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Taxonomic and faunistic study of Aulacidae (Hymenoptera, Evanioidea) from Iran, with illustrated key to species

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Abstract

Aulacidae are parasitoids of wood-boring larvae of Hymenoptera and Coleoptera, known in all zoogeographic regions of the World, except Antarctic. Two aulacids, *Pristaulacus compressus* (Spinola, 1808) and the rare *Pristaulacus mourguesi* Maneval, 1935, have been recently collected from Iran, the latter being a new record. Based on available data, the Iranian aulacid fauna includes five species within a single genus, *Pristaulacus* Kieffer 1900. A brief taxonomic treatment, as well as morphometric data and an illustrated key to species, are provided.

Introduction

The aulacid wasps, Aulacidae Shuckard, 1842 are endoparasitoids of wood-boring larvae Coleoptera (Cerambycidae and Buprestidae) and Hymenoptera (Xiphydriidae). The family Aulacidae is small distinct family in the superfamily Evanioidea. This family includes 262 extant species grouped within only two genera, *Aulacus* Jurine, 1807 with 83 species and *Pristaulacus* Kieffer, 1900 (including the former *Panaulix* Benoit, 1984), with 177 species (Jennings and Austin 2004, Turrisi et al. 2009, Chen et al. 2016, Turrisi and Nobile 2016; Turrisi 2017). According to the online Taxapad (Yu et al. 2012) this family contains four subfamilies and 11 genera, including fossils. Some identified fossils are not completely known and their inclusion within Aulacidae still remains somewhat questionable (Zhang and Rasnitsyn 2004).

Some evidence support strongly a close relationship between Aulacidae and Gasteruptiidae and each group are currently considered as distinct families (Jennings and Austin 2000, Turrisi et al. 2009). However, the current generic classification of the Aulacidae is not sufficiently robust and needs further study. There is strong support for the monophyly of *Pristaulacus* but not for *Aulacus*, which is largely paraphyletic in the cladistics analyses of Turrisi et al. (2009). The faunistic knowledge of Aulacidae is generally unsatisfactory due to their general rarity and difficulty in collecting by conventional methods, e.g., by net; there is a general paucity of available material, even in the large museums (Turrisi 2007).

The Iranian Aulacidae has been recently treated by Ghahari (2012), Lotfalizadeh et al. (2017) and Ghahari and Madl (2017). Nonetheless, continuous sampling in different ecosystems, particularly with Malaise traps, has resulted in new records which we present in this paper, along with an illustrated key to species.

Material and methods

The specimens examined in the present paper have been recently collected using a modified Malaise-trap (Funnel-Townes Style, B. Motamedinia, unpublished: BM-MTF-TS) placed in various localities of Kermanshah province (Western part of Iran), as well as in Eastern provinces (Fig. 1A–B). The traps were a basic Malaise trap supplemented with an additional internal collecting bottle. The insects bump into the black mesh panel and move towards the lighter mesh to escape due to their positive phototropism (van Achterberg 2009); at this point, they encounter the collection bottle and become permanently trapped. However, a considerable number of in-

Figure 1. Malaise traps; locations. **A** Kermanshah province, Dudan, adjacent to the river and valley; **B** Kermanshah province, Harsin, near the foothills; **C** and **D** Additional collecting bottle inside the trap.

sects fail to enter the collecting bottle for various reasons e.g., inappropriate installation of trap or collecting bottle, displacement of the trap by wind, or the particular behavior of the insects (Fig. 1C–D). The collected specimens were killed in 75% ethanol and then glued on triangular cards, according to AXA protocol (van Achterberg 2009). Finally, all of the specimens labeled using new pinning block (Ghafouri Moghaddam et al. 2017).

Specimens were examined under a Nikon® SMZ645 stereomicroscope (Nikon® Inc., Japan). Illustrations of taxonomically important body parts were taken using a Canon® EOS 700D (Canon® Inc., Japan), a simple light source with halogen lamp (manual) and 2× lenses mounted on Hund® Stereomicroscope (Wetzlar Inc., Germany). Multiple images were subsequently processed in Zerene Stacker™ version 1.04 software and post processed in Adobe Photoshop® CS6. The images in the illustrated key were prepared by the second author using voucher specimens already deposited in his private collection. Morphological terminology follows Crosskey (1951), Huber and Sharkey (1993) and Turrisi (2007). Terminology for surface sculpturing follows Harris (1979). A distributional map was generated using SimpleMappr (Shorthouse 2010) and collecting localities are given in Fig. 8. The following abbreviations are used for depositories: **CPTO**: Guido Pagliano collection, Torino, Italy; **DPPZ**: Collection of Department of Plant Protection, University of Zabol, Iran; **DU**: Depository Unknown; **MCSN**: Museo Civico di Storia Naturale "G. Doria", Genova, Italy; **MNHN**: Muséum National d'Histoire Naturelle, Laboratoire d'Entomologie, Paris, France; **NHMW**: Naturhistorisches Museum, Wien, Austria; **ZIN**: Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia; **ZMUC**: Zoological Museum, Copenhagen University, Denmark.

