa melanotricha has been reported from semi-deciduous forests, Atlantic forest and the Caatinga (500–1600 mm/yr) at elevations between 400 and 1350 m (Bembé 2004; Nemésio 2009). Judging from the dissimilarities between the conditions (precipitation, seasonality, and elevation) of the Prepuna and the previously reported regions, and the distance of ~190 km between San Joaquin and the nearest reported lowland location at Los Volcanes (Bembé 2004), the establishment of *Eg. melanotricha* in the Prepuna may be explained by long-distance dispersal from suitable habitats in lower elevations over the riparian vegetation of the Rio Grande (Fig. 1 B), and a successful founder event facilitated by the suitable conditions in the garden of San Joaquin.

The exclusive occurrence of the observed euglossine bees on introduced plants in the garden suggests that either they have low host plant specificities or have adapted their host plant preferences to local conditions, as has been previously observed in naturalized or insular euglossine bee populations (Eltz et al. 2005; Pemberton and Wheeler 2006; Ramírez et al. 2010).

The apparent persistence of euglossine bees in an area with low orchid species richness (see Lopez 2003; Thomas 2008) is consistent with the observation that male euglossine bees often obtain the volatiles they use in attracting mates from non-orchid sources (see Whitten et al. 1993; Ramirez et al. 2011). To date, the degree of dependence of euglossine bees on orchids as scent sources is poorly understood and only one study (Pemberton and Wheeler 2006) clearly demonstrates that a euglossine bee species can persistently exist in an area without euglossine bee-associated orchids. Further study of the Prepuna in Bolivia should help our understanding of the biology of euglossine bees in peripheral habitats.

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References

Abrahamczyk S, Gottleuber P, Kessler M (2012) Seasonal changes in odour preferences by male Euglossine bees (Hymenoptera: Apidae) and their ecological implications. Apidologie 43: 212–217. doi: 10.1007/s13592-011-0096-7

Abrahamczyk S, de Vos JM, Sedivy C, Gottleuber P, Kessler M (2013) A humped latitudinal phylogenetic diversity pattern of orchid bees (Hymenoptera: Apidae: Euglossini) in western Amazonia: assessing the influence of climate and geologic history. Ecography 37: 500–508. doi: 10.1111/j.1600-0587.2013.00417.x

Aguiar WM, Gaglianone MC (2012) Euglossine bee communities in small forest fragments of the Atlantic Forest, Rio de Janeiro state, southeastern Brazil (Hymenoptera, Apidae). Revista Brasileira de Entomologia 56: 210–219. doi: 10.13102/sociobiology.v61i1

Aguiar WM, Melo GAR, Gaglianone MC (2014) Does Forest Physiognomy affect the Structure of Orchid Bee (Hymenoptera, Apidae, Euglossini) Communities? A Study in the Atlantic Forest of Rio de Janeiro state, Brazil. Sociobiology 61: 68–77.

Ascher J, Pickering J (2014) Bee Species Guide (Hymenoptera: Apoidea: Anthophila). http://www.discoverlife.org/mp/20q?guide=Apoidea_species [accessed 10 January 2015]

Bembé B (2004) Revision der Euglossa cordata-Gruppe und Untersuchung zur Funktionsmorphologie und Faunistik der Euglossini. PhD Thesis, Ludwig-Maximilian-Universität München, Germany.

Dick CW, Roubik DW, Gruber KF, Bermingham E (2004) Long-distance gene flow and cross-Andean dispersal of lowland rainforest bees (Apidae: Euglossini) revealed by comparative mitochondrial DNA phylogeography. Molecular Ecology 13: 3775–3785. doi: 10.1111/j.1365-294X.2004.02374.x

Dressler RL (1982) Biology of the orchid bee (Euglossini). Annual Review of Ecology and Systematics 13: 373–394. doi: 10.1146/annurev.es.13.110182.002105

Eltz T, Roubik DW, Lunau K (2005) Experience dependent choices ensure species-specific fragrance accumulation in male orchid bees. Behavioural Ecology and Sociobiology 59: 146–156. doi: 10.1007/s00265-005-0021-z

Faria LRR, Silveira FA (2011) The orchid bee fauna (Hymenoptera, Apidae) of a core area of the Cerrado, Brazil: the role of riparian forests as corridors for forest-associated bees. Biota Neotropica 11(4): 87–94.

Garófalo CA, Rozen Jr. JG (2001) Parasitic behavior of *Exaerete smaragdina* with descriptions of its mature oocyte and larval instars (Hymenoptera: Apidae: Euglossini). American Museum Novitates 3349: 1–40. doi: 10.1206/0003-0082(2001)349<0001:PBOESW>2.0.CO;2

González VH, Engel MS (2004) The tropical Andean bee fauna (Insecta: Hymenoptera: Apoidea), with examples from Colombia. Entomologische Abhandlungen 62: 65–75.

Ibisch PL, Mérida G (2003) Biodiversidad: La riqueza de Bolivia. Estado de conocimiento y conservación. Ministerio de Desarrollo Sostenible, Editorial Fundación Amigos de la Naturaleza (FAN), Santa Cruz, Bolivia, 638 pp.

Kimsey LS (1982) Systematics of bees of the genus *Eufriesea*. University of California Publications, Entomology 95: 1–125.

Lopes AV, Machado IC, de Aguiar AV, Rebêlo JMM (2007) A scientific note on the occurrence of Euglossini bees in the Caatinga, a Brazilian tropical dry forest. Apidologie 38: 472–473. doi: 10.1051/apido:2007031

Lee I (2000) Phytoplasma casts a magic spell that turns the fair poinsettia into a Christmas showpiece. Online: Plant Health Progress doi: 10.1094/PHP-2000-0914-01-RV

López RP (2003) Diversidad florística y endemismo de los valles secos bolivianos. Ecologia en Bolivia 38(1): 27–60.

López RP, Valdivia S, Rivera ML, Rios RS (2013) Co-occurrence Patterns along a Regional Aridity Gradient of the Subtropical Andes Do Not Support Stress Gradient Hypotheses. PLoS ONE 8(3): e58518. doi: 10.1371/journal.pone.0058518

Mor Y, Halevy AH, Kofranek AM, Reid MS (1984) Postharvest handling of lily of the Nile flowers. Journal of the American Society for Horticultural Science 109: 494–497.

Nates-Parra G, Parra HA, Rodríguez A, Baquero P, Vélez D (2006) Abejas silvestres (Hymenoptera: Apoidea) en ecosistemas urbanos: Estudio en la ciudad de Bogotá y sus alrededores. Revista Colombiana de Entomología 32: 77–84.

Navarro G (2002) Vegetación y unidades biogeográficas de Bolivia. In: Navarro G, Maldonado M (Eds) Geografía Ecológica de Bolivia. Vegetación y Ambientes Acuáticos. Centro de Ecología Simón I. Patiño-Departamento de Difusión, Cochabamba, 500 pp.

Navarro G, Ferreira W (2011) Mapa de Sistemas Ecológicos de Bolivia, escala 1:250 000. Edición CD-ROM. RUMBOL SRL-TheNatureConservancy (TNC), Bolivia.

Nemésio A (2008) Orchid bee community (Hymenoptera, Apidae) at an altitudinal gradient in a large forest fragment in southeastern Brazil. Revista brasileira de zoociências 10(3): 249–256.

Nemésio A (2009) Orchid bees (Hymenoptera: Apidae) of the Brazilian Atlantic Forest. Zootaxa 2041: 1–242.

Nemésio A, Rasmussen C (2011) Nomenclatural issues in the orchid bees (Hymenoptera: Apidae: Euglossina) and an updated catalogue. Zootaxa 3006: 1–42.

Nemésio A, Rasmussen C (2014) Sampling a biodiversity hotspot: the orchid-bee fauna (Hymenoptera: Apidae) of Tarapoto, northeastern Peru, the richest and most diverse site of the Neotropics. Brazilian Journal of Biology 74: 33–44. doi: 10.1590/1519-6984.20412

Parra-H A, Nates-Parra G (2007) First record of Eufriesea bare González & Gaiani and notes on the distribution of three species of orchid bees pertaining to the genus Euglossa Latreille (Apidae: Euglossini) in Colombia. Revista de la Academia Colombiana de Ciencias Exactas 31(120): 415–423.

Pemberton RW, Wheeler GS (2006) Orchid bees don't need orchids: evidence from the naturalization of an orchid bee in Florida. Ecology 87(8): 1995–2001. doi: 10.1890/0012-9658(2006)87[1995:OBDNOE]2.0.CO;2

Perger R, Guerra F (2013) Longhorn beetles (Coleoptera: Cerambycidae) of the Tucuman-Bolivian forest in the Tariquía Flora and Fauna National Reserve, southern Bolivian Andes, with notes on ecoregion endemism and conservation. Pan-Pacific Entomologist 89(4): 209–221. doi: 10.3956/2013-19.1

Ramírez SR, Dressler RL, Ospina M (2002) Orchid bees (Hymenoptera: Apidae: Euglossini) from the Neotropical Region: A species checklist with notes on their biology. Biota Colombiana 3: 7–118.

Ramírez SR, Roubik DW, Skov C, Pierce NE (2010) Phylogeny, diversification patterns and historical biogeography of euglossine bees (Hymenoptera: Apidae). Biological Journal of the Linnean Society 100: 552–572. doi: 10.1111/j.1095-8312.2010.01440.x

Ramírez SR, Eltz T, Fujiwara MK, Goldman-Huertas B, Gerlach G, Tsutsui ND, Pierce NE (2011) Asynchronous diversification in a specialized plant-pollinator mutualism. Science 333: 1742–1746. doi: 10.1126/science.1209175

Rebêlo JMM (2001) História Natural das Euglossíneas. As abelhas das orquídeas. Lithograf Editora, São Luís, 152 pp.

Roubik DW (1989) Ecology and natural history of tropical bees. New York, Cambridge University Press, 514 pp. doi: 10.1017/CBO9780511574641

Roubik DW, Hanson PE (2004) Orchids bees of Tropical America: Biology and Field Guide. INBio Press, Heredia, Costa Rica, 370 pp.

Strecker MR, Alonso RN, Bookhagen B, Carrapa B, Hilley GE, Sobel ER, Trauth MH (2007) Tectonics and climate of the southern central Andes. Annual Review of Earth and Planetary Sciences 35: 747–787. doi: 10.1146/annurev.earth.35.031306.140158

Thomas E, Van Damme P, Goetghebeur P (2010) Some factors determining species diversity of prepuna and puna vegetations in a Bolivian Andes region. Plant Ecology and Evolution 9(1): 31–42. doi: 10.5091/plecevo.2010.416

Thomas E (2008) Quantitative Ethnobotanical Research on Knowledge and Use of Plants for Livelihood among Quechua, Yuracaré and Trinitario Communities in the Andes and Amazon Regions of Bolivia. PhD thesis. Faculty of Bioscience Engineering, Ghent University, Belgium, 496 pp.

Whitten WM, Young AM, Stern DL (1993) Non-floral sources of chemical that attract male euglossine bees (Apidae: Euglossini). Journal of Chemical Ecology 15: 1285–1295. doi: 10.1007/BF01014830

Zucchi R, Sakagami SF, de Camargo JMF (1969) Biological observations on a neotropical parasocial bee, *Eulaema nigrita*, with a review on the biology of Euglossinae (Hymenoptera, Apidae). A comparative study. Journal of the Faculty of Science, Hokkaido University, Series VI, Zool. 17(2): 271–380.

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RESEARCH ARTICLE

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A new species of *Schlettererius* Ashmead from China, with a key to the species (Hymenoptera, Stephanidae)

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Abstract

A new species of *Schlettererius* Ashmead, 1900, *S. chundanae* **sp. n.**, is described and illustrated from China. The other East Palaearctic species, *S. determinatorius* Madl, 1991, is redescribed and illustrated, the first host record is given and it is newly reported from China. A key to the species of the genus *Schlettererius* is included.

Keywords

Hymenoptera, Stephanidae, *Schlettererius*, new species, new record, China, key

Introduction

The small genus *Schlettererius* Ashmead, 1900 (Hymenoptera: Stephanidae) is Holarctic and contains two described species. The species were revised by Hong and Xu (2011) and Hong et al. (2011); a male from Qinling Mts (Shaanxi, NW China) was provisionally identified as *S. determinatorius* Madl, 1991. This species was described from Korea and is only known from the female holotype. Some differences were ob-

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served, especially in the shape of the first tergite, but this could be the result of sexual dimorphism. Recently, one of us (JLT) collected a female in the Qinling Mts which obviously belongs to a new species. The earlier recorded male fits well with the new species and is considered to be conspecific. The biology is known only of the Nearctic *S. cinctipes* (Cresson, 1880) introduced into Tasmania from California for biological control of the introduced *Sirex noctilio* (Fabricius, 1793) (Hymenoptera: Siricidae; Taylor 1967; van Achterberg 2002). In this paper we report the East Palaearctic *S. determinatoris* Madl, 1991, from *Chrysobothris succedana* (Saunders) (Coleoptera: Buprestidae) in *Larix* sp. The new species is authored by the first two authors because they made the key and the formal description.

Material and methods

The studied specimens of the genus *Schlettererius* Ashmead belong to the collection of the Northwest University at Xi'an (NWUX), the Insect Museum, General Station of Forest Pest Management, Shenyang (GSFPM), the Parasitic Hymenoptera Collection of Zhejiang University at Hangzhou (ZJUH), the Naturalis Biodiversity Center at Leiden (RMNH) and the Hungarian Natural History Museum at Budapest (HNHM). The holotype of the new species is deposited in the collection of the College of Life Sciences, Northwest University at Xi'an.

The morphological terminology follows van Achterberg (2002). Observations and descriptions were made either under an Olympus SZ40 or an Olympus SZX11 stereomicroscope. Photographic images were made with an Olympus SZX12 motorized stereomicroscope combined with AnalySIS Extended Focal Imaging software and processed with Adobe Photoshop CS5, mostly to adjust the size and background. For the illumination a pair of 30W Megaman or 45W Jinsilai fluorescent lamps were used allowing easy observation of the sculpture of the specimens.

Taxonomy

Genus *Schlettererius* Ashmead, 1900

Figs 1–35

Schlettererius Ashmead, 1900: 150; Aguiar 2004: 75 (list of literature); Hong and Xu 2011: 71–73; Hong et al. 2011: 46–47. Type species (by monotypy and original designation): *Stephanus cinctipes* Cresson, 1880.

Diagnosis. Posterior part of pronotum more or less angled with remainder of pronotum (Figs 2, 13, 26); vein 1-M of fore wing distinctly curved (Figs 1, 12, 25); vein cu-a of hind wing present as pigmented vein (Figs. 12, 25); hind coxa with small subapical dorsal tooth (Figs 6, 35), but absent in *S. chundanae* (Fig. 23); hind tibia not distinctly

narrowed and compressed basally (Figs 5, 29); hind tarsus of female 5-segmented (Fig. 16); sternite of first metasomal tergite differentiated from its tergite (Figs 17, 30), first tergite 2.4–4.6 times as long as its apical width, not cylindrical, about as long as second tergite (Figs 4, 28), but distinctly longer in *S. chundanae* (Fig. 15); second tergite sessile and smooth or slightly sculptured basally (Figs 4, 28); posterior part of eighth metasomal tergite of female with distinct pygidial process (Figs 4, 11, 24); ovipositor sheath with wide ivory subapical band (Figs 10, 11, 22, 24, 34).

Distribution. Nearctic, East Palaearctic and Australian (only Tasmania: introduced for biological control of introduced Siricidae).

Key to species of the genus *Schlettererius*

1 Posterior part of pronotum steeply elevated above anterior part of pronotum (Fig. 2); second-third tergites yellowish brown (Fig. 4); ovipositor sheath of female with subapical whitish band about 3.5 times as long as apical blackish part (Fig. 10); Nearctic, Australian ..... ***S. cinctipes* (Cresson, 1880)**

– Posterior part of pronotum moderately elevated above anterior part of pronotum (Figs 13, 26); second-third metasomal tergites black or dark brown (Figs 11, 24); subapical ivory band of ovipositor sheath of female 1.7-1.8 times as long as its apical blackish part (Figs 22, 34); Palaearctic..... **2**

2 Length of first metasomal tergite about twice (♀) its maximum width (Fig. 28); hind coxa largely smooth (except some short striae) and with a small (in lateral view acute) subapical dorsal tooth (Figs 29, 35); in dorsal view head slightly widened behind eyes (Fig. 31); first metasomal segment wide in lateral view (Fig. 30) ..... ***S. determinatoris* Madl, 1991**

– Length of first tergite 3.8-4.6 times (♀♂) its maximum width (Fig. 15); hind coxa with strong and sparse rugae, and without dorsal tooth (Figs 18, 23); in dorsal view head parallel-sided behind eyes (Fig. 19); first segment narrow in lateral view (Fig. 30) ..... ***S. chundanae* sp. n.**

Schlettererius chundanae Tan & van Achterberg, sp. n.

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Figures 11–23

Schlettererius determinatori(u)s; Hong and Xu 2011: 71–73 (only male); Hong et al. 2011: 46–47, 103–104 (only male).

Type material. Holotype, ♀ (NWUX): "NW. **China:** Shaanxi, Guanghuojie, Qinling Mts, c. 1000 m, 27.vi.2013, Jiangli Tan, NWUX". Paratype: 1 ♂ (ZJUH): "[China:] Shaanxi, Liuba, Mt. Zibai, 1632 m, 4.viii.2004, Zhang Hong-ying, No. 20047080".

Diagnosis. Head in dorsal view parallel-sided behind eyes (Fig. 19); posterior half of pronotum comparatively low and dorso-posteriorly finely transversely rugose (Fig.

13); first subdiscal cell of fore wing comparatively robust and 2.0–2.5 times longer than wide (Fig. 12); hind coxa with strong and sparse rugae, and without dorsal tooth (Figs 18, 23); first-third metasomal tergites black or dark brown (Fig. 11); first metasomal segment narrow in lateral view (Fig. 30); first tergite 3.8-4.6 times (♀♂) as long as its maximum width and irregularly coarsely transversely rugose (Fig. 15).

Description. Holotype, female, length of body 12.4 mm, and of fore wing 9.2 mm.

Head. Antenna with 30 segments; frons coarsely obliquely rugose; three anterior coronal teeth large and acute, both posterior ones arcuate and lamelliform, with two small lobe-shaped carinae on each side in front of both posterior ocelli; behind level of coronal area having four curved, progressively smaller carinae followed by rugose area, rugae rather coarse, posteriorly narrowly reaching occipital carina and widely smooth laterally; temple non-angulate (Fig. 19), punctulate but largely smooth and shiny.

Mesosoma. Neck short and robust, transversely rugose, neck at much lower level than middle part of pronotum (Fig. 14); middle part of pronotum largely smooth and without a distinct carina posteriorly; propleuron with sparse large punctures, shiny and rather densely setose; mesonotum irregularly foveolate and area between smooth; notauli and median groove distinct; scutellum with some coarse punctures medially, foveolate laterally; axillae coarsely punctate; mesopleuron distinctly convex, convex part foveolate-punctate and covered with long whitish setae, medially convex part of metapleuron rugose and with long whitish setae, anteriorly crenulate and intermediate area smooth; propodeum densely irregularly rugose (Fig. 14).

Wings. Fore wing (Fig. 12): vein 1-M 3.4 times as long as vein 1-SR and curved; vein r ends slightly before level of apex of pterostigma; first subdiscal cell robust, 2.2 times as long as its maximum width, vein cu-a entirely pigmented.

Legs. Hind coxa robust, without tubercle dorsally and with strong and sparse rugae (Figs 18, 23); hind femur widened, sparsely punctate and with whitish setae ventrally and dark brown setae dorsally, area in between punctures smooth and shiny, ventrally with 3 large acute teeth (the anterior one much smaller than posterior ones) and several denticles in between (Fig. 16); hind tibia 1.3 times as long as hind femur, basal narrow part of hind tibia about 0.8 times as long as widened part, widened part ventrally distinctly obliquely carinate; hind basitarsus subparallel-sided, length of hind basitarsus 3.7 times as long as wide and 1.3 times as long as second tarsal segment.

