

A new genus from Vietnam (Hymenoptera, Braconidae, Opiinae), and the description of two new species

Qiong Wu¹, Cornelis van Achterberg², Ying-yi Sheng¹, Xue-xin Chen¹

1 Institute of Insect Sciences, Zhejiang University, Zijingang Campus, Yuhangtang Road 866, Hangzhou 310058, China **2** Shaanxi Key Laboratory for Animal Conservation, Northwest University, 229 North Taibai Road, Xi'an, Shaanxi 710069, China

Corresponding author: Xue-xin Chen (xxchen@zju.edu.cn)

Academic editor: G. Broad | Received 5 August 2018 | Accepted 17 September 2018 | Published 31 October 2018

<http://zoobank.org/155C57C6-E09F-49A8-BFB7-6FF4F7E82EA8>

Citation: Wu Q, van Achterberg C, Sheng Y-Y, Chen X-X (2018) A new genus from Vietnam (Hymenoptera, Braconidae, Opiinae), and the description of two new species. Journal of Hymenoptera Research 66: 1–13. <https://doi.org/10.3897/jhr.66.28881>

Abstract

Two aberrant species of Opiinae are described and illustrated from Vietnam, of which one is included into a new genus (*Canalopius* **gen. n.**; type species: *C. periscopus* **sp. n.**). The other species, *Xynobius chrysops* **sp. n.** belongs to an aberrant group of species near *X. maculipennis* (Enderlein, 1912).

Keywords

Braconidae, Opiinae, *Canalopius*, *Xynobius*, new genus, new species, Oriental, Vietnam

Introduction

The large subfamily Opiinae (Braconidae), with 2,060+ valid species (Yu et al. 2016), is a common group of parasitoid wasps. It has a worldwide distribution and the world fauna has been reviewed by Fischer (1972, 1977, 1986, 1987) with most species dumped into one genus (*Opius* Wesmael, 1835 *sensu lato*). The number of genera and the limits of several genera are still a matter of discussion, despite updates by Wharton (1988, 1997), van Achterberg (1997, 2004a, 2004b), van Achterberg and Salvo (1997), van Achterberg and Chen (2004), and Li et al. (2013). Currently about 39 genera are used, with about 60 additional names circulating in the existing literature;

mostly as subgenera in the genus *Opius* Wesmael *s.l.* Recently, 28 subgenera were synonymized in Li et al. (2013).

Xynobius is a fairly large genus, of which many described species remain wrongly classified in *Opius*. Another problem is the undercollecting of this group; we have seen many new species from the Palaearctic and Oriental regions in the few recently made collections. One of these collections is from Vietnam assembled by a joint effort of Naturalis Biodiversity Center (RMNH, Leiden) and the Institute of Ecology & Biological Resources (IEBR, Hanoi). During a short visit to Leiden the first author sorted the two highly aberrant species of Opiinae described in this paper.

Opiinae are solitary koinobiont endoparasitoids of dipteran larvae. The parasitoid larva has its final development when the host larva has made its puparium; after pupation the adult wasp emerges from this puparium (Shaw and Huddleston 1991).

Material and methods

The material examined is deposited in the collection of Naturalis Biodiversity Center (RMNH) at Leiden. The specimens were collected in alcohol 70% using Malaise traps and the specimens were later prepared with the AXA method (van Achterberg 2009) and card-pointed.

For identification of the subfamily Opiinae, see van Achterberg (1990, 1993), for identification of the genera, see Wharton (1997, 2009), Chen and Weng (2005), Li et al. (2013), Tan et al. (2016) and the diagnosis of the new genus in this paper. For references to the biology, see Yu et al. (2016) and for the morphological terminology used in this paper, see van Achterberg (1988, 1993), including the abbreviations for the wing venation. Measurements are taken as indicated by van Achterberg (1988): for the length and the width of a body part the maximum length and width is taken, unless otherwise indicated. The length of the mesosoma is measured from the anterior border of the mesoscutum till the apex of the propodeum and of the first tergite from the posterior border of the adductor till the medio-posterior margin of the tergite.

Descriptions and measurements were made under a stereomicroscope (Zeiss Stemi SV 6). Photographs were made with a Keyence VHX-2000 digital microscope.

Taxonomy

Canalopius Wu & van Achterberg, gen. n.

<http://zoobank.org/13A7B5E2-9667-4B03-9067-4BAC30CA5B27>

Figs 1–11

Type species. *Canalopius periscopus* sp. n.

Etymology. From “canalis” (Latin for “groove, channel”) and the generic name *Opius*, because of the channel-like groove of the occiput. Gender: masculine.

Diagnosis. Vertex and occiput with very deep medial groove up to between posterior ocelli; vertex depressed near posterior ocelli; stemmaticum reversed “Y”- shaped, abruptly protruding and with anterior ocellus on anterior branch far above frons (Figs 1b–e, 5, 8); anterior ocellus close to level of antennal sockets and distance between anterior ocellus and posterior ocellus nearly twice distance between posterior ocelli; anterior ocellus on protruding crest; occipital carina entirely absent; mandible slightly twisted, its basal half dorsally and ventrally with fine carina, nearly straight ventrally, apically gradually narrowed and with second teeth much smaller than first tooth (Figs 2, 4); precoxal sulcus present medially; medio-posterior depression of mesoscutum absent; dorsal surface of propodeum narrow, coarsely crenulate in front of curved carina, and medio-longitudinal carina complete; vein 2-SR of fore wing present; base of hind tibia without carinula at inner side and setose; legs robust (Fig. 1a); dorsope absent; second slightly shorter than third tergite and both smooth; ovipositor sheath short, hardly protruding.

Distribution. Oriental (Vietnam).

Biology. Unknown.

Notes. The new genus will run in the key to world genera by Wharton (1997) and the key to Chinese genera by Chen and Weng (2005) to the genus *Opius* Wesmael, 1835; in the key by Fischer (1972) it ends up at *Desmiostoma* Foerster, 1863, because of the absence of an occipital carina. In Li et al. (2013) it runs to *Rhogadopsis* Brèthes, 1913, because of the venation and the medio-longitudinal carina of the propodeum. The new genus can be separated from all known genera as follows:

- 1 Anterior ocellus close to level of antennal sockets and distance between anterior ocellus and posterior ocellus nearly twice distance between posterior ocelli; anterior ocellus on protruding crest; occiput with deep median groove; occipital carina absent laterally; transverse carina of propodeum present
..... ***Canalopius* Wu & van Achterberg, gen. n.**
- Anterior ocellus distinctly removed from level of antennal sockets and distance between anterior ocellus and posterior ocellus similar to distance between posterior ocelli; anterior ocellus without crest; occiput without median groove; occipital carina usually present laterally, if absent (*Desmiostoma* and some *Opius* spp.) then also transverse carina of propodeum lacking
..... **other genera of Opiinae**

***Canalopius periscopus* Wu & van Achterberg, sp. n.**

<http://zoobank.org/4090EEFF-66E0-491E-BDFD-C315FC2817AD>

Figs 1–11

Type material. Holotype, ♀ (RMNH), “N. Vietnam: Hoa Binh, Pa Co Hang Kia N.R., 20°44'35"N, 104°56'22"E, 1030 m, 9–23.x.2009, Mal[aise] tr[ap] 2, C. van Achterberg & R. de Vries”. Paratypes: 1 ♀ (IEBR), “S. Vietnam: Dak Lak, Chu Yang Sin

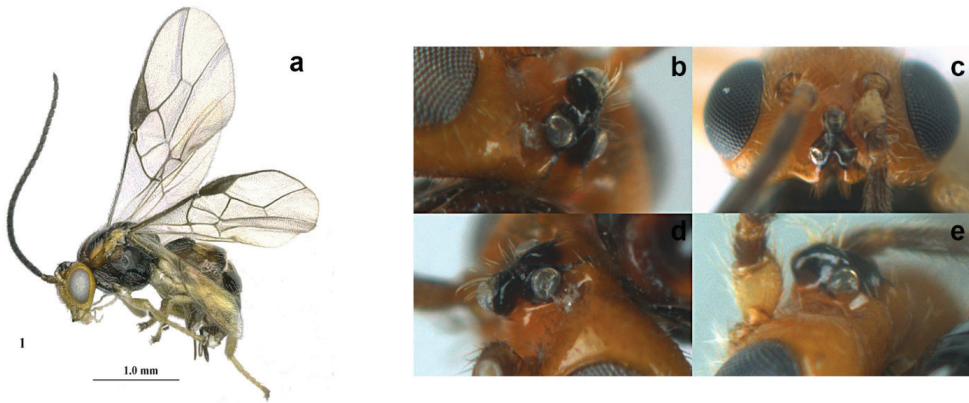


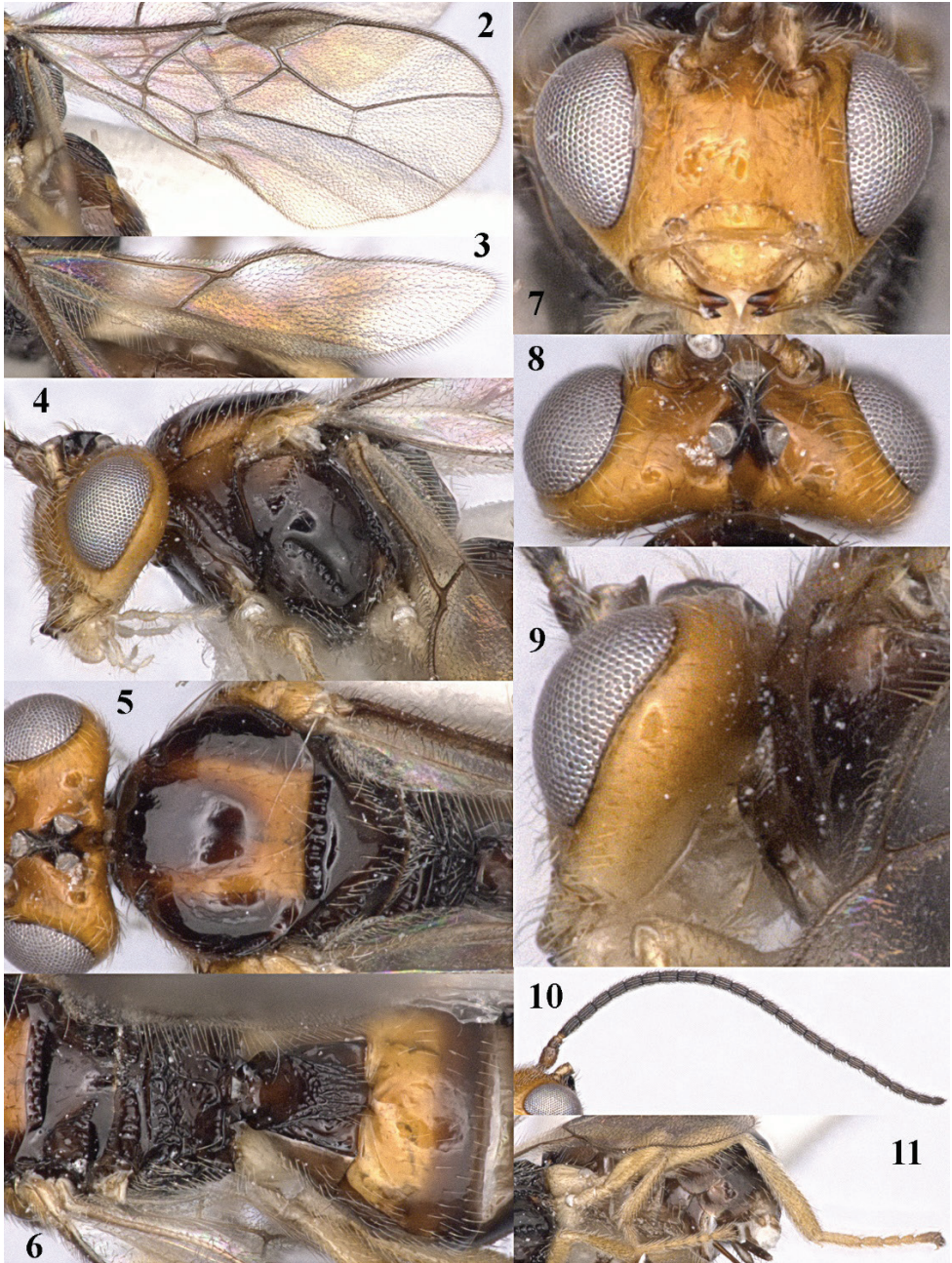
Figure 1. *Canaloapius periscopos* sp. n., ♀, holotype. **a** habitus, lateral aspect **b–e** stemmaticum and median furrow of vertex at different angles.

N.P., n[ea]r dam, 800–940 m, 2–10.vi.2007, Mal[aise] traps, C. van Achterberg & R. de Vries, RMNH'07"; 1 ♂ (RMNH), same data as paratype, but c. 500 m, 3–9.vi.2007.

Description. Holotype, ♀, length of body 2.8 mm, of fore wing 2.6 mm.

Head. Antenna with 27 segments, bristly setose and 1.05 times as long as fore wing; third segment 1.3 times as long as fourth segment, length of third, fourth and penultimate segments 2.7, 2.0 and 2.0 times their width, respectively (Fig. 10); length of maxillary palp 0.9 times height of head (Fig. 4); length of eye in dorsal view 2.6 times temple (Fig. 8); temple and vertex shiny, smooth, and with sparse setae; occiput and vertex medially with very deep vertical furrow up to between posterior ocelli; vertex depressed near posterior ocelli; stemmaticum reversed “Y”- shaped and abruptly protruding dorsally, with long setae dorsally and with anterior ocellus on anterior branch far above frons (Figs 1b–e, 5, 8); OOL: diameter of ocellus: POL= 13:4:3; occipital carina absent; hypostomal carina narrow (Fig. 9); face smooth and sparsely setose (Fig. 7); frons smooth behind antennal sockets; labrum glabrous and smooth, slightly depressed; clypeus transverse, smooth, convex, and its ventral margin truncate (Fig. 7); width of clypeus 3.4 times its maximum height and 0.5 times width of face; hypoclypeal depression rather large (Fig. 7); mandible slightly twisted, its basal half dorsally and ventrally with fine carina, nearly straight ventrally, apically gradually narrowed and with second teeth much smaller than first tooth (Figs 2, 4); malar suture absent; malar space 0.5 times as long as basal width of mandible.

Mesosoma. Length of mesosoma 1.4 times its height; dorsal pronope round and rather large, filled with white tissue; pronotal side largely smooth, but crenulate dorso-anteriorly and posteriorly (Fig. 4); propleuron flattened and largely glabrous except apically; epicnemial area smooth; precoxal sulcus medium-sized, moderately crenulate and distinctly impressed, but absent anteriorly and posteriorly (Fig. 4); remainder of mesopleuron smooth and shiny, sparsely setose antero-dorsally and postero-ventrally; only ventral half of pleural sulcus distinctly crenulate; mesosternum densely setose;



Figures 2–11. *Canalopius periscopus* sp. n., ♀, holotype. **2** fore wing **3** hind wing **4** head and mesosoma, lateral aspect **5** head and mesosoma, dorsal aspect **6** propodeum and first third metasomal tergites, dorsal aspect **7** head, anterior aspect **8** head, dorsal aspect **9** head, lateral aspect **10** antenna **11** hind leg, lateral aspect.

mesosternal sulcus deep, medium-sized and crenulate; postpectal carina absent; anterior groove of metapleuron largely smooth except a few crenulae; mesoscutum very shiny, smooth and with band of setae indicating imaginary course of notauli (Fig. 5); notauli only present basally and absent on disc; medio-posterior depression of mesoscutum absent; scutellar sulcus deep and with 7 short crenulae, parallel-sided; scutellum flattened and smooth, (Figs 5, 6); lateral axillar lamella narrow; dorsal surface of propodeum coarsely crenulate and narrow, posteriorly bordered by curved carina, medio-longitudinal carina complete, with some short rugae medio-dorsally, and remainder largely smooth (Fig. 6).

Wings. Fore wing: 1-SR 0.6 times longer than 1-M (Fig. 2); pterostigma wide triangular; 1-R1 ending at wing apex and 1.4 times as long as pterostigma; r long and linear with 3-SR with obtuse angle; r-m not tubular; r:3-SR:SR1 = 7:32:58; 2-SR:3-SR:r-m = 15:32:16; 1-M curved and SR1 nearly straight; m-cu distinctly postfurcal and straight; cu-a slightly postfurcal, nearly interstitial, and 1-CU1 widened; 1-CU1:2-CU1 = 3:31; first subdiscal cell closed; CU1b medium-sized; M+CU1 unsclerotized. Hind wing: 1-M of hind wing straight, resulting in subparallel-sided cell apically; M+CU:1-M:1-r-m = 12:10:7; cu-a straight; SR absent (Fig. 3).

Legs. Length of femur, tibia and basitarsus of hind leg 3.7, 7.8 and 2.7 times as long as width, respectively (Fig. 11); femur moderately setose, tarsus and tibia densely setose.

Metasoma. Length of first tergite 1.1 times its apical width, convex and irregularly rugose medio-posteriorly and remainder largely smooth (Fig. 6), dorsal carinae strong basally and reaching apex of tergite, dorsope absent; second suture almost invisible; basal depressions of second tergite shallow, wide and oblique, and second tergite 0.8 times as long as third tergite; second and following tergites smooth, shiny and with row of setae posteriorly; combined length of second and third metasomal tergites 0.3 times total length of metasoma; setose part of ovipositor sheath 0.1 times as long as fore wing (entire visible sheath 0.14 times), 0.5 times first tergite (entire sheath 0.9 times) and 0.3 times hind tibia (entire sheath 0.4 times); hypopygium nearly 0.2 times as long as metasoma, truncate apically and not reaching apex of metasoma (Fig. 11).

Colour. Dark brown; head (but teeth of mandible dark brown and stemmaticum black), scape ventrally, tegulae, mesoscutum laterally and imaginary courses of notauli and second tergite dorsally brownish yellow; scape dorsally, pedicellus ventrally, pronotal side dorsally and mesopleuron dorsally brown; pterostigma, veins, remainder of metasoma and ovipositor sheath largely dark brown; palpi, mandible, and legs pale yellowish (but telotarsus brown); fore wing membrane subhyaline.

Variation. Length of fore wing 2.0–2.6 mm, of body 2.1–2.8 mm; antennal segments 25 (1 ♂) or 27 (1 ♀), length of first tergite 1.1–1.3 times its apical width; mesosoma of male entirely black, of female paratype mesoscutum, scutellum, prothorax and dorsal half of mesopleuron brownish yellow.

Distribution. Vietnam.

Biology. Unknown.

Etymology. Name is derived from “peri” (Greek for “around”) and “skopos” (Greek for “watcher”) because the anterior ocellus is protruding from the head like a periscope.

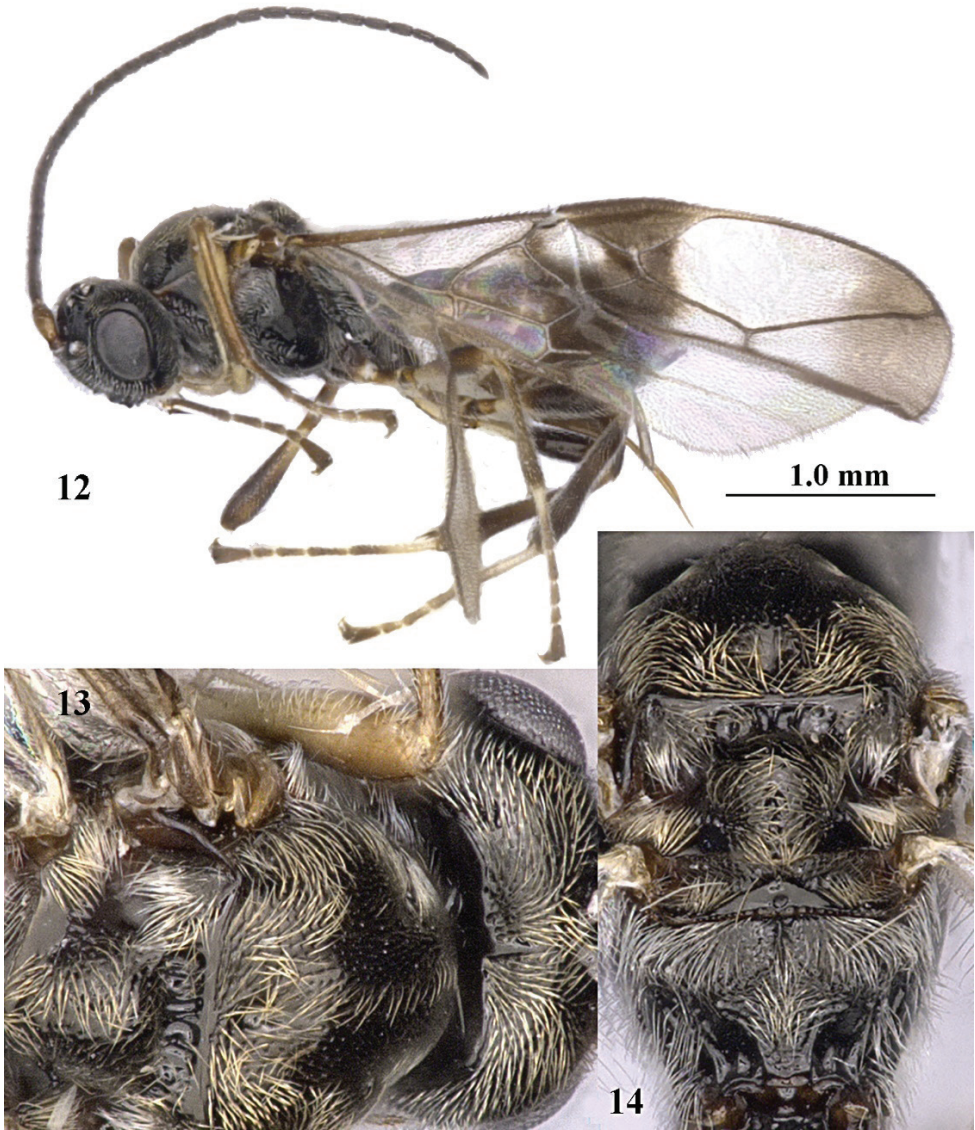
Genus *Xynobius* Foerster, 1863

Figs 12–23

- Xynobius* Foerster, 1863: 235; Li et al. 2013: 171. Type species (by original designation): *Xynobius pallipes* Foerster, 1863 (= *Opius caelatus* Haliday, 1837) [examined].
- Aclisis* Foerster, 1863: 267; Fischer 1972: 68 (as synonym of *Opius* Wesmael, 1835); van Achterberg 2004a: 315 (as synonym of *Xynobius* Foerster, 1863). Type species (by original designation): *Aclisis isomera* Foerster, 1863 (= *Opius caelatus* Haliday, 1837) [examined].
- Holconotus* Foerster, 1863: 259 (not Schmidt-Göbel, 1846); Fischer 1972: 67, 102; van Achterberg 2004a: 315 (as synonym of *Xynobius* Foerster, 1863). Type species (by original designation): *Opius comatus* Wesmael, 1835) [examined].
- Aulonotus* Ashmead, 1900: 368 (new name for *Holconotus* Foerster, 1863); Fischer 1972: 68, 102 (as subgenus of *Opius* Wesmael, 1835); van Achterberg 2004a: 315 (as synonym of *Xynobius* Foerster, 1863). Type species (by original designation): *Opius comatus* Wesmael, 1835) [examined].
- Eristerناولax* Viereck, 1913: 362; Fischer 1972: 68 (as synonym of *Opius* Wesmael, 1835, 102 (as synonym of subgenus *Aulonotus* Ashmead, 1900); van Achterberg 2004a: 315 (as synonym of *Xynobius* Foerster, 1863). Type species (by original designation): *Eristerناولax leucotaenia* Viereck, 1914) [examined].
- Stigmatopoea* Fischer, 1986: 610, 611 (as subgenus of *Opius* Wesmael, 1835), 1998: 25 (key to species); Wharton 1988: 356; 2006: 338 (as subgenus of *Eurytenes* Foerster, 1863; possible paraphyly in *Xynobius*); van Achterberg 2004a: 315 (as synonym of *Xynobius* Foerster, 1863). Type species (by original designation): *Opius macrocerus* Thomson, 1895 [examined].
- Xynobiotenes* Fischer, 1998: 23 (as subgenus of *Eurytenes* Foerster, 1863); Li et al. 2013: 171 (as synonym of *Xynobius* Foerster, 1863). Type species (by original designation): *Opius scutellatus* Fischer, 1962 [examined].

Diagnosis (modified after Li et al. 2013). Hypoclypeal depression present, often large, and medially ventral margin of clypeus above upper level of condyli of mandibles (“subcyclostome condition”) or near it (Fig. 20), rarely hypoclypeal depression nearly absent; occipital carina widely to narrowly interrupted dorsally or nearly contiguous (Fig. 18); mandible simple basally, at most with a narrow ventral carina (Fig. 20); notauli variable; medio-posterior depression of mesoscutum present (Fig. 14); precoxal sulcus present, smooth or crenulate, no indication of sternaulus; vein m-cu of fore wing usually (sub) parallel to vein 1-M (Fig. 12); vein r more or less angled with vein 3-SR of fore wing and distinctly shorter than vein 2-SR (Fig. 15); vein 3-SR distinctly longer than vein 2-SR; pterostigma long and narrow and more or less widened towards its apex, elliptical or triangular (Fig. 15); dorsope present, often bordered by lamelliform carinae (Fig. 19); second metasomal tergite striate or smooth; hypopygium of ♀ at most slightly incised.