Measurements were done with a micro-ruler. Morphometric ratios were measured in tpsDig *ver.* 2.05 (Rohlf 2006), using digitized coordinates of landmarks and capture outlines. It should be noted that we documented measurements to the nearest 0.001 mm with tpsDig, but we conservatively report them to an accuracy of two decimal places. Definitions and abbreviations for the measured characters are shown in Table 1 (see also Figs 2, 3, 5).

Table 1. Abbreviation for morphometric data, measured in the examined material.

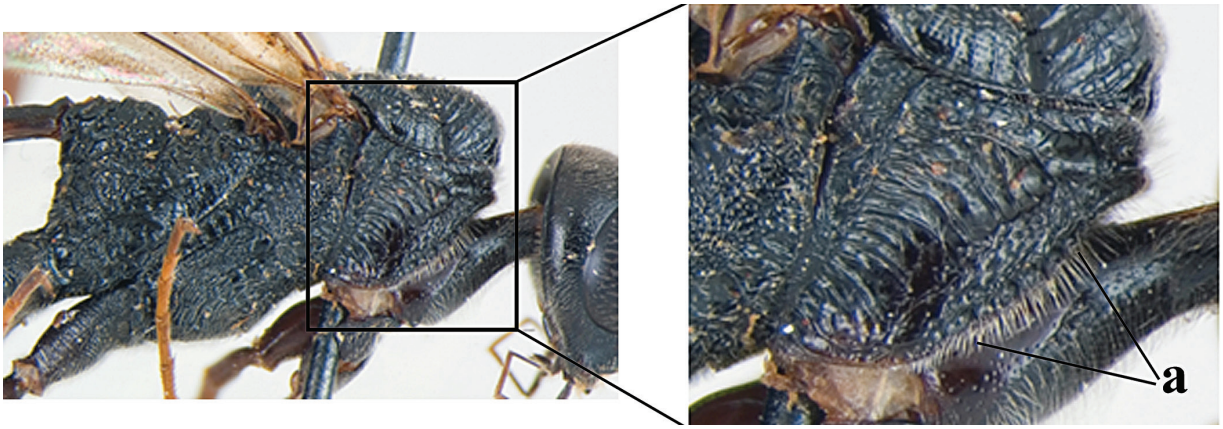
Abbreviation	Definition	Explanation
ClL	*Clypeal maximum length*	Full-face view, as in Fig 5A
ClOL	*Clypeus-ocellar line*	Distance between base of clypeus and median ocellus, full-face view (Fig 5A).
ClW	*Clypeal maximum width*	Full-face view, as in Fig 5A
CoL	*Hind coxa maximum length*	In lateral view, as in Fig 3C
CoW	*Hind coxa maximum width*	In lateral view, as in Fig 3C
EL	*Eye maximum length*	Vertical line length of compound eye, full-face view (Fig 2A)
EW	*Eye maximum width*	Horizontal line, width of the compound eye, full-face view (Fig 2A)
FWL	*Fore wing maximum length*	From median margin of first axillary sclerite to distal point of wing blade, as in Fig 3A
FWW	*Fore wing maximum width*	Longest line drawn perpendicular to the length axis, as in Fig 3A
HL	*Head maximum length*	From anterior prominence of head to base of occipital carina, dorsal view (Fig 2B)
HW	*Head maximum width*	Maximum distance between lateral margins of compound eyes dorsal view (Fig 2B)
IOL	*Inter-ocular line*	Shortest distance between inner margin of compound eyes, full-face view (Fig 2A)
MsL	*Mesosoma maximum length*	longest anatomical line that connects the posterior-most point of the propodeal lobe with the anterior-most point of the pronotum, but if one of the reference points is not visible, dorsal view may help, preferentially in lateral view (Fig 2D)
MsW	*Mesosoma maximum width*	In dorsal view, as in Fig 2E
MtL	*Metasoma maximum length*	From base of petiole to base of pygidium, lateral view (Fig. 3B)
OD	*Ocellar diameter*	In dorsal view, as in Fig 2B
OML	*Ocular-mandibular line*	Minimum distance between anterior margin of compound eye and mandibular insertion to head, full-face view (Fig 5A)
OOCL	*Ocular-occipital carina line*	Minimum distance between lateral margin of compound eye and base of occipital carina lateral view (Fig 2C)
OOL	*Oculo-ocellar line*	Shortest distance between margins of compound eye and ocellus, dorsal view (Fig 2B)
OTL	*Oculo-tentorial line*	Minimum distance between anterolateral margin of compound eye and tentorial pit, full-face view (Fig 5A)
PEL	*Petiole maximum length*	From anterior-most margin to posterior margin of petiole, dorsal view (Fig 2F)
PEW	*Petiole maximum width*	Dorsal view, as in Fig 2F
PL	*Propodeum maximum length*	From apex of scutellum to base of petiole, dorsal view (Fig 2E)
POL	*Posterior-ocellar line*	Shortest distance between margin of lateral ocelli, dorsal view (Fig 2B)
PSL	*Pterostigma maximum length*	As in Fig 3A
PSW	*Pterostigma maximum width*	As in Fig 3A
PW	*Propodeum maximum width*	In dorsal view, as in Fig 2E
TL	*Temple maximum length*	Minimum distance between anterior margin of compound eye and base of occipital carina, dorsal view (Fig 2B)