Metasoma. First tergite 3.8 times as long as its maximum width (Fig. 15), 1.2 times as long as second tergite and 0.4 times as long as metasoma without first tergite, sub-cylindrical, distinctly transversely rugose, but medially irregularly rugose; base of second tergite finely sparsely rugose; remainder of tergites smooth and shiny; setose part of ovipositor sheath 1.7 times as long as body and 2.3 times as long as fore wing.

Colour. Black or blackish brown; tegula and palpi dark brown; scapus, pedicellus, malar space, mandible and patch near basal quarter of hind tibia partly brown; base of femora and of fore and middle tibiae and tarsi pale yellowish brown; remainder of fore and middle tibiae brown; veins and pterostigma largely dark brown, but base of pterostigma ivory; wing membrane slightly brownish but fore wing darkened near vein r and below parastigma; subapical ivory band of ovipositor sheath 1.9 times as long as apical blackish part (Fig. 22).

Male. See Hong et al. (2011) for a detailed description. It has the first tergite 4.6 times as long as its maximum width.

Distribution. Palaearctic: China (Shaanxi).

Etymology. Named after Ms Chundan Hong (Guangzhou), who revised the Chinese species of the Stephanidae.

Schlettererius cinctipes **Cresson, 1880**

Figures 1–10

Stephanus cinctipes Cresson, 1880: xviii.

Schlettererius cinctipes; Ashmead 1900: 150; Aguiar 2004: 75 (list of literature); Hong and Xu 2011: 71–73; Hong et al. 2011: 46–47.

Diagnosis. Posterior part of pronotum steeply elevated above its anterior part (Fig. 2); first metasomal tergite irregularly transversely rugose and about twice as long as its apical width (Fig. 4); second and third tergites yellowish brown (Fig. 4); subapical ivory band of ovipositor sheath of female about 3.5 times as long as apical blackish part (Fig. 10).

Distribution. Nearctic. Introduced in the Australian region (Tasmania).

Schlettererius determinatoris **Madl, 1991**

Figures 24–35

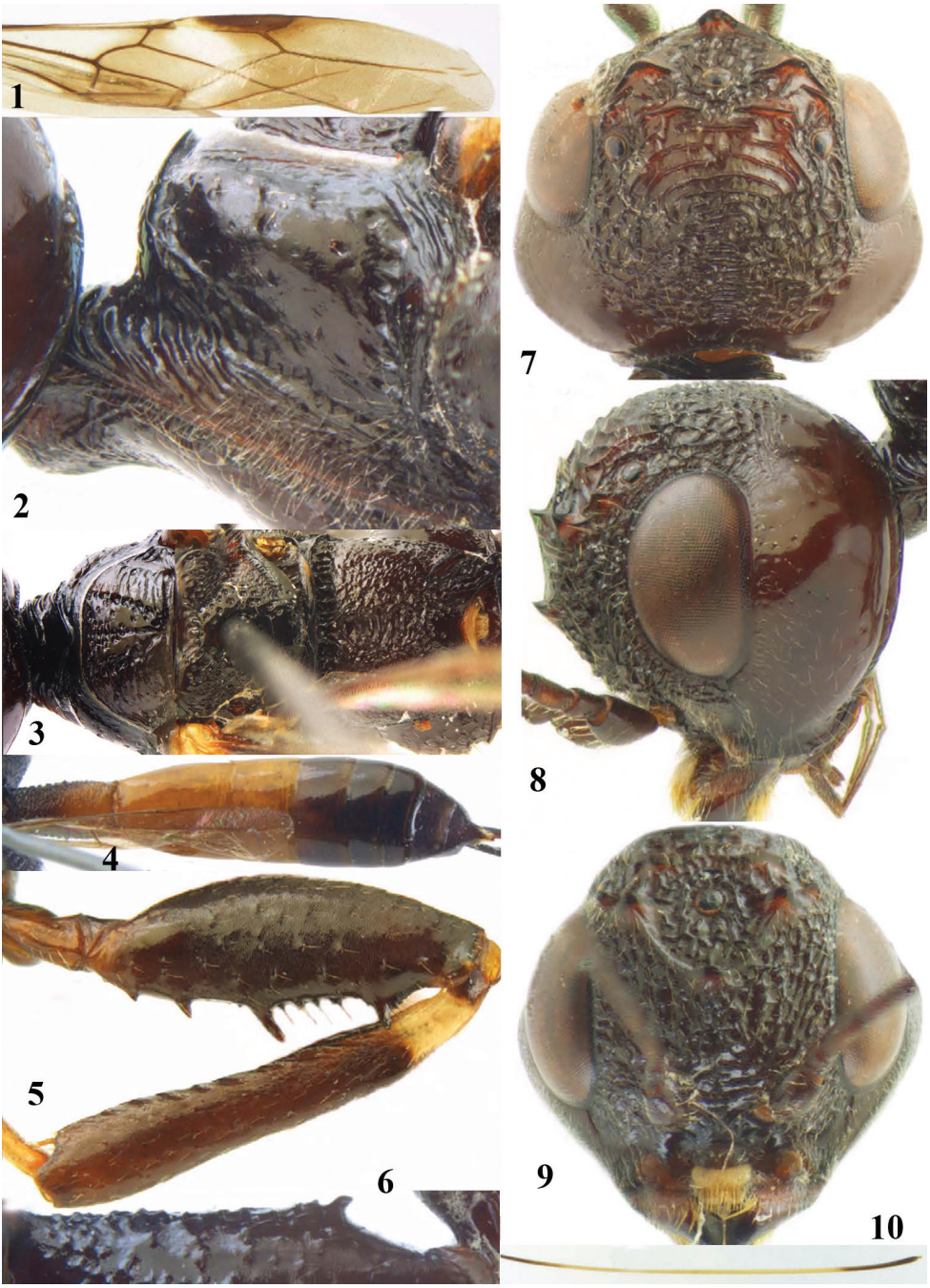
Schlettererius determinatoris Madl, 1991: 119–120; Belokobylskij 1995: 18; van Achterberg 2002: 198; Aguiar 2004: 75; Hong and Xu 2011: 71–73; Hong et al. 2011: 46.

Schlettererius determinatorius; Hong et al. 2011: 46, 103–104 (*lapsus*).

Type material. Holotype, ♀ (HNHM), "**Korea**, Prov. North Pyongan, Mt. Myohyang-san", "17.07.1982, No.815, leg. Dr. L. Forró & Dr. L. Ronkay", "Holotypus ♀ *Schlettererius determinatoris* n. sp. Madl, 1990", "OSUC 21616".

Additional material. 2 ♂ (GSFPM), "**China:** Liaoning, Kuandian Dandong, 21.v.2009, ex *Chrysobothris succedana* (Saunders) (Buprestidae) in *Larix* sp., Xiao-yi Wang".

Diagnosis. Head in dorsal view slightly widened behind eyes (Fig. 31); posterior half of pronotum moderately low and dorso-posteriorly finely transversely rugose (Figs 26, 27); first subdiscal cell of fore wing comparatively robust and about 2.5 times longer than wide (Fig. 25); hind coxa largely smooth (except some short striae) and with a small (in lateral view acute) subapical dorsal tooth (Figs 29, 35); first metasomal tergite irregularly transversely rugose and about 2.4 times as long as its apical width (Fig. 28); first metasomal segment wide in lateral view (Fig. 30); second-third tergites blackish or dark brown (Fig. 24); subapical ivory



Figures 1–10. *Schlettererius cinctipes* (Cresson), female, U.S.A. **1** fore wing **2** pronotum lateral **3** mesosoma dorsal **4** metasoma dorsal **5** hind femur and tibia lateral **6** hind coxa lateral **7** head dorsal **8** head lateral **9** head anterior **10** apex of ovipositor sheath. Modified after Hong et al. (2011).

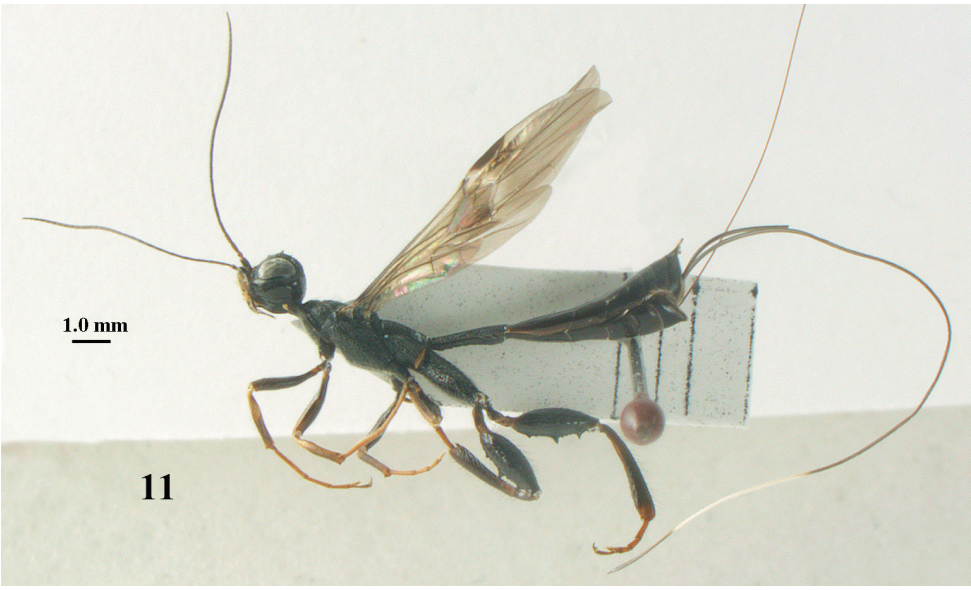


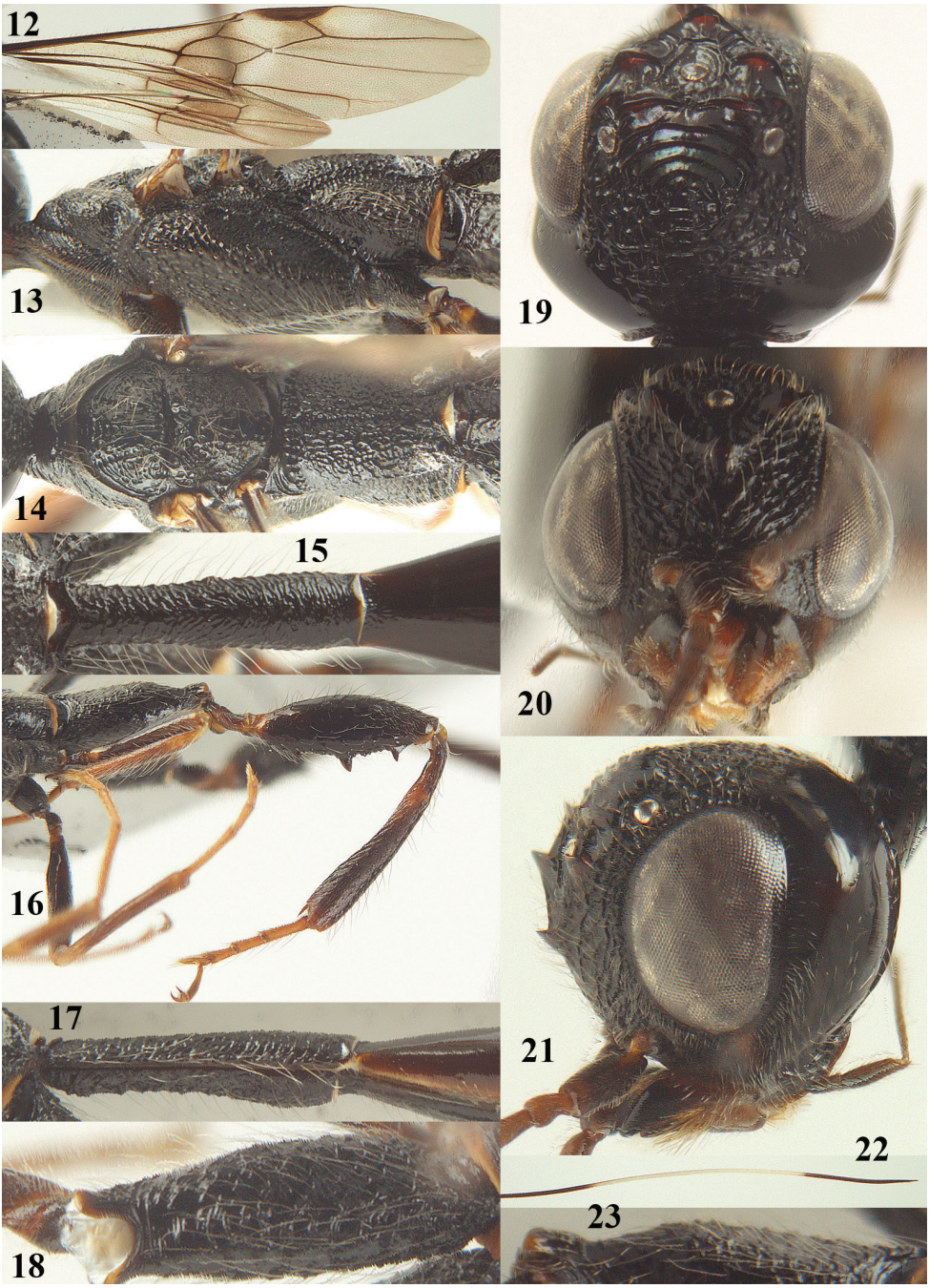
Figure 11. *Schlettererius chundanae* sp. n., female, holotype, habitus lateral.

band of ovipositor sheath of female about 1.7 times as long as apical blackish part (Figs 24, 34).

Description. Holotype, female, length of body 15.0 mm, and of fore wing 9.9 mm.

Head. Antenna with 29 (right) or 30 (left) segments; frons (Fig. 32) coarsely transversely rugose anteriorly and remainder reticulate-rugose; three anterior coronal teeth large and rather acute, both posterior ones arcuate and lamelliform, with one small lobe-shaped carina on each side in front of both posterior ocelli; behind coronal area with five curved, progressively smaller carinae followed by rugae laterally and fine transverse carinae medially, remaining narrowly separated from occipital carina (Fig. 31); temple smooth and shiny except for some small punctures near eye, slightly widened behind eyes and rather rounded in dorsal view (Fig. 31).

Mesosoma. Neck (Figs 26, 27) short and stout, anteriorly with 3 lamelliform carinae; middle and oblique part of pronotum largely smooth and with a distinct, sinuate carina medio-posteriorly and obliquely striate laterally; posterior part of pronotum medio-dorsally smooth and laterally indistinctly rugose; lateral oblique groove of pronotum rather narrow and smooth, but anteriorly with some crenulae; propleuron coriaceous laterally, smooth (except some punctures) and shiny ventrally; mesonotum irregularly and sparsely foveolate medially and area between fovea smooth, laterally transversely striate (Fig. 27); notauli and median groove shallow, crenulate; scutellum largely smooth medially, foveolate laterally (Fig. 27); axillae rugose-foveolate; mesopleuron strongly convex, convex part rugose-foveolate and covered with greyish se-



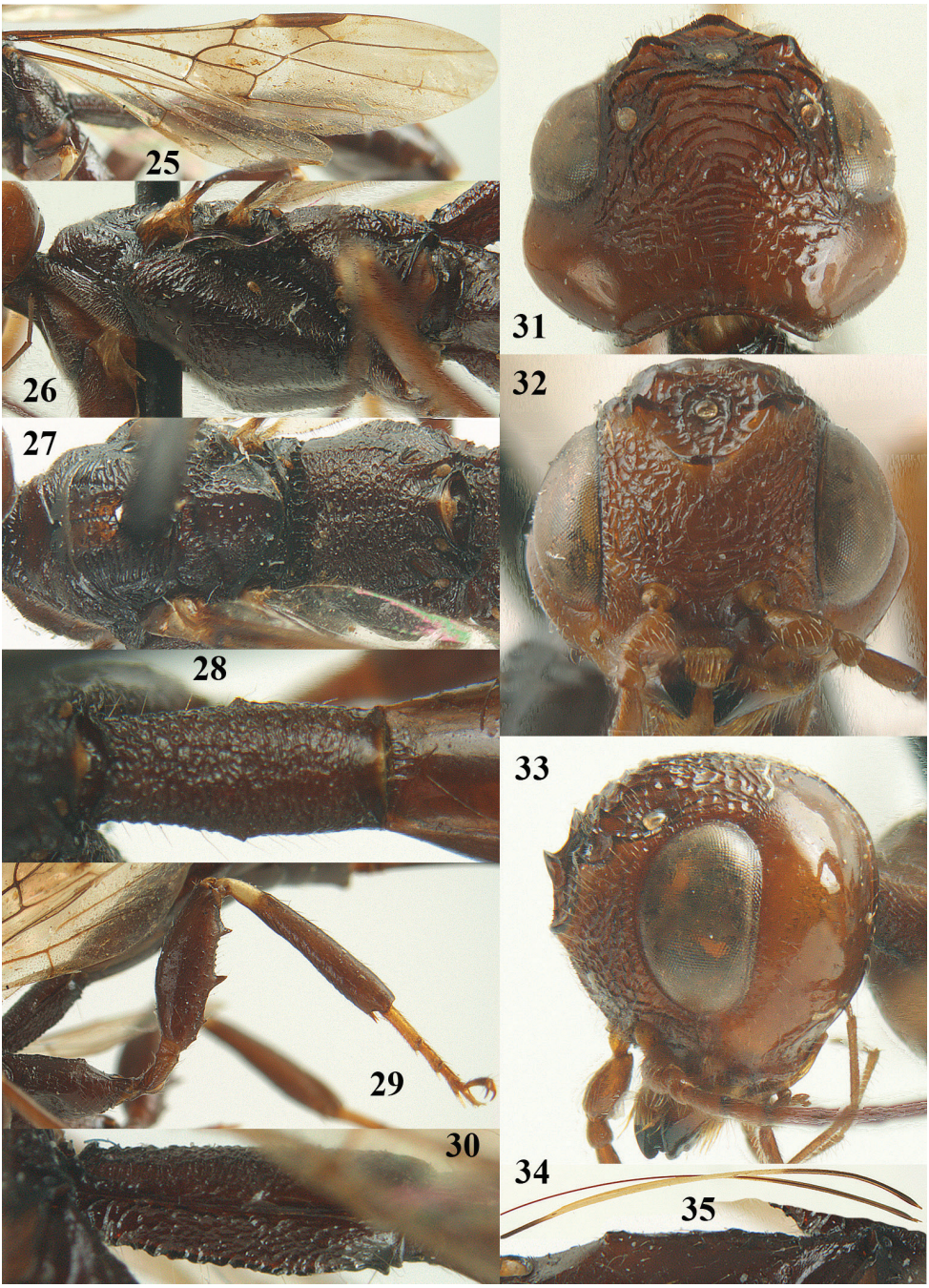
Figures 12–23. *Schlettererius chundanae* sp. n., female, holotype. **12** wings **13** mesosoma lateral **14** mesosoma dorsal **15** first metasomal tergite dorsal **16** hind leg lateral **17** first tergite lateral **18** hind coxa dorsal **19** head dorsal **20** head anterior **21** head lateral; **22** apex of ovipositor sheath; **23** detail of hind coxa lateral.

Figure 24. *Schlettererius determinatoris* Madl, female, holotype, habitus lateral.

tae, flat dorso-posterior part superficially rugose; mesosternum anteriorly superficially rugose-punctate and posteriorly coriaceous and laterally sparsely punctate; medial convex part of metapleuron coarsely rugose and with short greyish setae, antero-ventrally weakly crenulate, with antero-dorsal depression deep and antero-ventral depression less impressed; propodeum densely finely and irregularly rugose (Fig. 27).

Wings. Fore wing (Fig. 25): vein 1-M strongly curved and 2.4 times as long as vein 1-SR; vein r ends before level of apex of pterostigma; first subdiscal cell robust, 1.8 times as long as its maximum width.

Legs. Hind coxa stout, largely smooth, with some short striae and with a small (in lateral view acute) subapical dorsal tooth (Figs 29, 35); hind femur moderately slender, finely granulate and covered with sparse whitish setae, ventrally with 3 acute teeth (the basal one small) and some small teeth (denticles; Fig. 29); hind tibia 1.2 times as long as hind femur, basal narrow part of hind tibia 0.6 times as wide as widened part and with long ventral carina, widened part ventrally distinctly obliquely carinate (Fig. 29); length of hind basitarsus 3.6 times as long as wide.