Biology. Koinobiont endoparasitoids of leaf miners of Anthomyiidae, Tephritidae and Scathophagidae (Yu et al. 2016).



Figures 12–14. *Xynobius chrysops* sp. n., ♀, holotype. **12** habitus, lateral aspect **13** scutellum and posterior half of mesoscutum, dorsal aspect **14** metanotum and propodeum, dorsal aspect.

Notes. Wharton (1988) treated *Xynobius* as a synonym of the genus *Opius* Wesmael, 1837, but it has a distinct dorsope and according to the limited available molecular data (Li et al. 2013) it is not closely related to *Opius* s.s. as treated by Li et al. (2013). Part of it (the subgenus *Stigmatopoea* Fischer, 1986) has been included by Fischer (1998) and Weng and Chen (2005) in the genus *Eurytenes* Foerster, 1863, but it seems to fit better in *Xynobius* (van Achterberg 2004a; Li et al. 2013). Wharton (2006) and Walker and Wharton (2011) placed *Xynobius* as a subgenus of *Eurytenes*, but we prefer to keep them separated till more is known about their relationships.

***Xynobius chrysops* sp. n.**

<http://zoobank.org/024E09B3-B558-42F0-AADC-B671EF6CD9D8>

Figs 12–23

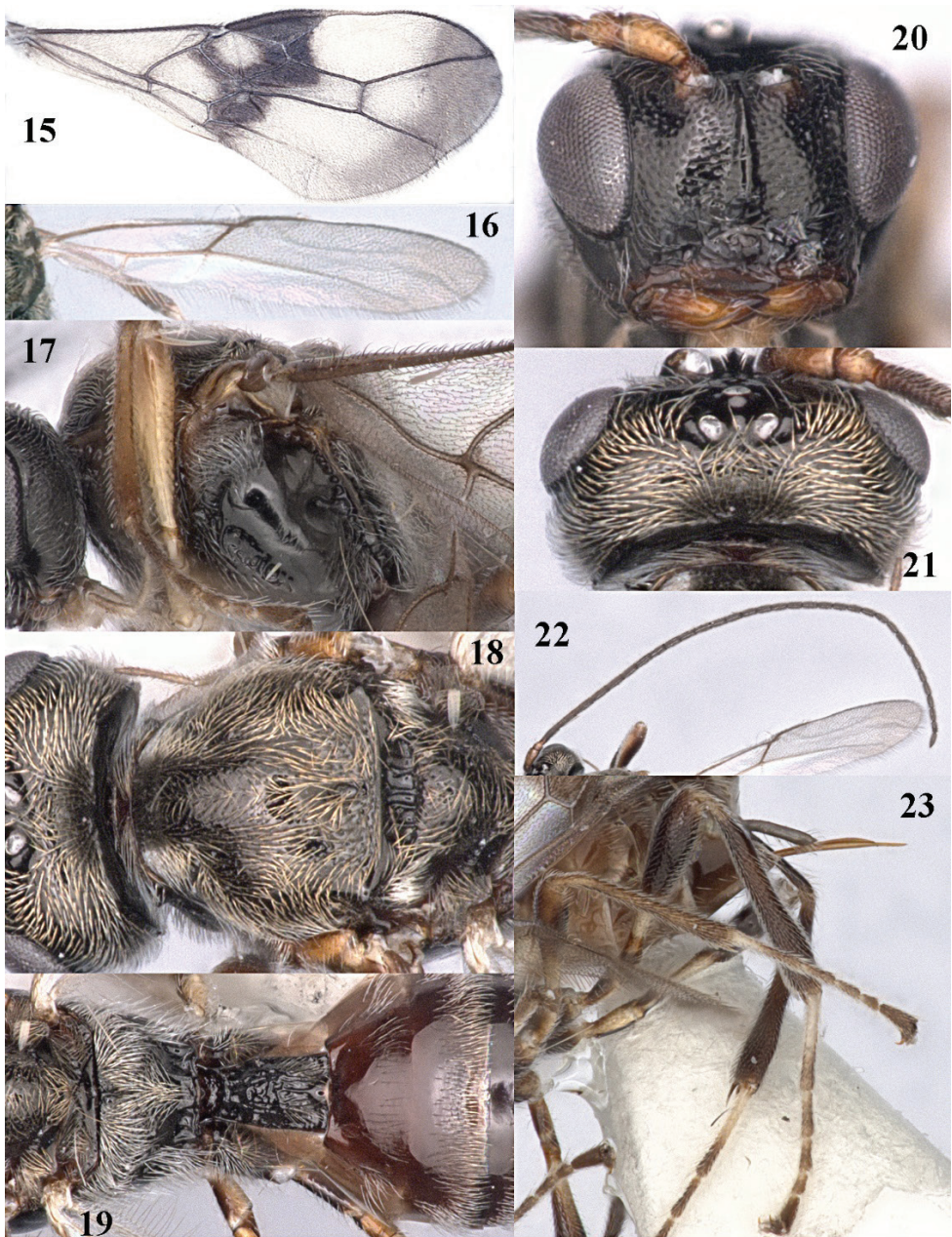
Type material. Holotype, ♀ (RMNH), “NW. **Vietnam:** Tonkin, Hoang Lien N.R., 15 km W [of] Sa Pa, c. 1900 m, 15–21.x.1999, Malaise traps, C. v. Achterberg, RMNH’99”.

Description. Holotype, ♀, length of body 3.3 mm, of fore wing 3.6 mm.

Head. Antenna with 35 segments, bristly setose and 1.3 times as long as fore wing; third segment 1.1 times as long as fourth segment, length of third, fourth and penultimate segments 5.0, 4.5 and 2.3 times their width, respectively (Figs 12, 22); length of maxillary palp 1.2 times height of head; length of eye in dorsal view as long as temple (Fig. 21); temple in dorsal view shiny, smooth, temple and vertex with adpressed setae; OOL: diameter of ocellus: POL = 1:1:3; face sparsely punctate, with a medio-longitudinal ridge extending to level of antennal sockets (Fig. 20); frons glabrous behind antennal sockets; in front of anterior ocellus shiny, smooth and glabrous but laterally setose (Fig. 20); labrum invisible; clypeus nearly semi-circular, with some oblique striae, convex but flattened ventrally, and its ventral margin truncate and narrow (Fig. 20); clypeus 2.1 times wider than its maximum height and 0.6 times wider than face; hypoclypeal depression narrow, slit-shaped; mandible straight ventrally, hardly twisted, apically gradually narrowed and second tooth small; mandible and with narrow ventral carina (Fig. 20); occipital carina remains far removed from hypostomal carina ventrally and horizontal dorsally, narrowly interrupted medio-dorsally; hypostomal carina narrow; malar suture distinct, narrow; length of malar space 0.9 times basal width of mandible.

Mesosoma. Length of mesosoma 1.5 times its height; dorsal pronope minute, round, (Figs 18, 21); pronotal side largely smooth, but crenulate dorso-anteriorly and densely setose anteriorly and posteriorly (Figs 12, 17); propleuron slightly convex, finely punctate and setose; epicnemial area densely setose dorsally, finely crenulate in groove ventrally; only anterior half of precoxal sulcus present, medium-sized and distinctly crenulate (Fig. 17); remainder of mesopleuron smooth and shiny; pleural sulcus distinctly crenulate; mesosternal sulcus moderately deep, narrow and crenulate; postpectal carina absent; mesoscutum very shiny, finely punctate, with golden setae and smooth interspaces (Figs 13, 18); notauli only anteriorly impressed, deep, narrow and crenulate and largely absent on disc; medio-posterior depression of mesoscutum droplet-shaped (Fig. 13); scutellar sulcus deep and with 4 short crenulae, parallel-sided medially; scutellum convex and smooth, finely punctate and densely setose (Fig. 14); side of scutellum and axilla densely golden setose, and lateral axillar lamella very wide (Figs 13, 14); metanotum glabrous medially and densely setose laterally; antero-dorsal part of propodeum densely setose, rugose near transverse ridge and with medio-longitudinal carina; posterior part of propodeum largely smooth, and with 4 long and curved carinae (Fig. 14).

Wings. Fore wing: 1-SR distinctly longer than wide and nearly linear with 1-M (Fig. 15); pterostigma wide triangular; 1-R1 ending at wing apex and twice as long as



Figures 15–23. *Xynobius chrysops* sp. n., ♀, holotype. **15** fore wing **16** hind wing **17** mesosoma, lateral aspect **18** head and mesosoma, dorsal aspect **19** propodeum and first-third metasomal tergites, dorsal aspect **20** head, anterior aspect **21** head, dorsal aspect **22** antenna **23** hind leg, lateral aspect.

pterostigma; r long and connected with 3-SR by obtuse angle; $r:3\text{-SR}:SR1 = 6:33:58$; $2\text{-SR}:3\text{-SR}:r\text{-m} = 8:11:4$; 1-M slightly curved and SR1 straight; m-cu distinctly postfurcal and straight; cu-a distinctly postfurcal and 1-CU1 slightly widened; $1\text{-CU1}:2\text{-CU1} = 1:18$; first subdiscal cell closed and CU1b medium-sized; entire M+CU1 sclerite

rotized (Fig. 17). Hind wing: 1-M of hind wing straight, resulting in subparallel-sided cell apically; M+CU:1-M:1r-m = 30:34:15; cu-a straight; m-cu unsclerotized, spectral; SR absent (Fig. 16).

Legs. Length of femur, tibia and basitarsus of hind leg 4.1, 7.8 and 9.0 times as long as width, respectively (Fig. 23); femur with long setae, tarsus and tibia densely setose; hind tibia slender medially; dorsally hind tibia with large smooth and glabrous patch subbasally (Fig. 23).

Metasoma. Length of first tergite 1.7 times to its apical width, convex, its surface irregularly rugose medially (Fig. 19), dorsal carinae strong and combined in its basal third and area below widely depressed, but dorsope small; second suture almost invisible; basal depressions of second tergite minute and tergite as long as third tergite, both with wide setose bands (Fig. 19); second and following tergites smooth, shiny and setose posteriorly, especially densely in third tergite; combined length of second and third metasomal tergites 0.4 times total length of metasoma; setose part of ovipositor sheath 0.07 times as long as fore wing (exposed sheath 0.11 times), 0.6 times first tergite (entire sheath as long as tergite), and 0.2 times hind tibia (entire sheath 0.4 times); hypopygium about 0.3 times as long as metasoma, truncate apically and not reaching apex of metasoma (Fig. 23).

Colour. Blackish brown, but scape, pedicellus, mandible (but teeth dark), tegulae, fore coxa dorsally, fore femur laterally and ventrally, fore tibia basally, trochantellus dorsally, second tergite laterally yellowish brown; ventral margin of clypeus, pterostigma and veins, markings of fore wing near veins r, 1-SR+M, 2-SR, basal half of 3-SR, m-cu, basal of second discal cell and second subdiscal cell, fore femur dorsally, trochanter dorsally, tarsus (but pale basally), second tergite medially and following tergites dark brown; palpi, inner side of fore coxae, trochanter ventrally, middle and hind tibia basally pale yellowish; setae on vertex, temple, mesoscutum, scutellum, side of scutellum and metanotum golden, remainder of setae silvery; remainder of fore wing membrane subhyaline.

Distribution. Vietnam.

Biology. Unknown.

Notes. This aberrantly coloured new species belongs to a small group of Asian spp. near *Xynobius maculipennis* (Enderlein, 1912) united by the subbasally widened hind tibia with the resulting small knob glabrous and shiny dorsally, the hypopygium dark brown, the head and mesoscutum densely pubescent, and the fore wing with a large Y-shaped dark brown area below para- and pterostigma (Fig. 15). The new species differs from all other species examined by having the third metasomal tergite with a wide band of setae apically (Fig. 19; narrow in other species); fore wing infusate apically (Fig. 15; subhyaline); the hypoclypeal depression nearly absent (distinct); the head and mesosoma dark golden pubescent combined with a slender first tergite (slightly widened apically and $1.6 \times$ longer than its apical width; other species have usually pale yellowish or silvery pubescence, if dark golden than first tergite 1.2–1.3 times as long as wide apically).

Etymology. Named after the partly golden setosity; “chrysops” is Greek for “gold-coloured”.

Acknowledgements

The field work was only possible because of the excellent help of staff of IEBR (Hanoi), in particular of Dr Khuat Dang Long. The second author received financial support from the Uyttenboogaart-Eliassen Stichting (Amsterdam) for research in Vietnam. The research was supported jointly by the State Key Program of National Natural Science Foundation of China (No. 31702035).

References

- Ashmead WH (1900) Some changes in generic names in Hymenoptera. Canadian Entomologist 32(12): 368. <https://doi.org/10.4039/Ent32368a-12>
- Chen J-H, Weng R-Q (2005) Systematic studies on Opiinae of China (Hymenoptera: Braconidae). Fujian Science and Technology Publishing House, Fujian, 1–2, 1–9, 1–269.
- Fischer M (1972) Hymenoptera Braconidae (Opiinae I). (Paläarktische Region). Das Tierreich 91: 1–620.
- Fischer M (1977) Hymenoptera Braconidae (Opiinae II). (Amerika). Das Tierreich 96: 1–1001.
- Fischer M (1986) Neue Bestimmungsschlüssel für paläarktische Opiinae, neue Subgenera, Redeskriptionen und eine neue Art (Hymenoptera, Braconidae). Annalen des Naturhistorischen Museums in Wien 88/89: 607–662.
- Fischer M (1987) Hymenoptera Braconidae (Opiinae III) – äthiopische, orientalische, australische und ozeanische Region. Das Tierreich 104: 1–734.
- Fischer M (1998) Neue taxonomische Untersuchungen über Madenwespen der Alten Welt mit besonderer Berücksichtigung der Gattungen *Eurytenes* Foerster, *Aulonotus* Ashmead, *Biosteres* Foerster und der Untergattung *Gastrosema* Fischer (Hymenoptera, Braconidae: Opiinae). Linzer Biologische Beiträge 30(1): 21–51.
- Foerster A (1863) Synopsis der Familien und Gattungen der Braconiden. Verhandlungen des Naturhistorischen Vereins der Preussischen Rheinlande und Westfalens 19[1862]: 225–288.
- Li X-Y, van Achterberg C, Tan J-C (2013) Revision of the subfamily Opiinae (Hymenoptera, Braconidae) from Hunan (China), including thirty-six new species and two new genera. ZooKeys 268: 1–168. <https://doi.org/10.3897/zookeys.268.4071>
- Shaw MR, Huddleston T (1991) Classification and biology of braconid wasps. Industrial & Engineering Chemistry 51(4): 507–509.
- Tan J-L, Tan Q-Q, van Achterberg C, Chen X-X (2016) A new genus *Carinopius* gen. n. of the subfamily Opiinae (Hymenoptera, Braconidae) from China and Vietnam, with description of a new species Zootaxa 4061(5): 569–574. <http://doi.org/10.11646/zootaxa.4061.5.6>
- van Achterberg C (1988) Revision of the subfamily Blacinae Foerster (Hymenoptera, Braconidae). Zoologische Verhandelingen Leiden 249: 1–324.
- van Achterberg C (1990) Illustrated key to the subfamilies of the Holarctic Braconidae (Hymenoptera: Ichneumonoidea). Zoologische Mededelingen Leiden 64: 1–20.
- van Achterberg C (1993) Illustrated key to the subfamilies of the Braconidae (Hymenoptera: Ichneumonoidea). Zoologische Verhandelingen Leiden 283: 1–189.

- van Achterberg C (1997) Revision of the Haliday collection of Braconidae (Hymenoptera). Zoologische Verhandelingen Leiden 314: 1–115.
- van Achterberg C, Salvo A (1997) Reared Opiinae (Hymenoptera: Braconidae) from Argentina. Zoologische Mededelingen Leiden 71(18): 189–214.
- van Achterberg C (2004a) New Indo-Australian subgenera and species of the genera *Xynobius* Foerster and *Ademoneuron* Fischer (Hymenoptera: Braconidae: Opiinae). Zoologische Mededelingen Leiden 78(20): 313–329.
- van Achterberg C (2004b) *Bitomoides* gen. nov. (Hymenoptera: Braconidae: Opiinae) from Europe. Zoologische Mededelingen Leiden 78(21): 331–335.
- van Achterberg C (2009) Can Townes type Malaise traps be improved? Some recent developments. Entomologische Berichten 69(4): 129–135.
- van Achterberg C, Chen X-X (2004) Six new genera of Braconidae (Hymenoptera) from China. Zoologische Mededelingen Leiden 78(2): 77–100.
- Viereck HL (1913) Descriptions of twenty-three new genera and thirty-one new species of Ichneumon-flies. Proceedings of the United States National Museum 46(2031): 359–386. <https://doi.org/10.5479/si.00963801.2031.359>
- Walker AK, Wharton RA (2011) A review of New World *Eurytenes* s. str. (Hymenoptera, Braconidae, Opiinae). Journal of Hymenoptera Research 20: 23–46. <https://doi.org/10.3897/jhr.29.877>
- Wesmael C (1835) Monographie des Braconides de Belgique. Nouveau memoires de l'academie royale des sciences et belles-lettres de Bruxelles 9: 1–252.
- Wharton RA (1988) Classification of the Braconid subfamily Opiinae (Hymenoptera). Canadian Entomologist 120: 333–360. <https://doi.org/10.4039/Ent120333-4>
- Wharton RA (1997) Generic relationships of opiine Braconidae (Hymenoptera) parasitic on fruit-infesting Tephritidae (Diptera). Contributions of the American Entomological Institute 30(3): 1–53.
- Wharton RA (2006) The species of *Sternaulopius* Fischer (Hymenoptera: Braconidae, Opiinae) and the braconid sternaulus. Journal of Hymenoptera Research 15(2): 317–347.
- Wharton RA (2009) Two new species of *Psytalia* Walker (Hymenoptera, Braconidae, Opiinae) reared from fruit-infesting tephritid (Diptera) hosts in Kenya. ZooKeys 20: 349–377. <https://doi.org/10.3897/zookeys.20.99>
- Yu DSK, van Achterberg C, Horstmann K (2016) Taxapad 2016, Ichneumonoidea 2015. Database on flash-drive. Nepean, Ontario. <http://www.taxapad.com>



First record of *Epipompilus excelsus* (Bradley, 1944) (Hymenoptera, Pompilidae) as a koinobiont ectoparasitoid of *Ariadna mollis* (Holmberg, 1876) (Araneae, Segestriidae)

German Antonio Villanueva-Bonilla¹, Antonio Domingos Brescovit²,
Eduardo Fernando dos Santos³, João Vasconcellos-Neto¹

1 Universidade Estadual de Campinas, Instituto de Biologia, Departamento de Biologia Animal, Rua Monteiro Lobato, 255, Campinas, São Paulo, Brazil **2** Laboratório Especial de Coleções Zoológicas, Instituto Butantã, São Paulo, SP, Brazil **3** Universidade Estadual Paulista “Júlio de Mesquita Filho”, Instituto de Biociências, Letras e Ciências Exatas, Departamento de Zoologia e Botânica, Rua Cristóvão Colombo, 2265, São José do Rio Preto, São Paulo, Brazil

Corresponding author: German Antonio Villanueva-Bonilla (germanvillanueva9@gmail.com)

Academic editor: M. Ohl | Received 6 August 2018 | Accepted 16 September 2018 | Published 31 October 2018

<http://zoobank.org/C836E6AD-F42F-4CD0-B959-376E848020BF>

Citation: Villanueva-Bonilla GA, Brescovit AD, dos Santos EF, Vasconcellos-Neto J (2018) First record of *Epipompilus excelsus* (Bradley, 1944) (Hymenoptera, Pompilidae) as a koinobiont ectoparasitoid of *Ariadna mollis* (Holmberg, 1876) (Araneae, Segestriidae). Journal of Hymenoptera Research 66: 15–21. <https://doi.org/10.3897/jhr.66.28915>

Abstract

Epipompilus Kohl comprises 52 species of wasps that are parasitoids of spiders; 16 species occur in the Neotropical region and 36 species occur in the Australian region. The biological knowledge of this genus is limited and its interactions and host spiders are still incipient. Here, we report some behavioural and biological characteristics of *E. excelsus*, a parasitoid of the tube-dwelling spider *Ariadna mollis*. We observed an *E. excelsus* female attacking an adult female of *A. mollis* in São Paulo, Brazil. We photographed daily the larval development of the wasp, from the egg stage to adult emergence. The entire developmental cycle of the wasp took 24 days. This period was shorter than the developmental periods of wasps belonging to other genera of Pompilidae. Although all species within Pompilidae use spiders as host, they present great behavioural diversity, characterized by different ethological sequences. In conclusion, this study demonstrated that the Neotropical species of *Epipompilus* exhibit biological characteristics similar to the Australian species, acting as a koinobiont ectoparasitoid, but displays differences in larval morphology. Studies on other species could elucidate the extent of these differences and similarities, contributing to our understanding of the evolutionary history of *Epipompilus*, and consequently of Pompilidae.

Keywords

Egg-wasp development, Neotropical, Parasitoid, Tube-dwelling spider

Introduction

Pompilidae is a megadiverse family of ectoparasitoid wasps, with more than 5,000 valid species distributed worldwide and approximately 1,000 species inhabiting the Neotropical region (Shimizu 1994, Pitts et al. 2006). Although some pompilid species show primitive levels of sociality, most species are solitary (Shimizu 2004, Shimizu et al. 2010, Santos et al. 2016). These species are known as “spider wasps”, since adult females usually uses spiders as food resource for their larva (Brothers and Finnamore 1993, Wasbauer 1995). Pompilids presents a wide diversity of behavioural strategies to parasitize their hosts, with species nesting in the ground, in pre-existing cavities, mud nests they have built, or using as hosts active spiders that are posteriorly killed by the wasp’s larvae (El-Hennawy 1996, Souza et al. 2015). Most species are solitary, but some show primitive levels of sociality (Shimizu 2004, Shimizu et al. 2010, Santos et al. 2016).

The genus *Epipompilus* Kohl comprises 52 species of spider wasps, 16 of which occur in the Neotropical region, one in the Nearctic region, and 36 species in the Australian region (Roig-Alsina and Barneche 2017). The current biological knowledge of this genus is based on three species from the Australian region, *E. insularis* Kohl, 1884, *E. exleyae* Evans, *E. reiki* Evans (Evans 1972, Pollard 1982, Harris 1987), and one Neotropical species, *E. platensis* (Roig-Alsina and Barneche 2017). Evans (1972) reported *E. exleyae* as an ectoparasitoid of immature Sparassidae, and *E. rieki* as an ectoparasitoid of an unidentified spider. Pollard (1982) and Harris (1987) reported *E. insularis* as a koinobiont ectoparasitoid of multiple cursorial spiders, including the clubionid *Clubiona cambridgei* Koch, 1873, and the salticids *Salticus* sp., *Trite auricomma* Urquhart, 1885 and *T. planiceps* Simon, 1899.

Segestriidae (Simon, 1893) consists of haplogyne spiders, small-to-medium in size (total body length between 2.8 and 20.25 mm) (Grismado 2008, Giroti and Brescovit 2018), usually found in loose barks, cracks in tree trunks, under rocks, or even in anthropomorphized places (Roig-Alsina and Barneche 2017). These spiders are nocturnal, sedentary, construct funnel-like webs and have been reported as a host of *Epipompilus platensis* (Roig-Alsina and Barneche 2017). Currently, Segestriidae comprises 130 species divided into four genera (World Spider Catalog 2018), among them *Segestria* Latreille, 1804 and *Ariadna* Audouin, 1826 occurs in South America (Grismado 2008, Giroti and Brescovit 2011, World Spider Catalog 2018).

The genus *Ariadna* currently consists of 105 of the 130 species included in Segestriidae (Giroti and Brescovit 2018). This genus is distributed across all continents, but the greatest number of species is found in tropical and subtropical regions. The knowledge of biology and ecology of *Ariadna* is quite incipient, based on a single study that reported *A. maxima* as host of the koinobiont ectoparasitoid *Sphaerops appendiculata* Philippi, 1865 (Diptera, Acroceridae). This acrocerid is the only external koinobiont

parasitoid of spiders known in the family, since other species develops inside the opistosoma of spiders (Schlinger 1987).

Here, we report *E. excelsus* (Bradley, 1944) as a koinobiont ectoparasitoid of the tube-dwelling spider *Ariadna mollis* (Holmberg, 1876), with behavioural and biological notes of this wasp-spider interaction.

Methods

We observed *E. excelsus* attacking *A. mollis* on May 5, 2017 at Serra do Japi (23°13'53.60"S, 46°52'47.01"W), a tropical forest located in the municipality of Jundiaí, São Paulo state, Brazil. After the wasp attack, we collected the parasitized spider and transported it to the Laboratório Especial de Coleções Zoológicas (LECZ) - Instituto Butantan, São Paulo, Brazil, where we recorded the larval development. We kept the spider inside a terrarium (15×15×13 cm) and provided cotton balls with water, a piece of loose bark from the tree that we found the spider (used as a shelter by the spider), and we fed the spider every two days with *Chrysomya putoria* (Wiedemann) (Diptera: Calliphoridae). To access the wasp development (i.e. from the egg stage to adult emergence), we photographed the parasitized spider daily upon a mm scale. We used the software Adobe Photoshop CS6 to analyze the photographs and measure the length and width of the larvae throughout its development. We deposited the remains of the spider carcass and the adult parasitoid in the Arachnida collection of Instituto Butantan, São Paulo, Brazil (Curator: A. D. Brescovit).