Results

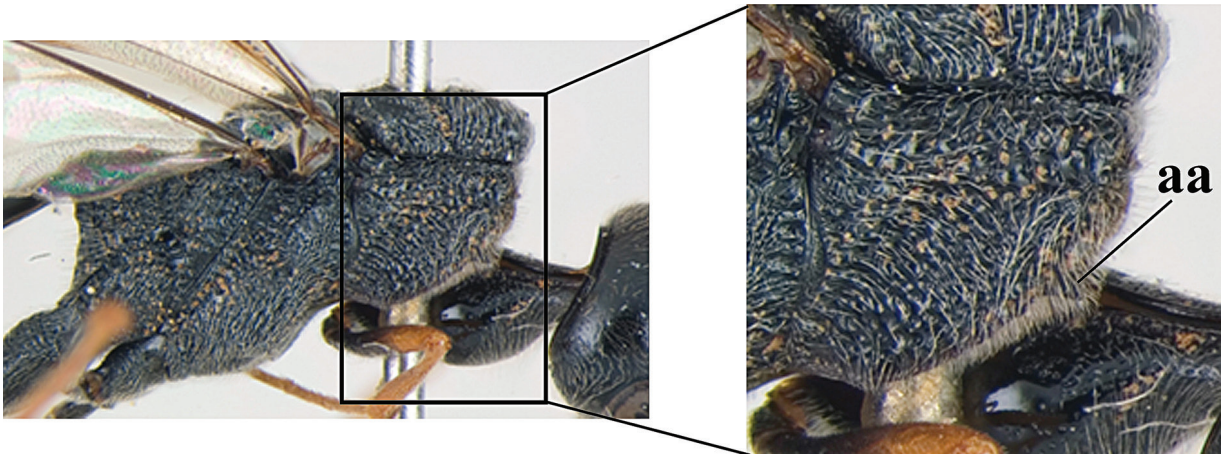
Five species belonging to the genus *Pristaulacus* are recorded from five provinces of Iran (East-Azarbaijan, Guilan, Kermanshah, Shiraz and West Azarbaijan) (Fig. 8). The species recorded for the first time from Iran and from individual provinces are marked with a single (*) or double (**) asterisks, respectively. It should be noted that no depository was mentioned for specimens of both *P. barbeyi* and *P. galitae* from Iran (Ghahari 2012), thus, it has not been possible to examine this material for confirmation. These taxa are marked below with an #.

Illustrated key to Iranian *Pristaulacus* Kieffer

1 Lateroventral margin of pronotum without tooth-like process (**a**)..... 2

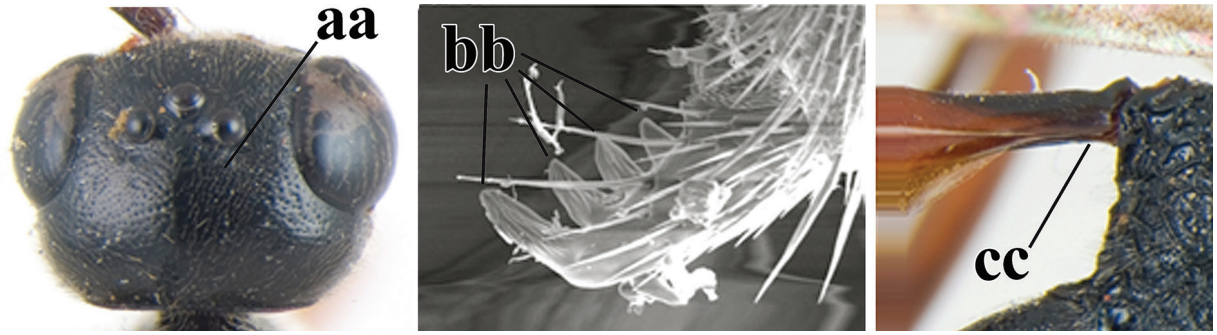


– Lateroventral margin of pronotum with at least one tooth-like process (**aa**) 3