Figures 25–35. *Schlettererius determinatoris* Madl, female, holotype. **25** wings **26** mesosoma lateral **27** mesosoma dorsal **28** first metasomal tergite dorsal **29** hind leg lateral **30** first tergite lateral **31** head dorsal **32** head anterior **33** head lateral; **34** apex of ovipositor sheath; **35** detail of hind coxa lateral.

Metasoma. First tergite stout, sub-cylindrical, 2.1 times as long as its maximum width and about 2.4 times as long as its apical width (Fig. 28), irregularly transversely rugose, posteriorly less developed than anteriorly, laterally with whitish setae; second tergite slightly shorter than first tergite and smooth except some short crenulae medio-anteriorly (Fig. 28); remainder of tergites smooth and shiny; ovipositor sheath 1.9 times as long as body and 2.9 times as long as fore wing.

Colour. Dark brown; head, scapus, pedicellus, fore leg (but tibia ivory basally), middle and hind tarsi and propleuron brown; malar space pale brown; wing membrane (but basally and area below base of pterostigma subhyaline) infuscate; all tibiae ivory basal band; subapical ivory band of ovipositor sheath of female about 1.7 times as long as apical blackish part (Fig. 34).

Male. Very similar to female, length of fore wing 10.0-10.2 mm, and of body 16-17 mm; both with 29 antennal segments and first tergite 2.4-2.5 times its apical width.

Distribution. Palaearctic: Korea, China (new record).

Biology. *Chrysobothris succedana* (Saunders) (Buprestidae) in *Larix* sp.

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References

Achterberg C van (2002) A revision of the Old World species of *Megischus* Brullé, *Stephanus* Jurine and *Pseudomegischus* gen. nov., with a key to the genera of the family Stephanidae (Hymenoptera: Stephanoidea). Zoologische Verhandelingen Leiden 339: 1–206.

Aguiar AP (2004) World catalog of the Stephanidae (Hymenoptera: Stephanoidea). Zootaxa 753: 1–120.

Ashmead WH (1900) Classification of Ichneumon Flies. Proceedings of the United States National Museum 23(1206): 1–220. doi: 10.5479/si.00963801.23-1206.1

Cresson ET (1880) Monthly proceedings. Transactions of the American Entomological Society 8: xvii–xviii.

Fabricius JC (1793) Entomologia systematica 2. Hafniae, 1–519.

Hong CD, Achterberg C van, Xu ZF (2011) A revision of the Chinese Stephanidae (Hymenoptera, Stephanoidea). ZooKeys 110: 1–108. doi: 10.3897/zookeys.110.918

Hong CD, Xu ZF (2011) A newly recorded genus and species of Family Stephanidae (Hymenoptera, Stephanoidea) from China. Entomotaxonomia 33(1): 71–73.

Madl M (1991) Zur Kenntnis der paläarktischen Stephanidae (Hymenoptera, Stephanoidea). Entomofauna 12: 117–126.

Taylor KL (1967) Parasitism on *Sirex noctilio* F. by *Schlettererius cinctipes* (Cresson) (Hymenoptera: Stephanidae). Journal of the Australian Entomological Society 6: 13–19. doi: 10.1111/j.1440-6055.1967.tb02132.x

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RESEARCH ARTICLE

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The genus *Gyrodonta* Cameron, with description of a new species and a key to species (Hymenoptera, Ichneumonidae, Ichneumoninae)

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Abstract

A new species, *Gyrodonta motuoica* **sp. n.**, collected from Motuo County, Xizang Autonomous Region, China is described. *Gyrodonta concava* (Uchida, 1937), previously known from Jiangxi, is reported from Hunan Province, China, and Nepal for the first time. Illustrations of both species are provided, as well as a key to species.

Keywords

Ichneumoninae, *Gyrodonta*, new species, taxonomy, key

Introduction

Gyrodonta Cameron, 1901, belonging to the tribe Ichneumonini of the subfamily Ichneumoninae (Hymenoptera: Ichneumonidae) and distributed in the Oriental Region, comprises two species (Yu et al. 2012), one of which, *G. concava* (Uchida, 1937), is from Jiangxi Province, China, and one, *G. flavomaculata* Cameron, 1901 is from India.

Gyrodonta was originally placed in its own tribe because it is so unusual-looking, distinctive within Ichneumoninae (Cameron, 1901). But Narayanan and Lal (1958)

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included it in the tribe Ichneumonini. Townes et al. (1961) transferred *Pielia concava* Uchida, 1937 to *Gyrodonta* and kept it in their tribe Joppini (Ichneumonini of other authors) in their reclassification of Indo-Australian Ichneumonidae. Gupta (1987) followed Schmiedeknecht's (1902) opinion, as a valid tribe Gyrodontini. Wahl and Mason (1995) used out Gyrodontina Schmiedeknecht, 1902 as a valid subtribe within the Ichneumonini. In the "world catalogue" (Yu and Horstmann 1997) and database (Yu, Achterberg and Horstmann 2012), *Gyrodonta* Cameron was again included in the Ichneumonini, as they do not list subtribes. We agree with Wahl & Mason's standpoint, *Gyrodonta* Cameron, 1901 belongs to the subtribe Gyrodontina within the tribe Ichneumonini.

In this article, one new *Gyrodonta* species, collected in Xizang Autonomous Region, China, and another species, collected in Hunan and in Nepal, previously known from Jiangxi, are described.

Material and methods

The holotype of *Gyrodonta motuoica* sp. n. was collected by Tao Li in Motuo County, Xizang Autonomous Region (China) on a blacklit sheet at night. The specimens of *G. concava* (Uchida, 1937) were collected by Ze-Jian Li (Lab of Insect Systematics and Evolutionary Biology, Central South University of Forestry and Technology, Changsha, China) using entomological nets in the forest of Mufushan, Hunan Province (CHINA) and by P. Cechovsky using a Malaise trap in Nepal.

Images were taken using a Leica M205A Stereomicroscope with LAS Montage MultiFocus.

All specimens, except one of *G. concava* from Nepal in the Biozentrum Linz, Austria, are deposited in the Insect Museum, General Station of Forest Pest Management (GSFPM), State Forestry Administration, People's Republic of China.

Taxonomic section

Gyrodonta Cameron, 1901

Gyrodonta Cameron, 1901: 485. Type-species: *Gyrodonta flavomaculata* Cameron.

Diagnosis. Head large, broad, greatly expanded behind the eyes. Inner margins of eyes parallel. Face wide, slightly concave, upper margin strongly elevated. Clypeal suture indistinct. Apical margin of clypeus slightly evenly convex forwards. Malar space wide. Gena broad. Mandible short, broad, apical portion bluntly rounded, without teeth; upper side with a strong tooth subbasally or near the middle; with basal transverse groove. Areolet pentagonal. Fore wing with vein 1cu-a opposite or distal of 1-M. Scutellum almost flat. Propodeum elongate, incompletely areolated; dorsal profile much longer

than posterior oblique profile. Spiracle elongate, curved. Legs stout; lower profiles of tarsomeres 1 to 4 with long thick hairs. Claw simple. Metasoma semiamblypygous. Gastrocoelus indistinct. Ovipositor sheath reaching to apex of metasoma.

Key to species of *Gyrodonta* Cameron

1 Apical portion of flagellum cylindrical. Tooth of upper margin of mandible located subbasally. Subapical portion of clypeus with median tooth. Propodeum with costula and distinct median longitudinal carinae **2**

– Apical portion of flagellum distinctly flattened below. Tooth of upper margin of mandible located almost at middle. Clypeus without distinct tooth. Propodeum without costula, median longitudinal carinae vestigial..... ..... ***G. motuoica* sp.n.**

2 Tergite 3 and subsequent tergites black, basal margins brown..... .....***G. flavomaculata* Cameron**

– Tergite 2 and subsequent tergites entirely reddish brown...***G. concava* (Uchida)**

Gyrodonta motuoica Sheng & Riedel, sp. n.

http://zoobank.org/75883CED-2170-4068-91D1-F5139D21B5E5
Figures 1–13

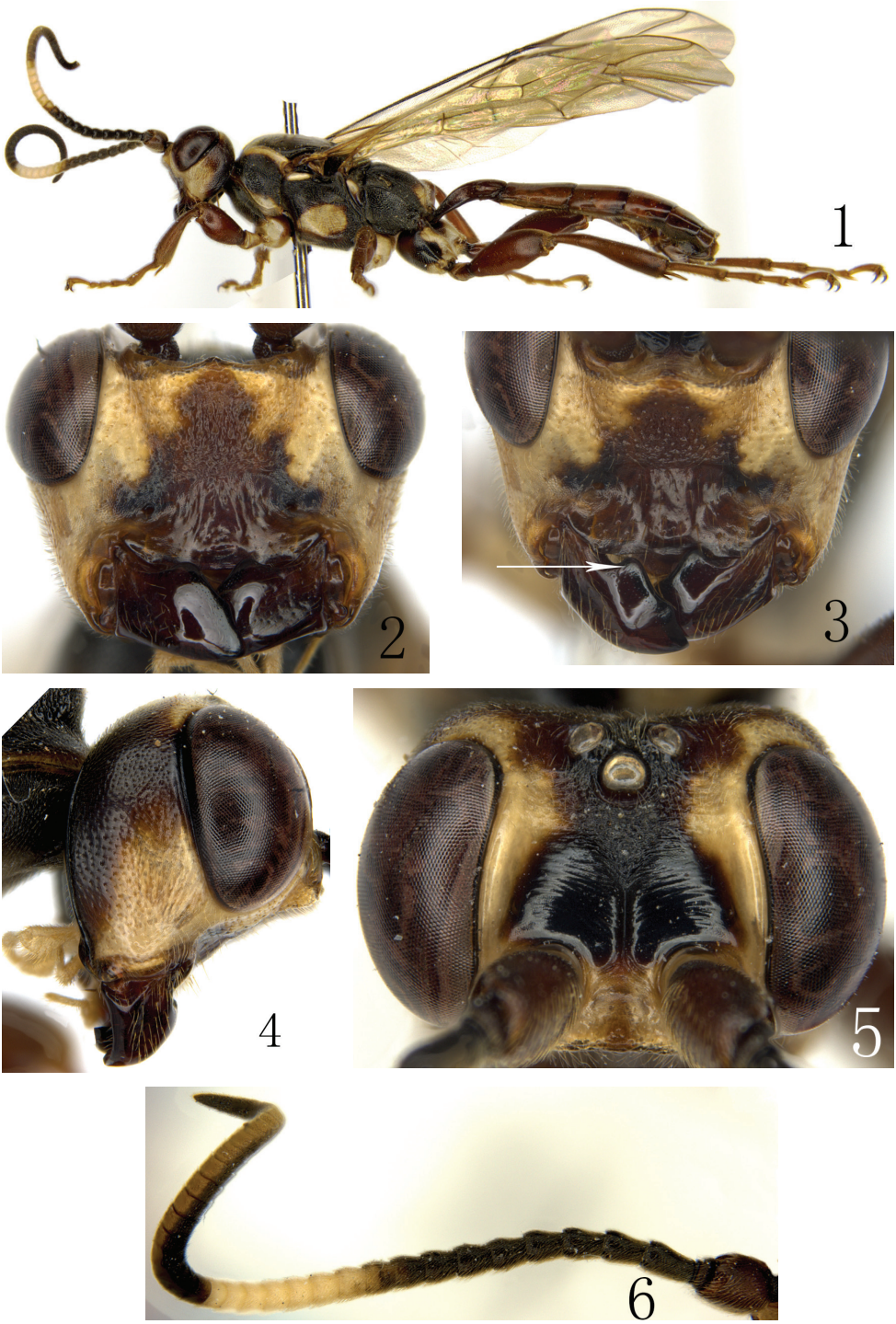
Etymology. The specific name is derived from the type locality

Material examined. Holotype, female, collected on blacklit sheet in the night by Tao Li on 10 July 2013, China: Motuo County, 1976m, Xizang Autonomous Region.

Diagnosis. Basal half of mandible longitudinally concave medially, with sparse, fine punctures; upper marginal tooth (Figure 3) located at center. Median longitudinal carinae of propodeum weak, incomplete, vestigial (Figure 11). Costula absent. Second tergite 1.25 times as long as apical width, with fine punctures (Figure 13). Mesosoma black, with white spots. Tergites almost entirely brownish red.

Description. Female. Body length approximately 15.0 mm. Forewing length approximately 11.5 mm.

Head. Face (Figure 2) slightly concave, with sparse, weak punctures; median portion with indistinct longitudinal wrinkles; upper margin with weak median triangular convexity; from outside of antennal socket to inner side of clypeal foveae with distinct oblique groove. Clypeus with different texture from face, shiny, irregularly longitudinally convex medially; subapical portion with sparse, indistinct, fine punctures; median section of apical margin almost truncate. Mandible large, basal half longitudinally concave medially, with sparse, fine punctures; upper marginal tooth (Figure 3) located at center. Malar area finely alutaceous; malar space approximately 0.9 times as long as basal width of mandible. Gena (Figures 4, 7) almost shiny, with distinct punctures, lower portion with indistinct wrinkles. Vertex with distinct, fine punctures. Interocellar



Figures 1–6. *Gyrodonta motuoica* sp. n. Holotype. Female **1** Habitus, lateral view **2** Head, anterior view **3** Head, dorsal-anterior view **4** Head, lateral view **5** Frons **6** Antenna.

Figures 7–13. *Gyrodonta motuoica* sp. n. Holotype. Female **7** Head and pronotum, lateral view **8** Mesoscutum **9** Mesosoma, lateral view **10** Hind tarsus **11** Propodeum **12** First tergite, lateral view **13** Tergites 1–3, dorsal view.

area with distinct longitudinal groove. Postocellar line approximately 0.5 times as long as ocular-ocellar line, 0.87 times maximum diameter of posterior ocellus. Frons (Figure 5) deeply concave, with distinct transverse wrinkles; lower portion with distinct median longitudinal carina. Antenna (Figure 6) slightly longer than head and mesosoma combined, with 38 flagellomeres; apical portion of flagellum distinctly flattened below; ratio

of length from first to fifth flagellomeres: 7.0:6.0:5.5:5.2:5.0. Occipital carina complete, lower end joining hypostomal carina slightly above base of mandible.

Mesosoma. Pronotum (Figure 7) with dense punctures, distance between punctures 0.2–1.5 times their diameter; lateral concavity broad, almost shiny, upper-anterior portion with weak transverse oblique wrinkles, lower-posterior with short transverse wrinkles. Epomia strong. Mesoscutum (Figure 8) slightly convex, with dense, distinct punctures, distance between punctures 0.5–2.0 times their diameter. Notaulus absent. Scutoscutellar groove narrow, deep. Scutellum almost flat, shiny, with distinct, fine punctures, distance between punctures 0.5–3.0 times their diameter. Postscutellum transversely convex, with deep, small anterior-lateral pit. Mesopleuron (Figure 9) with fine punctures, upper-anterior, under subtegular ridge, and lower-posterior portions with transverse oblique wrinkles. Speculum with distinct punctures. Upper end of epicnemial carina not reaching anterior margin of mesopleuron. Metapleuron slightly convex, upper-anterior portion with distinct punctures, remainder with indistinct oblique wrinkles. Submetapleural carina complete, strong. Wings slightly brownish, hyaline. Fore wing with vein 1cu-a slightly distal to 1-M, distance between them approximately as long as width of vein. Areolet pentagonal, receiving vein 2m-cu at middle. 2–Cu approximately 2.0 times as long as 2cu-a. Hind wing with vein 1-cu about 3.3 times as long as cu-a. Anterior tibia slightly compressed, anterior profile with dense thorn-like spines. Hind femur 2.8 times as long as maximum width. Hind tarsus (Figure 10) approximately 1.3 times as long as tibia. Ratio of length of hind tarsomeres 1:2:3:4:5 is 18.5:10.6:7.8:4.7:10.1. Propodeum (Figure 11) without costula, median longitudinal carinae weak, vestigial; lateral longitudinal, pleural and apical transverse carinae complete; area posteroexterna complete; area superomedia coarse, with indistinct, fine transverse wrinkles; anterior portions of lateral areas with distinct punctures, median with weak transverse wrinkles; area petiolaris with dense transverse wrinkles; area lateralis reticulate; spiracle elongate, approximately three times as long as wide.

Metasoma. First tergite approximately 3 times as long as apical width, dorsal profile of petiole with sparse punctures, lateral with indistinct longitudinal wrinkles (Figure 12). Postpetiole (Figure 13) with dense punctures, distance between punctures 0.5–2.5 times their diameter; lateral and apical portions shiny, very sparsely punctate. Second tergite (Figure 13) approximately 1.25 times as long as apical width, with fine punctures, distance between punctures 1.0–3.0 times their diameter. Third tergite approximately 0.9 times as long as apical width, with fine indistinct punctures. Ovipositor sheath reaching to apex of metasoma.

Color (Figure 1)**.** Head mainly brownish black; face and clypeus reddish brown; inner orbits irregularly, malar area, lower portion of gena, flagellomeres (apical portion of 9)10–16 white; median longitudinal portion of mandible, scape, apical ventral profile of flagellum dark brown. Mesosoma black. Dorsal anterior margin, upper margin and lower anterior corner of pronotum, longitudinal band of tegula, scutellum almost entirely, subtegular ridge, large median spot of mesopleuron, posterior lateral portion of propodeum white. Sublateral longitudinal band of mesoscutum dark brown. Femora, tibiae, main portion of anterior and mid coxae, anterior-basal spot of hind coxa, lower profiles

of anterior and mid trochanters brownish red. Main portions of anterior and mid coxae, dorsal profiles of trochanters, apical margin and dorsal spot of hind coxa white. Tarsus buff. Tergites brown red. Basal portion of first tergite, hind margins of fourth and subsequent tergites more or less darkish brown. Pterostigma brown. Veins brownish black.

Remarks. This new species is similar to *G. concava* (Uchida, 1937) but can easily be distinguished from the latter by the following combination of characters: apical portion of flagellum distinctly flattened below; upper marginal tooth of mandible located at middle; propodeum without costula, median longitudinal carinae vestigial; second tergite (Figure 13) 1.25 times as long as apical width, with distinct, fine punctures. *Gyrodonta concava*: apical portion of flagellum cylindrical; upper marginal tooth of mandible located subbasally; propodeum with distinct costula and median longitudinal carinae; second tergite almost 1.1 times as long as apical width, finely coriaceous, without punctures.

Gyrodonta flavomaculata Cameron, 1901

Gyrodonta flavomaculata Cameron, 1901: 486.
Gyrodonta flavomaculata Cameron, 1901. Gupta 1987: 966.
Gyrodonta flavomaculata Cameron, 1901. Heinrich 1937: 265.
Gyrodonta flavomaculata Cameron, 1901. Townes, Townes and Gupta 1961: 375.
Gyrodonta flavomaculata Cameron, 1901. Yu and Horstmann 1997: 583.

Specimens not examined.

Distribution. India.