Results and discussion

We found an adult female of *E. excelsus* in an inspection flight near a trunk of a *Plinia cauliflora* Mart. (Myrtaceae). The wasp found an adult female of *A. mollis* and flew around the spider for few (six minutes approximately) minutes, remaining at a distance of approximately 6 cm from the spider. The wasp then landed on the spider dorsum, stung and paralyzed the spider. Thereafter, the wasp laid an egg dorsally on the spider abdomen; oviposition took approximately three minutes. Then the wasp drummed the spider (Fig. 1A), and after five minutes, flew off leaving the parasitized spider paralyzed. After approximately two more minutes, the individual of *A. mollis* began to move slowly and continued its normal course on the tree trunk (Fig. 1B).

In laboratory, the parasitized spider constructed a tube-shaped shelter in the space between the terrarium wall and the piece of bark. The spider continued to feed on the flies normally during our observations. The egg developed in two days. Once it hatched, the first instar larva emerged and stuck to the spider abdomen. The larval development included four instars distinguished by abrupt increases of the larvae size between each larval stage. The first instar measured 0.3 mm in width and 2.2 mm in length (Fig. 1C). The larvae reached the second instar (1.1 mm wide and 4.1 mm long,

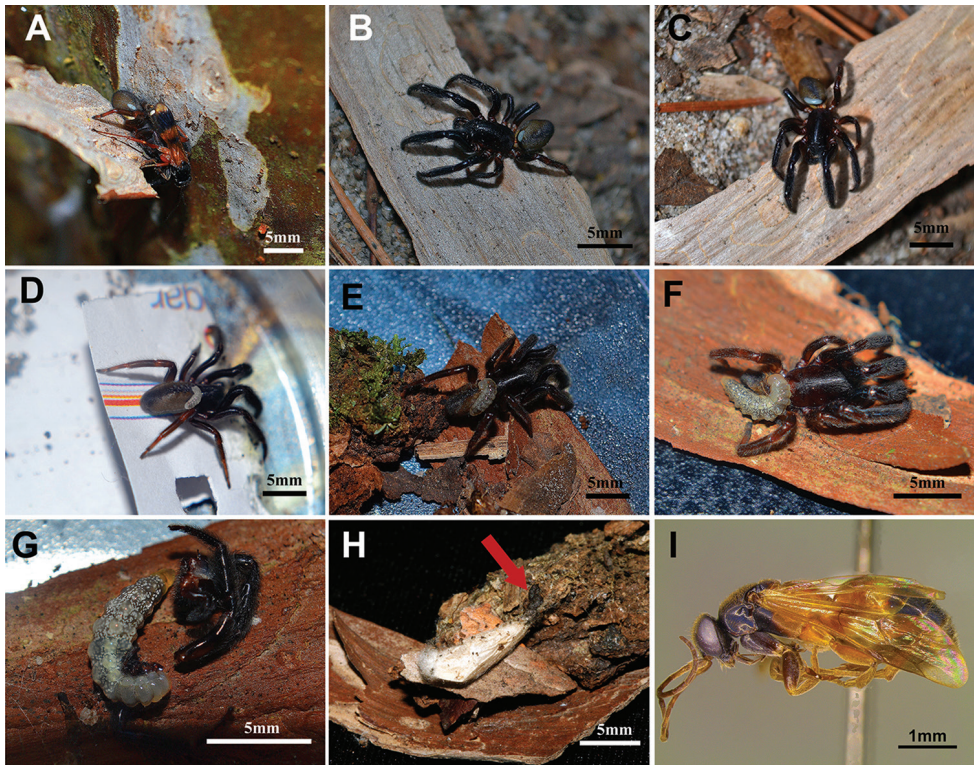


Figure 1. Adult female of *Ariadna mollis* (Segestriidae) parasitized by *Epipompilus excelsus* (Pompilidae). A) Wasp on the back of the spider (the arrow indicates the position of the egg in the abdomen). B) *A. mollis* moving slowly minutes after being paralyzed. C) Larval I instar of the wasp adhered to the abdomen of the spider. D) Larval II instar. E) Larval III instar. F) Larval IV instar feeding from the abdomen of the spider. G) Larva eating the remains of the legs and abdomen of the spider. H) The cocoon containing the meconium (red arrow). I) Adult female of *E. excelsus*.

Fig. 1D) five days later. After three days, the larvae reached the third instar and measured 1.7 mm wide and 6.1 mm long (Fig. 1E). Finally, the fourth instar was observed five days later, measuring 2.2 mm wide and 7.8 mm long, and presented 11 retractile dorsal tubercles (Fig. 1F). The fourth instar larvae killed the host and slowly consumed more than 50% of its body. Only the legs, the part of the ventral abdomen containing the genitalia, and the anterior part of the cephalothorax were not consumed by the larvae (Fig. 1G). On the next day, the larva began to construct a cocoon in the space between the bark and the wall of the terrarium, and fixed the apical portion of the cocoon in the bark (Fig. 1H). Emergence of the adult wasp occurred by the apical region of the cocoon five days after cocoon construction. The entire developmental cycle from oviposition until the emergence of adult wasp, took 24 days. This period is shorter than the developmental periods of wasps of other Pompilidae species. *Paracyphononyx scapulatus*, for example, develops in 54 days (Souza et al. 2015), *P. ruficus* in 30 days (El-Hennawy 1996), and *Notocyphus tyrannicus* Smith in 46 days (Martins et al. 2016).

Studies on congeneric species do not present a detailed description of the individual's life cycle (Roig-Alsina and Barneche 2017). Studies on the interaction between the parasitoid wasp *Epipompilus insularis* and the spiders *Clubiona cambridgei*, *Trite auricoma* or *T. planiceps* (Harris 1987) and the interaction between *E. insularis* and the spiders *C. cambridgei* or *Salticus* sp. (Pollard 1982) showed similar results to those of the present study. Harris (1987) and Pollard (1982) suggested that this genus of diurnal parasitoid wasps usually parasitize nocturnal non-weaver spiders because these spiders rest in shelters during the day, since this behavior of inactivity during daytime decreases the risk of attacks to the spiders, and thereby provides protection for the wasp egg and larvae. It is not possible to predict whether the parasitized spiders return to its shelters, but notably, our study specimen built a shelter and returned to it every day after goes out at night to capture the preys we offered. The spider was active during almost the entire larval development of *E. excelsus*, sheltering only in the final phase of development (fourth instar), before the wasp kill and consume the host. Harris (1987) reported a similar life cycle development time for *E. insularis* (22 days total) when compared to *E. excelsus* (24 days). The time of development time of each larval instar was also similar. However, the larval development of *E. insularis* involves five instars, while our study species presented four instars. Moreover, the final larval instar of *E. insularis* presents 12 lateral tubercles, while *E. excelsus* has 11 tubercles at the last instar.

Although all Pompilidae species use spiders as hosts, there are a high diversity of behavioural strategies characterized by different ethological sequences according to Evans (1953). This author classified the behaviour of *E. insularis* as VPO (*Venari* = to hunt; *Pungere* = to sting the prey; *Ovum parere* = to lay the egg) or VO (*Venari*= to hunt; *Ovum parere*= to lay the egg), and discussed that such ethological sequences represent primitive conditions within Aculeata, but derived conditions within Pompilidae. Species of other genera, such as *Notocyphus* Smith, 1855, *Paracyphononyx* Gribodo, 1884 and *Homonotus* Dahlbom, 1843 present the same ethological sequence (Evans 1953, Souza et al. 2015).

In conclusion, this study showed that the Neotropical species *E. excelsus* presents similar biological characteristics (e.g. koinobiont ectoparasitoidism) when compared to the Australian species. On the other hand, there are differences in larval morphology (e.g. number of tubercles) and development (e.g. number of larval instars). Studies on other koinobiont ectoparasitoid species would elucidate the extent of these differences and similarities, contributing to our understanding of the evolutionary history of *Epipompilus*, and consequently of Pompilidae.

Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001 (Villanueva-Bonilla GA). Also, we were financially supported by Instituto Nacional de Ciência e Tecnologia dos Hymenoptera Parasitoides (HYMPAR – CNPq/FAPESP/CAPES) and CNPq grant number 301776/2004-0 (Brescovit AD).

References

- Brothers DJ, Finnermore AT (1993) Superfamily Vespoidea. In: Goulet H, Huber JT (Eds) Hymenoptera of the World: An Identification Guide to Families. Agriculture Canada, Ottawa, 161–278.
- El-Hennawy HK (1996) A spider (*Lycosa?* sp.) (Araneida: Lycosidae) providing a shelter for its predator *Paracyphononyx rufcrus* (Klug, 1834) (Hymenoptera: Pompilidae). *Revue Suisse de Zoologie* 1: 185–188.
- Evans HE (1953) Comparative ethology and systematics of spider wasps. *Systematic Zoology* 2: 155–172. <https://doi.org/10.2307/2411559>
- Evans HE (1972) Revision of the Australian and New Guinean species of *Epipompilus* (Hymenoptera: Pompilidae). *Pacific Insects* 14(1): 101–131.
- Giroti AM, Brescovit AD (2011) The spider genus *Segestria* Latreille, 1804 in South America (Araneae: Segestriidae). *Zootaxa* 3046: 59–66. <https://doi.org/10.5281/zenodo.202337>
- Giroti AM, Brescovit AD (2018) The taxonomy of the American *Ariadna* Audouin (Araneae: Synspermiata: Segestriidae). *Zootaxa* 4400(1): 1–114. <https://doi.org/10.11646/zootaxa.4400.1.1>
- Grismado CJ (2008) A taxonomic revision of the spider genus *Ariadna* Audouin, 1826 in Argentina and Chile, with the description of five new species (Arachnida, Araneae, Segestriidae). *Zoosystema* 30(2): 333–360.
- Harris AC (1987) Pompilidae (Insecta: Hymenoptera), vol. 12. Fauna of New Zealand. DSIR.
- Martins AL, Gallão JE, Bichuette ME, Santos EF (2016) The first record of *Notocyphus tyrannicus* Smith (Hymenoptera: Pompilidae) as parasitoid of *Acanthoscurria* Ausserer, 1871 (Teraphosidae: Teraphosinae). *Brazilian Journal of Biology* 76: 806–807. <http://dx.doi.org/10.1590/1519-6984.07515>
- Pitts JP, Wasbauer MS, Von Ohlen CD (2006) Preliminary morphological analysis of relationships between the spider wasp subfamilies (Hymenoptera: Pompilidae): revisiting an old problem. *Zoologica Scripta* 35(1): 63–84. <https://doi.org/10.1111/j.1463-6409.2005.00217.x>
- Pollard SD (1982) *Epipompilus insularis* (Hymenoptera: Pompilidae), a parasitoid of hunting spiders. *New Zealand Journal of Zoology* 9: 37–40. <https://doi.org/10.1080/03014223.1982.10423835>
- Roig-Alsina A, Barneche J (2017) The genus *Epipompilus* in Argentina (Hymenoptera: Pompilidae). *Revista de la Sociedad Entomológica Argentina* 76(3–4): 33–38.
- Santos EF, Waichert C, Scott-Santos CP (2016) Behavioural notes on the Neotropical parasocial spider wasp *Ageniella (Lissagenia) flavipennis* (Banks) (Hymenoptera: Pompilidae), with host association. *Ecological Entomology* 42: 96–99. <https://doi.org/10.1111/een.12356>
- Schlinger EI (1987) The biology of Acroceridae (Diptera): True Endoparasitoids of spiders. In: Nentwig W (Ed.) *Ecophysiology of Spiders*. Springer-Verlag, Berlin Heidelberg, 319–331. https://doi.org/10.1007/978-3-642-71552-5_24
- Shimizu A (1994) Phylogeny and classification of the family Pompilidae (Hymenoptera). *Tokyo Metropolitan University Bulletin of Natural History* 2: 1–142.

- Shimizu A (2004) Natural history and behavior of a Japanese parasocial spider wasp, *Machaerotherix tsushimensis* (Hymenoptera: Pompilidae). Journal of the Kansas Entomological Society 77(4): 383–401. <https://doi.org/10.2317/E-30.1>
- Shimizu A, Wasbauer M, Takami Y (2010) Phylogeny and the evolution of nesting behaviour in the tribe Ageniellini (Insecta: Hymenoptera: Pompilidae). Zoological Journal of the Linnean Society 160: 88–117. <https://doi.org/10.1111/j.1096-3642.2009.00592.x>
- Souza HS, Messas YF, Masago F, dos Santos ED, Vasconcellos-Neto J (2015) *Paracyphononyx scapulatus* (Hymenoptera: Pompilidae), a koinobiont ectoparasitoid of *Trochosa* sp. (Araneae: Lycosidae). Journal of Hymenoptera Research 46: 165–172. <https://doi.org/10.3897/JHR.46.5833>
- Wasbauer MS (1995) Pompilidae. In: Hanson PE, Gauld ID (Eds) The Hymenoptera of Costa Rica, Oxford University Press, Oxford, 522–539.
- World Spider Catalog (2018) World Spider Catalog. Natural History Museum Bern. Version 19.0. <https://doi.org/10.24436/2> [Accessed 2018 June 28]

Changes in bee community structure (Hymenoptera, Apoidea) under three different land-use conditions

Alvaro E. Razo-León¹, Miguel Vásquez-Bolaños², Alejandro Muñoz-Urias¹,
Francisco M. Huerta-Martínez¹

1 Departamento de Ecología, CUCBA, Universidad de Guadalajara, km 15.5 carretera Guadalajara-Nogales, Las Agujas, Zapopan, C.P. 45110, Apdo. Postal 139, Jalisco, México **2** Departamento de Botánica y Zoología, CUCBA, Universidad de Guadalajara, km 15.5 carretera Guadalajara-Nogales, Las Agujas, Zapopan, C.P. 45110, Apdo. Postal 139, Jalisco, México

Corresponding author: Alejandro Muñoz-Urias (almurias@gmail.com)

Academic editor: J. Neff | Received 15 June 2018 | Accepted 1 October 2018 | Published 31 October 2018

<http://zoobank.org/63C5B5DA-4E3A-4D51-A8B3-2FC9026F14EE>

Citation: Razo-León AE, Vásquez-Bolaños M, Muñoz-Urias A, Huerta-Martínez FM (2018) Changes in bee community structure (Hymenoptera, Apoidea) under three different land-use conditions. Title. Journal of Hymenoptera Research 66: 23–38. <https://doi.org/10.3897/jhr.66.27367>

Abstract

Bee communities were studied with three different conditions of land-use: 1) urban area; 2) crops and livestock; and, 3) preserved vegetation. All three conditions have elements of tropical dry forest and are in the "Sierra de Quila" Flora and Fauna Protection Area and its influence zone. Sampling was carried out throughout the year (three days per month) for each land-use condition. Bee species and their abundance were registered with the intention of knowing how changes in the vegetation are related to bee community structure (richness, abundance, and α and β diversity).

A total of 14,054 individuals from 160 species were registered. A rarefaction analysis, showed that the preserved areas had significantly greater richness and diversity. Beta diversity analysis revealed a species turnover of nearly 32% among each pair of conditions. It is concluded that the changes in land-use negatively affect richness and diversity and causes major changes in species composition of the bee community. For this reason, it is recommended that the protection of the tropical dry forest, both for this study area but also in general for Mexico, is essential to guarantee the conservation of this group of insects, which are required for the reproduction of a great number wild and cultivated plant specie.

Keywords

Native bees, Mexico, tropical dry forest, bee abundance, bee diversity

Introduction

Pollinators are a key component for global biodiversity, because they assist in the sexual reproduction of many plant species and play a crucial role in maintaining terrestrial ecosystems and food security for human beings (Potts et al. 2010, van der Sluijs and Vaage 2016). Approximately 80% of angiosperms depend on biotic pollination (Klein et al. 2007, Quesada et al. 2012). Bees (Hymenoptera: Apoidea) are some of the most important pollinators (Winfree et al. 2008). It is estimated that nearly 73% of cultivated plant species and more than 75% of global vegetation are pollinated by these insects (Coro 2009), which are considered the principal pollinators in tropical regions (O'Toole and Raw 1999, Nantes-Parra 2005).

Tropical dry forest present a great bee species richness in Mexico (Ayala 1988, Ayala et al. 1996), which is explained by the high diversity of entomophilous plants (Ayala 2004), and their differentiated phenology (generally, tree species flowering in dry season while herbaceous and shrub species flowering in wet season), which provides to this group of organisms, resources for most of the year (Reyes-Novelo et al. 2009). This vegetation type covered approximately 270,000 km² in 1990 but currently there are great pressures exerted on this type of forest. For example Trejo and Dirzo (2000), reported that 50% was either fragmented or existed as relicts. Furthermore, they found changes in land use on 23% of the surface and that only 27% of this type of vegetation remained intact (Trejo and Dirzo 2000).

Land use change, such as degradation or fragmentation of tropical dry forest, could have consequences on the richness and composition of bee communities. According to previous studies, bees are susceptible to the loss of their natural habitats by the fragmentation and transformation of the landscape for agricultural, livestock and urban purposes (Martins et al. 2013, Woodcock et al. 2013, Le Féon et al. 2016, Mogren et al. 2016). For this reason, it is important to compare local bee communities from disturbed environments with one from a preserved environment in the same region, as this should provide useful information for making conservation-based decisions on bee community management (Dalmazzo 2010).

Two of the most important factors for bee communities are food availability (nectar and pollen) and nesting sites (Reyes-Novelo et al. 2009). Changes in land use are expected to affect both and consequently alter the structure of these communities. Due to this, the aims of this study were: 1) to ascertain whether landscape transformations affect bee community structure (richness, abundance, and α and β diversity) and, 2) to identify which are the bee groups most susceptible to these changes, as well as those who benefit from them.

Material and methods

Study area

The study is located at Área de protección de flora y fauna Sierra de Quila, (here and after APFFSQ) and its zone of influence, which is found in the south-central portion of Jalisco,

Mexico (Fig. 1). It is located within the Trans-Mexican Volcanic Belt physiographic region. The research was conducted in the municipalities of Tecolotlán, Tenamaxtlán, San Martín Hidalgo and Cocula. Geographically, it is found between 20°14' and 20°22'N; 103°57' and 104°07'W (DMS), with an area of 15,912 hectares (Villavicencio et al. 2012).

Data collection

Three conditions in tropical dry forest (TDF) with different land-use were selected. The first was an urbanized area (U) at Tecolotlán, a municipality with 9,189 inhabitants (IIEG 2015); the second was an agricultural area with crops and livestock (CL), which begins on the area surrounding the town, and is characterized by the presence of crops (mainly corn – *Zea mays* L.) as well as cattle ranches, which were slightly fragmented by secondary vegetation and some remaining trees of the TDF, used as living fences. The third was an area of preserved vegetation (P) of the TDF within the APFFSQ. Some of the most common trees in this area are from the following genera: *Bursera*, *Ceiba*, *Erythrina*, *Heliocarpus*, *Lysiloma*, *Stenocereus* and *Viguiera* (Fig. 1) (Guerrero-Nuño and López-Coronado 1997).

Sampling of wild bees was conducted throughout the year, with three sampling days per month (one working day per condition, from 10:00 to 16:00 hours). Four plots, 50 × 5 m, were randomly located for each land use condition and the bees were sample walking along the transect during periods of 60 minutes per collection. Bee species presences and their abundance were recorded. Bee species that could not be determined in the field were collected using an entomological net with extension of 2.70 m on tree strata and an extension of 1.00 m for herbaceous strata. Specimens were processed according to Michener et al. (1994). Bees were then identified as precisely as possible with the help of the specialized literature, whether at a species or genus level, and then separated by morphospecies. The specimens were deposited at the Entomological Collection of Centro de Estudios en Zoología of Universidad de Guadalajara (CZUG).

Data analysis

Sampling efficiency and richness comparison

A species accumulation curve was performed to evaluate the sampling effort per site and, as well as to compare the richness among the different conditions using ESTIMATES 9.1.0. (Colwell 2016). A rarefaction curve was also prepared using the same program.

Bees abundance

Bee abundances with and without *Apis mellifera* were compared via analysis of variance (ANOVA) for the first case, and Kruskal-Wallis followed by the Nemenyi *post-hoc* test,

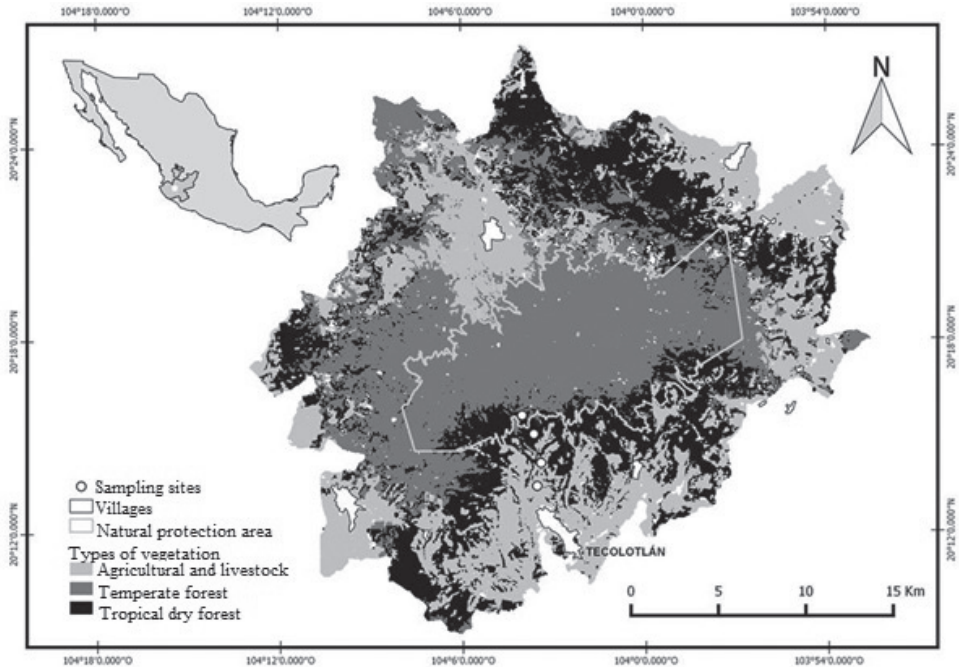


Figure 1. Location of the APFFSQ and sampling sites.

for the second case. Furthermore, Pearson's chi-squared test and residual analysis were used to compare the abundance of different bee families among the land-use conditions using the R 3.2.5 Software (R Core Team 2016).

Diversity analysis

The Shannon-Wiener index was used to compare alpha diversity of sites via a confidence interval obtained using bootstrap in PAST 3.15 software (Hammer et al. 2001). In order to contrast the composition of tribes in the study areas, beta diversity index (β_{sim}) was estimated, while non-metric multidimensional scaling (NMDS) was used with the R 3.2.5 software (R Core Team 2016) via the 'vegan' package (Oksanen et al. 2013).

Results

Sampling efficiency and comparison of specific richness

A total of 14,054 bees individuals were registered, belonging to five families, 52 genera, and 160 species (Table 1) (Appendix 1). The richest (34.9 %) and most abundant (83.3 %) family was Apidae and the poorest (7 %) and least abundant (1.2 %) fam-

Table 1. Richness and abundance of the bee families registered.

Family	Genera	Species	Abundance
Apidae	23	60	12,170
Halictidae	8	33	759
Megachilidae	13	35	739
Andrenidae	5	20	214
Colletidae	3	12	172
Total	52	160	14,054

ily was Colletidae. The bee species with the highest number of individuals were all eusocial species: *Apis mellifera*, with 7,030 individuals (49.9% of total abundance); *Partamona billineata*, with 768 individuals (5.4%); *Scaptotrigona hellwegeri* with 718 individuals (5.1%); and, *Trigona nigra* with 529 individuals (3.8 %).

The richest condition was P, with 120 species, followed by CL with 98 species and, finally U, with 81 species. The rarefaction curve among different land-use conditions indicated greater richness in P than in U and CL, although they did not present statistically significant differences (Fig. 2). Furthermore, a sampling efficiency of 88% was obtained for P (135 spp.), 77% for CL (127 spp.), and 79% for U (102 spp.) in accordance with the richness estimated by Chao 1).

Abundance of bees

The highest number of bee individuals was observed in P (5,067), followed by CL (4,786) and U (4,202). The ANOVA ($df = 2$, $F = 0.352$, $p = 0.704$) showed no significant differences between the registered abundance of bees for the different types of land-use. If only wild bees are considered (excluding *Apis mellifera*), the greatest abundance was in P (2,731), followed by U (2,418) and, finally, CL (1,876). In this case, Kruskal-Wallis test ($df = 2$, $K = 7.265$, $p = 0.026$) indicated significant differences between median abundances, while the Nemenyi *post-hoc* test demonstrated significant differences ($p = 0.023$) only in terms of the abundances of bees between P and CL.

Pearson's chi-squared test showed a dependency between land-use and bee family abundance ($df = 8$, $\chi^2 = 560.2715$, $p < 0.05$) (Table 2), while residual analysis indicated that abundance of Colletidae, Andrenidae and Megachilidae are positively related to P. The Halictidae was primarily associated with U where they were most abundant, while the Apidae registered the highest abundance in CL (Fig. 3).