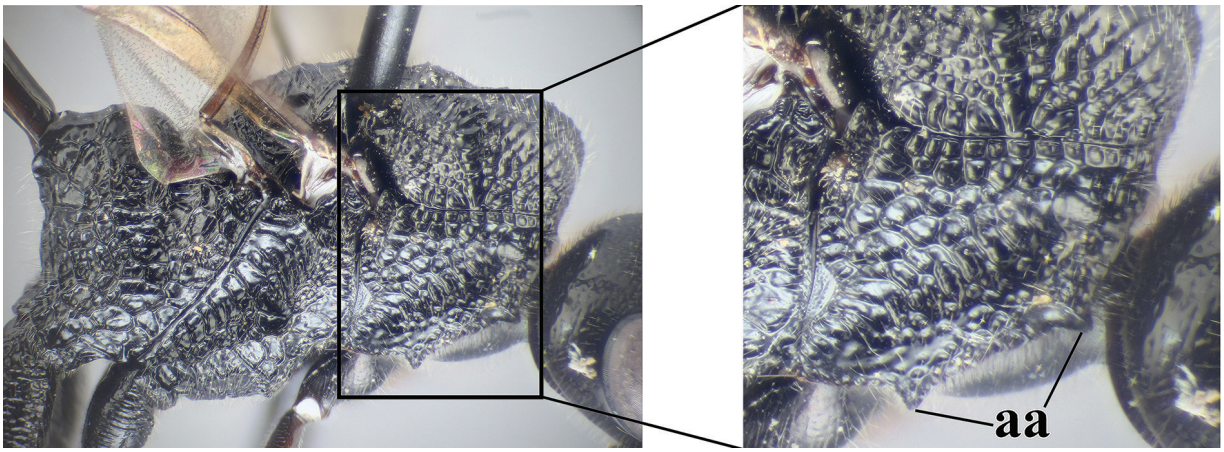


2 Head dull to weakly shiny, extensively transverse striolate (**a**); hind tarsus dark brown; tarsal claw with two tooth-like processes (**b**); petiole stocky and short (**c**).....*P. barbeyi* (Ferrière, 1933)

– Head shiny, mostly polished, except frons weakly striolate punctate (**aa**); hind tarsus yellow; tarsal claw with four tooth-like processes (**bb**); petiole slender and elongate (**cc**) ..... *P. gloriator* (Fabricius, 1804)

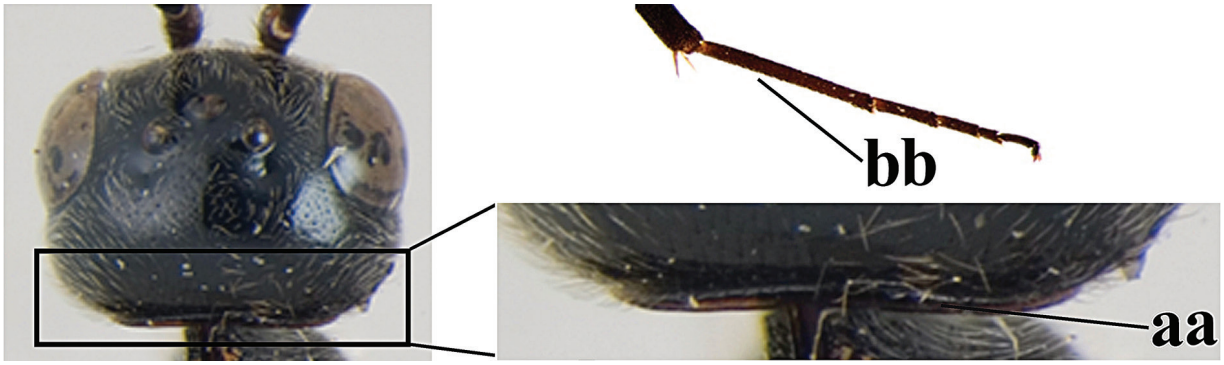


3 Lateroventral margin of pronotum with one tooth-like process (see first couplet)..... 4
– Lateroventral margin of pronotum with two tooth-like processes (**aa**) ..... *P. compressus* (Spinola, 1808)