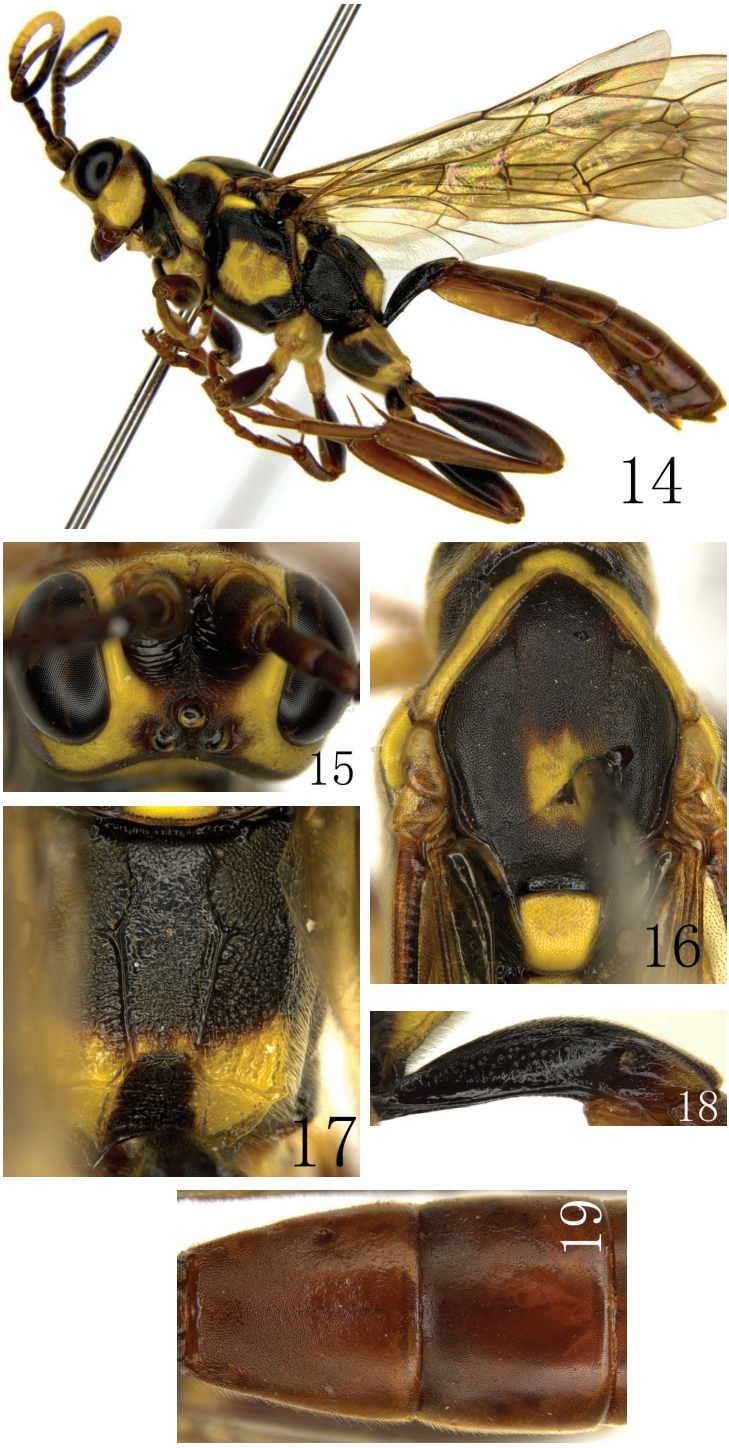
Gyrodonta concava (Uchida, 1937)

Figures 14–19

Pielia concava Uchida, 1937: 92.
Gyrodonta concava (Uchida, 1937). Townes, Townes and Gupta 1961: 375.
Gyrodonta concava (Uchida, 1937). Yu and Horstmann 1997: 583.

Diagnosis. Face without oblique groove from outside of antennal socket to inner side of clypeal foveae. Subapical portion of clypeus with median tubercle. Upper marginal tooth of mandible located at subbase. Hind portion of scutellum distinctly slanted. Hind femur (Figure 14) 3.5 times as long as maximum width. Propodeum (Figure 17) with distinct costula and median longitudinal carinae. Lateral profile of first tergite (Figure 18) with sparse, distinct punctures. Second tergite (Figure 19) almost 1.1 times as long as apical width, finely coriaceous, without punctures.

Specimen examined. 1 female, China: Mufushan, 860m, Hunan province, 27 May 2007, leg. Ze-Jian Li. 1 female, Nepal: Kosi Zone, Dhankula District, Arun



Figures 14–19. *Gyrodonta concava* (Uchida, 1937) Female **14** Habitus, lateral view **15** Frons **16** Mesoscutum **17** Propodeum **18** First tergite, lateral view **19** Tergites 2–3, dorsal view.

valley, Hille Skidna Bhedetar 2000–2700 m, 24–28 May 1996, leg. P. Cechovsky (Malaise Trap) (LINZ).

Distribution. China, Nepal.

Acknowledgements

The authors are deeply grateful to Dr. Gavin Broad, Department of Life Sciences, the Natural History Museum, London, UK, and two anonymous reviewers for reviewing this manuscript. This research was supported by the National Natural Science Foundation of China (NSFC, No. 31372246, No. 31070585).

References

Cameron P (1901) Descriptions of seventeen new genera of Ichneumonidae from India and one from Australia. Annals and Magazine of Natural History 7: 480–487. doi: 10.1080/00222930108678502

Gupta VK (1987) The Ichneumonidae of the Indo-Australian area (Hymenoptera). Memoirs of the American Entomological Institute 41: 1–1210.

Heinrich G (1937) A list and some notes on the synonymy of the types of the subfamily Ichneumoninae Ashmead (Hymenoptera) in the collections of the British Museum and the Hope Department of the Oxford University Museum. Annals and Magazine of Natural History (10) 20: 257–279. doi: 10.1080/00222933708655342

Heinrich GH (1967) Synopsis and reclassification of the Ichneumoninae Stenopneusticae of Africa south of Sahara (Hym.). 1. Farmington State College Press, 250 pp.

Narayanan ES, Lal K (1958) A revised classification of the Indian Ichneumonidae. Indian Journal of Entomology 20: 7–20.

Schmiedeknecht O (1902) Opuscula Ichneumonologica. I. Band. (Fasc. I.) Allgemeine Eintheilung. Die Gattungen der Joppinen, Ichneumoninen, Listrodrominen, Heresiarchinen, Gyrodontinen und Alomyinen. Bestimmungstabelle der paläarktischen Arten der Gattung Ichneumon. Blankenburg in Thüringen, 1–80.

Townes HK, Townes M, Gupta VK (1961) A catalogue and reclassification of the Indo-Australian Ichneumonidae. Memoirs of the American Entomological Institute 1: 1–522.

Uchida T (1937) Die von Herrn O. Piel gesammelten chinesischen Ichneumonidenarten. Insecta Matsumurana 11: 81–95.

Wahl DB, Mason WRM (1995) The family-group names of the Ichneumoninae (Hymenoptera: Ichneumonidae). Journal of Hymenoptera Research 4: 285–293.

Yu DS, Horstmann K (1997) A catalogue of world Ichneumonidae (Hymenoptera). Memoirs of the American Entomological Institute 58: 1–1558.

Yu DS, van Achterberg C, Horstmann K (2012) Taxapad 2012 – World Ichneumonoidea 2011. Taxonomy, Biology, Morphology and Distribution. Ottawa, Ontario, Canada. www.taxapad.com

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RESEARCH ARTICLE

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Review of the genus *Aristelix* Nixon, 1943 (Hymenoptera, Braconidae, Alysiinae), with description of a new species from Iran and clarification of the status of *Antrusa chrysogastra* (Tobias, 1986)

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Abstract

The species of the Western Palaearctic genus *Aristelix* Nixon, 1943 are reviewed. The new species *Aristelix persica* **sp. n.** is described from Iran. Redescriptions and illustrations of *A. phaenicura* (Haliday, 1839) and *Antrusa chrysogastra* (Tobias, 1986), **comb. n.** are presented. A key to the known *Aristelix* species is provided.

Keywords

Braconidae, Alysiinae, Dacnusini, parasitoids, *Antrusa*, new species, new combination, redescriptions, Iran

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Introduction

Aristelix Nixon, 1943 is a rare, previously monotypic genus of the tribe Dacnusini (Nixon 1943, Shenefelt 1974, Tobias 1998). The genus is restricted exclusively to the Western Palaearctic region (Tobias 1986, Yu et al. 2012) and initially included only the type species, *A. phaenicura* (Haliday, 1839), relatively widely distributed in several European countries (Yu et al. 2012).

The main diagnostic characters of *Aristelix* are as follows: at least mesosoma, but sometimes also temple, hind coxa and femur granulate; mandibles short, always with four distinct teeth, its median (second) tooth the longest; metasoma elongate, apical metasomal tergites usually with more than one row of setae; second metasomal tergite rugose-striate at least in basal half; radial (r) vein originating distinctly before middle of pterostigma (Tobias 1986, Achterberg 1993).

Exotela (*Antrusa*) *chrysogastra* Tobias, 1986, described from Moldova by Tobias (1986) (at this time treated regarded *Antrusa* Nixon, 1943 as a subgenus of *Exotela* Foerster, 1862), was also transferred to the genus *Aristelix* by Fischer (1990). However, examination of the holotype of this species showed that it is not member of *Aristelix* because it lacks all the main diagnostic characters of this genus, listed above. Actually this species belongs to the genus *Antrusa* Nixon due to vein 2-M merging with the submarginal cell, as opposed to the discal cell in *Exotela* Forster, 1862 (Tobias 1998; Pardo 2010). *Antrusa* comprises a total of 36 species described from the Palaeartic Region (Yu et al. 2012) and it is characterized by the apical metasomal tergites each with only one row of setae, mandible 3-dentate, middle longitudinal ridge on the first metasomal tergite developed, and vein m-cu antefurcal (Tobias 1986, 1998; Pardo 2010). Keys for identification of all genera discussed here were published by Tobias (1998), Perepechaenko (2000) and Pardo (2010).

According to Tobias (1998), *Orientelix* Tobias, 1998 (type species *O. marginalis* Tobias, 1998), recently described from the Russian Far East genus , is closely related to *Aristelix* due to the similar mandible structure, elongate mesosoma and sculpture of the second tergite. We suppose it is a geographical vicariant of the genus *Aristelix* in the Eastern Palaearctic.

In this work, we describe a peculiar new species of *Aristelix* from Iran, as well as redescribe and illustrate the type species, and provide a key for determination of these two species. Additionally, *Antrusa chrysogastra* (Tobias, 1986) is redescribed and its taxonomic position redefined.

Materials and methods

Two specimens of *Aristelix* were collected using Malaise traps in the single locality of Hormozgan Province of Iran (Fig. 1), where more than 70% of territory is covered by mountains and hills (Zaeifi 2001).

Figure 1. Habitats in Hormozgan Province, where *Aristelix* specimens were collected. **A** General landscape **B** Malaise trap habitat.

Photographs were taken with a Digital Microscope VHX-2000 and with a Nikon® D700 mounted on a Leica® S8APO microscope, with images combined using Helicon Focus® and edited using Adobe Photoshop® imaging system. For terminology of morphological features and sculpture, measurements and wing venation nomenclature see van Achterberg (1993) and HymAO (Hymenoptera Anatomy Ontology Portal: http://portal.hymao.org/) (Yoder et al. 2010).

The types of new species are deposited in the collection of the Zoological Institute of the Russian Academy of Sciences, St Petersburg, Russia (ZISP).

Taxonomic part

***Aristelix phaenicura* (Haliday, 1839)**
Figs 2, 3

Alysia (*Dacnusa*) *phaenicura* Haliday 1839: 6.
Alysia (*Dacnusa*) *phoenicura*: Haliday 1839: 27, 66, Dalla Torre 1898: 28 (mispelling: Haliday spelt the species as phaenicura in the description but as phoenicura in the index).
Dacnusa phaenicura: Nixon 1937: 49.
Dacnusa phoenicura: Marshall 1895: 463, 1897: 2, Szépligeti 1904: 195, Telenga 1935: 119.
Aristelix phaenicura: Nixon 1943: 27, Shenefelt 1974: 1030, Riegel 1982: 61, Tobias 1986: 269, Docavo and Tormos 1988: 162, Quicke et al. 1997: 26, Fischer 1999: 17, Belokobylskij et al. 2003: 357, Papp 2004: 133, 2005: 145, Yu et al. 2012.
Aristelix phoenicura: van Achterberg 1997: 65, Perepechayenko 2008: 365, Broad et al. 2012: 13.

Material examined. 1 female, Moldova, Tatareshty, steppe meadow in the forest, 6.vi.1967 (Tobias coll.), 1 male, Russia, Sochi, Lazarevskoe, terraced slope, forest, 8–9.v.1975 (Tobias coll.)

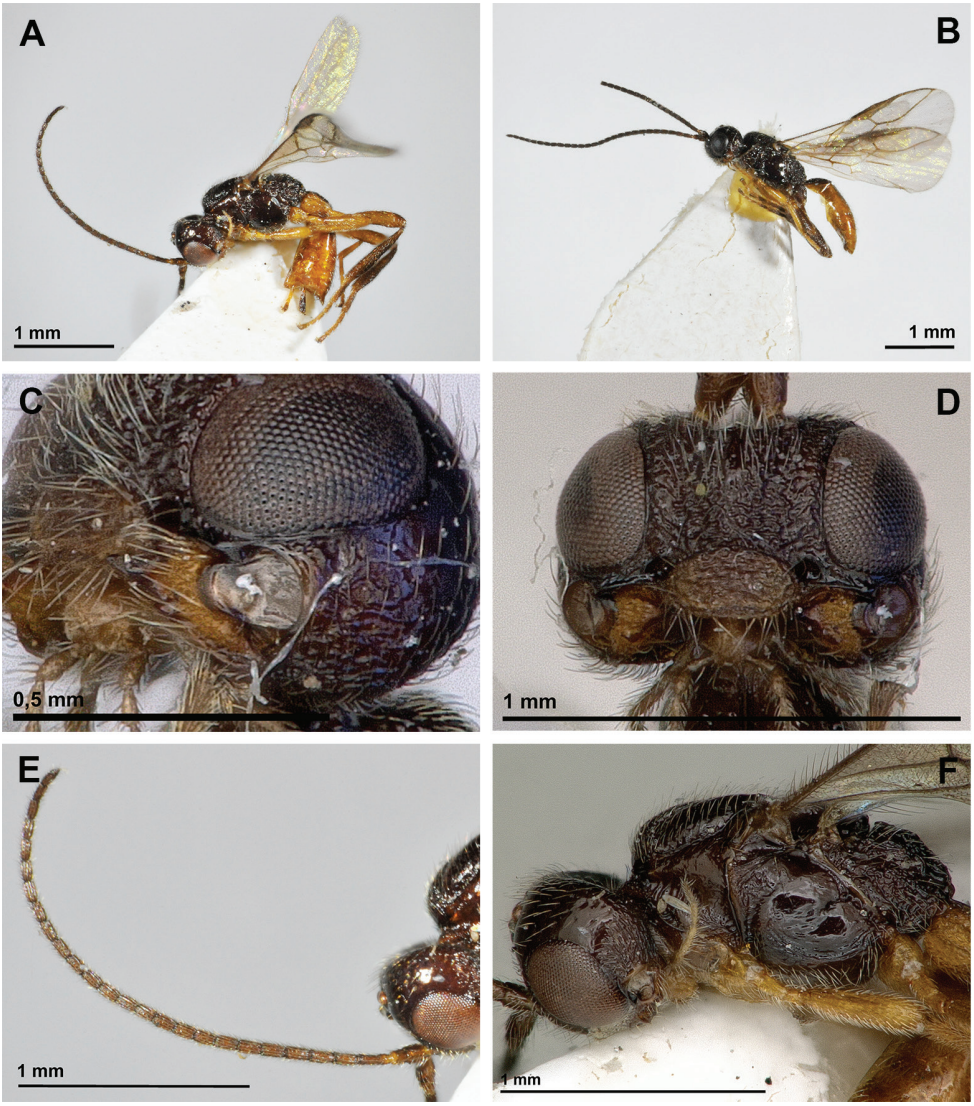

Figure 2. *Aristelix phaenicura* (Haliday) (**A, C–F** female **B** male) **A, B** Habitus, lateral view **C** Mandible **D** Head, front view **E** Antenna **F** Head and mesosoma, lateral view.

Redescription. Female. Body length 2.6 mm; fore wing length 2.6 mm.

Head in dorsal view 1.7 times as wide as median length, 1.45 times as wide as mesoscutum, vertex smooth, with small groove between occiput and ocelli. Eye in lateral view 1.5 times as high as wide and 1.2 times as wide as temple medially. POL 1.4 times OD; OOL 2.6 times OD. Face punctate, with scattered short setae, 1.4 times as wide as high; inner margins of eyes subparallel. Clypeus slightly curved ventrally, 1.9 times as wide as high. Mandible 4-dentate, not widened towards apex, 1.1 times as long as maximum width. Upper tooth of mandible small, distinctly shorter than lower

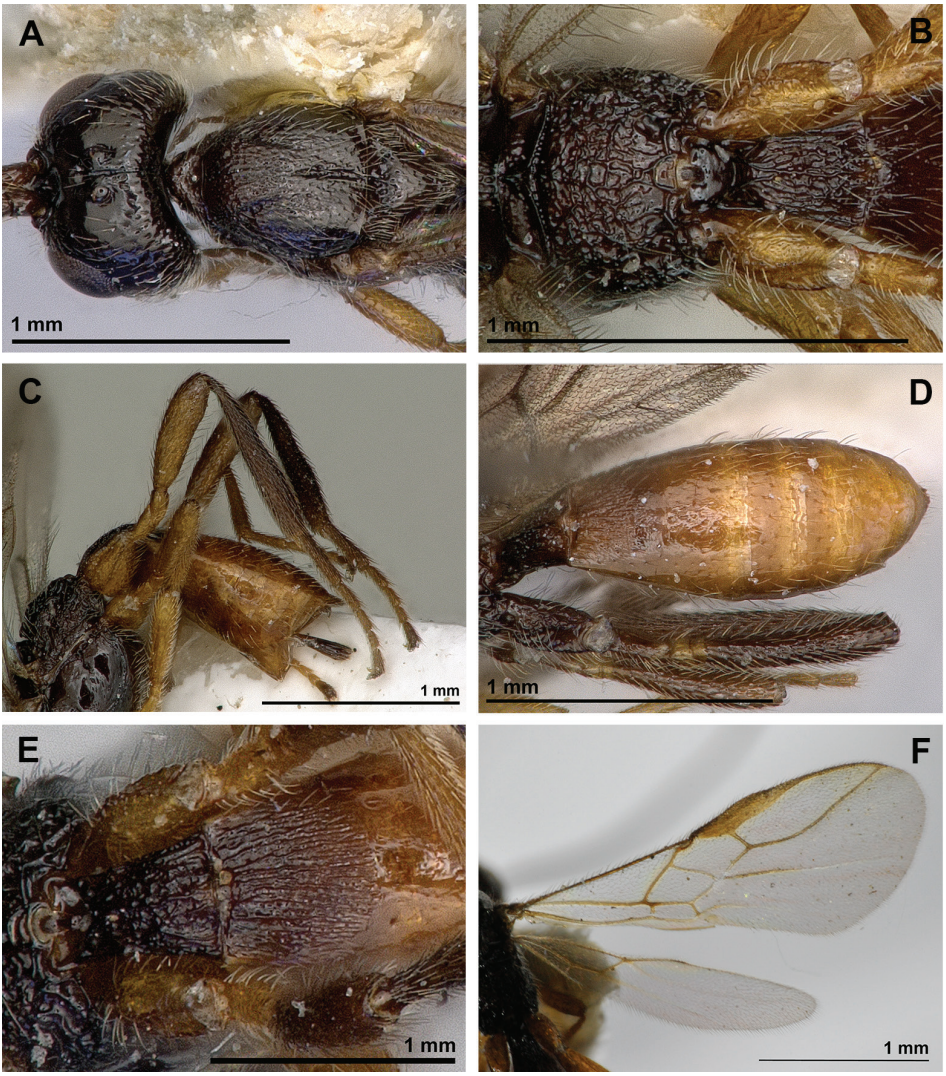

Figure 3. *Aristelix phaenicura* (Haliday) (female) **A** Head and mesonotum, dorsal view **B** Propodeum and first metasomal tergite, dorsal view **C** Legs, metasoma and ovipositor, lateral view **D** Metasoma, dorsal view **E** First to third metasomal tergites, dorsal view **F** Fore and hind wings.

tooth, pointed apically; second (median) tooth longest, wide basally and distinctly narrowed towards apex, pointed apically; third tooth small, about as long as first tooth, pointed, arising from base of second tooth and situated above it; lower tooth rather large, pointed apically, distinctly separated.

Antenna longer than body, 27-segmented. Scape twice as long as pedicel. First flagellar segment 3.2 times as long as its apical width, 1.25 times as long as first segment; second segment 2.5 times as long as its maximum width. Penultimate segment 2.2–2.3 times as long as wide; apical segment 3.0 times as long as maximum width.