Diversity analysis

The Shannon-Wiener index (H') values presented significant differences with a $p < 0.05$, P obtained a greater level of diversity compared to the other types of land-use, followed by U and, finally CL. Evenness (J') is lower in CL, while U and P presented similar even-

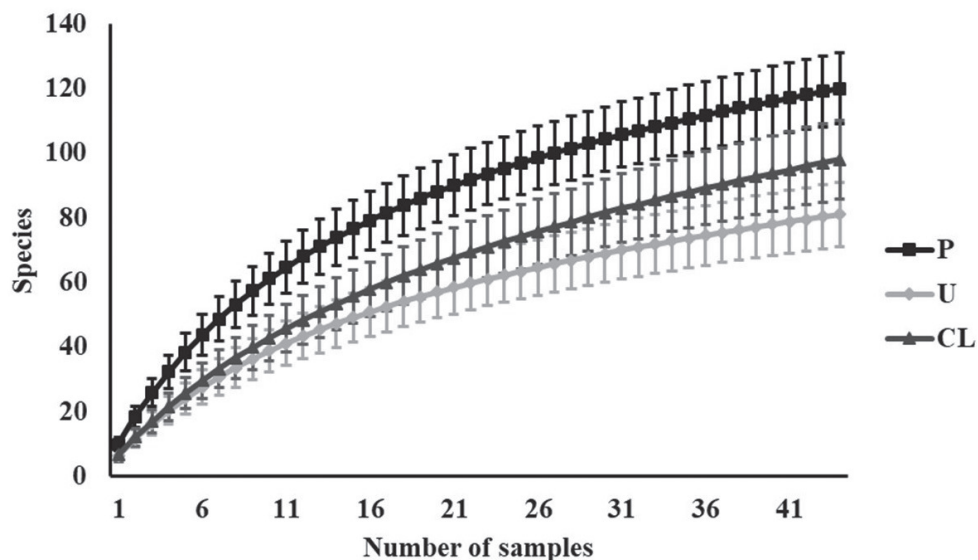


Figure 2. Rarefaction curve for bee richness among the different land-use conditions.

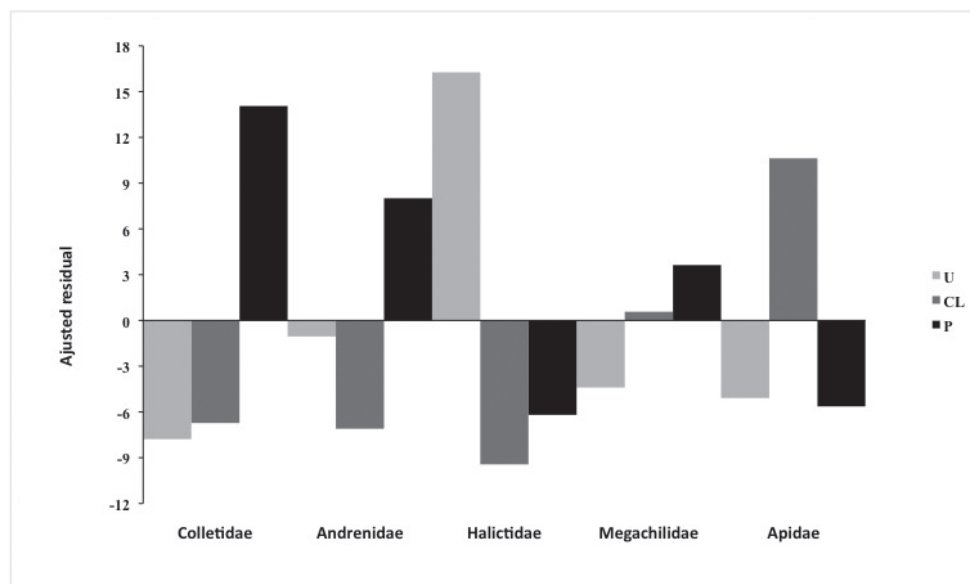


Figure 3. Residual analysis with Pearson's chi-squared test to compare independence between bee family and land use conditions.

ness. Moreover, when only wild bees were considered, diversity was higher in P. This is due to the elevated abundance of *Apis mellifera* (Table 3).

The beta diversity index (β_{sim}) showed an average species turnover rate of about 32% for each condition. In terms of bee species composition change, the highest was between U and CL (36%), followed by P and U with 30% and finally between CL and P with 27%.

Table 2. Abundance per bee family in different conditions of land-use. Abundance of Apidae without *Apis mellifera* between parentheses.

Family	U	CL	P
Apidae	3,545 (1,748)	4,345 (1,434)	4,279 (1,943)
Halictidae	427	141	192
Megachilidae	168	259	313
Andrenidae	57	24	133
Colletidae	5	17	150

Table 3. Shannon-Wiener diversity index (H') per land-use condition and their confidence intervals (IC 95%) via bootstrap, and maximum diversity (H'max), Evenness (J'), including *Apis mellifera* and excluding *A. mellifera*.

	H'	-CI 95%	+CI 95%	H'max	J'
Including <i>A. mellifera</i>					
U	2.605 ^b	2.561	2.666	4.40	0.591
CL	1.933 ^c	1.889	2.00	4.58	0.421
P	2.755 ^a	2.703	2.813	4.79	0.574
Excluding <i>A. mellifera</i>					
U	3.342 ^b	3.313	3.403	4.39	0.760
CL	3.225 ^b	3.187	3.319	4.57	0.704
P	3.830 ^a	3.790	3.878	4.78	0.800

Measurements with the same letter do not differ statistically, according to the confidence intervals.

The indirect ordination performed with NMDS resulted in a stress value of 0.1326, that shows a gradual separation of the three different land-use conditions along the first axis, where on the left side are located U sites, CL sites in the center, and P sites on the right side. The tribe Anthophorini and tribes of the Halictidae were associated with the U, while tribes of the Apidae and one megachilid tribe were located principally between the U and CL areas. The Lithurgini, two tribes of the Andrenidae and two cleptoparasite tribes (Ericrocidini, Epeolini) were associated with the CL, while the Xylocopini was associated with the P and CL areas. Tribes of Colletidae, Andrenidae, and Megachilidae and two apid tribes were found in P (Fig. 4).

Discussion

The highest bee richness was registered in P while the only significant differences were recorded between U and P. The results indicate a gradient in richness related to the habitat conservation. This finding is supported by different studies which show that the destruction of the habitat, for agriculture or urbanization, is principally responsible for bee species reduction, up to the point of local extinction for some species (Frankie et al. 1997, Martins et al. 2013). Furthermore, in a meta-analysis, Winfree

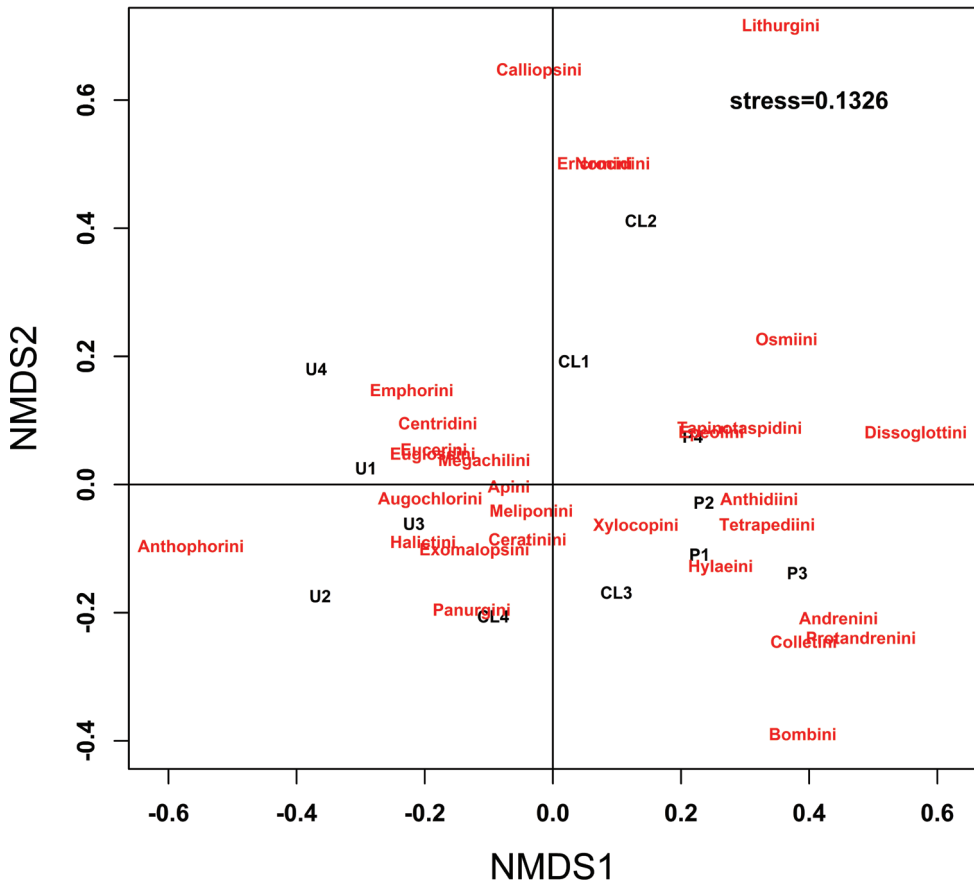


Figure 4. Ordination diagram derived from NMDS for the different land-use areas and bee tribal data.

et al. (2009), report that bee richness decreases with increasing anthropogenic disturbance, while Ricketts et al. (2008), found that on average the richness of pollinators (principally bees) in crops decreased by half as the distance from preserved habitat increased to 1500 m.

The decrease in bee richness is related to their dependence on various resources to complete their lifecycle, such as food resources (pollen and nectar) and nesting substrates (either from the soil or vegetation), and materials for constructing their nests (Winfree 2010). The reason that a greater number of bee species is registered in the preserved area is possibly due to a greater availability of plant species for food, being that bee richness has been positively related to the richness of flowers (Carper et al. 2014) and to a great floral diversity, which provide food to a great variety of specialist and generalist bee species (Martins et al. 2013).

The abundance of bees did not differ significantly between the three land-use conditions. This agrees with various studies that report a similar or greater abundance in human modified areas (Carper et al. 2014, Mallinger et al. 2016, Nantes-Parra et al. 2008, Olalde-Estrada et al. 2015, Otero and Sandino 2003, Tonhasca et al. 2002); this occurs in sites

with moderate disturbance with gaps on forest canopy, which facilitate grow of herbaceous layer (Carper et al. 2014). This also shows that urban areas could be important for bee communities, despite the modification of vegetation, because they offer ornamental and wild flowers, particularly because they are watering them in times when native vegetation is diminished, as well as nesting resources associated to human constructions (Dalmazzo 2010). The differences in abundance between the P and CL when *Apis mellifera* is excluded from analysis could be due to the same reasons that affect bee richness in addition to the use of pesticides in the crops which affect wild bees (Winfree 2010).

The number of individuals per family varied, Andrenidae, Megachilidae and Colletidae being far less abundant than the Apidae and Halictidae. Potts et al. (2003) found the Andrenidae positively associated with annual plant diversity, and Megachile with plant richness, pollen and available nectar. Vergara (2005) suggests that, in areas with agricultural activity, bee genera that nest in the soil, including andrenids and colletids, are under-represented due to plowing for agricultural activities and the presence of livestock, which affect nesting. While Halictidae presented greater abundance in the urban area, this is possibly because most of the registered bees of this family are small (<1 cm) and most of them are polilectic (Michener 2000).

Banaszak-Cibicka and Zmihorski (2012), reported that urban areas contain small green isolated island (parks and gardens), that promote the abundances of small bees, which require only a small amount of food. Winfree et al. (2009), indicate that they do not have problems in finding nesting sites in disturbed areas.

Total bee abundance tends to decline at disturbed sites, while individual species present different responses, some of them show drastic reduction in their populations, while others remain stable or even increase with land-use change (Winfree et al. 2008). For this reason, the use of the habitat according to bee species plays an important role. Bees that require specific conditions for their development, become the most vulnerable to the disappearance of their habitat. On the other hand, if the resources generated by the modification of the habitat is exploited by the bees, they could survive in disturbed areas (Winfree 2010). That is the reason why bees that can use a wide variety of resources are often able to compensate when circumstances change, although some species disappear due to land use changes. The higher richness and evenness patterns in preserved areas is supported by Reyes-Novelo et al. (2009), who explain that in disturbed areas some species disappear locally and the abundance of others decreases, which modifies dominance.

Finally, β diversity showed a medium level of species turnover rate among conditions, despite the maximum distance between sampling sites was 6 km. The structure of bee community contrasts with P and U, in which tribes such as Halictini and Anthophorini (due to the high abundance of *Anthophora squammulosa*) are associated with the urban area. The tribes of the Andrenidae, Colletidae, Megachilidae and Apidae, such as bumblebees (Bombini), are strongly associated with P, while the CL area is found at the mid-point of the gradient. This suggests that disturbance, with its variations in micro-environments and food and nesting resource has a significant effect on bee community species composition.

The bee fauna of the TDF in Mexico is one of the richest and most diverse in the country (Ayala 2004), so, the protection of this type of vegetation is crucial for the conservation of this group of insects, given that the reduction of these native pollinators could have a negative economic impact on crops (Maass et al. 2005). As the expansion of human settlement and the population growth or production activities have led to the process of deforestation, fragmentation and degradation of this forest (Maass et al. 2010), Trejo and Dirzo (2000) report that approximately 3.7% of the TDF of the total area of Mexico (72,850 km²) remains relatively intact and with a high annual deforestation rate of 2.02% of the total coverage.

Conclusions

The APFFSQ is an important site for maintaining wild bee diversity, given that 200 species of bees were registered in the area, of which 160 are present in the TDF (Razo-León 2015). According to Ortega, (2007), the TDF covered 19.84% of APFFSQ (2,797 ha) in 1993, by the year 2000, it only covered 15.25% (2,149 ha), this means that the TDF lost 23.2% of its area in seven years, because it is rounded by agricultural or livestock production areas which make it more vulnerable to transformation. This leads to the conclusion that change in land-use negatively affects the richness, abundance, and diversity of species of bee community, for this reason it is recommended that the TDF in Mexico should be protected in order to guarantee the conservation of this group of insects.

Acknowledgments

We thank anonymous reviewers for suggesting improvements to the manuscript. A doctoral scholarship from CONACYT, Hugo Eduardo Fierros-López (CUCBA, University of Guadalajara) for the identification of bees, Regional Committee for the Protection and Promotion of the Natural Resources of the Sierra de Quila A.C. for all its institutional and logistical support, Raymundo Villavicencio and Victoria Belen Muñoz for the preparation of the map.

References

- Ayala R (1988) Abejas silvestres (Hymenoptera: Apoidea) de Chamela, Jalisco, México. *Folia Entomologica Mexicana* 73: 395–493.
- Ayala R, Griswold TL, Yanega D (1996) Apoidea (Hymenoptera). In: Llorente J, García A, González E (Eds) *Biodiversidad, taxonomía, y biogeografía de artrópodos de México: Hacia una síntesis de su conocimiento*. UNAM-CONABIO, Ciudad de México, 423–464.
- Ayala R (2004) Fauna de abejas silvestres (Hymenoptera: Apoidea). In: García AN, Ayala R (Eds) *Artrópodos de Chamela*. UNAM, Ciudad de México, 193–219.

- Banaszack-Cibicka W, Zmihorski M (2012) Wild bees along an urban gradient: winners and loser. *Journal of Insect Conservation* 16(3): 331–343. <https://doi.org/10.1007/s10841-011-9419-2>
- Campos-Navarrete MJ, Parra-Tabla V, Ramos-Zapata J, Díaz-Castelazo C, Reyes-Novelo E (2013) Structure of plant–Hymenoptera networks in two coastal shrub sites in Mexico. *Arthropod Plant Interaction* 7(6): 607–617. <https://doi.org/10.1007/s11829-013-9280-1>
- Carper AL, Adler LS, Warren PS, Irwin RE (2014) Effects of suburbanization on forest bee communities. *Environmental Entomology* 43(2): 253–262. <https://doi.org/10.1603/EN13078>
- Colwell RK (2016) EstimateS 9.1.0. University of Connecticut, Storrs, USA. <http://purl.oclc.org/estimates>
- Coro AM (2009) La crisis de los polinizadores. *Biodiversitas* 85: 1–5.
- Dalmazzo M (2010) Diversidad y aspectos biológicos de abejas silvestres de un ambiente urbano y otro natural de la región central de Santa Fe, Argentina. *Revista de la Sociedad Entomológica Argentina* 69(1–2): 33–44.
- Frankie GW, Vinson SB, Rizzardi MA, Griswold TL, O’Keefe S, Snelling RR (1997) Diversity and abundance of bees visiting a mass flowering tree species in disturbed seasonal dry forest, Costa Rica. *Journal of the Kansas Entomological Society* 70(4): 281–296.
- Guerrero-Nuño JJ, López-Coronado GA (1997) La vegetación y la flora de la Sierra de Quila. Universidad de Guadalajara, Guadalajara, 134 pp.
- Hammer Ř, Harper DAT, Ryan PD (2001) PAST: Paleontological Statistics Software Package for Education and Data Analysis *Palaeontologia Electronica*. http://palaeo-electronica.org/2001_1/past/issue1_01.htm
- IIEG (2015) Instituto de Información Estadística y Geográfica del Estado de Jalisco con base en INEGI, censos y conteos nacionales. <http://www.iieg.gob.mx/contenido/Municipios/Tecolotlan.pdf>
- Klein AM, Vaissiere BE, Cane JH, Steffan-Dewenter I, Cunningham SA, Kremen C, Tscharntke T (2007) Importance of pollinators in changing landscapes for world crops. *Proceedings of Royal Society B* 274(1608): 303–313. <https://doi.org/10.1098/rspb.2006.3721>
- Le Féon V, Poggio SL, Torretta JP, Bertrand C, Molina GA, Burel F, Ghersa CM (2016) Diversity and life-history traits of wild bees (Insecta: Hymenoptera) in intensive agricultural landscapes in the Rolling Pampa, Argentina. *Journal of Natural History* 50(19–20): 1175–1196. <https://doi.org/10.1080/00222933.2015.1113315>
- Maass M, Balvanera P, Castillo A, Daily GC, Mooney HA, Ehrlich P, Quesada M, Miranda A, Jaramillo VJ, Garcia-Oliva F, Martinez-Yrizar A, Cotler H, Lopez-Blanco J, Perez-Jimenez A, Burquez A, Tinoco C, Ceballos G, Barraza L, Ayala R, Sar J (2005) Ecosystem services of tropical dry forests: insights from long-term ecological and social research on the Pacific Coast of Mexico. *Ecology and Society* 10(1): 17–39. <https://doi.org/10.5751/ES-01219-100117>
- Maass M, Búrquez A, Trejo I, Valenzuela D, González MA, Rodríguez M, Arias H (2010) Amenazas. In: Ceballos G, Martínez L, García A, Espinoza E, Creel JB, Dirzo R (Eds) *Diversidad, amenazas y áreas prioritarias para la conservación de las Selvas Secas del Pacífico de México*. FCE-CONABIO-TELMEX-CONANP-WWF México-EcoCiencia SC, Ciudad de México, 321–346.

- Mallinger RE, Gibbs J, Gratton C (2016) Diverse landscapes have a higher abundance and species richness of spring wild bees by providing complementary floral resources over bees' foraging periods. *Landscape Ecology* 31(7): 1523–1535. <https://doi.org/10.1007/s10980-015-0332-z>
- Martins AC, Gonçalves RB, Melo GA (2013) Changes in wild bee fauna of a grassland in Brazil reveal negative effects associated with growing urbanization during the last 40 years. *Zoologia (Curitiba)* 30(2): 157–176. <https://doi.org/10.1590/S1984-46702013000200006>
- Michener CD, McGinley RJ, Fanforth BN (1994) *The Bee Genera of North and Central America (Hymenoptera: Apoidea)*. Smithsonian Institution Press, Washington, 208 pp.
- Mogren CL, Rand TA, Fausti SW, Lundgren JG (2016) The effects of crop intensification on the diversity of native pollinator communities. *Environmental Entomology* 45(4): 865–872. <https://doi.org/10.1093/ee/nvw066>
- Nantes-Parra G (2005) Abejas silvestres y polinización. *Manejo Integrado de Plagas y Agroecología* 75: 7–20.
- Nantes-Parra G, Palacios E, Parra A (2008) Efecto del cambio del paisaje en la estructura de la comunidad de abejas sin aguijón (Hymenoptera: Apidae) en Meta, Colombia. *Revista de Biología Tropical* 56(3): 1295–1308.
- O'Toole C, Raw A (1999) *Bees of the world*. Facts on file, New York, 192 pp.
- Oksanen J, Blanchet FG, Kindt R, Legendre P, Minchin PR, O'Hara RB, Simpson GL, Solyomos P, Henry M, Stevens H, Szoecs E, Wagner H (2013) Package 'vegan' version 2.0–10. En *Community ecology package*. <http://www.r-project.org>.
- Olalde-Estrada I, Cano-Santana Z, Castellanos-Vargas II, Balboa-Aguilar CC (2015) Variación Espacio-Temporal en la Densidad y Diversidad de Abejas en sitios de Bosque Tropical Caducifolio Sujetos a Disturbio en el Ejido San José Tilapa, Puebla. *Entomología Mexicana* 2: 533–539.
- Ortega CCA (2007) Estudio Temporal de la Fragmentación Forestal del Área de Protección de Flora y Fauna "Sierra de Quila" en el Estado de Jalisco, Mediante Sistemas de Información Geográfica (SIG). Thesis. Universidad de Guadalajara, Guadalajara.
- Otero JT, Sandino JC (2003) Capture Rates of Male Euglossine Bees across a Human Intervention Gradient, Chocó Region, Colombia. *Biotropica* 35(4): 520–529.
- Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE (2010) Global pollinator declines: trends, impact and drivers. *Trends in Ecology and Evolution* 25(6): 345–353. <https://doi.org/10.1016/j.tree.2010.01.007>
- Potts SG, Vulliamy B, Dafni A, Ne'eman G, Willmer P (2003) Linking bees and flowers: How do floral communities structure pollinator communities? *Ecology* 84(10): 2628–2642. <https://doi.org/10.1890/02-0136>
- Quesada M, Rosas F, Lópezaraiza M, Aguilar R, Ashworth L, Rosas GV, Sánchez MG, Marén RS (2012) Ecología y Conservación Biológica de Sistemas de Polinización de Plantas Tropicales. In: del Val E, Bouge K (Eds) *Ecología y Evolución de las Interacciones bióticas*. Fondo de Cultura Económica, CIECO y UNAM. Ciudad de México, 75–100.
- R Core Team (2016) *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna. <http://www.R-project.org/>
- Reyes-Novelo E, Meléndez VR, Ayala R, Delfín HG (2009) Abejas Silvetres (Hymenoptera: Apidae) como Bioindicadores en el Neotrópico. *Tropical and Subtropical Agroecosystems* 10(1): 1–13.

- Ricketts TH, Regetz, J, Steffan-Dewenter I, Cunningham SA, Kremen C, Bogdanski A, Morandin LA (2008) Landscape effects on crop pollination services: are there general patterns? *Ecology letters* 11(5): 499–515. <https://doi.org/10.1111/j.1461-0248.2008.01157.x>
- Tonhasca Jr A, Blackmer JL, Albuquerque GS (2002) Abundance and Diversity of Euglossine Bees in the Fragmented Landscape of the Brazilian Atlantic Forest. *Biotropica* 34(3): 416–422. <https://doi.org/10.1111/j.1744-7429.2002.tb00555.x>
- Trejo I, Dirzo R (2000) Deforestation of seasonally dry tropical forest: a national and local analysis in Mexico. *Biological Conservation* 94(2): 133–142. [https://doi.org/10.1016/S0006-3207\(99\)00188-3](https://doi.org/10.1016/S0006-3207(99)00188-3)
- van der Sluijs JP, Vaage NS (2016) Pollinators and Global Food Security: The Need for Holistic Global Stewardship. *Food Ethics* 1(1): 75–91. <https://doi.org/10.1007/s41055-016-0003-z>
- Vergara CH (2005) Effects of Agriculture on Bee Community (Hymenoptera: Apoidea). *Journal of Agronomy* 4(4): 277–280. <https://doi.org/10.3923/ja.2005.277.280>
- Villavicencio R, Santiago AL, Godínez JJ, Chávez JM, Toledo SL (2012) Efecto de la fragmentación sobre la regeneración natural en la Sierra de Quila, Jalisco. *Revista Mexicana de Ciencias Forestales* 3(11): 9–23.
- Winfree R, Williams NM, Gaines H, Ascher JS, Kremen C (2008) Wild Bee Pollinators Provide the Majority of Crop Visitation across Land-Use Gradients in New Jersey and Pennsylvania, USA. *Journal Applied Ecology* 45(3): 793–802. <https://doi.org/10.1111/j.1365-2664.2007.01418.x>
- Winfree R, Aguilar R, Vázquez DP, LeBuhn G, Aizen MA (2009) A meta-analysis of bees' responses to anthropogenic disturbance. *Ecology* 90(8): 2068–2076. <https://doi.org/10.1890/08-1245.1>
- Winfree R (2010) The conservation and restoration of wild bees. *Annals of the New York Academic of Sciences* 1195: 169–197. <https://doi.org/10.1111/j.1749-6632.2010.05449.x>
- Woodcock BA, Edwards M, Redhead J, Meek WR, Nuttall P, Falk S, Pywell RF (2013) Crop flower visitation by honeybees, bumblebees and solitary bees: Behavioural differences and diversity responses to landscape. *Agriculture, Ecosystems and Environment* 171: 1–8. <https://doi.org/10.1016/j.agee.2013.03.005>

Appendix I

Table AI. Number of individuals per bee species registered in different land use conditions.