Mesosoma 1.7 times as long as high (lateral view). Mesoscutum 0.95 times as long as its maximum width, with numerous scattered setae. Notauli shallow on posterior half of mesoscutum. Mesoscutal midpit present, distinctly elongate. Prescutellar depression smooth, with median carina but without lateral carinae. Precoxal suture present, weakly rugulose, reaching anterior and posterior margins of mesopleuron. Mesepimeral sulcus crenulate below. Lower part of mesopleuron and metapleuron with long whitish setae. Propodeum completely rugose-reticulate. Propodeal spiracle relatively small.

Wings. Length of fore wing 2.6 times its maximum width. Marginal cell short, ending before apex of wing, 3.7 times as long as its maximum width. Vein r arising distinctly before middle of pterostigma. Second submarginal cell closed, 2.5 times as long as its maximum width. Hind wing 5.3 times as long as maximum width.

Legs. Hind femur 3.5 times as long as maximum width. Hind tibia distinctly widened towards apex, 7.9 times as long as its maximum subapical width, 1.05 times as long as hind tarsus. First segment of hind tarsus (basitarsus) 1.25 times as long as second segment.

Metasoma compressed. First tergite striate, with scattered setae, weakly widened towards apex, twice as long as apical width. Second tergite mainly striate, smooth on apical sides. Tergites from third to sixth with more them one row of setae. Ovipositor weakly projecting beyond apex of metasoma, 0.85 times as long as first tergite, 0.5 times as long as hind femur.

Colour. Head, antenna, mesosoma, hind tibia, first segment of hind tarsus and ovipositor sheaths dark brown. Legs brownish yellow. First and second metasomal tergite almost black, following tergites yellowish brown. Wings hyaline. Pterostigma brown.

Male. Body length 2.7 mm; fore wing 2.7 mm. Antenna 29-segmented. First flagellar segment 2.2 times and second segment twice as long as their maximum width. Hind femur 3.8 times as long as maximum width. All coxae, hind femur and tibia dark brown. Otherwise similar to female.

Comparative diagnosis. Differences between *Aristelix phaenicura* and *A. persica* sp. n. are described in the key below.

Distribution. Belgium, Germany, Hungary, Ireland, Moldova, Russia, Slovakia, Spain, Ukraine, United Kingdom (Yu et al. 2012).

Aristelix persica Peris-Felipo, sp. n.

http://zoobank.org/3B3E17D6-AD40-4B9E-B58F-6CECC961BFCB
Figs 4, 5

Type material. Holotype: female, Iran, Hormozgan Province, Geno, 27°24'16.16"N, 56°08'51.80"E, 1274 m, 20.iii.2012 (Ameri leg.) (ZISP). Paratype: 1 male, same label as holotype (ZISP).

Description. Female. Body length 2.8 mm, fore wing length 2.5 mm.

Head in dorsal view 1.4 times as wide as median length, 1.3 times as wide as mesoscutum; vertex smooth, with dark line between occiput and ocelli. Eye in lateral view

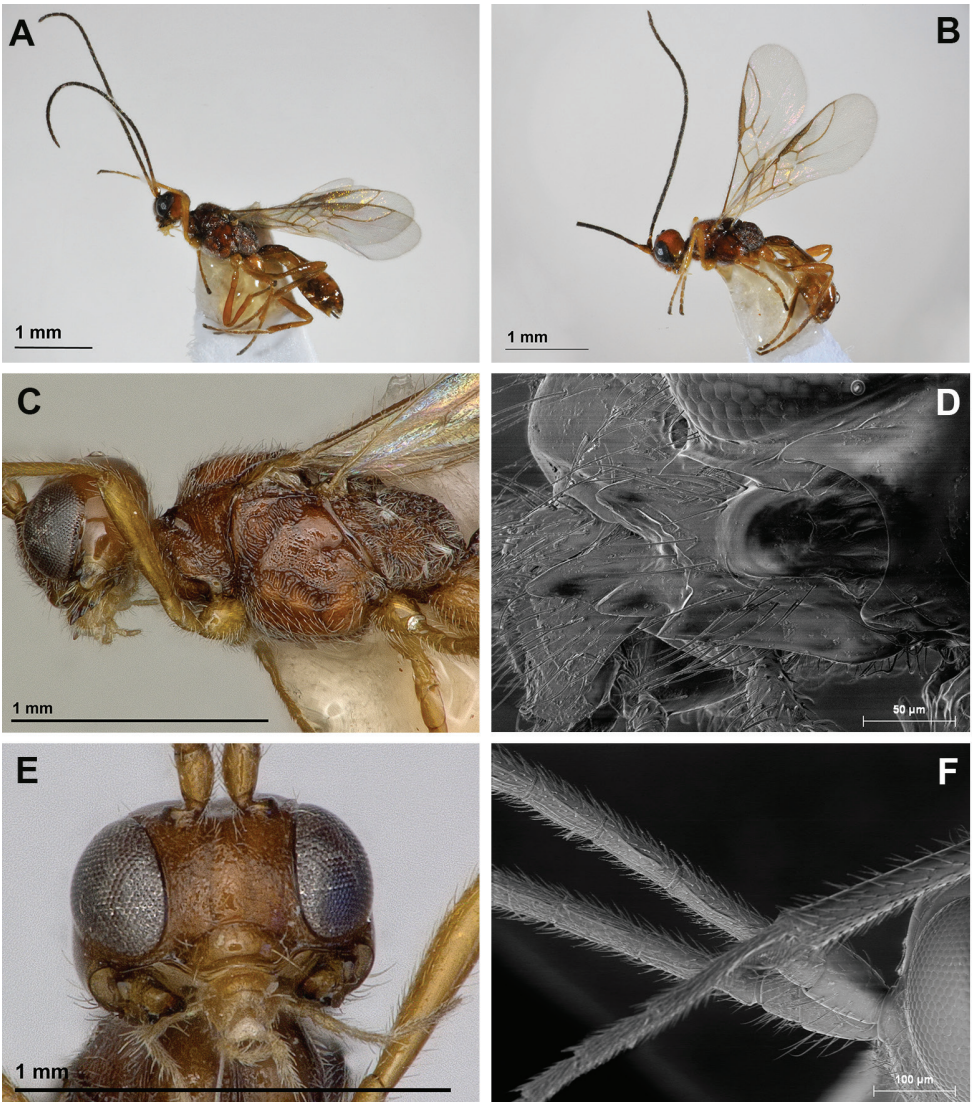

Figure 4. *Aristelix persica* sp. n. (**A, C–F** female **B** male) **A, B** Habitus, lateral view **C** Head and mesosoma, lateral view **D** Mandible **E** Head, front view **F** Basal segments of antenna.

1.5 times as high as wide and as wide as temple medially. POL 1.4 times OD; OOL 2.8 times OD. Face smooth, with scattered short setae, 1.65 times as wide as high; inner margins of eyes subparallel. Clypeus slightly curved ventrally, twice as wide as high. Anterior tentorial pit short, not reached middle half distance between clypeus and eye. Mandible 4-dentate, not widened towards apex, 1.2 times as long as maximum width. Upper tooth of mandible rather wide, longer than lower tooth, pointed apically; second (median) tooth longest, wide basally and distinctly narrowed towards apex, subpointed apically; third tooth about as long as first tooth, pointed, arising

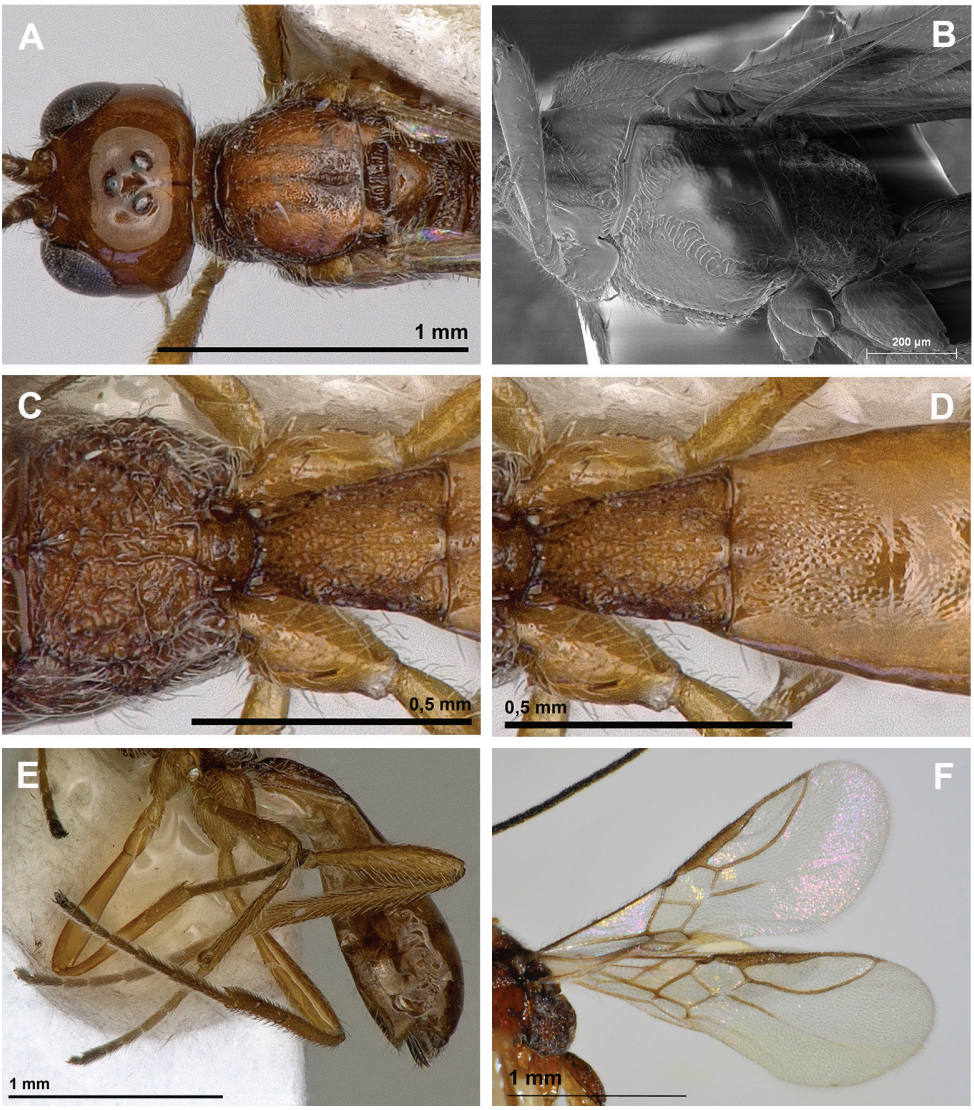

Figure 5. *Aristelix persica* sp. n. (female) **A** Head and mesonotum, dorsal view **B** Mesosoma, lateral view **C** Propodeum and first metasomal tergite, dorsal view **D** First and second metasomal tergites, dorsal view **E** Legs, metasoma and ovipositor, lateral view **F** Fore and hind wings.

from base of second tooth and situated upper it; lower tooth shortest, pointed apically, distinctly separated.

Antenna longer than body, 26-segmented. Scape twice as long as pedicel. First flagellar segment 3.9 times as long as its apical width, 1.3 times as long as first segment; second segment 3.2 times as long as its maximum width. Penultimate segment about 2.2 times and apical segment 3.0 times as long as their maximum width accordingly.

Mesosoma 1.4 times as long as high (lateral view). Mesoscutum 0.95 times as long as its maximum width, with numerous scattered setae. Notauli shallow on posterior half of mesoscutum. Mesoscutal midpit present, distinctly elongate. Prescutellar depression smooth, with median and lateral carinae. Precoxal suture present, wide and coarsely crenulate, reaching anterior and posterior margins of mesopleuron. Mesepimeral sulcus crenulate below. Lower part of mesopleuron and metapleuron with long whitish setae. Propodeum completely rugose-reticulate. Propodeal spiracle relatively small.

Wings. Length of fore wing 2.8 times its maximum width. Marginal cell short, ending before apex of wing, 3.5 times as long as its maximum width. Vein r arising distinctly before middle of pterostigma. Second submarginal cell closed, 2.8 times as long as its maximum width. Hind wing 5.6 times as long as maximum width.

Legs. Hind femur 4.15 times as long as maximum width. Hind tibia weakly widened towards apex, 10.8 times as long as its maximum subapical width, 0.9 times as long as hind tarsus. First segment of hind tarsus (basitarsus) 1.6 times as long as second segment.

Metasoma compressed laterally. First tergite striate; weakly widened towards apex; 1.7 times as long as apical width; with scattered setae. Second tergite almost completely longitudinally rugose-punctate. Tergites third to sixth with only one row of setae on their apical halves. Ovipositor not projecting beyond apex of metasoma, 0.35 times as long as first tergite, 0.25 times as long as hind femur.

Colour. Body mainly light reddish brown and partly darker reddish. Antenna mainly, mesosoma in lateral furrows and depressions, tracks of notauli, prescutellar depression, propodeum, metapleuron and apical tergites of metasoma dark brown. Basal segments of antenna and legs yellowish brown, hind leg darkened. Wings hyaline. Pterostigma brown.

Male. Body length 2.5 mm; fore wing 2.4 mm. Antenna 26-segmented. First flagellar segment 4.2 times as long as its maximum width; second segment 3.0 times as long as its maximum width. Otherwise similar to female.

Etymology. The name refers to the historical name of the country, Persia, where this new species was discovered.

Comparative diagnosis. Differences between *Aristelix persica* sp. n. and *A. phaenicura* (Haliday) are described in the following key.

Key to species of the genus *Aristelix*

1 Hind tibia dark (Fig. 3C, D). Precoxal suture finely rugulose (Fig. 2F). Eye in lateral view 1.5 times as wide as temple medially (Fig. 2F). Basal half of temple punctate (Fig. 2C, F). First flagellar segment 3.2 times as long as its maximum width (Fig. 2E). Mesosoma in lateral view 1.7 times as long as high (Fig. 2F). Hind femur 3.5–3.8 times as long as maximum width (Fig. 3C). First metasomal tergite 2.0 times as long as apical width (Figs 3B, 3E) . ..... ***A. phaenicura*** (Haliday)

– Hind tibia light reddish brown (Fig. 5E). Precoxal suture coarsely crenulate (Figs 4C, 5B). Eye in lateral view as wide as temple medially (Fig. 4C). Basal half of temple smooth (Fig. 4C). First flagellar segment 3.9 times as long as its maximum width (Fig. 4F). Mesosoma in lateral view 1.4 times as long as high (Figs 4C, 5B). Hind femur 4.1–4.2 times as long as maximum width (Fig. 5E). First metasomal tergite 1.7 times as long as apical width (Figs 5C, 5D)..... ***A. persica* sp. n.**

***Antrusa chrysogastra* (Tobias, 1986), comb. n.**
Figs 6, 7

Exotela (*Antrusa*) *chrysogastra* Tobias 1986: 351.
Antrusa chrysogastra: Perepechaenko 2000: 75; Tormos et al. 2009: 258.
Aristelix chrysogastra: Fischer 1999: 17; Yu et al. 2012.

Material examined. Holotype (ZISP; examined): male, Moldova (Moldavia) "Tatareshty [47°12'15.8"N, 28°32'19.0"E], ostepn[yonnyi] lug v lesu [= steppe meadow in the forest], Tobias [collector], 6.vi.[1]967"; "Holotypus *Exotela* (*Antrusa*) *chrysogastra* Tobias".

Redescription. Male. Body length 2.5 mm; fore wing length 2.85 mm.

Head in dorsal view twice as wide as median length, 1.3 times as wide as mesoscutum, vertex entirely smooth, with scattered setae. Eye in lateral view 1.5 times as high as wide and 1.2 times as wide as temple medially. POL 1.85 times OD; OOL 3.0 times OD. Face punctate, with middle carina in upper half, with scattered long setae, twice as wide as high; inner margins of eyes subparallel. Clypeus slightly curved ventrally, 2.9 times as wide as high. Mandible 3-dentate, widened towards apex, 1.25 times as long as maximum width. Upper tooth of mandible longer than lower tooth, rounded apically; middle tooth long, wide basally and narrowed towards apex, rounded apically; lower tooth pointed apically.

Antenna longer than body, 29-segmented. Scape about 1.7 times as long as pedicel. First flagellar segment 2.6 times as long as its apical width, 1.25 times as long as first segment; second segment 2.15 times as long as its maximum width. Penultimate segments 1.3 times as long as wide; apical segment 2.3 times as long as maximum width.

Mesosoma 1.25 times as long as high (lateral view). Mesoscutum as long as its maximum width, with numerous setae on its middle surface and scattered setae on lateral areas. Notauli shallow on horizontal surface of mesoscutum. Mesoscutal midpit present, distinctly elongate. Prescutellar depression smooth, with median and lateral carinae. Precoxal suture present, wide, rugose, reached anterior margin of mesopleuron and not reaching its posterior margin. Mesepimeral sulcus crenulate below. Lower part of mesopleuron and metapleuron with long whitish setae. Propodeum completely rugose-reticulate. Propodeal spiracle relatively small.

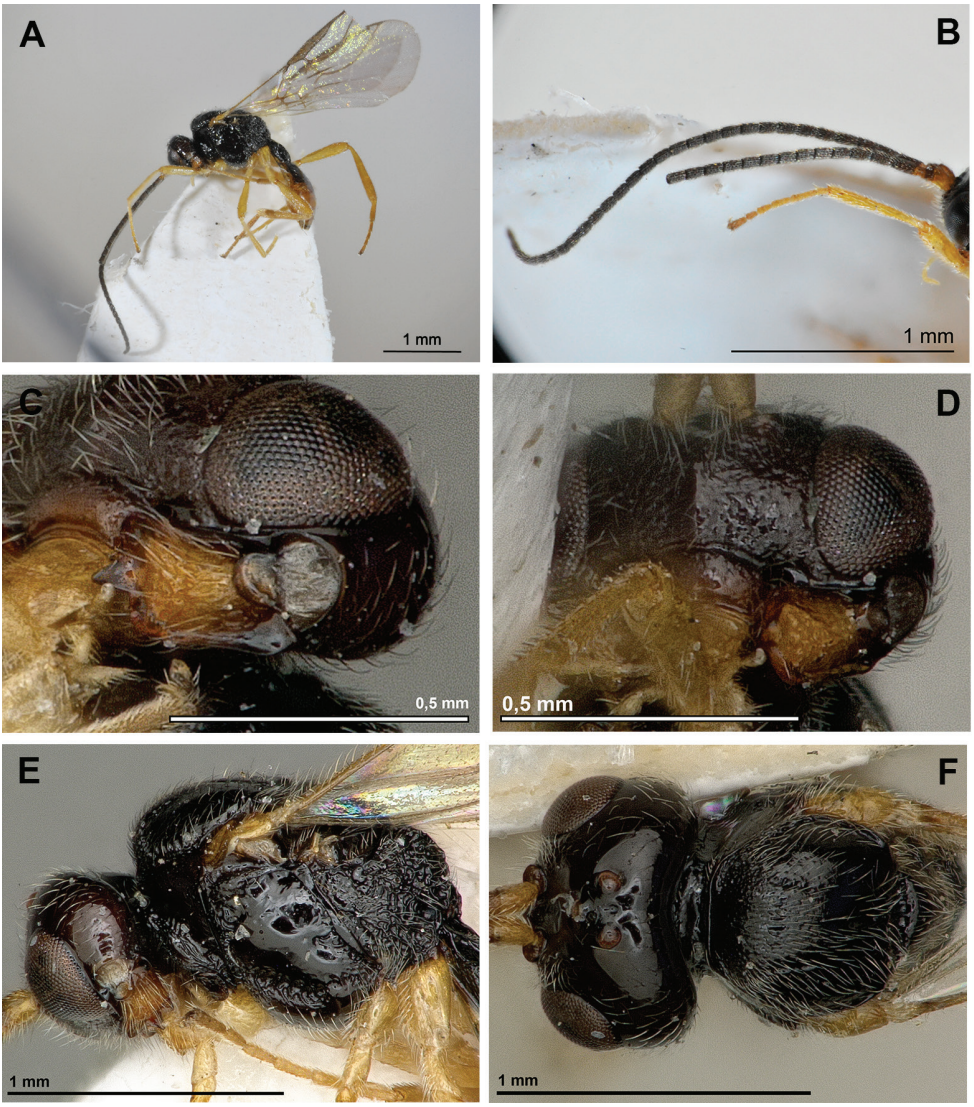

Figure 6. *Antrusa chrysogastra* (Tobias) (male) **A** Habitus, lateral view **B** Antenna **C** Mandible **D** Head, front view **E** Head and mesosoma, lateral view **F** Head and mesonotum, dorsal view.