Species	U	CL	P
<i>Agapostemon leunculus</i> Vachal, 1903	20	6	21
<i>Agapostemon nasutus</i> Smith, 1853	9	0	1
<i>Ancyloscelis apiformis</i> (Fabricius, 1793)	35	2	8
<i>Andrena</i> sp. 1	0	0	25
<i>Andrena</i> sp. 2	0	0	12
<i>Andrena</i> sp. 3	0	0	1
<i>Andrena</i> sp. 4	0	1	0
<i>Anthidiellum apicale</i> (Cresson, 1878)	1	13	42
<i>Anthidiellum azteca</i> (Urban, 2001)	0	0	2
<i>Anthidium parkeri</i> González & Griswold, 2013	0	0	8
<i>Anthodioctes gualanensis</i> (Cockerell, 1912)	0	0	1
<i>Anthodioctes</i> sp. 1	0	4	7
<i>Anthophora capistrata</i> Cresson, 1878	0	0	1
<i>Anthophora squammulosa</i> Dours, 1864	160	39	0
<i>Anthophorula serrata</i> (Friese, 1899)	0	31	26
<i>Apis mellifera</i> Linnaeus, 1758	178	2910	2336
<i>Ashmeadiella buconis</i> (Cresson, 1878)	0	29	0
<i>Ashmeadiella opuntiae</i> (Cockerell, 1879)	0	0	1
<i>Augochlora aurifera</i> Cockerell, 1897	42	0	0
<i>Augochlora quiriguensis</i> Cockerell, 1913	6	17	28
<i>Augochlora sidaefolia</i> Cockerell, 1913	9	6	4
<i>Augochlora smaragdina</i> Friese, 1917	13	11	12
<i>Augochlora</i> sp. 1	29	2	34
<i>Augochlora</i> sp. 2	37	0	0
<i>Augochlora</i> sp. 3	0	0	2
<i>Augochlorella neglectula</i> (Cockerell, 1897)	25	28	3
<i>Augochloropsis ignita</i> (Smith, 1861)	4	1	0
<i>Augochloropsis metallica</i> (Fabricius, 1793)	30	11	39
<i>Aztecantidium xochipillium</i> Michener & Ordway, 1964	0	0	2
<i>Bombus diligens</i> Smith, 1861	0	1	3
<i>Bombus steindachneri</i> Handlirsch, 1888	0	1	9
<i>Calliopsis hondurasica</i> Cockerell, 1897	0	2	0
<i>Calliopsis</i> sp. 1	1	0	0
<i>Calliopsis</i> sp. 2	0	0	1
<i>Centris agilis</i> Smith, 1874	0	0	3
<i>Centris aterrima</i> Smith, 1854	0	6	0
<i>Centris atripes</i> Mocsáry, 1899	0	1	4
<i>Centris flavofasciata</i> Friese, 1899	0	4	0
<i>Centris nitida</i> Smith, 1874	37	30	68
<i>Centris trigonoides</i> Lepeletier, 1841	125	14	3
<i>Centris varia</i> (Erichson, 1848)	18	0	0
<i>Ceratina arizonensis</i> Cockerell, 1898	1	3	5
<i>Ceratina capitosa</i> Smith, 1879	1	1	6
<i>Ceratina eximia</i> Smith, 1862	3	0	7
<i>Ceratina</i> sp. 1	1	47	42
<i>Ceratina</i> sp. 2	20	9	12
<i>Ceratina</i> sp. 3	20	5	10
<i>Ceratina</i> sp. 4	7	0	0
<i>Coelioxys aztecus</i> Cresson, 1878	1	1	1
<i>Coelioxys</i> sp. 1	0	1	0
<i>Coelioxys</i> sp. 2	0	1	0

<i>Colletes macconnelli</i> Metz, 1910	0	0	16
<i>Colletes</i> sp. 1	0	0	42
<i>Colletes</i> sp. 2	1	1	5
<i>Colletes</i> sp. 3	0	0	1
<i>Colletes</i> sp. 4	0	0	1
<i>Colletes</i> sp. 5	0	0	8
<i>Diadasia australis</i> (Cresson, 1878)	56	159	5
<i>Diadasia</i> sp. 1	0	1	0
<i>Dianthidium macrurum</i> (Cockerell, 1913)	0	70	20
<i>Dianthidium</i> sp. 1	0	1	10
<i>Dieunomia micheneri</i> (Cross, 1958)	0	1	0
<i>Epicharis elegans</i> Smith, 1861	6	0	0
<i>Eufriesea micheneri</i> Ayala and Engel, 2008	0	0	3
<i>Euglossa viridissima</i> Friese, 1899	76	8	66
<i>Eulaema polychroma</i> (Mocsáry, 1899)	6	0	11
<i>Exomalopsis similis arida</i> Cockerell, 1929	0	1	0
<i>Exomalopsis similis moesta</i> Timberlake, 1890	51	25	2
<i>Exomalopsis</i> sp. 1	0	21	33
<i>Exomalopsis</i> sp. 2	26	2	3
<i>Exomalopsis</i> sp. 4	8	0	7
<i>Exomalopsis</i> sp. 5	0	0	4
<i>Frieseomelitta nigra</i> Cresson, 1878	122	320	87
<i>Halictus ligatus</i> Say, 1837	113	0	3
<i>Heriades bruneri</i> Titus, 1904	0	0	1
<i>Heriades variolosa</i> Cockerell, 1929	0	6	20
<i>Hylaeus</i> sp. 1	2	5	26
<i>Hylaeus</i> sp. 2	1	4	0
<i>Hylaeus</i> sp. 3	0	0	4
<i>Hylaeus</i> sp. 4	1	0	0
<i>Hylaeus</i> sp. 5	0	0	4
<i>Hypanthidium mexicanum</i> (Cresson, 1878)	0	0	1
<i>Lasioglossum acarophyllum</i> McGinley, 1986	1	0	11
<i>Lasioglossum desertum</i> Smith, 1879	1	0	0
<i>Lasioglossum</i> sp. 1	0	3	0
<i>Lasioglossum</i> sp. 2	0	3	0
<i>Lasioglossum</i> sp. 3	2	0	2
<i>Lasioglossum</i> sp. 4	0	18	2
<i>Lasioglossum</i> sp. 5	0	4	0
<i>Lasioglossum</i> sp. 6	0	0	5
<i>Lasioglossum</i> sp. 7	1	3	0
<i>Lasioglossum</i> sp. 8	0	2	4
<i>Lasioglossum</i> sp. 9	0	0	5
<i>Lasioglossum</i> sp. 10	1	0	6
<i>Lasioglossum</i> sp. 11	3	16	3
<i>Lasioglossum</i> sp. 12	0	0	3
<i>Lasioglossum</i> sp. 13	9	0	0
<i>Lasioglossum</i> sp. 14	2	1	1
<i>Lasioglossum</i> sp. 15	4	1	0
<i>Lasioglossum</i> sp. 16	0	0	1
<i>Lithurgopsis apicalis</i> Cresson, 1875	0	52	5
<i>Megachile albitarsis</i> Cresson, 1872	13	0	8
<i>Megachile concinna</i> Smith, 1879	2	5	2
<i>Megachile exilis</i> Cresson, 1878	38	0	11
<i>Megachile flavihirsuta</i> Mitchell, 1939	2	1	14
<i>Megachile frugalis</i> Cresson, 1872	0	17	10
<i>Megachile gentilis</i> Cresson, 1872	23	13	62

<i>Megachile otomita</i> Cresson 1878	69	0	0
<i>Megachile parallela</i> Smith, 1853	2	1	2
<i>Megachile petulans</i> Cresson, 1878	5	4	9
<i>Megachile reflexa</i> (Snell, 1990)	8	36	4
<i>Megachile</i> sp. 1	0	0	1
<i>Megachile</i> sp. 2	1	0	0
<i>Megachile zapoteca</i> Cresson, 1872	0	1	16
<i>Melissodes morrilli</i> Cockerell, 1918	46	18	8
<i>Melissodes</i> sp. 1	0	1	0
<i>Melissodes</i> sp. 2	3	6	7
<i>Melissodes</i> sp. 3	20	12	12
<i>Melissodes</i> sp. 4	0	2	0
<i>Melissodes tepaneca</i> Cresson, 1878	1	28	7
<i>Melitoma marginella</i> (Cresson, 1872)	70	1	49
<i>Mesochora bicolor</i> (Fabricius, 1804)	0	5	0
<i>Mexalictus</i> sp. 1	0	0	3
<i>Mydosoma serratum</i> (Friese, 1899)	0	7	43
<i>Panathidium jugatorium</i> (Say, 1824)	0	2	14
<i>Panathidium vespoides</i> (Friese, 1921)	3	0	54
<i>Paratetrapedia moesta</i> (Cresson, 1878)	0	4	9
<i>Partamona bilineata</i> (Say, 1837)	439	84	245
<i>Peponapis azteca</i> (Hurd and Linsley, 1966)	125	49	1
<i>Peponapis utahensis</i> (Cockerell, 1905)	1	0	0
<i>Perdita</i> sp. 1	0	2	20
<i>Plebeia cora</i> Ayala, 1999	0	0	145
<i>Protandrena</i> sp. 1	12	1	41
<i>Protandrena</i> sp. 2	37	0	16
<i>Protandrena</i> sp. 3	0	11	0
<i>Protandrena</i> sp. 4	3	3	0
<i>Protandrena</i> sp. 5	0	0	2
<i>Protandrena</i> sp. 6	1	0	0
<i>Pseudaugochlora graminea</i> (Fabricius, 1804)	66	6	2
<i>Pseudopanurgus</i> sp. 1	1	1	14
<i>Pseudopanurgus</i> sp. 2	0	2	0
<i>Pseudopanurgus</i> sp. 3	1	0	0
<i>Pseudopanurgus</i> sp. 4	0	0	1
<i>Pseudopanurgus</i> sp. 5	1	1	0
<i>Scaptotrigona belluegeri</i> (Friese, 1900)	134	388	196
<i>Stelis costaricensis</i> Friese, 1921	0	0	1
<i>Tetraloniella balluca</i> LaBerge, 2001	0	2	1
<i>Tetraloniella donata</i> (Cresson, 1878)	0	6	19
<i>Tetraloniella pomonae</i> (Cockerell, 1915)	5	14	22
<i>Tetraloniella salviae</i> LaBerge, 1989	0	2	32
<i>Tetrapedia maura</i> Cresson, 1878	0	23	8
<i>Trachusa pectinata</i> Brooks and Griswold, 1988	0	1	38
<i>Triepeolus</i> sp. 1	2	0	25
<i>Trigona fulviventris</i> Guérin, 1835	0	14	172
<i>Xenoglossa gabbii</i> (Cresson, 1878)	1	0	0
<i>Xylocopa guatemalensis</i> Cockerell, 1912	0	1	214
<i>Xylocopa mexicanorum</i> Cockerell, 1912	134	43	124
<i>Xylocopa muscaria</i> (Fabricius, 1775)	1	1	53
<i>Xylocopa tabaniformis tabaniformis</i> (Smith, 1854)	0	0	108
Total	4202	4786	5067

The cuckoo bee genus *Sphecodes* Latreille, 1804 (Hymenoptera, Halictidae) in Iran

Yulia V. Astafurova¹, Maxim Yu. Proshchalykin², Maximilian Schwarz³

1 Zoological Institute, Russian Academy of Sciences, Universitetskaya Nab., 1, Saint Petersburg 199034, Russia

2 Federal Scientific Centre of the East Asia Terrestrial Biodiversity, Far Eastern Branch of Russian Academy of Sciences, Vladivostok 690022, Russia **3** A-4052, Ansfelden, Austria

Corresponding author: Maxim Yu. Proshchalykin (proshchalikin@biosoil.ru)

Academic editor: Michael Ohl | Received 23 August 2018 | Accepted 23 October 2018 | Published 31 October 2018

<http://zoobank.org/EF9187E1-BFB7-487F-8C48-7ABDE55EC329>

Citation: Astafurova YV, Proshchalykin MY, Schwarz M (2018) The cuckoo bee genus *Sphecodes* Latreille, 1804 (Hymenoptera, Halictidae) in Iran. Journal of Hymenoptera Research 66: 39–53. <https://doi.org/10.3897/jhr.66.29269>

Abstract

An overview is provided of the Iranian fauna of cleptoparasitic bee species in the genus *Sphecodes* Latreille (Halictinae: Halictini: Sphecodina). In total, 25 species are recorded from Iran, eight of which are newly recorded for the country: *Sphecodes anatolicus* Warncke, 1992, *S. croaticus* Meyer, 1922, *S. haladai* Warncke, 1992, *S. pectoralis* Morawitz, 1876, *S. rubicundus* Hagens, 1875, *S. rufiventris* (Panzer, 1798), *S. saxicolus* Warncke, 1992, and *S. tadschicus* Blüthgen, 1935. A new species *S. ebmeri* Astafurova & Proshchalykin, **sp. n.** (Mazandaran) is described and illustrated. For many species of *Sphecodes* the distribution data within Iran are enlarged.

Keywords

taxonomy, new species, new records, fauna, Palaearctic region

Introduction

Sphecodes Latreille, 1804 is a large genus of family Halictidae distributed worldwide except in the Polar Regions. Most *Sphecodes* species are cleptoparasites of *Lasioglossum* Curtis and *Halictus* Latreille (Halictidae), but some attack nests of other pollen-collecting

short-tongued bees, *Nomioides* Schenck (Halictidae), *Andrena* Fabricius, *Calliopsis* Smith, *Melitturga* Latreille, and *Perdita* Smith (Andrenidae), *Colletes* Latreille and *Lonchopria* Vachal (Colletidae), and perhaps *Dasypoda* Latreille (Melittidae) (Michener 2007).

The present paper is part of a series of works dealing with the bees of the genus *Sphcodes* of the territory of the Palaearctic region (Astafurova and Proshchalykin 2014, 2015a, b, c, 2016a, b, 2017a, b, c, 2018, Astafurova et al. 2014, 2015, 2018a, b, c). Currently 77 species are known from this region, but the *Sphcodes* fauna of Iran is particularly under-recorded.

There are currently 862 species of bee known from Iran (Ascher and Pickering 2018), but new records and species continue to be added (e.g., Khodaparast and Monfared 2012, Khaghaninia et al. 2013, Nadimi et al. 2014; Kuhlmann and Proshchalykin 2015, Safi et al. 2018, Proshchalykin and Kuhlmann 2018). The genus *Sphcodes* has been one of the more overlooked taxa partly due to the complexity of positively identifying material. Only one species – *Sphcodes persicus* Blüthgen, 1924 (= *S. pinguius* Pérez, 1903) of this genus has been described from Iran (Blüthgen 1924) so far, and in total only 16 species have been recorded for the country (Warncke 1992, Ascher and Pickering 2018). Records of *Sphcodes* from Iran in other published sources (Bogusch and Straka 2012, Özbek et al. 2015, Astafurova and Proshchalykin 2017b) were not original and referenced from a previous paper (Warncke 1992).

Here we have attempted to build a survey of Iranian material available and to provide an overview of the 25 species found across Iran. Of these species, eight are recorded for the first time for the Iranian fauna and one species is described as new. For each species we provide a list of Iranian localities from the material examined and give previously published occurrences along with a summary of the wider distribution.

Materials and methods

The results presented in this paper are based on 324 specimens collected in Iran and currently housed in the Zoological Institute (St. Petersburg, Russia) and private collection of Maximilian Schwarz (Ansfelden, Austria). Acronyms for collections from which specimens were borrowed or are deposited are as follows: OÖLM – Oberösterreichisches Landesmuseum, Linz, Austria; PCMS – private collection of Maximilian Schwarz, Ansfelden, Austria; ZISP – Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia.

The taxonomy and distribution of species generally follows that of Warncke (1992), Bogusch and Straka (2012), Astafurova and Proshchalykin (2017b), and Özbek et al. (2015). A detailed current synonymy of the species has been given by Astafurova and Proshchalykin (2017b). Morphological terminology employed below follows that of Michener (2007) and Engel (2001). The ventral surfaces of some flagellomeres bear a distinctive patch or zone of sensilla trichodea A (sensu Årgent and Svensson 1982), and we refer to these as the “tyloids”, easily observable under light microscopy. The abbreviations F, T, and S are used for flagellomere, metasomal tergum, and metasomal

sternum, respectively. The density of integumental punctures is described using the following formula: puncture diameters (in μm) / ratio of distance between punctures to average puncture diameter, e.g., 15–20 μm / 0.5–1.5. Integumental sculpturing, aside from distinctive surface punctation, is described as follows: reticulate: superficially net-like or made up of a network of raised lines; rugose: irregular, nonparallel, wrinkled raised lines (rugae); tessellate: a regular network of shallow grooves with flat interspaces.

Specimens were studied with the use of a Leica M205A stereomicroscope and photographs taken with a combination of stereomicroscope Olympus SZX10 and digital camera Canon EOS70D. Final images representing a composite of several photographs taken at different focal planes and combined using Helicon Focus 6. All images were post-processed for contrast and brightness using Adobe Photoshop.

The species are presented alphabetically and those that could not be inspected in this paper are quoted from published sources. Provinces are presented in alphabetical order and the names of provinces are given in bold type. New distributional records are noted with an asterisk (*).

Taxonomy

Sphecodes albilabris (Fabricius, 1793)

Published records. Warncke 1992: 50 (map); Ascher and Pickering 2018 (Alborz, Tehran).

Material examined. Golestan: 70 km E Minudasht, 1050 m, 12.VI.2010, (1 ♀), leg. M. Halada [PCMS]. Semnan: 10 km W Damghan, 10.VI.2010, (1 ♀), leg. M. Halada [PCMS].

Distribution. Europe (north to Finland and Sweden), North Africa, Caucasus, Turkey, Iran (Alborz, *Golestan, Tehran, Semnan), Central Asia, Syria, Israel, Russia (east to Far East), China (Liaoning, Inner Mongolia, Hebei, Beijing, Shanxi, Gansu).

Sphecodes alternatus Smith, 1853

Published records. Warncke 1992: 47 (map); Ascher and Pickering 2018 (Isfahan, Tehran).

Material examined. East Azerbaijan: 10 km E Shabeslar, 1540 m, 19.VI.2010, (1 ♂), leg. M. Halada [PCMS]. Golestan: 70 km E Minudasht, 1050 m, 12.VI.2010, (1 ♂), leg. M. Halada [PCMS]. Kerman: 30 km S Sirjan, 1730 m, 7.VI.2010, (3 ♂), leg. M. Halada [PCMS]. Mazandaran: 20 km S Amoi, 430 m, 6.VI.2014, (4 ♂), leg. J. Halada [PCMS]; 10 km S Chaloos, 380 m, 15.VI.2010, (5 ♂), leg. M. Halada [PCMS].

Distribution. South and Central Europe, North Africa, Caucasus, Turkey, Iran (*East Azerbaijan, *Golestan, Isfahan, *Kerman, *Mazandaran, Tehran), Central Asia, Russia (east to Khakass Republic), China (Gansu, Xinjiang).

***Sphecodes anatolicus* Warncke, 1992**

Material examined. East Azerbaijan: 10 km E Shabeslar, 1540 m, 19.VI.2010, (1 ♂), leg. M. Halada [PCMS].

Distribution. Italy (Sicily), Georgia, Armenia, Turkey, *Iran (East Azerbaijan), Central Asia.

***Sphecodes crassus* Thomson, 1870**

Published records. Ascher and Pickering 2018 (Mazandaran).

Material examined. Mazandaran: Elbrus, 50 km S Chalus, 2800 m, 26.VII.1977, (1 ♀, 8 ♂), leg. A. Ebmer [PCMS]. West Azerbaijan: Serou, 1650 m, 28.V.2010, (2 ♀), leg. M. Halada [PCMS].

Distribution. Europe (north to 64°), Russia (east to Far East), North Africa, Caucasus, Turkey, Iran (Mazandaran, *West Azerbaijan), Central Asia, Mongolia, China (Inner Mongolia, Shanxi), Japan (Hokkaido, Honshu).

Variation. Specimens from Iran differ from specimens from the rest of the range by having an entirely dark metasoma with distinctly punctate T2 in male.

***Sphecodes croaticus* Meyer, 1922**

Material examined. East Azerbaijan: 10 km E Shabestar, 1540 m, 19.VI.2010, (1 ♂), M. Halada [PCMS].

Distribution. South and Central Europe, Russia (European part), Caucasus, Turkey, *Iran (East Azerbaijan), Turkmenistan.

***Sphecodes ebmeri* Astafurova & Proshchalykin, sp. n.**

<http://zoobank.org/3F92729D-F60F-4655-8DA6-F3D4EC DFA7BC>

Figure 1 a–e, g

Material examined. Holotype ♂: Iran, Mazandaran, Elbrus, 50 km S (90 km Straße) Chalus, 2800 m, 26.VII.1977, leg. A.W. Ebmer [OÖLM].

Diagnosis. The male is close to *Sphecodes nomioideis* Pesenko, 1979 owing to similar structure, sculpture of the body including distinctly punctate metasomal terga and similar small trapezoidal gonostylar shape (Fig. 1a, b). In gonostylar shape the new species is also close to *S. geoffrellus* (Kirby, 1802) (Fig. 1c), but differs from both species by having less developed tyloids covering about 1/2 ventral surface of flagellomeres (Fig. 1d) (covering at least 4/5 ventral surface of flagellomeres in *S. nomioideis* and *S. geoffrellus*) (Fig. 1e).

Description. (Male). (Fig. 1f). Total body length 5.5 mm. Head (Fig. 1g) black (except brown mouthparts and antenna); weakly transverse, at most 1.1 times as wide as long; vertex not elevated, distance from top of head to upper margin of a lateral ocellus

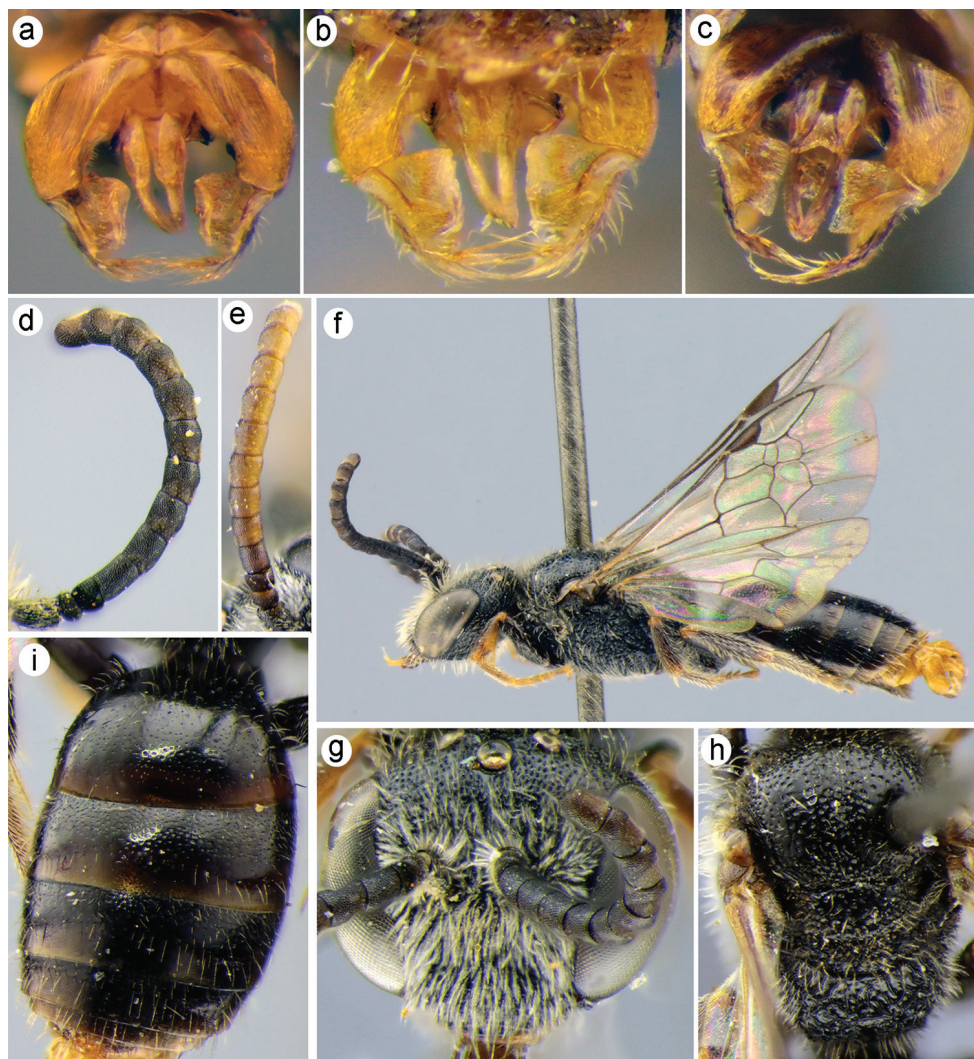


Figure 1. *Sphecodes ebmeri* Astafurova & Proshchalykin, sp. n., holotype, male (**a, d, f–i**), *S. nomioides* Pesenko, male (**b, e**), and *S. geoffrellus* (Kirby), male (**c**): **a–c** genitalia, dorsal view **d, e** antennae, lateral view **f** habitus, lateral view **g** head, frontal view **h** mesosoma, dorsal view **i** metasoma, dorsal view.

about 2 lateral ocellar diameters as seen in dorsal view; antenna attain middle of mesoscutum, F1 transverse, 0.75 times as long as wide, F2 1.3 times as long as wide, remaining flagellomeres about 1.2 times as long as wide; tyloids (from F3 onwards) covering about 1/2 ventral surface of flagellomeres; clypeus, paraocular area and frons with confluent punctures (15–25 μ m); area between ocellus and eye with punctures separated at most by 1.5 of a puncture diameter; vertex behind ocellus and gena rugose; face below antennal toruli with snow-white, plumose pubescence, obscuring the underlying integument.

Mesosoma black; mesoscutum and mesoscutellum with coarse punctures (20–30 μ m) separated by 0.5–2 puncture diameters (Fig. 1h); mesepisternum and hy-

poepimeral area shiny, reticulate-rugose, with sparse, erect, plumose pubescence; propodeal triangle (metapostnotum) and remainder of propodeum shiny, coarsely rugose; femur dark brown, tibia and tarsi brownish with yellow. Hind wing with basal vein strongly curved; costal margin with 5 hamuli.

Metasoma (Fig. 1i) dark-brown; terga distinctly punctate (ca 10 μm / 2–4); marginal zones impunctate, smooth on T1 and T2 and finely tessellate on T3 and T4; sterna finely tessellate with sparse microscopic setae pores; gonocoxite dorsally with impression; membranous part of gonostylus small, trapezoidal.

Female unknown.

Etymology. This species is dedicated to the Austrian hymenopterist Andreas W. Ebmer in recognition of his outstanding contributions to bee researches.

General distribution. Only known from the type locality in Iran (Mazandaran).

Sphecodes ephippius (Linnaeus, 1767)

Published records. Warncke 1992: 42 (map); Ascher and Pickering 2018 (Mazandaran, Zanjan).

Material examined. Golestan: 40 km Minudasht, 750 m, 1.VI.2014, (1 ♂), leg. J. Halada [PCMS]. Mazandaran: 10 km N Gashar, 2300 m, 7.VI.2014, (1 ♀), leg. J. Halada [PCMS].

Distribution. Europe (north to 62°), Caucasus, Turkey, Iran (*Golestan, Mazandaran, Zanjan), Central Asia, Mongolia, Russia (east to Irkutsk Prov.), China (Xinjiang).

Sphecodes gibbus (Linnaeus, 1758)

Published records. Warncke 1992: 49 (map); Ascher and Pickering 2018 (Alborz, Mazandaran, Qazvin, Tehran).

Material examined. East Azerbaijan: 10 km E Shabeslar, 1540 m, 19.VI.2010, (1 ♀, 7 ♂), leg. M. Halada [PCMS]. Gilan: 15 km SE Tutkaban, 1100 m, 9.VI.2014, (2 ♀), leg. J. Halada [PCMS]; Tulkaban near Roodbar, 16.VI.2010, (1 ♂), leg. M. Halada [PCMS]. Fars: 10 km E Kazerum, 1990 m, 23.V.2014, (2 ♀, 2 ♂), leg. J. Halada [PCMS]. Golestan: 70 km E Minudasht, 1050 m, 12.VI.2010, (2 ♀, 97 ♂), leg. M. Halada [PCMS]. Kerman: 30 km S Sirjan, 1730 m, 7.VI.2010, (21 ♂), leg. M. Halada [PCMS]; Deh Bakri, 1640 m, 3.VI.2010, (1 ♂), leg. M. Halada [PCMS]; 8 km N Bardsir, 2050 m, 6.VI.2010, (1 ♂), leg. M. Halada [PCMS]; 25 km E Jiroft (Mijan), 1650 m, 27.V.2014, (1 ♀, 1 ♂), leg. M. Halada [PCMS]. Razavi Khorasan: Gerirud[=Tedzhen] River, Khorasan, 9.IV.1898, (1 ♀), leg. N. Zarudny [ZISP]. West Azerbaijan: Serou, 1650 m, 28.V.2010, (1 ♀), leg. M. Halada [PCMS].

Distribution. Europe (north to 63°), North Africa, Turkey, Iran (Alborz, *East Azerbaijan, *Fars, *Gilan, *Golestan, *Kerman, Mazandaran, Qazvin, *Razavi Kho-

rasan, Tehran, *West Azerbaijan), Pakistan, Israel, Central Asia, Mongolia, Russia (east to Yakutia), China (Xinjiang), India (Assam, Sikkim).

Sphecodes haladai Warncke, 1992

Material examined. Kerman: 20 km E Ghobria, 1780 m, 5.VI.2010, (1 ♀), leg. M. Halada [PCMS].

Distribution. *Iran (Kerman), Central Asia.

Sphecodes longulus Hagens, 1882

Published records. Ascher and Pickering 2018 (Zanjan).

Material examined. East Azerbaijan: Tavriz [=Tebriz], 6.VI.1914, (1 ♀), leg. Andrievskiy [ZISP].

Distribution. Europe (north to Finland, Sweden, Denmark and England), Turkey, Iran (*East Azerbaijan, Zanjan), Syria, Central Asia, China (Gansu, Shanxi, Hebei, Inner Mongolia), Russia (east to Far East), Japan (Hokkaido, Kyushu, Honshu, Okinawa).

Sphecodes majalis Pérez, 1903

Published records. Ascher and Pickering 2018 (Alborz).

Material examined. Hamadan: 100 km NE Hamadan, 2100 m, 22.V.1975, (1 ♂), leg. Y. Ressler [PCMS]. Lorestan: Dorud, Laninabad, 670 m, 11.V.2016, (1 ♀), leg. M. Kafka [PCMS]. West Azerbaijan: Serou, 1650 m, 28.V.2010, (3 ♂), leg. M. Halada [PCMS]; Ilam pr. Ada Man, Dinar Gaouh, 1830 m, 12.V.2016, (2 ♀, 3 ♂), leg. M. Kafka [PCMS].

Distribution. Europe (north to the Netherlands), Russia (European part), North Africa, Caucasus, Turkey, Iran (Alborz, *Hamadan, *Lorestan, *West Azerbaijan).

Sphecodes monilicornis (Kirby, 1802)

Published records. Warncke 1992: 44 (map); Ascher and Pickering 2018 (Alborz, East Azerbaijan, Mazandaran, Zanjan).

Material examined. East Azerbaijan: Sis, 10 km E Shabeslar, 1540 m, 19.VI.2010, (1 ♂), leg. M. Halada [PCMS]. Fars: Pab E Neyriz, 2060 m, 18.V.1978, (1 ♀), leg. K. Warncke [PCMS]; 15 km SE Sarvestan, 1800 m, 17.V.1978, (1 ♀), leg. M. Kraus [PCMS]. Gilan: Tulkabon near Roodbar, 16.VI.2010, (2 ♂), leg. M. Halada [PCMS]; 15 km SE Tulkabon, 1100 m, 9.VI.2014, (1 ♀), leg. M. Halada [PCMS]. Golestan: 70 km E Minudasht, 1050 m, 12.VI.2010, (1 ♀), leg. M. Halada [PCMS]. Kerman:

50 km N Sabzavaran, 2170 m, 24.V.1978, (1 ♀, 1 ♂), leg. K. Warncke [PCMS]; 25 km E Jiroft (Mijan), 1650 m, 27.V.2014, (1 ♀, 3 ♂), leg. J. Halada [PCMS]; 40 km S Sirjan, 1870 m, 29.V.2014, (6 ♂), leg. J. Halada [PCMS]. Kohgiluyeh and Boyer-Ahmad: Kuh Gol near Sisakht, 9.VI.2010, (1 ♀), leg. M. Halada [PCMS]. Mazandaran: 10 km S Chaloos, 380 m, 15.VI.2010, (5 ♀, 21 ♂), leg. M. Halada [PCMS]; 20 km S Amoi, 430 m, 6.VI.2014, (1 ♂), leg. J. Halada [PCMS]. North Khorasan: 10 km W Raz, Kopet Dag, 1200 m, 27.V.2014, (1 ♀, 1 ♂), leg. J. Halada [PCMS]. Sistan and Baluchestan: Khash, Iranshekhr, 21.V.1955, (1 ♀), leg. D. Steinberg [ZISP]. South Khorasan: Birjand, 18.VI.1896, (1 ♂), leg. N. Zarudny [ZISP].

Distribution. Europe (north to 64°), North Africa, Caucasus, Turkey, Iran (Alborz, East Azerbaijan, *Fars, *Gilan, *Golestan, *Kerman, *Kohgiluyeh and Boyer-Ahmad, Mazandaran, *North Khorasan, *Sistan and Baluchestan, *South Khorasan, Zanjan), Pakistan, Central Asia, Mongolia, China (Heilongjiang), Russia (east to Far East), India (Jammu, Kashmir).

Sphecodes olivieri Lepeletier de Saint Fargeau, 1825

Published records. Warncke 1992: 46 (map); Ascher and Pickering 2018 (Hamadan, Isfahan, Tehran).

Material examined. Golestan: 70 km E Minudasht, 1050 m, 12.VI.2010, (1 ♀, 3 ♂), M. Halada [PCMS]. Kerman: Jupar, 1900 m, 1.VI.2010, (1 ♀), leg. M. Halada [PCMS]; Raziabad, 1160 m, 4.VI.2010, (2 ♂), leg. M. Halada [PCMS]; 20 km E Ghobria, 1780 m, 5.VI.2010, (2 ♀, 6 ♂), leg. M. Halada [PCMS]; 8 km N Bardsir, 2050 m, 6.VI.2010, (1 ♀, 3 ♂), leg. M. Halada [PCMS]; 30 km S Sirjan, 1730 m, 7.VI.2010, (3 ♂), leg. M. Halada [PCMS]. Khuzestan: Half Tapeh, 300 km N di Abadan, Canale Dario, 30.VI.1965, (2 ♂), leg. Giordani Soika, Mavromoustakis [PCMS].

Distribution. South Europe, Russia (South of European part), North Africa, Caucasus, Turkey, Iran (*Golestan, Hamadan, Isfahan, *Kerman, *Khuzestan, Tehran), Pakistan, Israel, Arabian Peninsula, Central Asia, China (Gansu, Xinjiang), India (Gujarat).

Sphecodes pectoralis Morawitz, 1876

Material examined. Razavi Khorasan: "Khorasan", 3–4.VIII.1901, (1 ♀), leg. N. Zarudny [ZISP].

Distribution. *Iran (Razavi Khorasan), Central Asia, China (Gansu, Xinjiang).

Sphecodes pellucidus Smith, 1845

Published records. Ascher and Pickering 2018 (Isfahan, Kermanshah, Mazandaran, Tehran).

Material examined. East Azerbaijan: Sis, 10 km E Shabeslar, 1540 m, 19.VI.2010, (15 ♂), leg. M. Halada [PCMS]. Gilan: 15 km SE Tutkabon, 1100 m, 9.VI.2014, (1 ♀), leg. J. Halada [PCMS]. Kerman: Jupar, 1900 m, 1.VI.2010, (1 ♀), leg. M. Halada [PCMS]; 20 km E Ghobria, 1780 m, 5.VI.2010, (8 ♂), leg. M. Halada [PCMS]. West Azerbaijan: Serou, 1650 m, 28.V.2010, (1 ♀), leg. M. Halada [PCMS].

Distribution. Europe (north to 66°), North Africa, Turkey, Iran (*East Azerbaijan, Isfahan, Kermanshah, Mazandaran, Tehran), Central Asia, Mongolia, Russia (east to Far East), China (Gansu, Xinjiang, Sichuan).

Sphecodes pinguiculus Pérez, 1903

Published records. Blüthgen 1924: 509, as *Sphecodes persicus*; Warncke 1992: 52 (map); Ascher and Pickering 2018 (Iran, without province).

Material examined. Fars: Monti steppici, 5 km N Di Persepolis, 6.VII.1965, (1 ♀), leg. Giordani Soika, Mavromoustakis [PCMS]. Hamadan: Hamadan, 10.VIII.1964, (1 ♂), leg. G. Bohart [PCMS]. Khuzestan: Half Tapeh, 300 km N di Abadan, Canale Dario, 30.VI.1965, (1 ♀), leg. Giordani Soika, Mavromoustakis [PCMS]. Tehran: Elburz, Pulour, 22 km N di Ab Ali, 11.VII.1965, (1 ♀), leg. Giordani Soika, Mavromoustakis [PCMS].

Distribution. South Europe, North Africa, Turkey, Israel, Iran (*Fars, Hamadan, *Khuzestan, Tehran), Central Asia, Mongolia, China (Gansu, Inner Mongolia), Russia (east to Buryatia), Cape Verde Islands.

Sphecodes puncticeps Thomson, 1870

Published records. Ascher and Pickering 2018 (Alborz, Hamadan, Tehran).

Material examined. East Azerbaijan: Sis, 10 km E Shabeslar, 1540 m, 19.VI.2010, (1 ♀, 13 ♂), leg. M. Halada [PCMS]. Fars: 10 km E Kazerum, 1990 m, 23.V.2014, (1 ♀), leg. J. Halada [PCMS]; Dasht Arjan, 2040 m, 6.V.2016, (1 ♀), leg. M. Kafka [PCMS].

Distribution. Europe (north to Finland and Sweden), North Africa, Turkey, Iran (Alborz, *East Azerbaijan, *Fars, Hamadan, Tehran), Israel, Central Asia, Mongolia, Russia (east to Far East).

Sphecodes reticulatus Thomson, 1870

Published records. Ascher and Pickering 2018 (Alborz).

Material examined. No material examined.

Distribution. Turkey, Iran (Alborz), Central Asia, Russia (east to Irkutsk Prov.).

***Sphecodes rubicundus* Hagens, 1875**

Material examined. West Azerbaijan: Serou, 1650 m, 28.V.2010, (1 ♀), leg. M. Halada [PCMS].

Distribution. Europe (north to 56°), Russia (European part), North Africa, Caucasus, Turkey, *Iran (West Azerbaijan).

***Sphecodes rufiventris* (Panzer, 1798)**

Material examined. Fars: 10 km E Kazerum, 1990 m, 23.V.2014, (2 ♀), leg. J. Halada [PCMS]. Gilan: 15 km SE Tutkaban, 1100 m, 9.VI.2014, (1 ♂), leg. J. Halada [PCMS]. Mazandaran: 15 km S Alamdeh, 530 m, 7.VI.2014, (1 ♂), leg. J. Halada [PCMS].

Distribution. Europe (north to 57°), North Africa, Turkey, *Iran (Fars, Mazandaran), Central Asia, Russia (east to Khakass Republic).

***Sphecodes saxicolus* Warncke, 1992**

Material examined. Kerman: Zurabad, 3.IV.1898, (1 ♀), leg. N. Zarudny [ZISP].

Distribution. *Iran (Kerman), Central Asia.

***Sphecodes scabricollis* Wesmael, 1835**

Published records. Ascher and Pickering 2018 (Mazadaran).

Material examined. No material examined.

Distribution. Europe (north to southern England and Latvia), Caucasus, Turkey, Iran (Mazadaran), Central Asia, China (Heilongjiang, Liaoning, Beijing, Shaanxi, Qinghai, Zhejiang), Russia (east to Far East), South Korea, Japan (Hokkaido, Honshu, Shikoku, Kyushu), India (Tamil Nadu).

***Sphecodes schenckii* Hagens, 1882**

Published records. Warncke 1992: 48 (map); Bogusch and Straka 2012: 17 (Iran, without province); Ascher and Pickering 2018 (Alborz).

Material examined. No material examined.

Remark. We examined some specimens determined by K. Warncke, P. Bogusch, J. Starka and M. Schwarz from Iran deposited in PCMS and concluded that *Sphecodes schenckii* has been confused with *S. tadschicus* Blüthgen in Popov, 1935. The specimen recorded from Alborz Province (Ascher and Pickering 2018) probably also belongs to

S. tadschicus Blüthgen in Popov, 1935. Nevertheless records of this species in north-western provinces of Iran are certain in the future as it is known from Caucasus and Turkey.

Distribution. Europe (north to Germany), Russia (European part), Caucasus, Turkey, Iran (?), Israel.

Sphecodes spinulosus Hagens, 1875

Published records. Ascher and Pickering 2018 (Alborz, Mazandaran).

Material examined. Lorestan: 10 km Dorud, 1520 m, 27.V.2014, (1 ♀), leg. J. Halada [PCMS].

Distribution. Europe (north to 56°), North Africa, Turkey, Iran, Central Asia, Russia (east to Altai).

Sphecodes tadschicus Blüthgen in Popov, 1935

Sphecodes schenkii: Warncke 1992: 48, part.; Bogusch and Straka 2012: 17, part.

Material examined. East Azerbaijan: Sis, 10 km E Shabestar, 1540 m, 19.VI.2010, (1 ♂), leg. M. Halada [PCMS]. Gilan: 15 km SE Tutkabon, 1100 m, 9.VI.2014, (1 ♀), leg. J. Halada [PCMS]. Golestan: 70 km E Minudasht, 1050 m, 12.VI.2010, (2 ♀, 1 ♂), leg. M. Halada [PCMS]. Semnan: Chashm, 2232 m, 5-7.VII.2011, (1 ♂), leg. A. Timokhov [ZISP]. Mazandaran: Bastam, 27.VI.1965, (1 ♀), leg. Matile [PCMS]; Damavand, 2800 m, 7-8.VII.2011, (1 ♀), leg. A. Timokhov [ZISP]; 20 km S Amol, 430 m, 6.VI.2014, (1 ♀), J. Halada [PCMS]. Yazd: Sanij, 1-4.VI.2011, (1 ♂), leg. A. Timokhov [ZISP].

Distribution. *Iran, Central Asia.

Discussion

Iran is a mostly mountainous country, with a landscape dominated by mountain ranges that separate various basins or plateaux from one another. A great variety of terrestrial ecosystems are situated on the territory of Iran: desert, semi-desert, steppe, forest steppe, forests and woodlands. However, dry biotopes occupy the majority of the Country and only 7% of the surface area is forested (most forest is found on the mountain slopes). Landscape and biotope diversity have a great effect on the diversity of bees, observable in the *Sphecodes* fauna of Iran, which includes forest species of temperate zoneas well as steppe and desert species of subtropics and endemic mountain species.

The majority of the *Sphecodes* fauna of Iran is formed by 14 widespread species, distributed from Europe to West Siberia or even to the Russian Far East and Japan: These are *S. albilabris*, *S. alternatus*, *S. crassus*, *S. ephippius*, *S. gibbus*, *S. longulus*, *S. monilicornis*,

Table 1. List of *Sphecodes* species recorded in Iran, Turkey, Caucasus and Central Asia.

	<i>Sphecodes</i> species	Iran	Turkey	Caucasus	Central Asia
1	<i>Sphecodes albilabris</i> (Fabricius, 1793)	+	+	+	+
2	<i>S. alternatus</i> Smith, 1853	+	+	+	+
3	<i>S. anatolicus</i> Warncke, 1992	+	+	+	+
4	* <i>S. armeniacus</i> Warncke, 1992	–	+	–	+
5	<i>S. barbatus</i> Blüthgen, 1923	–	+	–	–
6	* <i>S. crassus</i> Warncke, 1992	–	+	–	–
7	<i>S. crassus</i> Thomson, 1870	+	+	+	+
8	* <i>S. cristatus</i> Hagens, 1882	–	+	+	+
9	<i>S. croaticus</i> Meyer, 1922	+	+	+	+
10	* <i>S. dusmeti</i> Blüthgen, 1924	–	+	–	+
11	<i>S. ebmeri</i> Astafurova & Proshchalykin, sp. n.	+	–	–	–
12	<i>S. ephippius</i> (Linné, 1767)	+	+	+	+
13	* <i>S. ferruginatus</i> Hagens, 1882	–	+	+	+
14	* <i>S. geoffrellus</i> (Kirby, 1802)	–	+	+	+
15	<i>S. gibbus</i> (Linnaeus, 1758)	+	+	+	+
16	* <i>S. hakkariensis</i> Warncke, 1992	–	+	–	+
17	<i>S. haladai</i> Warncke, 1992	+	–	–	+
18	<i>S. hyalinatus</i> Hagens, 1882	–	–	+	+
19	* <i>S. intermedius</i> Blüthgen, 1923	–	+	+	+
20	<i>S. longulus</i> Hagens, 1882	+	+	+	+
21	<i>S. majalis</i> Pérez, 1903	+	+	+	–
22	<i>S. miniatus</i> Hagens, 1882	–	–	+	+
23	<i>S. monilicornis</i> (Kirby, 1802)	+	+	+	+
24	* <i>S. niger</i> Hagens, 1874	–	+	+	–
25	* <i>S. nomioideis</i> Pesenko, 1979	–	+	–	–
26	* <i>S. nurekensis</i> Warncke, 1992	–	–	–	+
27	<i>S. olivieri</i> Lepeletier de Saint Fargeau, 1825	+	+	+	+
28	<i>S. pectoralis</i> Morawitz, 1876	+	–	–	+
29	<i>S. pellucidus</i> Smith, 1845	+	+	+	+
30	<i>S. pesenkoi</i> Astafurova & Proshchalykin, 2018	–	–	–	+
31	<i>S. pinguiculus</i> Pérez, 1903	+	+	+	+
32	<i>S. pseudofasciatus</i> Blüthgen, 1925	–	+	+	–
33	<i>S. puncticeps</i> Thomson, 1870	+	+	+	+
34	<i>S. reticulatus</i> Thomson, 1870	+	+	+	+
35	<i>S. rubicundus</i> Hagens, 1875	+	+	+	–
36	<i>S. ruficrus</i> (Erichson, 1835)	–	+	+	–
37	<i>S. rufiventris</i> (Panzer, 1798)	+	+	+	+
38	<i>S. sandykachi</i> Astafurova & Proshchalykin, 2018	–	–	–	+
39	<i>S. saxicolus</i> Warncke, 1992	+	–	–	+
40	<i>S. scabricollis</i> Wesmael, 1835	+	+	+	+
41	<i>S. schenckii</i> Hagens, 1882	+	+	+	–
42	<i>S. schwarzi</i> Astafurova & Proshchalykin, 2015	–	–	–	+
43	<i>S. spinulosus</i> Hagens, 1875	+	+	+	+
44	<i>S. tadschicus</i> Blüthgen, 1935	+	–	–	+
45	<i>S. trjapitzini</i> Astafurova & Proshchalykin, 2018	–	–	–	+
46	<i>S. turanicus</i> Astafurova & Proshchalykin, 2017	–	–	–	+
47	<i>S. zangherii</i> Noskiewicz, 1931	–	+	–	–
Total:		25	34	29	36

* – species probably could be found in Iran; Caucasus – Armenia, Georgia, Azerbaijan, and South European part of Russia; Central Asia – Kazakhstan, Kyrgyzstan, Uzbekistan, Turkmenistan, Tajikistan. The number of *Sphecodes* species are given according to Özбек et al. 2015 (Turkey), Astafurova and Proshchalykin 2017b, and Astafurova et al. 2018 (Central Asia) and Astafurova and Proshchalykin 2016a, b (Caucasus).

S. pellucidus, *S. pinguiculus*, *S. puncticeps*, *S. reticulatus*, *S. rufiventris*, *S. scabricollis*, and *S. spinulosus*. Some of these species (*S. ephippius*, *S. reticulatus*, *S. scabricollis*, *S. crassus*) occur in the mountains of Iran where their ranges follow their host ranges from the temperate zone of Palaearctic region. *Sphecodes pinguiculus* is distributed in steppe and desert zones of the Palaearctic region and does not occur above mountain steppe in Iran. Such species as *S. alternatus*, *S. monilicornis*, *S. pellucidus*, *S. albilabris*, *S. gibbus*, *S. longulus*, and *S. puncticeps* are widespread from north to south of Palaearctic region and occur in different native zones from forest to desert. *Sphecodes majalis*, *S. croaticus* and *S. rubicundus* are steppe species, distributed in central and south Europe and reaching north-western Iran through Turkey and the Caucasus. *Sphecodes haladai*, *S. pectoralis*, *S. saxicolus* and *S. tadschicus* are desert and steppe Irano-Turanian species distributed in Central Asia and Iran. *Sphecodes anatolicus* is a rare mountain species known from Mediterranean and Caucasian Regions to Central Asia. *Sphecodes olivieri* is widespread in semi-desert and desert of the Western Palaearctic. *Sphecodes ebmeri* sp. n. is a mountain endemic of Elbrus which also could be found in mountain Turkey and the Caucasus.

In total, 25 species of *Sphecodes* are recorded from Iran. This is distinctly less in comparison with the adjacent fauna of Turkey, Caucasus and Central Asia (Table 1). However this number will probably increase at least by a third and could be richer owing to eleven Western Palaearctic species which could be found in Iran: *S. cristatus*, *S. hakkariensis*, *S. ferruginatus*, *S. nomioidis*, *S. dusmeti*, *S. niger*, *S. nurekensis*, *S. intermedius*, *S. armeniacus*, *S. crassanus*, and *S. geoffrellus*. There are some species distributed in southern Europe, Turkey and the Caucasus that could be found in north-western Iran, whereas species mostly distributed in Central Asia could be recorded in central and eastern Iran. Because of these species the Iranian fauna of *Sphecodes* may be more diverse than those of Turkey or Central Asia.

Acknowledgments

We are grateful to Fritz Gusenleitner for help during our visit to Austria, and Andrew Grace for checking the English. We also wish to thank Michael Ohl, Arkady Lelej, and Rodrigo Gonçalves, who reviewed the manuscript and helped to improve this text. This investigation was supported by the Russian Funds for Basic Research (grant numbers 16-04-00197 and 17-04-00259) and the State Research Project (AAAA-A17-117030310210-3).