Wings. Length of fore wing 3.0 times its maximum width. Marginal cell short, ending before apex of wing, 3.5 times as long as its maximum width. Vein r arising distinctly before middle of pterostigma. Second submarginal cell closed, 2.2 times as long as its maximum width. Hind wing 5.0 times as long as maximum width.

Legs. Hind femur 4.0 times as long as maximum width. Hind tibia weakly widened towards apex, 10.0 times as long as its maximum subapical width, 1.25 times as long as hind tarsus. First segment of hind tarsus (basitarsus) 1.7 times as long as second segment.

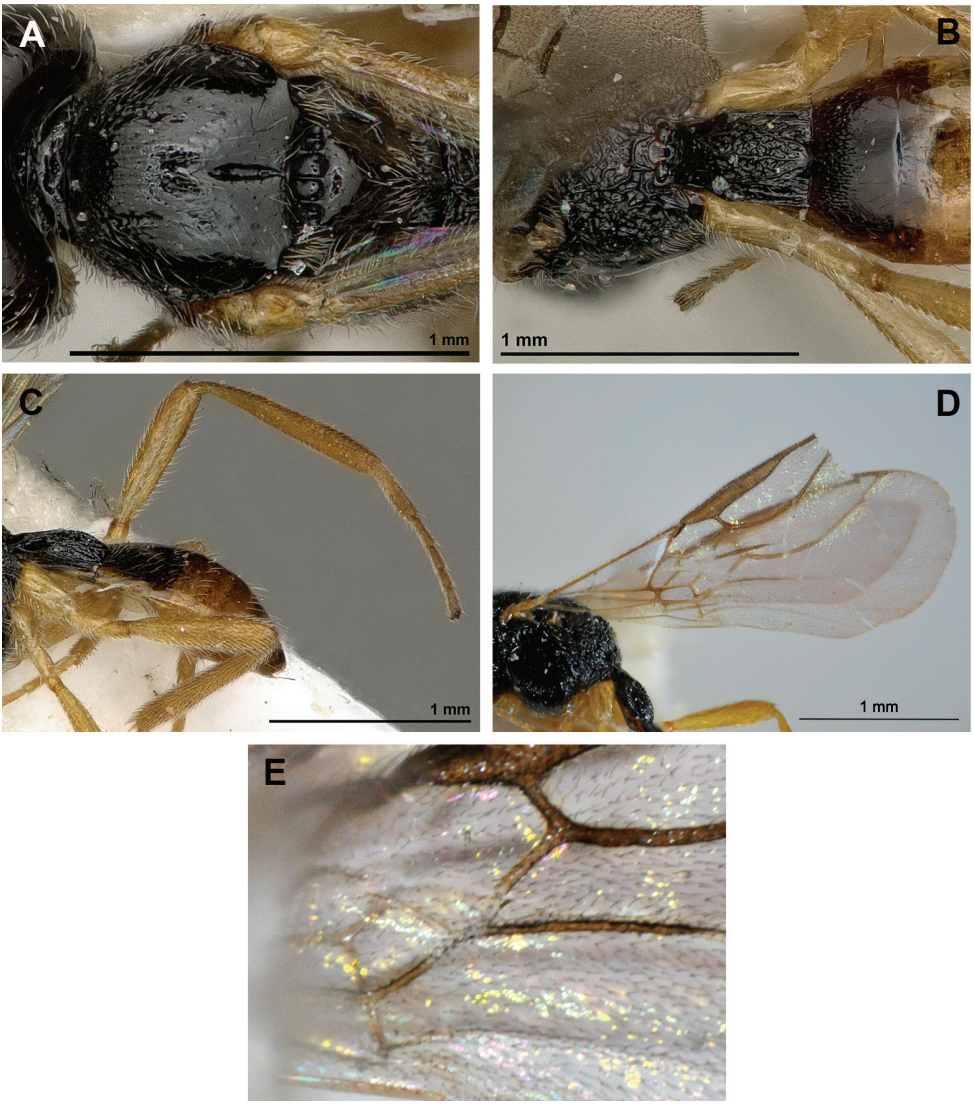

Figure 7. *Antrusa chrysogastra* (Tobias) (male) **A** Mesosoma, dorsal view **B** Propodeum and first to third metasoma tergites, dorsal view **C** Hind leg and metasoma, lateral view **D** Fore wing **E** Median part of fore wing.

Metasoma distinctly compressed. First tergite entirely striate, with scattered setae, weakly widened towards apex, 1.5 times as long as apical width. Second tergite striate in apical half and here with scattered setae, 0.4 times as long medially as basal its width. Fourth to sixth tergites each with single row of setae in apical half.

Colour. Head, antennal segments, mesosoma, first and second tergite black. Scape, pedicel and most part of metasoma yellowish brown, first and second metasomal tergites black. Legs yellow. Wings hyaline. Pterostigma brown.

Female. Unknown.

Comparative diagnosis. According to Tobias' key (1986), *Antrusa chrysogastra* (Tobias) differs from *A. chrysotegula* (Tobias, 1986) in having the first metasomal tergite rugose-punctate (longitudinally striate in *A. chrysotegula*), hind femur 4.5 times as long as its maximum width (5.5 times in *A. chrysotegula*), mesonotum almost entirely with short semi-erecte setae (only anteriorly pubescent in *A. chrysotegula*), and metasoma yellow in the apical half (dark to black in apical half in *A. chrysotegula*).

Distribution. Moldova.

Remarks. The main characters of *Antrusa* Förster are vein 2-M usually merging with the submarginal cell; m-cu antefurcal; mandibles widened apically and with only three teeth; first metasomal tergite with a median longitudinal keel; metasoma and head without granulate sculpture; second metasomal tergite usually smooth; apical metasomal tergites each with a single transverse line of setae; and no sexual dimorphism in the pterostigma (Tobias 1986, van Achterberg 1993, Perepechaenko 2000, Tormos et al. 2009, Pardo 2010). According to characters listed here, *A. chrysogastra* (Tobias) undoubtedly belongs to the genus *Antrusa*, but not to *Aristelix*.

Acknowledgement

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References

Achterberg C van (1993) Illustrated key to the subfamilies of the Braconidae (Hymenoptera: Ichneumonoidea). Zoologische Verhandelingen 283: 1–189.

Achterberg C van (1997) Revision of the Haliday collection of Braconidae (Hymenoptera). Zoologische Verhandelingen 314: 1–115.

Belokobylskij SA, Taeger A, Achterberg C van, Haeselbarth E, Riedel M (2003) Checklist of the Braconidae (Hymenoptera) of Germany. Beiträge fur Entomologie 53(2): 341–435.

Broad GR, Shaw MR, Godfray HCJ (2012) Checklist of British and Irish Braconidae (Hymenoptera). http://www.nhm.ac.uk/resources-rx/files/braconidae-checklist-for-web-34139.pdf [accessed 17 September 2014]

Dalla Torre CG de (1898) Catalogus Hymenopterorum. Volumen IV. Braconidae. Guilelmi Engelmann, Lipsiae, 323 pp.

Docavo I, Tormos J (1988) Further developments in the study of Spanish Dacnusini (II) (Hymenoptera, Braconidae). Boletín Asociación Española de Entomología 12: 161–163.

Fischer M (1999) Einiges über Kieferwespen (Hymenoptera, Braconidae, Alysiinae). Linzer Biologische Beiträge 31(1): 5–56.

Haliday AH (1839) Hymenoptera Brittanica: *Alysia*. London, Ballerie, 28 pp.

Marshall TA (1895) A monograph of the British Braconidae Part VI. XXIV. Alysiides cont. Transactions of the Royal Entomological Society of London 1895: 363–398.

Marshall TA (1897) A monograph of British Braconidae. Part VII. Transactions of the Entomological Society of London 1897: 1–31.

Nixon GEJ (1937) British species of *Dacnusa* (Braconidae). Transactions of the Society for British Entomology 4: 1–88.

Nixon GEJ (1943) A revision of the European Dacnusini (Hym., Braconidae, Dacnusinae). Entomologist's Monthly Magazine 79: 20–34.

Papp J (2004) A monograph of the braconid fauna of the Bakony Mountains (Hymenoptera, Braconidae) V. Agathidinae, Alysiinae. Folia Musei Historico Naturalis Bakonyiensis 21: 111–154.

Papp J (2005) A checklist of the Braconidae of Hungary (Hymenoptera). Folia Entomologica Hungarica 66: 137–194.

Pardo X (2010) Bracónidos exodontos de España (Hymenoptera, Braconidae, Alysiinae). Tesis Doctoral (PhD Thesis), Salamanca, 351 pp. http://gredos.usal.es/jspui/handle/10366/76503 [accessed 10 February 2012]

Perepechayenko VL (2000) Review of genera of the tribe Dacnusini (Hymenoptera: Braconidae: Alysiinae) of Palaearctic region. Izvestiya Kharkovskogo Entomologicheskogo Obshchestva 8(1): 57–79. [In Russian]

Perepechayenko VL (2008) An annotated list of the braconid wasps of the tribe Dacnusini (Hymenoptera: Braconidae: Alysiinae) of Ukraine. II Genera with haired eyes and genera with 4-toothed mandibles. Kavkazskiy Entomologicheskiy Byulleten 4(3): 363–380. [In Russian]

Quicke DLJ, Achterberg van C, Godfray HCJ (1997) Comparative morphology of the venom gland and reservoir in opiine and alysiine braconid wasps (Insecta, Hymenoptera, Braconidae). Zoologica Scripta 26(1): 23–50. doi: 10.1111/j.1463-6409.1997.tb00407.x

Riegel GT (1982) The American species of Dacnusinae, excluding certain Dacnusini (Hymenoptera: Braconidae). Novitates Arthropodae 1(3): 1–185.

Shenefelt RD (1974) Braconidae 7. Alysiinae. Hymenopterum Catalogus. Pars 11: 937–1113.

Szépligeti G (1904) Hymenoptera. Fam. Braconidae. Genera Insectorum 22: 1–253.

Telenga NA (1935) Uebersicht der aus U.S.S.R. bekannten Arten der Unterfamilie Dacnusinae (Braconidae, Hymenoptera). Vereinsschrift der Gesellschaft Luxemburger Naturfreunde 1934(12): 107–125.

Tobias VI (1986) Subfam. Alysiinae. In: Medvedev GS (Ed.) Opredelitel nasekomykh Evropeiskoi chasti SSSR [Key to insects of the European part of the USSR] 3(5). Nauka, Leningrad, 100–231. [In Russian]

Tobias VI (1998) Alysiinae (Dacnusini). In: Ler PA (Ed.) Key to insects of Russian Far East. Vol. 4. Neuropteroidea, Mecoptera, Hymenoptera. Pt 3. Dal'nauka, Vladivostok, 299–411. [In Russian]

Tormos J, Pardo X, Asís JD, Gayubo SF, de La Nuez A (2009) A new species of Dacnusini from Montecristo Island, with description of the preimaginal phases and venom appara-

tus of *Antrusa curtitempus* (Hymenoptera, Braconidae, Alysiinae). Florida Entomologist, 92(29): 255–260. doi: 10.1653/024.092.0209

Yoder MJ, Mikó I, Seltmann KC, Bertone MA, Deans AR (2010) A Gross Anatomy Ontology for Hymenoptera. PLoS ONE 5(12): e15991. doi: 10.1371/journal.pone.0015991

Yu DS, Achterberg C van, Horstman K (2012) Taxapad 2012, Ichneumonoidea 2011. Database on flash-drive. Ottawa, Ontario, Canada.

Zaeifi M (2001) The flora of Hormozgan province. Research Center of Agriculture and Natural Resources Publications, Bandar Abbas, 87 pp.

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RESEARCH ARTICLE

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Clarification of the author and year of publication of *Cotesia chilonis*, a species used widely for biological control of *Chilo* stem borers

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Abstract

Cotesia chilonis (Munakata, 1912) (Hymenoptera: Braconidae, Microgastrinae) is a species used widely for biological control of several species of *Chilo* (Lepidoptera: Crambidae) stem borers. The genus name, species author and year of publication associated with this parasitoid wasp species have varied historically. Based on the available evidence, a complete account of the history and nomenclatural acts associated with *C. chilonis* is presented, the different alternatives are weighed and discussed, and what is considered as the best alternative is proposed. It is expected that this paper will contribute to clarity and stability in the use of this species name, author and year.

Keywords

Cotesia chilonis, Microgastrinae, *Chilo* stem borers, biocontrol, taxonomy, Japan

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Introduction

Cotesia chilonis (Munakata, 1912) is a parasitoid wasp (Braconidae: Microgastrinae) originally described from Japan and widely used in biological control projects against caterpillar stem borers in the genus *Chilo* (Lepidoptera: Crambidae), pests of graminaceous crops in the Oriental and Afrotropical regions (Kfir et al. 1992, Polaszek and Walker 1992, Polaszek 1998).

Cotesia chilonis belongs to the *Cotesia flavipes* species complex, which includes four species parasitizing stemboring pests associated with sugarcane and cereal crops (Walker 1994, Muirhead et al. 2008). The monophyly of the complex is well supported by molecular (Smith and Kambhampati 1999; Michel-Salzat and Whitfield 2004; Muirhead et al. 2006, 2008) and morphological characters, such as a dorsoventrally compressed mesosoma (Watanabe 1965; Walker 1994, Muirhead et al. 2008).

The correct genus of the species, as well as its author and publication year (= original description) have long been in a state of confusion. As a result, the considerable literature on *C. chilonis* is replete with errors. The species has been placed either in *Apanteles* or in *Cotesia*, the authorship has been attributed either to Tetsuzo Munakata or to Shonen Matsumura, and the year of the original description has been cited as either 1910 or 1912.

Because of the importance of this species in biological control, the generic placement, author and year of description of *Cotesia chilonis* must be clarified.

Methods

We carefully examined the scientific literature relating to this species, including the report in which the species was originally described (Anonymous 1912). We made an effort to study all taxonomic references to *Cotesia chilonis* that we are aware of, and also consulted several colleagues who are proficient in Japanese and/or had seen the original paper (see Acknowledgments).

We estimated the number of citations for the different variants of the species names, species author, and year of publication by performing searches on Zoological Record, Google Scholar, and Google.

Results

Cotesia chilonis was originally described in *Apanteles* (the original description has 'Apanteles' misspelled as 'Apantetus', see Fig. 1). However, Mason (1981) divided *Apanteles* into several genera, either new or resurrected (such as *Cotesia* Cameron, 1891) and transferred many known species, but unfortunately not *Apanteles chilonis,* to his newly proposed genera. Mason's (1981) study was instrumental in highlighting the polyphyly of *Apanteles* s.l., a finding that led to the separation of *Cotesia* and *Apanteles* s.str. as separate, unrelated genera.

墨色、複眼黑褐色楕圓形、單眼三個頭頂ニアリ、触角系狀二十六節ヨリナル、胸部黑色翅蓋及ビ翅ノ基部黃色、翅透明、翅脈黃褐色、脚ハ橙黃色ヲ呈シ、後脛節ノ末端ハ黑色腹部紡錘形八節ヨリナリ產卵管赤褐色、

四、アヲモリコマユバチ

學名 Microplitis aomoriensis Mats.

（第二圖ノ四）

♀、体長二分、翅ノ開張四分二厘計リアリ、頭部黑色、複眼楕圓形ニシテ黑色、單眼三個、触角糸狀十八節ヨリナル、第一節ハ膨大シ第二節ト共ニ黑色ナレ共第三節以下ハ橙黃色ヲ呈ス、胸部黑色翅殆ント透明ニシテ翅脈黃褐ナリ、第二副前緣室ハ頗ル小形ニシテ第三副前緣室ハ脛室ト合一シ背走脈一個ヲ有ス、脚ハ基節ノ基部跗節ノ末端及ビ後脛節ノ末端ヲ除クノ外ハ悉ク橙黃色ナリ、腹部橙黃色ニシテ八節ヨリナリ腹端部ニ黑班ヲ有ス、產卵管赤褐色ニシテ長サ六厘許リアリ、♂ハ後脚跗節ノ黑色ナルト腹部ノ後端ニ於ケル黑色部多キトニヨリ區別セラル、

五、メイチユウコマユバチ、

學名 Apantetus chilonis Mats.

（第二圖ノ五）

♀、体長八厘、翅ノ開張一分六七厘アリ、頭部黑色、腹眼黑褐色ニシテ楕圓形、單眼橙黃色、触角糸狀十八節ヨリナル、胸部黑色ニシテ細毛ヲ裝ヒ、翅透明、翅脈橙黃色、脛室

六九

Figure 1. Copy of page 69 of the 1912 anonymous report with the original description of *Cotesia chilonis* (Munakata, 1912). The red square shows the original species name and attributed author.

Austin and Dangerfield (1989: 137) were the first authors to propose unequivocally the new combination, and to formally transfer the species to *Cotesia* (although they did so briefly in a paper section discussing unrelated species of *Apanteles*, and the nomenclatural act was not mentioned elsewhere). One year later Papp (1990: 117), unaware of that reference, proposed the same new combination (he did so in an Appendix rather unrelated to the main content of his paper, which was devoted to reporting Microgastrinae species from Korea). The fact that the new nomenclatural act was not clearly visible or referenced in either of those two papers probably contributed to subsequent overlooking of the new generic placement of *chilonis*. [Both Austin and Dangerfield (1989) and Papp (1990) attributed the authorship of the species to Matsumura instead of Munakata, see below for more discussion on that].

Cotesia has been universally recognized and accepted as a valid genus by the taxonomic and biological control research community (e.g., Yu et al. 2012, and references to the genus cited therein). However, due to the confusing circumstances detailed above, the species *C. chilonis* has continued to be variously placed in either *Apanteles* or *Cotesia*. For example, basic searches made in November, 2014 using the names '*Apanteles chilonis*' or '*Cotesia chilonis*' revealed, respectively 35 and 28 citations in Zoological Record and, 651 and 714 citations in Google Scholar. At the same time a general search in Google reveals 4,280 and 6,020 results, respectively.

Searches performed with Zoological Record, Google Scholar, and Google revealed an equally confusing mix for the author and publication year of *C. chilonis* (Table 1). *Cotesia chilonis* was originally described in a report of the Agriculture Experiment Station of Aomori, Japan. The report does not clearly state its author, but apparently it was written by Tetsuzo Munakata, although the species is mentioned in the paper as '*Apantetus chilonis* Mats.' (Fig. 1).

Watanabe (1965) provided additional and useful information on the author and year of publication, and it should be taken as the best information available to settle the issue. Watanabe (1965: 114, reproduced in Fig. 2) states that "In 1912 *Apanteles chilonis* was originally described anonymously as a parasite of the rice stem borer, *Chilo suppressalis*, but there are certain evidences that the author is Tetsuzo Munakata." The next sentences from Watanabe (see Fig. 2) suggest that Munakata sent the

Table 1. Searches performed in November 2014 on three different online databases or search engines, using two different strings of words: "Apanteles+Cotesia+chilonis+Matsumura" or "Apanteles+Cotesia+chilonis+Munakata".

Online Database/ Search Engine	*Apanteles/Cotesia chilonis* Matsumura (Total)	*Apanteles/Cotesia chilonis* Munakata (Total)
Zoological Record	8	9
Google Scholar	66	49
Google	3180	256

114

Okinawa, Mauritius and Australia.

Apanteles chilonis [Munakata]

Apantetus (!) *chilonis* [Munakata], Extra Report Agr. Exp. Sta. Aomori No. 2: 69, 1912. JAPAN: Aomori. Host: *Chilo suppressalis* (= *C. simplex*).

Apanteles (*Stenopleura*) *chilocida* Viereck. Proc. U. S. Nat. Mus. 43: 582, 1913. JAPAN. Host: *Chilo suppressalis*.

Apanteles chilocida: Wilkinson, Bull. Ent. Res. 19: 94, 1928.

Apanteles flavipes f. *chilonis*: Watanabe, Trans. Sapporo Nat. Hist. Soc. 12: 69, 1932.