References

- Årgent L, Svensson B (1982) Flagellar sensilla on *Sphecodes* bees (Hymenoptera, Halictidae). *Zoologica Scripta* 11: 45–54. <https://doi.org/10.1111/j.1463-6409.1982.tb00517.x>

- Ascher JS, Pickering J (2018) Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila). http://www.discoverlife.org/mp/20q?guide=Apoidea_species [accessed 25 May 2018]
- Astafurova YuV, Proshchalykin MYu (2014) The bees of the genus *Sphecodes* Latreille 1804 of the Russian Far East, with key to species (Hymenoptera: Apoidea: Halictidae). *Zootaxa* 3887(5): 501–528. <https://doi.org/10.11646/Zootaxa.3887.5.1>
- Astafurova YuV, Proshchalykin MYu (2015a) Bees of the genus *Sphecodes* Latreille 1804 of Siberia, with a key to species (Hymenoptera: Apoidea: Halictidae). *Zootaxa* 4052(1): 65–95. <https://doi.org/10.11646/zootaxa.4052.1.3>
- Astafurova YuV, Proshchalykin MYu (2015b) New and little known bees of the genus *Sphecodes* Latreille (Hymenoptera: Halictidae) from Mongolia. *Far Eastern Entomologist* 289: 1–9. <http://www.biosoil.ru/FEE/Publication/479>
- Astafurova YuV, Proshchalykin MYu (2015c) The bees of the genus *Sphecodes* Latreille, 1804 (Hymenoptera: Halictidae) of the Eastern Palaearctic Region. *Proceedings of the Russian Entomological Society* 86(2): 17–21. <https://www.zin.ru/societies/res/rus/periodicals/horae/86-2.pdf> [In Russian]
- Astafurova YuV, Proshchalykin MYu (2016a) To the knowledge of the genus *Sphecodes* Latreille (Hymenoptera: Halictidae) of Caucasus. *Euroasian Entomological Journal* 5(Supplement 1): 15–19. http://www.eco.nsc.ru/eej/supplement_2016_15_1.html
- Astafurova YuV, Proshchalykin MYu (2016b) The bees of the genus *Sphecodes* Latreille (Hymenoptera: Halictidae) of the European part of Russia. *Far Eastern Entomologist* 321: 1–21. <http://www.biosoil.ru/FEE/Publication/526>
- Astafurova YuV, Proshchalykin MYu (2017a) To the knowledge of the *Sphecodes hyalinatus* species-group (Hymenoptera, Halictidae). *Entomological Review* 97(5): 664–671. <https://doi.org/10.1134/S0013873817050104>
- Astafurova YuV, Proshchalykin MYu (2017b) The genus *Sphecodes* Latreille 1804 (Hymenoptera: Apoidea: Halictidae) in Central Asia. *Zootaxa* 4324(2): 249–284. <https://doi.org/10.11646/zootaxa.4324.2.3>
- Astafurova YuV, Proshchalykin MYu (2017c) Family Halictidae. In: Lelej AS, Proshchalykin MYu, Loktionov VM (Eds) *Annotated catalog of the Hymenoptera of Russia. Volume I. Symphyta and Aculeata*. Russkaya kolleksiya SpB (St. Petersburg): 277–292. https://www.zin.ru/journals/trudyzin/doc/vol_321_s6/TZ_321_6_Supplement_Belokobylskij-Lelej.pdf
- Astafurova YuV, Proshchalykin MYu (2018) A new species of the genus *Sphecodes* Latreille (Hymenoptera, Halictidae) from Kazakhstan. *Entomological Review* 98(6): 743–747. <https://doi.org/10.1134/S0013873817060118>
- Astafurova YuV, Proshchalykin MYu, Engel MS (2018a) The cuckoo bee genus *Sphecodes* Latreille, 1804 (Hymenoptera: Halictidae) in Kazakhstan. *Far Eastern Entomologist* 369: 1–47. <https://doi.org/10.25221/fee.369.1>
- Astafurova YuV, Proshchalykin MYu, Niu ZQ, Zhu CD (2018b) New record of bees of the genus *Sphecodes* Latreille in the Palaearctic part of China (Hymenoptera, Halictidae). *ZooKeys* 792: 15–44. <https://doi.org/10.3897/zookeys.792.28042>
- Astafurova YuV, Proshchalykin MYu, Schwarz M (2015) New data on the genus *Sphecodes* Latreille (Hymenoptera: Halictidae) from Mongolia. *Far Eastern Entomologist* 302: 1–9. <http://www.biosoil.ru/FEE/Publication/479>

- Astafurova YuV, Proshchalykin MYu, Schwarz M (2018c) New and little known bees of the genus *Sphecodes* Latreille, 1804 (Hymenoptera: Apoidea: Halictidae) from Central Asia. *Zootaxa* 4441(1): 76–88. <https://doi.org/10.11646/zootaxa.4441.1.4>
- Astafurova YuV, Proshchalykin MYu, Shlyakhtenok AS (2014). Contribution to the knowledge of bee fauna of the genus *Sphecodes* Latreille (Hymenoptera: Halictidae) of the Republic of Belarus. *Far Eastern Entomologist* 280: 1–8. <http://www.biosoil.ru/FEE/Publication/437>
- Blüthgen P (1924) Beiträge zur Systematik der Bienengattung *Sphecodes* Latr. II. *Deutsche Entomologische Zeitschrift* 1924: 457–516. <https://onlinelibrary.wiley.com/doi/abs/10.1002/mmnd.192419240601>
- Bogusch P, Straka J (2012) Review and identification of the cuckoo bees of central Europe (Hymenoptera: Halictidae: *Sphecodes*). *Zootaxa* 3311: 1–41. <http://www.mapress.com/j/zt/article/view/13484>
- Engel MS (2001) A monograph of the Baltic amber bees and evolution of the Apoidea (Hymenoptera). *Bulletin of the American Museum of Natural History* 259: 1–192. [https://doi.org/10.1206/0003-0090\(2001\)259<0001:AMOTBA>2.0.CO;2](https://doi.org/10.1206/0003-0090(2001)259<0001:AMOTBA>2.0.CO;2)
- Khaghaninia S, Güler Y, Dikmen F (2013) New records for the bee fauna of Iran (Hymenoptera: Apoidea). *Zoology in the Middle East* 59(4): 319–325. <https://doi.org/10.1080/09397140.2013.868134>
- Khodaparast R, Monfared A (2012) A survey of bees (Hymenoptera: Apoidea) from Fars Province, Iran. *Zootaxa* 3445: 37–58. <http://mapress.com/j/zt/article/view/14027>
- Kuhlmann M, Proshchalykin MYu (2015) New and remarkable Asian and North African species of *Colletes* Latreille (Hymenoptera: Colletidae). *Zootaxa* 4028: 81–101. <https://doi.org/10.11646/zootaxa.4028.1.3>
- Michener CD (2007) *The Bees of the World* (2nd edn). Johns Hopkins University Press, Baltimore, 953 pp. [+ 20 pls] <http://base.dnsgb.com.ua/files/book/Agriculture/Beekeeping/Thep-Bees-of-the-World.pdf>
- Nadimi A, Talebi AA, Zhu C-D, Fathipour Y (2014) Study of the tribe Anthidiini (Hymenoptera: Megachilidae) in northern Iran, with the description of a new species. *North-Western Journal of Zoology* 10(2): 413–424. <http://biozoojournals.ro/nwjz/index.htm>
- Özbek H, Bogusch P, Straka J (2015) A contribution to the kleptoparasitic bees of Turkey: Part I., the genus *Sphecodes* Latreille (Hymenoptera: Halictidae). *Turkish Journal of Zoology* 39: 1095–1109. <https://doi.org/10.3906/zoo-1501-43>
- Proshchalykin MYu, Kuhlmann M (2018) New records of rarely collected bees of the genus *Colletes* Latreille (Hymenoptera, Colletidae) from Asia and the Caucasus. *Far Eastern Entomologist* 355: 1–12. <https://doi.org/10.25221/fee.355.1>
- Safi Z, Nadimi A, Yazdanian M, Radchenko V (2018) Report of one rare bee new to Iran, with the checklist of the Persian bee subfamily Nomiodinae (Hymenoptera: Halictidae). *North-Western Journal of Zoology* e171202. [In press] http://biozoojournals.ro/nwjz/content/acc/nwjz_e171202_Safi_acc.pdf
- Warncke K (1992) Die westpaläarktischen Arten der Bienengattung *Sphecodes* Latr. *Bericht der Naturforschende Gesellschaft Augsburg* 52: 9–64. https://www.zobodat.at/pdf/Ber-Naturf-Ges-Augsburg_052_1992_0009-0064.pdf

Identity and distribution of *Celonites hermon* Gusenleitner, 2002 (Hymenoptera, Vespidae, Masarinae) from the Middle East with a description of the hitherto unknown male

Volker Mauss¹, Rainer Prosi²

1 Staatliches Museum für Naturkunde, Abt. Entomologie, Rosenstein 1, D-70191 Stuttgart, Germany **2** Lerchenstraße 81, D-74564 Crailsheim, Germany

Corresponding author: Volker Mauss (volker.mauss@gmx.de)

Academic editor: M. Ohl | Received 16 September 2018 | Accepted 23 October 2018 | Published 31 October 2018

<http://zoobank.org/ADA1A7C2-3976-4FA1-A63C-8D6EDB8EA71C>

Citation: Mauss V, Prosi R (2018) Identity and distribution of *Celonites hermon* Gusenleitner, 2002 (Hymenoptera, Vespidae, Masarinae) from the Middle East with a description of the hitherto unknown male. Journal of Hymenoptera Research 66: 55–70. <https://doi.org/10.3897/jhr.66.29795>

Abstract

Based on the morphological examination of the exoskeleton and the male genitalia of newly discovered specimens from Syria the status and taxonomic position of *Celonites hermon* Gusenleitner, 2002 is re-investigated. The hitherto unknown male is formally described. *Celonites hermon* is a member of the *C. abbreviatus*-complex. It shares several probably derived characters with *C. andreamuelleri*, from which it is considered to be reproductively isolated by differences in the male genitalia, the form of sternum VIII and tergum VII as well as the colour pattern of the male antennae. Therefore *C. hermon* is hypothesized to represent a separate biospecies. It has been recorded only from a small area in the mountain ranges along the Lebanese section of the Dead Sea Transform in Syria and Israel.

Keywords

Pollen wasps, biogeography, taxonomy, Palearctic, Israel, Syria

Introduction

The genus *Celonites* is very distinct from other pollen wasps in the wide horizontal lamellae on the propodeum and the acute sides of the metasoma (Richards 1962). Both characters are related to the outstanding ability of the imagines to roll up (Gess and Gess 2010). Approximately 46 species of the genus (including six well separated subspecies) have been recognized in the Palaearctic region (according to the list of Carpenter 2001, combined with newly described or synonymized species by Gusenleitner 2002, 2007, 2012, 2018; Mauss 2013, Mauss et al. 2016). Within the Palaearctic *Celonites abbreviatus*-group (sensu Richards 1962) the *Celonites abbreviatus*-complex constitutes a well defined monophylum characterized by the existence of knobbed setae at the front of the head forming a pollen collecting apparatus (Mauss 2013). All members of this species-complex for which flower visits have been recorded were observed to visit nototribic flowers of Lamiaceae (Bequaert 1940, Schremmer 1959, Müller 1996, Mauss 2006, Mauss 2013, Mauss et al. 2016). During pollen uptake from these flowers a female would stand on the lower lip of the corolla, while she performs at a high frequency slight back and forth movements, rubbing her head over the nototribic anthers. In this manner pollen grains are removed from the anthers with the stiff knobbed setae on frons and clypeus of the female (Schremmer 1959, Müller 1996, Mauss 2006, Mauss et al. 2016). The species-complex includes six nominate species, namely *Celonites abbreviatus* (Villers), *C. andreasmuelleri* Mauss, *C. hermon* Gusenleitner, *C. mayeti* Richards, *C. persicus* Richards and *C. tauricus* Kostylev (= *C. spinosus* Gusenleitner) (Mauss 2013, Mauss et al. 2016).

Celonites hermon was described from a single female collected by Bytinski-Salz at Mount Hermon in the Golan Mountains by Gusenleitner in 2002. He separated the specimen from the “very similar” *Celonites abbreviatus* because of its extremely long proboscis that reaches the distal end of the abdomen (Gusenleitner 2002). As already pointed out by Mauss (2013) proboscis length can not be examined in most *Celonites* specimens, since the mouthparts are usually retracted, while the protruded proboscis of the type specimen is an exception. This may have misled Gusenleitner (2002) into believing, that the length of the proboscis is outstanding in *C. hermon*. In fact, the careful investigation by Schremmer (1961) had already demonstrated that the proboscis of *C. abbreviatus* clearly exceeds the tip of the metasoma. Moreover, Mauss (2013) referred to a female of *C. abbreviatus* in his collection with protruded mouthparts extending beyond the end of the metasoma as well. Therefore *C. hermon* does not distinctly differ from *C. abbreviatus* in the character that mainly substantiated its description and was considered to be a junior synonym of *C. abbreviatus*.

However, Mauss (2013) avoided formal synonymy of both taxa as the situation appeared to be more complicated. The club of the antenna of the type of *C. hermon* is completely orange, which is also the case in specimens of *C. abbreviatus* from the

Balkan and Aegean populations whereas the antennae of Central and West European specimens of *C. abbreviatus* are much darker suggesting that the eastern populations might belong to a different subspecies or even species that could be identical with *C. hermon*. Subsequently Mauss et al. (2016) demonstrated that *Celonites tauricus* differs distinctly from *C. abbreviatus* in that the likewise orange antennal club of *C. tauricus* has always a dark tip, which is possibly related to different male signals during mating behaviour. Since the tip of the antennal club of the holotype of *Celonites hermon* is completely orange, it can not be identical with *C. tauricus*. The distribution area of *Celonites abbreviatus* extends from Northwest Africa over the Iberian Peninsula, Southern and Central Europe eastwards to the Balkan and the western Aegean. *Celonites tauricus* is allopatrically distributed with regard to *Celonites abbreviatus* and has been recorded from the Crimea, Kos, Rhodes, Cyprus and Asia Minor (Mauss et al. 2016, Mauss unpubl.) (Fig. 11), separating the locus typicus of *C. hermon* by more than 1000 km from the eastern margin of the distribution range of *C. abbreviatus*. Therefore *C. hermon* could be hypothesized to represent a relict population of *C. abbreviatus* in the Golan Mountains that was separated from the Balkan and Aegean populations of *C. abbreviatus* as a result of range expansion of *C. tauricus*. An alternative hypothesis is that *Celonites hermon* is an indigenous biospecies. In this case one would expect closer relationship to other members of the *C. abbreviatus*-complex from geographically adjacent areas in the Middle East, that is *Celonites tauricus* or *Celonites andreasmuelleri*.

Based on new material of *Celonites hermon*, the aim of this study is to reinvestigate the status of the taxon carefully, to characterize its taxonomic position within the genus *Celonites* and to describe the newly discovered male.

Material and methods

The specimens of *Celonites* studied belong to the public collection of the Upper Austrian State Museum (Linz, Austria) (OLML), as well as to the private collection of J. Gusenleitner (Linz, Austria) (JG). The specimens were investigated under a WILD M3 stereo microscope (maximum magnification 80 times). Measurements of the exoskeleton were made using an ocular micrometer (highest resolution 0.011 mm). Distances between the ocelli, the compound eyes and the mesonotum width were measured according to Eck (1978). The genitalia of all males were extracted after re-softening the specimens and were then studied in 80% ethanol or 85% glycerol. Nomenclature of male genitalia follows that of Birker-Smith (1981). Drawings were made with a drawing tube (WILD Type 308700). Micro-photos were taken with a Leica IC 80 HD camera mounted on a Leica MS 5 stereomicroscope. Multifocus-pictures were generated with Leica Application Suite (LAS) software. The scapus of the antenna is referred to as antennal article A1 and the pedicellus as A2, the flagellum consists of the articles A3–A12.

Systematics

Celonites hermon Gusenleitner, 2002

Figs 1–9

Material studied. **Israel:** Mt. Hermon, 33.416111N, 35.857500E, 1900 m a.s.l., 17.07.1971, 1♀ (holotype, dbM No. 3579), leg. Bytinski-Salz, coll. JG. **Syria:** 40 km NE of Damascus, 33.416667N, 35.866667E, 13.05.1996, 4♀♀ (dbM No. 3684, 3685, 3686, 3687), 2♂♂ (dbM No. 3688, 3689), leg. Mi. Halada, coll. OLML; West Syria, Tartus env., 34.900000N, 35.883333E, 25.05.1996, 2♀♀ (dbM No. 3691, 3692), leg. Mi. Halada, coll. OLML.

Diagnosis. Pale markings light yellowish to yellow without reddish tinges (Fig. 1). Immediate tip of antennal club (A8–12) and especially ventral side of A12 orange to orange-brown, not markedly contrasting in colour from adjacent light ventral side of antennal club. Axilla of mesoscutellum with short blunt lateral projection that only slightly projects over adjacent posterior part of tegula. Frons and clypeus covered with pale, stiff pollen collecting setae (Fig. 3). In females most, in males at least some of these setae with tiny spherical enlargement at tip (“knob”). Diameter of median ocellus distinctly larger than diameter of lateral ocelli, ocelli larger than in *C. abbreviatus* and *C. tauricus*. Median ocellus circular, lateral ocelli more or less obliquely oval (Figs 4, 7). Vertex falling away obliquely towards the occipital carina immediately behind ocelli (Figs 4, 7).

Females with head in front view more elongated in relation to its length. Clypeus with lateral margins more continuously rounded leading to elongated appearance (Fig. 2). Cuticula on frons and at least dorsal half of clypeus densely and strongly shagreened leading to a conspicuous dull region covered with knobbed pollen-collecting setae, changing gradually into the adjacent smooth, shiny cuticula on vertex and less densely shagreened cuticula ventrally on clypeus (Figs 2, 4). Knobbed pollen collecting setae on frons distinctly longer and relatively thinner in comparison with *Celonites abbreviatus* and *C. tauricus*, up to 1.4 times as long as diameter of median ocellus, with diameter almost equal along most of length, only weakly broadened towards base (Figs 3, 4).

Males with only two oval-shaped tyloids situated ventrally on articles A9 and A10 of club-shaped antennae. Midcoxa with a small but distinct spine at distal end, on anterior side of midcoxa close to its antero-medial angle. Tergum VII markedly lobed posteriorly (Fig. 6). Sternum VIII only shallowly emarginate, surface not much sunk in towards emargination (Fig. 8). Tergum VII with medial lobe distinctly emarginate leading to quadrilobed appearance of posterior margin (Fig. 6). Emargination of posterior margin of sternum VIII medially angled, laterally with a transverse section well set off by protruded edge with distinct little spine on each side of posterior margin (Fig. 8). Posterior margin of stipes of male genitalia with dorso-medial concavity (Figs 9, 10). Stipes in dorsal view elongated, with medial and lateral margin running more or less parallel towards posterior end (Figs 9, 10). Posterior process of volsella



Figure 1. Imagines of *Celonites hermon* in lateral view (female dbM No. 3692, male dbM No. 3689).

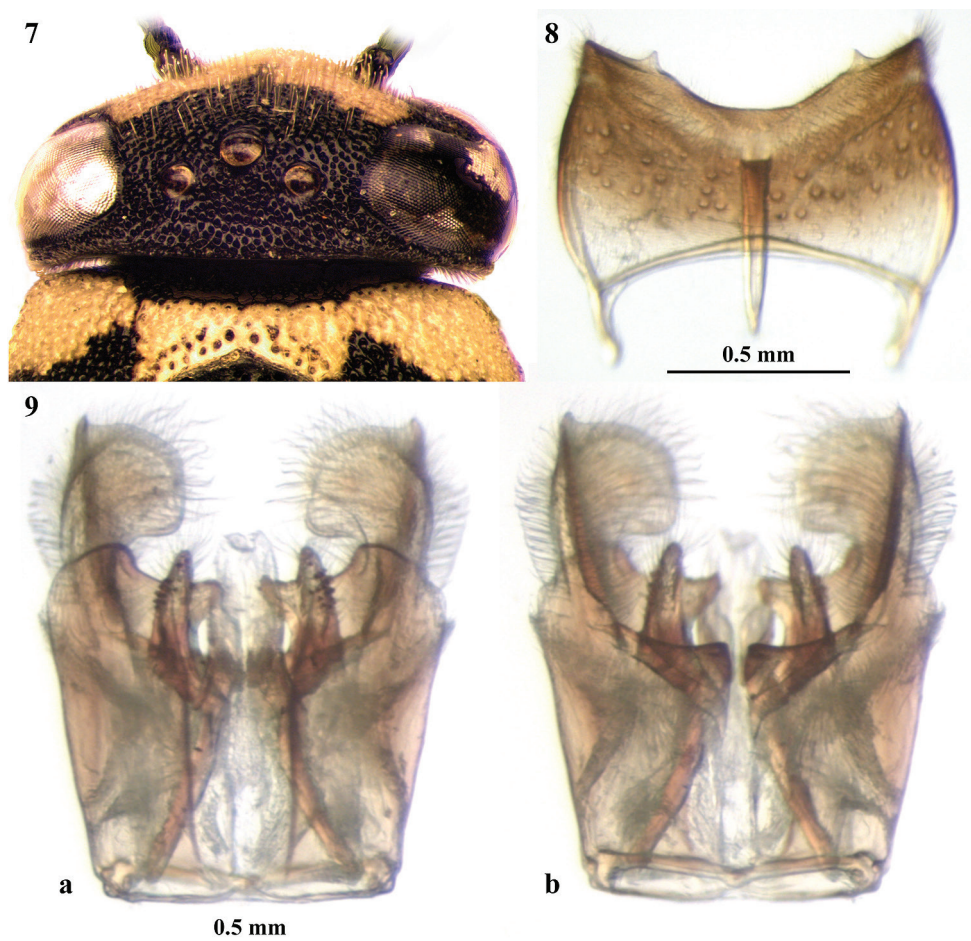
conically rounded, proximally continuing into shaft of volsella. Medial process of volsella set off distinctly from shaft by longitudinal fold (Figs 9, 10).

Description of the male. Colour (Fig. 1): Black, changing into blackish-brown on strongly sclerotized parts of labio-maxillary complex, sterna, coxae, trochanters and femora. The following are light yellowish: large basal spot on mandible; labrum; central area of clypeus except small lateral and ventral margin; broad parallel-sided band at front of frons, shortly interrupted medially on the supra-antennal area, laterally extending obliquely towards upper inner margin of eye where it terminates with straight truncated end; small spot on ocular sinus; narrow streak on tempora along occipital carina at dorso-lateral corner of head; large spot on antero-dorsal angle of pronotum (humeral spot); stripe along dorso-medial (inner) margin of pronotum, posteriorly small becoming distinctly broader antero-medially where it continues into humeral spot in one specimen (Fig. 7); large spot on dorsal mesopleura; tegula except small black marking along anterior part of medial margin; medium-sized median spot on scutellum; propodeal lamella; distal part of femora, tibiae and tarsi (weakly mixed with reddish-brown in parts especially distally); continuous posterior bands on terga I–VI, somewhat smaller on each side of middle (Fig. 6), extending over lateral margin on ventral part of tergum; continuous broad posterior band on sternum II; small spots postero-laterally on sternum III. Reddish-brown are: distal two thirds of mandible; ventral margin of clypeus; claws. Antenna with A1–2 black; A3–6 anteriorly with light yellowish stripe otherwise blackish to dark orange-brown; A7–A12 orange-brown, posteriorly with blackish marking becoming lighter distally, anteriorly and on ventral side markedly orange without black. Wings translucent, weakly yellowish-brown.

Structure: Head in front view as long as broad. Clypeus a little broader than long, distal margin deeply emarginate; cuticula shiny and smooth with close macropunctuation becoming less distinct towards distal margin; pale stiff setae arising from macropunctures without distal “knob”; lateral setae with distal ends frequently curved in distal-medial direction. Frons diagonally striated with moderately spaced to close macropunctuation, interstices smooth; bearing pale stiff setae, up to 0.22 mm long, 1.1 times as long as diameter of median ocellus, laterally some with curved distal end, in centre mainly with tiny distal “knob”; frontal line in one specimen raised to form a small pro-



Figures 2–6. Head of female of *Celonites hermon* (dbM No. 3685) **2** in frontal view **3** in lateral view showing pollen collecting apparatus with “knobbed” setae on frons and clypeus **4** in dorsal view **5–6** Metasoma of *Celonites hermon* in dorsal view **5** female (dbM No. 3685) **6** male (dbM No. 3689).



Figures 7–9. Head of male *Celonites hermon* in dorsal view (dbM No. 3456) **8** Metasomal sternum VIII of male of *C. hermon* in ventral view (dbM No. 3689) **9** Male genital of *Celonites hermon* (dbM No. 3689) **a** in dorsal **b** ventral view.

tubercle in centre of frons. Median ocellus circular, lateral ocelli more or less obliquely oval; diameter of median ocellus distinctly larger than diameter of lateral ocelli. Vertex falling away obliquely towards occipital carina immediately behind ocelli (Fig. 7); cuticula with close macropunctuation becoming more distinct and closely reticulate behind ocelli, where longitudinal interstices are more strongly raised forming lines; cuticula of interstices shiny and smooth; covered with short setae arising from macropunctures. Compound eye sparsely covered with small setae. Gena very narrow; preoccipital carina sharp. Antenna with articles A8-A12 forming ventrally flattened club about 2.0 times as long as broad (viewed dorsally) (Fig. 1); two oval-shaped, perhaps sensory, depressions (tyloids) on concave, ventral side of club, situated within antennal articles A9 and A10.