In 1912 *Apanteles chilonis* was originally described anonymously as a parasite of the rice stem borer, *Chilo suppressalis*, but there are certain evidences that the author is Tetsuzo Munakata. The type is lost, and yet in the Entomological Institute, Hokkaido University, are deposited authentic material (4 ♀♀, Aomori, 1911, on a block of pith with a determination label — "*Apanteles chilonis* n. sp." — in Matsumura's own hand-writing) which was sent by Munakata to Prof. Matsumura for identification. From the series I have selected as neotype of *chilonis* the single female which is in the best condition. Just after the above-mentioned publication Viereck (1913) described originally *Apanteles chilocida* as a parasite of the same host. This name, however, already has been suppressed as a synonym of *chilonis* by Watanabe (1932).

This insect is so closely related to *A. flavipes* that there are two different views about the taxonomy of the Japanese form: Wilkinson (1928, etc.) treats it as a full species; on the other hand Watanabe (1932, etc.) considers it a form of *flavipes*. Having examined a number of specimens of both the forms I am much inclined to the opinion that *chilonis* should be treated as a distinct species. Differences are noticeable between the two in the punctuation of the prothorax, mesopleura and hind coxae as well as in the colouration of the hind coxae as states in the present key. These differences would seem to be more reliable to separate the two than the prominence of the face and the declivity of the propodeum which are characters used by Wilkinson in his key: because in *chilonis* those features tend to become inconspicuous, while in *flavipes* they seem to be very variable in strength.

In general, this species is darker in colour than *flavipes*: the antennae are yellowish brown to brown, not reddish yellow as in *flavipes*. Having examined the genitalia of both sexes I have found that there are no special differences between the two species in genital structures. The first abscissa of the radius is not clearly shorter than the transverse cubitus but as long as or sometimes rather longer than the latter.

JAPAN: Aomori, 4 ♀♀ (including the neotype of *chilonis*), 1911 (T. Munakata). Many other specimens examined are collected at the following localities: —Kyushu: Taniyama (S. Fukamachi); Yokkaichi and Fukuoka (I. Tateishi); Futsukaichi (K. Yano); and Miyazaki (H. Sakimura). Honshu: Masuda, Taito, Hikawa, Ota and Hamada (T. Fujishima); Kanazawa (H. Kawase); Shonai and Omagari (T. Hidaka); Nishiki-mura and Omagari (M. Kikuchi); and Morioka (H. Omori).

Figure 2. Copy of page 114 of Watanabe (1965). The red square shows the most relevant paragraphs. The words underlined with gray were made by an unknown source to the copy available to us for study, and are not related to the present paper.

specimens to Shonen Matsumura, who identified the species as '*Apanteles chilonis* n. sp.' and sent it back to Munakata, who then published the report with the species description in 1912.

From the above account, it seems evident that Matsumura was the one recognizing the new species, but Munakata was the one publishing it. This opinion from Watanabe agrees with that of other Japanese entomologists, e.g. the braconid specialist Kaoru Maeto (personal communication) and the ichneumonid specialist Jinhaku Sonan (1930: 141). Actually, the 1930 paper from Sonan provides an interesting fact. Sonan was dealing with another species described in the 1912 report (the ichneumonid '*Ophionellus biguttulus*' currently named '*Temelucha biguttula*'), and he also considered that, even though the original paper had written '*Ophionellus biguttulus* Mats.', Matsumura did not describe the species but it was Munakata (compare Figs 3 and 4).

Because the author of the species is not clear from the contents of the 1912 report, the author of the report (Munakata) should also be considered as the author of the species, as explained in The International Code of Zoological Nomenclature (ICZN). Article 50.1.1 states "However, if it is clear from the contents that some person other than an author of the work is alone responsible both for the name or act and for satisfying the criteria of availability other than actual publication, then that other person is the author of the name or act. "*If the identity of that other person is not explicit in the work itself, then the author is deemed to be the person who publishes the work.*" The last sentence (our italics) clearly applies here, and it should be used to recognize Munakata as the author of the species.

Watanabe, who should also be considered as the First Reviser, *sensu* Article 24.2 of the ICZN, unambiguously stated the authorship of the species in two papers: Watanabe (1932a: 69) and Wanatabe (1965: 114). Unfortunately he was not followed by subsequent authors. Most notably, the latest comprehensive list of world species of Braconidae (Shenefelt 1972: 468) mentioned Matsumura as the author. Shenefelt was probably the source of the mistake followed by other important references on Microgastrinae (Table 2) which unintentionally contributed to perpetuating the mistake –at least partially– until the present.

Last but not least, the year of publication has, at times, been confused by some sources (Table 2). The most common mistake (1910 instead of 1912) might have originated from another paper of Shenefelt (1965: 400), which misspelled Munakata as 'Munakato' and incorrectly assigned 1910 as the date for his report on *Cotesia chilonis*. For clarification about the actual date, we again follow Watanabe (1932a, 1932b, 1965), as he actually saw the report, studied Munakata's specimens, and even designated a neotype (Watanabe 1965: 114; see also Fig. 2).

The unfortunate chain of omissions and confusion in publications on *Cotesia chilonis* has led to this important species to be referred to by several generic names, authors, and years of publication. For the sake of clarity and stability, it is useful to provide in a single paper a complete account of the history and nomenclatural acts associated with this species. Based on the revised evidence, the history of names associated with *C. chilonis* is presented below. It is hoped that the correct names and dates (as presently understood) are adopted by future researchers.

J. Sonan: A few host-known Ichneumonidae found in Formosa (Hym.) (2). 141

$^2/_3$ as long as the body; mesonotum abruptly sloping apically, closely punctate and shortly pubescent, notauli obsolete; scutellum convex, closely rugose; propodeum rugose, with a rather broad, but sharrow median furrow, which is transversely striated, external and lateral areae distinct; spiracles elliptical; first tergite linear, glabrous, apex fusiform; 4th-9th tergites strongly compressed laterally throughout; tarsal claws pectinate.

Black. Apex of mandibles reddish brown; palpi, tegulae and legs yellowish brown; antennae, coxae and hind trochanter black; hind femolae reddish brown, base and apex of tibiae, apex of metatarsi and 2nd-5th joints dark brown; wings hyaline, stigma brown, areolet somewhat large, triangular, with a distinctly petiole; recurrent nervure straight, emiting from a little beyond the middle of areolet; basal nervure continuous.

Length: Body 8mm; ovipositor 4mm; fore wing 5mm.

Host. Larvae of *Homona menciana* Walker (Author).

Hab. Type ♀, Shiuchiku, Apr. 4, 1921 (Author): Paratype ♀, Heichin (Shinchiku-Shu), May 1, 1930 (Author).

This species is allied to *Limnerium forticarinatum* Cameron (1906) and *L. quettaeus* Cameron (1906), but differs from them by the wanting of areola of propodeum, elliptical spiracles, yellowish brown legs, and black apices of hind tibiae.

CREMASTUS, Cravenhorst. Ichn. Europ. iii, p. 730(1829).

Subgen. **TARYTIA** Cameron, Journ. Bombay Nat. Hist. Soc. p. 588 (1907) 14764

CREMASTIDEA, Viereck, Proc. U. S. Nat. Mus. 43, no. 1942 p. 587 (1912).

7950 **Cremastus (Tarytia) biguttulus** (Munakata).

Ophioellus biguttulus Matsumura (non desc.), Munakata. Extra Report Agric. Exp. Stat. Aomori, no. 2, p. 67, pl. ii

142 Trans. N. H. S. F. Vol. XX. (Jun. 1930)

fig. 1, ♀ (1910); Kondo, Extra Rept. Agric. Stat. Nagagaki, no. 15, p. 101 (1917); Nawa, Insect world Gifu, xix, no. 219, p. 456 (1915). (Japan).

1,7275 *Cremastus* (*Cremastidea*) *chinensis* Viereck, Proc. U. S. Nat. Mus. 43, no. 1942, p. 587, ♂ ♀ (1912). (China, Japan).

Deaparsis japonica Uchida (nec Ashmead), Jour. Fac. Agric. Hokk. Imp. Univ Sapporo, xxi, pt. 2, p. 285, pl. vi, fig. 16, ♀ (1928).

Figure 3. Copy of pages 141 and 142 (partially) of Sonan (1930). The red square shows Sonan's interpretation of the species author for one of the species described by Munakata in 1912. The annotations added with a pencil (in gray) were made by an unknown source to the copy available to us for study, and are not related to the present paper.

本調査ニ依レバ藁打法ハ螟虫驅除法ノ中最モ有効ナルモノノ一タルヲ失ハズ、而シテ其ノ回數ハ五十回ヲ以テ最適度ト認ムベキガ如シ、

七、敵蟲ニ關スル調査

第二十五、寄生蜂ニ關スル調査

本縣產二化螟虫ノ寄生蜂ニシテ從來發見シタルモノ六種アリ(內一種ハ第二寄生蜂ト認ムベキモノナリ)皆幼虫ニ寄生スルモノニシテ彼ノ他縣ニ多キ卵蜂ハ未ダ終ニ採集シタル事ナシ、寄生蜂ニ關シテハ目下研究中ニ屬シ何レ他日ノ調査ヲ俟チテ再ビ發表スル處アルベシト雖モ、今回ハ聊カ從來ノ發見ニ係ル寄生蜂ノ種類及ビ形態ノ概要ヲ記載シ以テ讀者ノ參考ニ供セントス、而シテ標本ハ全部東北帝國大學農科大學教授松村博士ノ鑑定ヲ乞ヒシニ何レモ新種トセラレ博士ノ好意ニヨリ學名及ビ和名ノ通知ヲ得タルモノナリ、

四十二年乃至四十四年調査

一、メイチユウアメバチ (第二圖ノ一)

學名 Ophioneilus bigutulus Mats.

六七

Figure 4. Copy of page 67 of the 1912 anonymous report. The red square shows the original species name and attributed author (compare it against Figure 3 above).

Table 2. Important published and/or web resources about Microgastrinae with differing accounts for the species *Cotesia chilonis* (Munakata, 1912). Comments in square brackets provide additional information when needed.

a) Sources with Munakata as author of the species, and publication year of 1912 (unless a different date is indicated in square brackets):

- Taxapad (http://www.taxapad.com/local.php?&indexstartGS=53166&taxgroupGS=ichneumonoidea) [As *Cotesia chilonis* (Munakata, 1910), the year 1910 and the authorship used in Taxapad were based on the following reference: Shenefelt, R.D. 1965. A contribution towards knowledge of the world literature regarding Braconidae (Hymenoptera: Braconidae). Beiträge zur Entomologie. 15(3/4):243-500. On page 400, the Munakata paper is dated as 1910 – and the name Munakata is misspelled as Munakato].
- Catalog of Life (http://www.catalogueoflife.org/annual-checklist/2014/search/all/key/*Cotesia+chilonis*/match/1).
- GBIF (http://www.gbif.org/species/1257878).
- Encyclopedia of Life (http://eol.org/pages/12063541/overview).
- Wikipedia (http://en.wikipedia.org/wiki/List_of_*Cotesia*_species) [Merely a citation from EOL].
- Microgastrinae Wasps of the World (http://microgastrinae.myspecies.info/microgastrinae/*Cotesia-chilonis*).
- Barcode of Life Data Systems (http://www.boldsystems.org/index.php/Public_SearchTerms?query=%22*Cotesia*%20*chilonis*%22[tax]) [The records included in BOLD were mined from GenBank].

b) Sources with Matsumura as author of the species, and publication year of 1912 (unless a different date is indicated in square brackets):

- ZooBank (http://zoobank.org/Search?search_term=*Apanteles+chilonis*) [As *Apanteles chilonis* Matsumura, 1912. ZooBank does not have any record as '*Cotesia chilonis*'].
- Shenefelt 1972 (Braconidae 4. Microgasterinae: *Apanteles*. Hymenopterorum Catalogus, 1972: page 468) [This paper represents the last comprehensive list of world species of Braconidae].
- Whitfield Lab website (http://www.life.illinois.edu/whitfield/*Cotesia*/*Cotesia*.htm) [As *Cotesia chilonis* Matsumura, 1926; the year is most likely a typographical mistake. This website contains a significant number of *Cotesia* species illustrations and is a valuable reference on the topic].
- Sharkey Lab website (http://www.sharkeylab.org/*Cotesia*/*Cotesia*.cgi) [This website contains a significant number of *Cotesia* species illustrations and is a valuable reference on the topic].

Cotesia chilonis (Munakata, 1912)

Apantetus chilonis Munakata, 1912: 69. Original description. Misspelling of the genus name.

Apanteles chilonis Matsumura in Munakata, 1912: 69. Shenefelt 1972: 468. Incorrect assignment of author of the species. [Subsequently followed by a substantial number of authors, websites, and online databases].

Apanteles flavipes f. *chilonis* Watanabe, 1932: 84. Junior subjective synonym [In the References below, this paper is cited as 'Watanabe 1932b' to distinguish it from another work published by Watanabe in 1932 and also cited in the present paper].

Apanteles chilonis Munakata, 1912. Watanabe 1965: 114. Reinstatement as valid species.

Cotesia chilonis (Matsumura, 1912). Austin and Dangerfield 1989: 137. New combination. Incorrect assignment of author of the species.

Cotesia chilonis (Matsumura, 1912). Papp 1990: 117. Unnecessary 'new combination'. Incorrect assignment of author of the species.

Cotesia chilonis Munakata, 1910. Yu et al. 2012. Incorrect assignment of date for species description.

Apanteles chilocida Viereck, 1912: 582. Watanabe 1932: 69. Junior subjective synonym. Incorrect date (1913) assigned to Viereck's paper. [In the References below, this paper is cited as 'Watanabe 1932a' to distinguish it from another work published by Watanabe in 1932 and also cited in the present paper].

Acknowledgements

The decisions made in this paper about names, authors and dates related to *Cotesia chilonis* benefited considerably from fruitful discussion with several colleagues. Dr John Steel (University of Otago, New Zealand) helped in establishing contact with Japanese colleagues and kindly sent copies of some of the most important references used for this paper. Dr Katsuhiko Sayama (Hokkaido Research Center, Forestry and Forest Products Research Institute, Japan) kindly provided useful comments and copies of some of the most important references used for this paper. Dr Kaoru Maeto (Kobe University, Japan) kindly shared his opinions on the names and authors historically associated with the species. Dr John Huber and Dr Gary Gibson (Canadian National Collection of Insects, Ottawa, Canada) revised earlier versions of the manuscript and helped to clarify contents.

References

Anonymous (1912) Extra Report Agric. Exp. Stat. Aomori 2: 67–69.

Austin AD, Dangerfield PC (1989) The taxonomy of New World microgastrine braconids (Hymenoptera) parasitic on *Diatraea* spp. (Lepidoptera: Pyralidae). Bulletin of Entomological Research 79(1): 131–144. doi: 10.1017/S0007485300018642

Kfir R, Overholt WA, Khan Z, Polaszek A (2002) Biology and management of economically important lepidopterous cereal stem borers in Africa. Annual Review of Entomology 47: 701–731. doi: 10.1146/annurev.ento.47.091201.145254

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.

Michel-Salzat A, Whitfield JB (2004) Preliminary evolutionary relationships within the parasitoid wasp genus *Cotesia* (Hymenoptera: Braconidae: Microgastrinae): combined analysis of four genes. Systematic Entomology 29: 1–12. doi: 10.1111/j.0307-6970.2004.00246.x

Muirhead KA, Murphy NP, Sallam MN, Donnellan SC, Austin AD (2006) Mitochondrial DNA phylogeography of the *Cotesia flavipes* complex of parasitic wasps (Hymenoptera: Braconidae). Annales de la Société Entomologique de France 42: 309–318. doi: 10.1080/00379271.2006.10697462

Muirhead KA, Austin AD, Sallam MN (2008) The systematics and biology of *Cotesia nonagriae* (Olliff) stat. rev. (Hymenoptera: Braconidae: Microgastrinae), a newly recognized member of the *Cotesia flavipes* species complex. Zootaxa 1846: 35–46.

Papp J (1990) Braconidae (Hymenoptera) from Korea. XII. Acta Zoologica Hungarica 36(1–2): 87–119.

Polaszek A (Ed.) (1998) African cereal stem borers: Economic importance, taxonomy, natural enemies and control. CAB International, 530 pp.

Polaszek A, Walker AK (1992) The *Cotesia flavipes* species-complex: parasitoids of cereal stem borers in the tropics. Redia 74: (3) "Appendice" (1991): 335–341.

Shenefelt RD (1965) A contribution towards knowledge of the world literature regarding Braconidae (Hymenoptera: Braconidae). Beiträge zur Entomologie 15(3/4): 243–500.

Shenefelt RD (1972) Braconidae 4. Microgasterinae: *Apanteles*. Hymenopterorum Catalogus (nova editio), Pars 7, 429–668.

Smith PT, Kambhampati S (1999) Status of the *Cotesia flavipes* species complex (Braconidae: Microgastrinae) based on mitochondrial 16S, rRNA and NADH 1 dehydrogenase gene sequence. Journal of the Kansas Entomological Society 72: 306–314.

Sonan J (1930) A few host-known Ichneumonidae found in Formosa (Hym.) (2). Transactions of the Natural History Society of Formosa. Taihoku 20: 137–144.

Walker AK (1994) Species of Microgastrinae (Hymenoptera: Braconidae) parasitizing lepidopterous cereal stem borers in Africa. Bulletin of Entomological Research 84: 421–434. doi: 10.1017/S0007485300032557

Watanabe C (1932a) A revision of Braconid-species parasitic in the injurious insects of rice-plant and sugar-cane in Japan and Formosa. Transactions of the Sapporo Natural History Society 12: 63–71.

Watanabe C (1932b) Notes on the Braconidae. III. *Apanteles*. Insecta Matsumurana 7: 74–102.

Watanabe C (1965) Notes on the *Apanteles flavipes* complex (Hymenoptera, Braconidae). Mushi 38: 111–116.

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

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SHORT COMMUNICATION

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Diploid males of *Scaptotrigona depilis* are able to join reproductive aggregations (Apidae, Meliponini)

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Abstract

The sex determination system in the eusocial stingless bees (Apidae, Meliponini) is based on the combination of alleles at the complementary sex determination (CSD) locus. In this system, males are haploid and females are diploid. However, diploid males can develop from fertilized eggs when they are homozygous at single or multiple sex loci. The production of such males can negatively affect population viability, since they are usually infertile or inviable. Moreover, when they are viable but infertile, or siring sterile triploid offspring, this could cause another load on the population, leading the fertilized offspring of other females to be only haploid males or triploid sterile daughters. In this context, our aim was to verify whether diploid males of the stingless bee *Scaptotrigona depilis* do in fact join reproductive aggregations. We showed that of 360 marked males from two different colonies, five were participating in a reproductive aggregation *ca*. 20 meters from their natal colonies. Using microsatellites markers, it was confirmed that three of these five males were diploid. They were captured in the mating aggregations when they were 15 to 20 days old. Further research is necessary to determine the mating success of stingless bee diploid males under natural conditions and to determine their impact on stingless bee population extinction risks.

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Keywords
Inbreeding, diploid male load, population viability, stingless bees

Introduction

The system of sex determination in the eusocial stingless bees (Apidae, Meliponini) has been shown to be based on the combination of alleles at the complementary sex determination (CSD) locus (Camargo 1979), like many other Hymenoptera (Whiting 1943). Under this system, individuals that are heterozygotes at the CSD locus are females, while the hemizygotes (haploid individuals) and the homozygotes are males (Whiting 1943; Cook and Crozier 1995).

With few exceptions (El Agoze et al. 1994; Cowan and Stahlhut 2004; Kureck et al. 2013), diploid males are highly disadvantageous for the Hymenoptera species they occur in, imposing fitness costs on their relatives. Most of the time they are unviable, infertile or lead to the production of infertile triploid broods (Heimpel and de Boer 2008). They also lead to the decrease of females in the population, since the diploid individuals were supposed to develop into females, increasing the extinction risks of the population (Zayed and Packer 2005).

Simulation models have shown that extinction risks increase when diploid males are viable and can mate (Zayed and Packer 2005). This is expected because females mortality would increase over two generations, first in the diploid offspring that was supposed to be female but ends as an infertile diploid male, and secondly because the females that mate with diploid male would produce triploid daughters or only haploid males (Harpur et al. 2013). Indeed it has been shown that in several hymenopteran species the diploid males are able to mate (reviewed in Heimpel and de Boer 2008).

The extinction risks are even more extreme for stingless bees, since their nests are sparse and, together with habitat fragmentation, there are few effective population sizes (Packer and Owen 2001; Zayed 2009). It is well known that the queens mate only once in this group (Peters et al. 1999), causing half of their diploid brood to develop into diploid males when there is a matched mating (queen mating with a male with the same sex allele), greatly reducing their fitness (Cook and Crozier 1995) and increasing population extinction risks when there is low population size or low sex alleles variability (Alves et al. 2011). Therefore, to assess the effects of the diploid males on stingless bee conservation, it is important to know the viability of diploid males and their participation on the reproductive events. Despite some previous observations of aggressive behaviour of workers towards the diploid males in *Melipona interrupta*, suggesting that although the diploid males are viable they would be killed before leaving the nest (Francini et al. 2012), diploid males of *Tetragonisca angustula* were found in a reproductive aggregation close to the entrance of a queenless colony (Santos et al. 2013).

Here we investigate the fate of diploid males of *Scaptotrigona depilis* and aimed to answer the question: do diploid males leave their colonies to join mating aggregations?

Table 1. Age at collection and genotypes of diploid males of *Scaptotrigona depilis* in a reproductive aggregation.

Colony and male	Age (days)	Males' genotypes at locus					
		T1	T3	T4	T8	Sxant 06	Sxant 18
1-a	18	140/142	125/129	132/140	147/153	175/177	172/192
1-b	15	140/142	125/129	132/138	153/153	177/181	170/172
2-c	19	138/142	125/129	132/140	147/153	177/179	172/174

In order to answer this question, two free-foraging colonies kept in wooden boxes in the Biology Department at São Paulo University (Ribeirão Preto, Brazil) were utilised. These colonies were chosen because their queens were producing diploid males, as previously confirmed through genotyping ten male pupae from each colony following the methods described below. We collected brood combs containing mature pupae and let the bees emerge in an incubator. Thirty newly emerged males of each colony were marked with nontoxic paint (Revell GmbH & Co. KG, Germany) on their thorax for six days, using a different colour for each day (total 360 marked males) and all the males were reintroduced into their natal nest on the day of marking. During the time of the study, the mating aggregations were observed twice a day, and any marked males present were collected. They were preserved in absolute ethanol for genetic analysis. The DNA was extracted using the Chelex method and males were genotyped at six microsatellite *loci*, T1, T3, T4 and T8 (Paxton et al. 1999), and Sxant06 and Sxant18 (Duarte et al. 2011). Microsatellite amplification and visualization were done as described previously by Francisco et al. (2011). Males were categorized as diploid if they were heterozygous at one or more loci (Alves et al. 2011).

Five marked males were found at two mating aggregations which were approximately 20 meters from their natal colonies. Three of them were diploid, since almost all loci showed two different alleles (Table 1), whereas the other two were likely haploid. The age of diploid males within the aggregation ranged from 15 to 20 days old (Table 1), and the haploid were from 16 and 20 days old.

These findings suggest that the presence of stingless bee diploid males in mating aggregations may be more common than previously suspected. Our data are in accordance with those obtained by Santos et al. (2013), who also found diploid males in a mating aggregation of *T. angustula*. Although the workers of stingless bees are supposed to recognize and kill diploid males inside the nests (Francini et al. 2012), it is clear that some of these escape worker policing, depart from their colonies, and become a member of a reproductive aggregation (Santos et al. 2013; this study). It is important to note that removing the brood combs and allowing the pupae to emerge out of the colony context might have enhanced their survival. However, no aggressive behaviour towards males in colonies producing diploid males during their emergence was observed (this study). Camargo (1982) verified that the average lifespan of diploid males of *M. quadrifasciata* is only three days, while haploid males live 15 days on average, both in artificial conditions. The average lifespans of haploid and diploid males of

S. depilis were not compared, but if there are any physiological constraints that limit the diploid males' life span, at least some of them must live long enough to be able to join mating aggregations.

Some new information about the mating strategies of *S. depilis* males was discovered. Despite the fact that stingless bee males disperse away from their natal nests to avoid inbreeding (Paxton 2000; Cameron et al. 2004; Kraus et al. 2008), some of them (haploid or diploid) join aggregations very close to their original colonies. It is important to note that this is a managed population kept in a stingless bee apiary maintaining up to 100 nests in a small area. Further research on this topic is needed to draw stronger conclusions.

These results add more precision as to the age of sexual maturity age of male stingless bees, since previous studies considered only the age that males of leave the nest (an average of 18.6 days old in *M. favosa*; van Veen et al. 1997). It is showed here that both haploid and diploid males join mating aggregations from 15 to 20 days old. It was not possible to ascertain that this was their first experience in a mating aggregation since they could have already visited one previously. However, considering that Pech-May et al. (2012) found that *M. beecheii* males are sexually mature at *ca*. 14 days old, it is possible that males of *S. depilis* also mature later in life, and would join reproductive aggregations only when mature.

Despite the few diploid males found in mating aggregation compared to the marking effort and presence of approximately one thousand individuals therein, there is a great chance that a much higher fraction of diploid males produced by *S. depilis* leave the nest to search for an aggregation site, since there is good evidence that males disperse from their natal nests (Cameron et al. 2004; Kraus et al. 2008). This could also explain why only *ca*. 1.4% of the marked males were recaptured. Probably, the majority of males had dispersed to distant aggregations that we did not sample. However, some did not disperse and thus increased the risks of inbreeding. It is important to note that our manipulation may have allowed the males to live normally by minimizing worker policing. Additionally, diploid male production in social insects under monandry is predicted to be very high, since half of the diploid brood are diploid males when a matched mating is performed. As this species produces approximately 200 or more new brood cells per day (this study), even if just a small fraction of the diploid males succeeded in leaving the nest, the total amount could be high.

All these factors together (high rate of production of diploid males, survivorship, and visit to mating sites) strongly suggest that diploid males could be dangerous to stingless bee populations from the females' point of view (Harpur et al. 2013). Further research is needed to verify the potential mating success of *S. depilis* diploid males, since we had no success when testing this under controlled conditions, following the protocol established by Engels and Engels (1984). If it is established that diploid males of *S. depilis* can successfully mate, this would suggest that this species is under a higher risk of extinction due to the decreased fitness of queens that mate with them (Zayed 2009; Harpur et al. 2013).

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References

Alves DA, Imperatriz-Fonseca VL, Francoy TM, Santos P, Billen J, Wenseleers T (2011) Successful maintenance of a stingless bee population despite a severe genetic bottleneck. Conservation Genetics 12(3): 647–658. doi: 10.1007/s10592-010-0171-z

Camargo CA (1982) Longevity of diploid males, haploid males, and workers of the social bee *Melipona quadrifasciata* Lep. (Hymenoptera: Apidae). Journal of the Kansas Entomological Society 55(1): 8–12.

Camargo CA (1979) Sex determination in bees. XI Production of diploid males and sex determination in *Melipona quadrifasciata*. Journal of Apicultural Research 18: 77–84.

Cameron EC, Franck P, Oldroyd BP (2004) Genetic structure of nest aggregations and drone congregations of the southeast Asian stingless bee *Trigona collina*. Molecular Ecology 13(8): 2357. doi: 10.1111/j.1365-294x.2004.02194.x

Cook J, Crozier RH (1995) Sex determination and population biology in the Hymenoptera. Trends in Ecology and Evolution 10: 281–286. doi: 10.1016/0169-5347(95)90011-X

Cowan DP, Stahlhut JK (2004) Functionally reproductive diploid and haploid males in an inbreeding hymenopteran with complementary sex determination. Proceedings of the National Academy of Sciences USA 101(28): 10374–10379. doi: 10.1073/pnas.0402481101

Duarte OMP, Gaiotto FA, Souza AP, Mori GM, Costa MA (2011) Isolation and characterization of microsatellites from *Scaptotrigona xanthotricha* (Apidae, Meliponini): a stingless bee in the Brazilian Atlantic rainforest. Apidologie 43(2): 432–435.

El Agoze M, Drezen J, Renault S, Periquet G (1994) Analysis of the reproductive potential of diploid males in the wasp *Diadromus pulchellus* (Hymenoptera: Ichneumonidae). Bulletin of Entomological Research 84(2): 213–218. doi: 10.1017/S0007485300039717

Engels E, Engels W (1984) Drone aggregations near the nest of the stingless bee, *Scaptotrigona postica*. Apidologie 15(3): 315–328. doi: 10.1051/apido:19840304

Francini IB, Nunes-Silva CG, Carvalho-Zilse GA (2012) Diploid male production of two Amazonian *Melipona* bees (Hymenoptera: Apidae). Psyche 2012: ID 484618.

Francisco FO, Brito RM, Santiago LR, Gonçalves PHP, Pioker FC, Domingues-Yamada AMT, Arias MC (2011) Isolation and characterization of 15 microsatellite loci in the stingless bee *Plebeia remota* (Apidae: Meliponini). Conservation Genetics Resources 3(3): 417–419. doi: 10.1007/s12686-010-9369-0

Harpur BA, Sobhani M, Zayed A (2013) A review of the consequences of complementary sex determination and diploid male production on mating failures in the Hymenoptera. Entomologia Experimentalis et Applicata 146(1): 156–164. doi: 10.1111/j.1570-7458.2012.01306.x

Heimpel GE, de Boer JG (2008) Sex determination in the Hymenoptera. Annual Review of Entomology 53: 209–230. doi: 10.1146/annurev.ento.53.103106.093441

Kraus FB, Weinhold S, Moritz RFA (2008) Genetic structure of drone congregations of the stingless bee *Scaptotrigona mexicana*. Insectes Sociaux 55(1): 22–27. doi: 10.1007/s00040-007-0966-1

Kureck IM, Nicolai B, Foitzik S (2013) Similar performance of diploid and haploid males in an ant species without inbreeding avoidance. Ethology 119: 360–367. doi: 10.1111/eth.12073

Packer L, Owen R (2001) Population genetic aspects of pollinator decline. Conservation Ecology 5(1): 4.

Paxton RJ (2000) Genetic structure of colonies and a male aggregation in the stingless bee *Scaptotrigona postica*, as revealed by microsatellite analysis. Insectes Sociaux 47(1): 63–69. doi: 10.1007/s000400050010

Paxton RJ, Weissschuh N, Quezada-Euán JJG (1999) Characterization of dinucleotide microsatellite loci for stingless bees. Molecular Ecology 8(4): 690–692. doi: 10.1046/j.1365-294x.1999.00874.x

Pech-May FG, Medina-Medina L, May-Itzá WJ, Paxton RJ, Quezada-Euán JJG (2012) Colony pollen reserves affect body size, sperm production and sexual development in males of the stingless bee *Melipona beecheii*. Insectes Sociaux 59: 417–424. doi: 10.1007/s00040-012-0236-8

Peters JM, Queller DC, Imperatriz-Fonseca VL, Roubik DW, Strassmann JE (1999) Mate number, kin selection and social conflicts in stingless bees and honeybees. Proceedings of the Royal Society of London B 266(1417): 379–384. doi: 10.1098/rspb.1999.0648

Santos CF, Menezes C, Imperatriz-Fonseca VL, Arias MC (2013) A scientific note on diploid males in a reproductive event of a eusocial bee. Apidologie 44(5): 519–521. doi: 10.1007/s13592-013-0202-0

van Veen JW, Sommeijer MJ, Meeuwsen F (1997) Behaviour of drones in *Melipona* (Apidae, Meliponinae). Insectes Sociaux 44(4): 435–447. doi: 10.1007/s000400050063

Whiting P (1943) Multiple alleles in complementary sex determination of *Habrobracon*. Genetics 28(5): 365–382.

Zayed A (2009) Bee genetics and conservation. Apidologie 40(3): 237–262. doi: 10.1051/apido/2009026

Zayed A, Packer L (2005) Complementary sex determination substantially increases extinction proneness of haplodiploid populations. Proceedings of the Natonal Academy of Sciences USA 102(30): 10742. doi: 10.1073/pnas.0502271102

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SHORT COMMUNICATION

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Further observations on the nesting behavior of *Penepodium luteipenne* (Hymenoptera, Sphecidae)

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Abstract

Stereotyped motor patterns related to oviposition and prey transport of the cockroach-hunting solitary wasp *Penepodium luteipenne* (Fabricius, 1804) are described. Notes on provision, structure and aggregation of the nests are also provided. The fieldwork was carried out in the Biological Station of Santa Lúcia, an area covered with Atlantic Forest in Southeastern Brazil.

Keywords

Biology, stereotyped motor patterns, Podiini, *Podium*, *Trigonopsis*, *Dynatus*

Introduction

The neotropical genus *Penepodium* Menke *in* Bohart & Menke, 1976, with 22 recognized species (Pulawski 2015a), is part of a monophyletic group of four genera of cockroach-hunting wasps (Ohl 1996) in the tribe Podiini (Pulawski 2015b). Because the biology of this genus is poorly known, we have studied *Penepodium luteipenne* (Fabricius, 1904) in forested areas of Rio de Janeiro State, southeastern Brazil (Buys 2001, 2009, 2011, 2012). Here, we present further observations on the reproductive behavior of this species.

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Methods

The observations were carried out in the Biological Station of Santa Lúcia, an area with 440 hectares of preserved Atlantic Forest in city of Santa Teresa (19°56'10"S and 40°36'06"W), Espírito Santo State, southeastern Brazil. Six nesting females were observed in 2008 and 2009; another female was observed and filmed in details in 2012 during two consecutive days. Voucher specimens were deposited in the Entomological Collection of the Instituto Oswaldo Cruz, Rio de Janeiro, RJ, Brazil.

Results and discussion

Nest provision, structure and aggregation

The females provided the nests with one to four nymphs or adults of a species of the genus *Poeciloderrhis* Stål, 1874 (Blattodea: Blaberidae). The nests were unicellular and consisted of not branched vertical tunnels, with a narrower canal that leads the opening to the cell (Fig. 1), similar to those described by Buys (2012). The nests were found in compacted clay soil, in open sites, exposed to the sun.

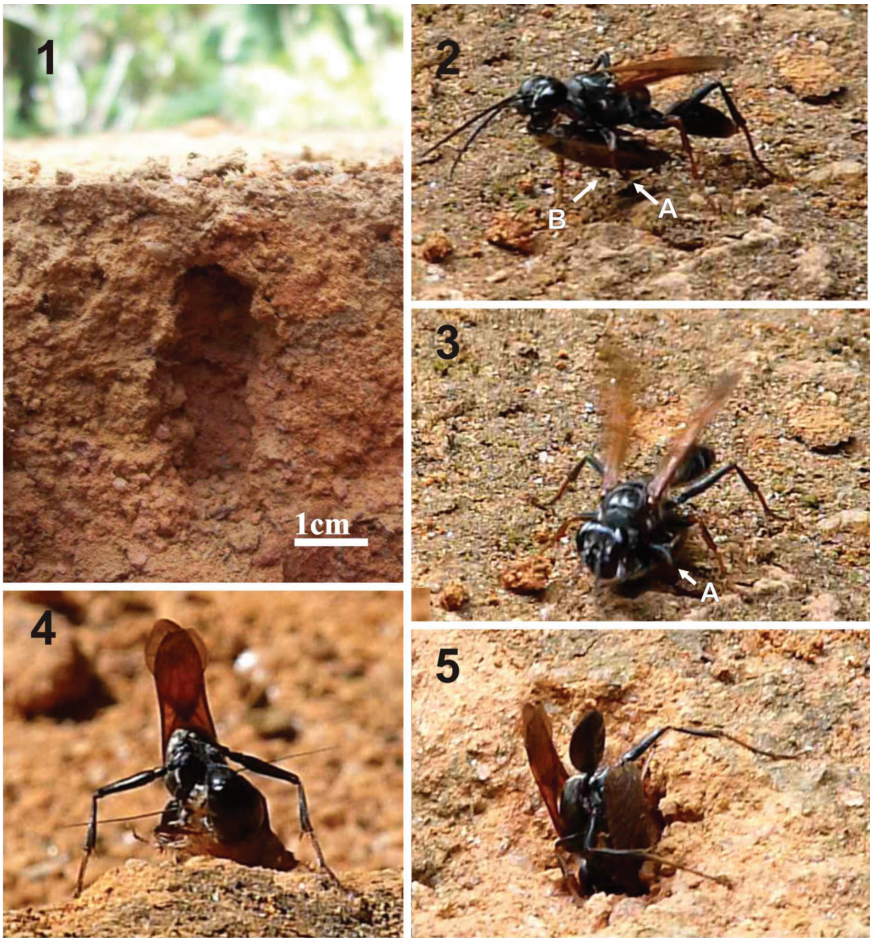
At one nesting site, within an area of about 1.5 m^2, we excavated 16 nests, whose entrances were separated from one another by 9–129 cm. Since females *P. luteipenne* dig several nests gregariously and defend the nesting site against conspecific females and other walking insects (Buys 2012), it is possible that all of these nests, or at least part of them, has been dug by the same female. Measurements of some of these nests are showed in Table 1.

Prey-carrying behavior

The carrying prey mechanism of *P. luteipenne* was previously described (Buys 2012), but herein a new noteworthy observation is added: females carry small prey by holding the bodies of the prey with one midleg and one foreleg (Figs 2–3), besides grasping the prey antennae with the mandibles. This represents a relatively unusual form of transport.

Oviposition behavior

To our earlier observations, we can now add the following. While ovipositing, a female *P. luteipenne* uses one middle leg to move the forelegs of the prey aside, aiding it to lay eggs in hidden and protected places behind the forecoxae of the prey (Fig. 4). At the same time, the female extends her long hind legs and raises the posterior portion of the prey (Fig. 4), so she can use her middle legs to manipulate the prey. The female also uses her hind legs to anchor her body when she places prey inside the nest (Fig. 5).



Figures 1–5. Nesting behavior of a female *Penepodium luteipenne*. **1** Nest in profile, the narrower canal that the leads the opening to the cell is entirely closed with a plug of earth **2–3** carrying of the prey (A = left foreleg, B = right middle leg) **4** oviposition **5** deposition of the prey inside the nest.

Table 1. Nest length and cell width of nests of *Penepodium luteipenne*.

Nest number	Nest length (cm)	Cell width (cm)
1	5.5	-
2	4.9	-
3	5.0	1.2
4	5.0	1.1
5	5.0	1.4
6	4.8	1.0
7	4.7	-
8	4.8	1.4
9	5.0	-
10	4.9	-
11	4.5	-

Buys (2012) already discussed that the oviposition outside the nest may be due to the lack of space inside her small nests to the female executing the stereotyped sequence of ovipositing behavior; the present observation reinforces this hypothesis.

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Reference

Buys SC (2001) Last instar larva of *Penepodium dubium* (Hymenoptera: Sphecidae). Revista de Biología Tropical 49 (1): 327–330.

Buys SC (2009) Larval behaviour and development of *Penepodium luteipenne* (Fabricius, 1804). Mitteilungen des Internationalen Entomologischen Vereins 34: 33–40.

Buys SC (2011) Seasonal change in the nesting site of an aggregation of a sphecid wasp in the southeastern Brazil (Hymenoptera: Apoidea: Sphecidae). Mitteilungen des Internationalen Entomologischen Vereins 36(3/4): 99–105.

Buys SC (2012) Nesting habits, alternative nesting tactics and female territoriality of the cockroach-hunting solitary wasp *Penepodium luteipenne* (Hymenoptera, Sphecidae). Journal of Hymenoptera Research 24: 27–41. doi: 10.3897/JHR.24.1828

Ohl M (1996) The Phylogenetic Relationships within the Neotropical Podiinae with Special Reference to Podium Fabricius (Hymenoptera: Apoidae: "Sphecidae"). Deutsche Entomologische Zeitschrift 43: 189–218. doi: 10.1002/mmnd.19960430204

Pulawski WJ (2015a) *Penepodium*. http://researcharchive.calacademy.org/research/entomology/Entomology_Resources/Hymenoptera/sphecidae/Genera/Penepodium.pdf [accessed May 19, 2015]

Pulawski WJ (2015b) Family group names and classification. http://researcharchive.calacademy.org/research/entomology/Entomology_Resources/Hymenoptera/sphecidae/Family_group_names_and_classification.pdf [accessed May 19, 2015]