Anterior margin of pronotum raised to carina especially sharp medially (erroneously termed anterior pronotal carina by Mauss 2013). Short anterior pronotal carina (sensu Carpenter 1988) distinctly present at antero-ventral angle of pronotum running parallel to anterior margin, preceding crenate groove; distance between anterior pronotal carina and anterior margin of pronotum about width of fore metatarsus. Posterior pronotal carina forms narrow translucent sinuate crest on humeral angle of pronotum. Posterior margin of pronotum raised to short carina dorsally in front of tegula. Cuticula of pronotum shiny, with close to reticulate macropunctuation, interstices smooth, rounded, with very sparse uneven micropunctuation; laterally fairly horizontally striated due to slightly more raised interstices. Cuticula of mesoscutum and mesoscutellum shiny, reticulate with close, deep macropunctuation and raised interstices. Postero-medial cuticula of mesoscutum and especially of mesoscutellum with longitudinal interstices becoming narrower and more strongly raised to sharp edges leading to distinctly striated appearance; interstices smooth, laterally on mesoscutellum somewhat finely longitudinally wrinkled. Mesoscutellum laterally with distinct carina along posterior margin, carina medially reduced to a few small tooth-like projections along posterior margin. Carina along posterior margin of metanotum medially with small tooth-like projections. Axilla with short blunt lateral projection only slightly projecting over adjacent, somewhat emarginate, posterior part of tegula. Tegula shiny, closely covered by macropunctures except less densely punctured or completely smooth central convex area. Mesepisternum with pronounced epicnemial carina deflexed backwards to run transversely in front of mid coxa; cuticula shiny, with close macropunctuation; horizontally striated by raised interstices; area ventral to scrobal groove coarsely punctured with some interstices strongly raised to knife-like edges forming coarse honeycomb-like sculpture. Process at mesepisternal scrobal groove of moderate size; cuticula on posterior side shiny in centre with irregularly moderately spaced distinct micropunctuation, ventrally densely longitudinally wrinkled. Horizontal propodeal triangle laterally delimited by a perpendicular declivity, somewhat laterally produced at postero-lateral edge of propodeal triangle, posteriorly bordered by serrated carina; cuticula shiny, coarsely punctured, interstices almost knife-like. Posterior surface of propodeum striated by strong vertical cuticula-folds; cuticula shiny, without punctuation, weakly coriaceous and covered with short fine pale setae. Cuticula of sides of propodeum and metepisternum shiny, densely horizontally wrinkled. Lateral lamella broad and somewhat convex; lateral margin slightly convex; posterior margin straight, not crenate; medially where lamella joins central part of propodeum with a rounded emargination, ventro-medial edge of which produced to a small blunt protrusion; dorsal cuticula of lamella shiny, with moderately spaced macropunctuation, interstices medially smooth, dorso-laterally shagreened. Midcoxa with small but distinct spine at distal end on anterior side close to antero-medial angle. Claws ventrally with small tooth.

Metasomal terga with dark anterior part continuing into posterior pale part by slight declivity; postero-lateral corners slightly produced; posterior margin of tergum I weakly crenulated, crenulation not produced into spines and not projecting over smooth translucent posterior margin of tergum; posterior margin of terga II–VI crenulated, crenulation produced into short partially posteriorly truncated spines, not or only slightly projecting over smooth translucent lower posterior margin of terga (Fig. 6);

cuticula with silken sheen, densely covered with moderately coarse macropunctuation, diameter of punctures and distance between them fairly larger on posterior pale part of tergum, with about seven macropunctures along median axis of tergum III; single thin seta arises from bottom of each macropuncture, only slightly protruding over rim of puncture; interstices finely shagreened, moderately covered with very tiny, decumbent, pale setae, all setae orientated towards caudal end. Posterior margin of tergum VII with two lateral deep emarginations, resulting in two lateral lobes that continue laterally into margins of tergum and single medial lobe divided into two lanceolate more or less pointed medial projections of variable length (Fig. 6). Metasomal sternum I shiny, finely shagreened, with tiny setae but without punctures. Sterna II–VI posteriorly with broad stripe of aetose, translucent cuticula adjacent to posterior margin of more strongly sclerotized cuticula; small sparse band of setae along posterior sclerotized margin somewhat projecting over anterior part of translucent stripe of cuticula; sclerotized cuticula shiny, close to anterior margin faintly shagreened, on posterior half of sternum II–VI medially and laterally with sparse punctuation of shallow micropunctures from which short pale setae arise, on sternum II antero-laterally with a few small shallow macropunctures from which short pale setae arise, on sternum III–VI anteriorly with moderate to sparse shallow macropunctuation. Sternum VIII with distinct little spine on each side of posterior margin; emargination of posterior margin medially angled, laterally with a transverse section well set off by protruded edge (Fig. 8).

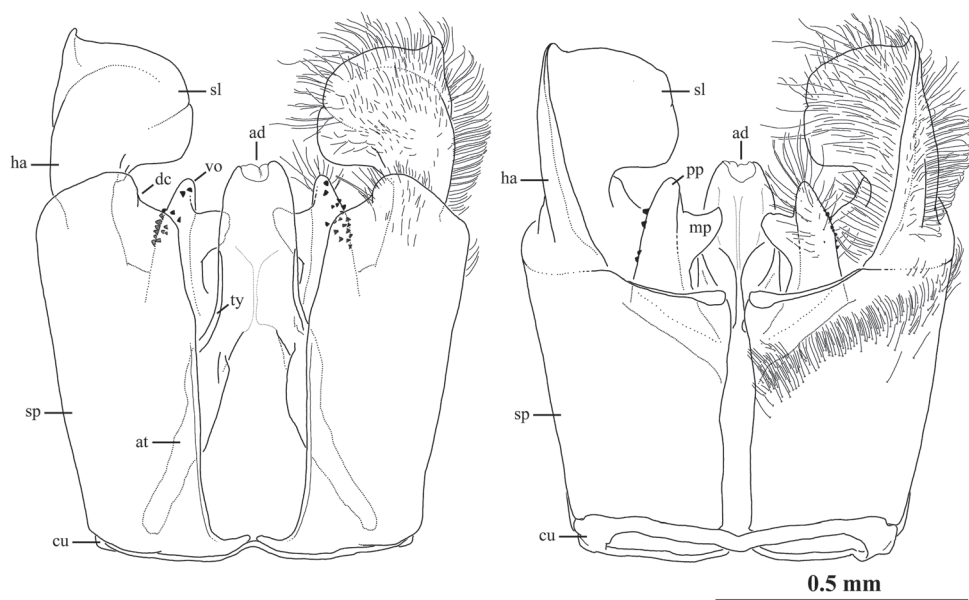


Figure 10. Male genital of *Celonites hermon* (dbM No. 3689) in dorsal (left) and ventral view (right). Setae only shown on one side of each drawing. Nomenclature follows that of Birket-Smith (1981): ad, aedeagus; at, apodema thyrso; cu, cupula; dc, dorso-medial concavity of the posterior margin of the stipes; ha, harpide; mp, medial process of volsella; pp, posterior process of volsella; sl, shovel-like dorso-medial lobe of harpide; sp, stipes; ty, thyrso; vo, volsella.

Male genitalia as in Figs 9–10. Dorso-medial shovel-like lobe of harpide large, densely covered ventrally with long setae. Dorso-posterior margin of stipes with dorso-medial concavity angled. Stipes in dorsal view elongated, with medial and lateral margin running more or less parallel towards posterior end. Sides of stipites converging continuously anteriorly towards cupula. Volsella moderately large and broad, not reaching antero-medial margin of dorso-medial lobe of harpide; dorsal area with strongly sclerotized, large, dark tubercles; distances between tubercles moderate; plane medial process curved more or less hook-like towards posterior end, set off distinctly from shaft by longitudinal fold; posterior process conically rounded, proximally continuing into shaft of volsella. Sides of thyrsos more or less parallel only slightly converging towards posterior (apical) end of aedoeagus. Each thyrsos continues anteriorly into apodema thyrsos with a distinct outwardly directed curve. On ventral side cupula medially protruded towards anterior end projecting over dorsal margin of cupula in ventral view of genital capsule.

Measurements. Measurements of the exoskeleton are summarized in Table 1.

Floral association. Unknown.

Distribution. *Celonites hermon* is known only from three localities in the ranges of the Lebanon and Anti-Lebanon Mountains along the Lebanese section of the Dead Sea Transform (Fig. 11).

Table 1. Measurements of the exoskeleton of imagines of *Celonites hermon* (x = median; min = minimum, max = maximum; measurements were made with a Wild M3 stereomicroscope with maximum magnification 80×, maximum accuracy 0.011 mm, all distances in mm).

Parameter	Female				Male			
	x	min	max	n	x	min	max	n
lateral ocelli distance	0.46	0.42	0.47	7	0.43	0.42	0.45	2
median/lateral ocellus distance	0.17	0.15	0.18	7	0.15	0.15	0.15	2
compound eyes distance	1.28	1.22	1.36	7	1.16	1.16	1.16	2
A1 length	0.18	0.17	0.20	7	0.19	0.19	0.19	2
A3 length	0.24	0.22	0.26	7	0.24	0.23	0.24	2
A3 width	0.11	0.11	0.11	7	0.13	0.13	0.13	2
A4–5 length	0.20	0.19	0.20	7	0.21	0.21	0.21	2
A8–12 length	0.77	0.73	0.87	7	1.08	1.08	1.08	2
A8–12 width	0.40	0.37	0.42	7	0.53	0.52	0.55	2
antennal sockets distance	0.81	0.76	0.84	7	0.61	0.59	0.62	2
clypeus maximum width	1.11	1.04	1.16	7	0.99	0.98	1.00	2
clypeus apical width	0.52	0.51	0.61	7	0.46	0.44	0.48	2
clypeus length	0.90	0.84	1.38	7	0.79	0.76	0.81	2
mesonotum width	2.74	2.55	2.80	6	2.60	2.49	2.72	2
mesoscutum length	1.96	1.88	2.10	6	1.96	1.88	2.04	2
wing length	5.54	5.25	5.68	7	5.47	5.40	5.54	2
R+Sc length	2.94	2.81	3.13	7	2.88	2.85	2.90	2
number of hamuli	12	10	14	7	10	10	10	2
femur I length	1.39	1.34	1.48	6	1.33	1.31	1.34	2
tibia I length	0.95	0.87	0.98	7	0.89	0.88	0.89	2
metatarsus I length	0.56	0.55	0.57	7	0.50	0.46	0.53	2
tergum I width	2.74	2.58	2.81	7	2.65	2.60	2.69	2
tergum I length	1.00	0.95	1.14	7	1.04	0.94	1.14	2
tergum II width	2.77	2.63	2.90	7	2.67	2.60	2.74	2
total length	7.2	6.7	7.5	7	7.3	7.0	7.5	2

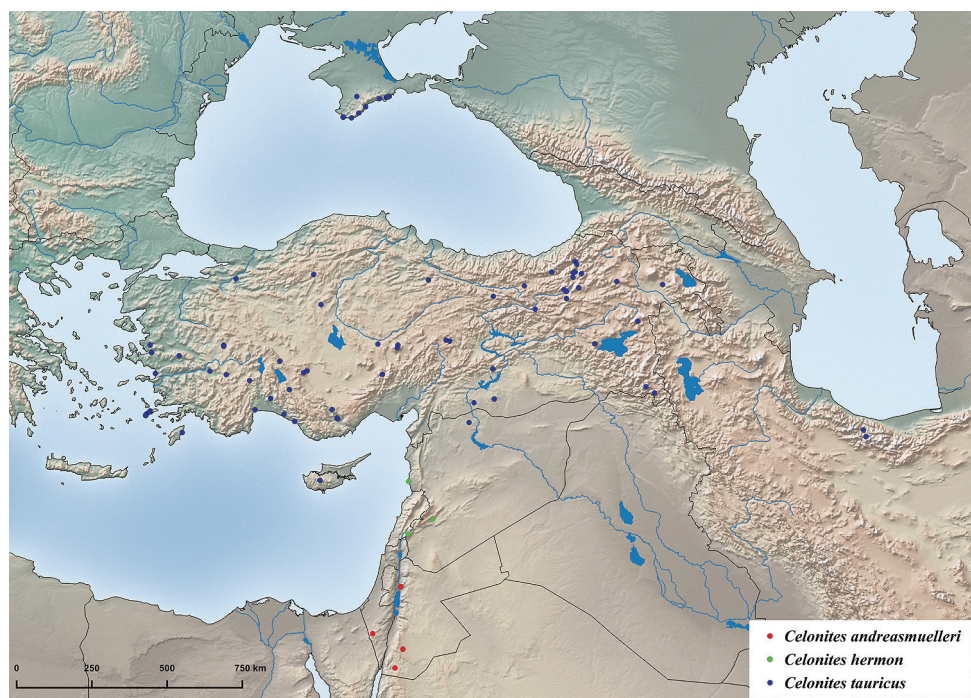


Figure 11. Geographic distribution of the species of the *Celonites abbreviatus*-complex occurring in the Middle East. Records of *Celonites andreasmuelleri* taken from Mauss 2013 and Mauss unpublished, records of *Celonites tauricus* according to Mauss et al. 2016 and Mauss unpublished.

Key to separate *Celonites hermon* from its next relatives *C. abbreviatus*, *C. tauricus* and *C. andreasmuelleri*

For illustrations of the morphological characters of *C. abbreviatus*, *C. tauricus* and *C. andreasmuelleri* see Mauss (2013) and Mauss et al. (2016).

- | | | |
|---|---|--|
| 1 | Female | 2 |
| – | Male | 5 |
| 2 | Cuticula on frons with a dull, densely shagreened, semi-circular central area covered with knobbed pollen-collecting setae, contrasting distinctly to the adjacent smooth, shiny cuticula. Clypeus and vertex much more shiny. Terga of metasoma with extensive yellowish-white and reddish markings | <i>Celonites andreasmuelleri</i> Mauss, 2013 |
| – | Cuticula on frons and at least dorsal half of clypeus densely and strongly shagreened leading to a conspicuous dull region covered with knobbed pollen-collecting setae, changing gradually into the adjacent smooth, shiny cuticula on vertex (Fig. 2). Terga of metasoma with yellowish-white to yellow markings without reddish tinge (exception being made for <i>C. abbreviatus</i> from | |

- the Peloponnesus with small reddish markings close to the lateral margin of the terga) **3**
- 3 Pollen collecting knobbed setae on frons longer and thinner, up to 1.4 times as long as diameter of median ocellus (Figs 3, 4). Ocelli larger, with diameter of median ocellus distinctly larger than diameter of lateral ocelli (Fig. 4). Lateral ocelli more or less obliquely oval (Fig. 4). Vertex falls away obliquely towards the occipital carina immediately behind the ocelli (Fig. 4). Mesoscutum shiny with dense, moderately coarse punctures separated by rounded, not knife-like interstices..... ***Celonites hermon* Gusenleitner, 2002**
- Pollen collecting knobbed setae on frons shorter and more robust, not more than 1.0 times as long as diameter of median ocellus. Ocelli smaller, with median ocellus only slightly larger than lateral ocelli. Lateral ocelli more evenly rounded. Vertex continues more or less horizontally behind ocelli towards occipital carina. Mesoscutum less shiny, with dense, moderately coarse punctures separated by knife-like interstices, especially anteriorly resulting in a more comb-like appearance **4**
- 4 Antennal club (A8–12) with dark tip, that is, at least distal end of A12 is blackish markedly contrasting on ventral side to adjacent light reddish brown area of antennal club. On dorsal side blackish marking extends usually over distal parts of A11 fading gradually towards proximal end (for differences between geographic populations see Mauss et al. 2016) ***Celonites tauricus* Kostylev, 1935**
- Antennal club (A8–12) of individuals from Balkan populations completely orange, in some dark coloured individuals from western populations club becomes darker dorsally, while immediate tip and especially ventral side of A12 remain lighter..... ***Celonites abbreviatus* (Villers, 1789)**
- 5 Tergum VII trilobed. Posterior emargination of sternum VIII medially bent at an angle of about 135°. Laterally the posterior, angled margin of sternum VIII continues directly into the lateral surface of the sternum without a prominent edge or a distinct spine, so that even a small postero-lateral transverse section is lacking. Genitalia as in Mauss 2013: fig. 26. Metasoma black with extensive yellowish-white and reddish markings..... ***Celonites andreasmuelleri* Mauss, 2013**
- Tergum VII quadrilobed, since the median lobe is medially distinctly emarginate (Fig. 6). Sternum VIII different, with a distinct little spine on each side of the posterior margin (Fig. 8). Genitalia different. Metasoma black with extensive yellowish-white or yellow but without reddish markings (exception being made for *C. abbreviatus* from the Peloponnesus with small reddish tinges close to the lateral margins of the terga) **6**
- 6 Posterior margin of stipes of male genitalia with dorso-medial concavity (Figs 9, 10). Stipes in dorsal view elongated, with medial and lateral margin running more or less parallel towards posterior end (Figs 9, 10). Posterior process of volsella conically rounded. Medial process of volsella set off dis-

- tinctly from shaft by longitudinal fold (Figs 9, 10). Ocelli larger. Vertex falling away obliquely towards occipital carina immediately behind ocelli.....
 ***Celonites hermon* Gusenleitner, 2002**
- Posterior margin of stipes of male genitalia straight, without dorso-medial concavity. Stipes in dorsal view shorter, with medial and lateral margin diverging continuously towards posterior end. Posterior process of volsella flat. Medial process of volsella continues gradually into shaft. Ocelli smaller. Vertex running more or less horizontally towards occipital carina behind ocelli7
- 7 Antennal club (A8–12) orange, ventrally with distinct blackish marking on A12 extending on distal parts of A11 well set off from orange of adjacent ventral area, orange on dorso-posterior parts of A8–A12 can be darkened to variable extend. Clypeus white to whitish-yellow. Emargination of sternum VIII more evenly concave. Male genital broader. Volsella strongly sclerotized, with a larger medial process ***Celonites tauricus* Kostylev, 1935**
- Antennal club (A8–12) of individuals from Balkan populations completely orange, in some dark coloured individuals from western populations club becomes darker dorsally, while immediate tip and especially ventral side of A12 remain lighter. Clypeus yellow, except in one rare variety from Switzerland in which it is nearly white. Emargination of sternum VIII medially angled. Genital less broad. Volsella less sclerotized, with a smaller medial process.....
 ***Celonites abbreviatus* (Villers, 1789)**

Discussion

Status and taxonomic position of *Celonites hermon*

Celonites hermon can be assigned to the subgenus *Celonites* s.str., the *Celonites abbreviatus*-group and finally the *C. abbreviatus*-complex without contradiction as it shares all characters of these taxa established by Richards (1962) and Mauss (2013). Among the members of the *C. abbreviatus*-complex *Celonites hermon* resembles *C. andreasmuelleri* most of all in the comparatively thin pollen collecting knobbed setae that are of equal diameter along most of their length, the enlarged ocelli, with a distinctly large circular median ocellus and smaller oval shaped lateral ocelli and the characteristic form of the head, that falls away obliquely towards the occipital carina immediately behind the ocelli. Moreover, in the male genitalia the posterior margin of the stipes has a characteristic dorso-medial concavity and the medial and lateral margin of the stipes are running more or less parallel towards the posterior end. These distinctive similarities are probably synapomorphic characters of both taxa, as they are not present in other members of the *C. abbreviatus*-complex and even the whole *C. abbreviatus*-group.

On the other hand, *Celonites hermon* is lacking some of the potential autapomorphies of *C. andreasmuelleri* recognized by Mauss (2013), i.e. the characteristic semi-

circular cuticula structure on the frons of the females, as well as the differing form of sternum VIII and tergum VII and the considerably larger shovel-like dorso-medial lobe of the harpide in the males of *C. andreasmuelleri*. Moreover, both taxa differ in colour, the colour pattern on the ventral side of the tip of the antennal club and the form of the volsella. The distinct differences in the male genitalia, the form of sternum VIII and tergum VII as well as the colour pattern on the ventral side of the antennal club that has been assumed by Mauss et al. (2016) to be associated with mate recognition, lead to the conclusion that both taxa are probably reproductively isolated and represent two separate biospecies (*sensu* Mayr 1967).

The hypotheses proposed by Mauss (2013) that *Celonites hermon* is identical with *C. abbreviatus*, is rejected. Both species differ clearly in form and length of the pollen collecting knobbed setae, the size of the ocelli and the shape of the vertex. Moreover, there are distinct differences in the male genitalia. The misinterpretation of the morphological characters of the type by Mauss (2013) resulted to some extent from the mediocre condition of the female specimen, of which the setae on frons and vertex are stuck together to a high degree by remnants of a viscous liquid, giving them a shorter and stouter appearance and partly covering the exoskeleton.

Biogeography

Celonites hermon has been recorded only from a small area in the mountain ranges along by both sides of the Lebanese section of the Dead Sea Transform (Fig. 11). Since *C. hermon* differs significantly from *C. abbreviatus* in various morphological characters, it cannot represent a relict population of *C. abbreviatus* as implied by Mauss (2013). Moreover, the morphological similarities between *C. hermon* and *C. andreasmuelleri* indicate a close relationship between them and a more distant relationship to *C. abbreviatus* and *C. tauricus*. Therefore, it can be hypothesized that *C. hermon* and *C. andreasmuelleri* originated from a common stem species that inhabited the area along the Dead Sea Transform. Geographic isolation and succeeding speciation may have led to the recent allopatric distribution with *C. hermon* being restricted to the northern Lebanese section of the Dead Sea Transform and *C. andreasmuelleri* to the southerly adjacent area of the Jordan Rift Valley (Fig. 11).

Acknowledgements

Fritz Gusenleitner (Upper Austrian State Museum, Linz) and Josef Gusenleitner (Linz) generously provided the investigated specimens of *Celonites hermon*. We are especially grateful to Jim Carpenter (American Museum of Natural History, New York) for valuable comments on the manuscript and improvement of our English and Rainer Neumeyer and Andreas Müller for their careful reviews.

References

- Bequaert J (1940) Notes on the distribution of *Pseudomasaris* and the food plants of Masaridinae and Gayellinae (Hymenoptera Vespidae). Bulletin of the Brooklyn Entomological Society 35: 37–45.
- Birket-Smith SJR (1981) The male genitalia of Hymenoptera – a review based on morphology in Dorylidae (Formicidae). Entomologica scandinavica Supplement 15: 377–397.
- Carpenter JM (1989/1988) The phylogenetic system of the Gayellini (Hymenoptera: Vespidae, Masarinae). Psyche 95: 211–241. <https://doi.org/10.1155/1988/45034>
- Carpenter JM (2001) Checklist of species of the subfamily Masarinae (Hymenoptera: Vespidae). American Museum Novitates 3325: 1–40. [https://doi.org/10.1206/0003-0082\(2001\)325<0001:COOTS>2.0.CO;2](https://doi.org/10.1206/0003-0082(2001)325<0001:COOTS>2.0.CO;2)
- Eck R (1978) Biometrische Untersuchung zur Klärung der Artunterschiede bei sozialen Faltenwespen (Hymenoptera: Vespidae). Entomologische Abhandlungen des Staatlichen Museums für Tierkunde Dresden 42: 315–344.
- Gess S, Gess F (2010) Pollen wasps and flowers in southern Africa. SANBI Biodiversity Series 18: 1–147.
- Gusenleitner J (2002) Neue oder bemerkenswerte Vespoidea aus dem Nahen Osten (Hymenoptera: Eumenidae, Masaridae). Linzer biologische Beiträge 34: 335–343.
- Gusenleitner J (2007) Eine neue *Celonites*-Art aus Sibirien (Hymenoptera: Vespidae, Masarinae). Linzer Biologische Beiträge 39: 133–135.
- Gusenleitner J (2012) Neue Masarinae aus der paläarktischen Region (Hymenoptera: Vespidae: Masarinae). Linzer Biologische Beiträge 44: 319–326.
- Gusenleitner J (2018) Neue asiatische Faltenwespen (Hymenoptera, Vespidae: Eumeninae, Masarinae). Linzer Biologische Beiträge 50: 303–308.
- Mauss V (2006) Observations on flower association and mating behaviour of the pollen wasp species *Celonites abbreviatus* (Villers, 1789) in Greece (Hymenoptera: Vespidae, Masarinae). Journal of Hymenoptera Research 15: 266–269.
- Mauss V (2013) Description of *Celonites andreasmuelleri* sp. n. (Hymenoptera, Vespidae, Masarinae) from the Middle East with a key to the Palearctic species of the *C. abbreviatus*-complex of the subgenus *Celonites* s.str. Journal of Hymenoptera Research 31: 79–95. <https://doi.org/10.3897/JHR.31.4235>
- Mauss V, Fateryga A, Prosi R (2016) Taxonomy, distribution and bionomics of *Celonites tauricus* Kostylev, 1935, stat. n. (Hymenoptera, Vespidae, Masarinae). Journal of Hymenoptera Research 48: 33–66. <https://doi.org/10.3897/JHR.48.6884>
- Mayr E (1967) Artbegriff und Evolution. Paul Parey, Hamburg, 617 pp.
- Müller A (1996) Convergent evolution of morphological specializations in Central European bee and honey wasp species as an adaptation to the uptake of pollen from nototribic flowers (Hymenoptera, Apoidea and Masaridae). Biological Journal of the Linnean Society 57: 235–252. <https://doi.org/10.1111/j.1095-8312.1996.tb00311.x>
- Richards OW (1962) A revisional study of the masarid wasps (Hymenoptera, Vespoidea). British Museum (Natural History), London, 294 pp.

- Schremmer F (1959) Der bisher unbekannte Pollensammelapparat der Honigwespe *Celonites abbreviatus* Vill. (Vespidae, Masarinae). Zeitschrift für Morphologie und Ökologie der Tiere 48: 424–438. <https://doi.org/10.1007/BF00408580>
- Schremmer F (1961) Morphologische Anpassungen von Tieren - insbesondere Insekten - an die Gewinnung von Blummahrung. Verhandlungen der Deutschen Zoologischen Gesellschaft (Zoologischer Anzeiger Supplement) 25: 375–401.