4 Large sized species (body length, excluding ovipositor, 16.5–18.5 mm); occipital carina rim-like, blackish, 0.2× diameter of an ocellus (**a**); hind basitarsus weakly but distinctly curved, 1.5× longer than tarsomeres 2–5 (**b**); ovipositor 1.4× fore wing length ..... *P. mourguesi* Maneval, 1935

– Medium sized species (body length, excluding ovipositor, 8.0–11.5 mm); occipital carina cerciniform, brownish, 0.5× diameter of an ocellus (**aa**); hind basitarsus straight, 1.1× longer than tarsomeres 2–5 (**bb**); ovipositor 1.2× fore wing length ..... *P. galitae* (Gribodo, 1879)



Family Aulacidae Shuckard, 1842

***Pristaulacus* Kieffer, 1900**

***Pristaulacus barbeyi* (Ferrière, 1933) #**

Odontaulacus barbeyi Ferrière, 1933: 141, Holotype ♀ and paratype ♂. — Algeria, Babor (MNHN).

Distribution. Algeria, Greece, Morocco, Spain, Turkey (Turrisi 2007) and Iran (Ghahari 2012; Turrisi 2013a, b, c).

Distribution in Iran. West Azarbaijan province (Ghahari 2012: DU).

Diagnosis. *P. barbeyi* is a small to medium-sized species, with body length (excluding ovipositor) of 6.7–11.8 mm, fore wing length 5.1–8.1 mm; ovipositor length 1.3× fore wing length (holotype), but variable length among specimens from Turkey. It is readily distinguished by the shape of the head with a very narrow cerciniform occipital carina (width less than 0.2× ocellus diameter), rounded latero-ventral margin of pronotum without tooth-like processes, tarsal claw bearing two tooth-like processes along the inner margin, and a short and stocky petiole.

Hosts. Ghahari (2012) mentioned an unknown Buprestidae as host of this species in Iran, living on *Abies*.

Pristaulacus compressus* (Spinola, 1808) *

Figs 2, 3, 4

Aulacus compressus Spinola, 1808: 48, Holotype ♂. — Italy, Liguria, Habitat in montibus Orerii (MCSN).

Specimens examined. 2♀, DPPZ. Iran, Kermanshah province, Dudan, 35°01′00″N, 46°11′32″E, 1155m, 20.VI.2016, Malaise trap no. 2 mounted in orchard, leg.: M. Zardouei Heidari; 1♀, DPPZ. Iran, Kermanshah province, Harsin, 34°16’18.89”N, 47°36’16.63”E, 1568 m, 05.VII.2016, Malaise trap no. 1 mounted in orchard, leg.: M. Zardouei Heidari.

Distribution. Austria, Bulgaria, Czech Republic, France, Germany, Greece, Hungary, Iran, Iraq, Italy, Lebanon, Morocco, Poland, Romania, Russia (western territories), Slovakia, Spain, Switzerland, Turkey, Ukraine and former Yugoslavia (Madl 1990, Turrisi 2007, 2011, 2013a).

Distribution in Iran. Shiraz (Madl 1990: 114, NHMW), East-Azarbaijan (Lotfalizadeh et al. 2017: DU), and Kermanshah province (**new record**).

Diagnosis. It is a medium sized species with a body length of 8.8–14.2 mm (excluding ovipositor), fore wing length 6.6–9.5 mm. It is readily distinguished by having a wide occipital carina (width equal to ocellus diameter), a pair of tooth-like processes on each latero-ventral margin of pronotum, reddish-orange hind tarsus, and ovipositor length 1.1–1.3× fore wing length.

Morphometric ratios. CIOL/ClL: 1.10; ClL/ClW: 3.33; ClW/OML: 0.69; CoL/CoW: 2.61; EL/EW: 2.42; EL/OML: 2.90; EW/OOCL: 0.40; EW/OTL: 1.21; FWL/FWW: 3.10; HL/ClL: 4.04; HL/TL: 2.07; HW/EW: 9.48; HW/HL: 1.21; IOL/CIOL: 1.36; IOL/EW: 2.91; IOL/HW: 0.30; IOL/OML: 3.48; MsL/MsW: 2.18; MtL/MtW: 2.57; PEL/PEW: 1.90; PL/PW: 0.67; POL/OD: 1.46; POL/OOL: 1.00; SL/SW: 2.89; TL/EL: 1.55.

Hosts. This species was reared from *Chlorophorus adelii* Holzschuh, 1974 (Coleoptera, Cerambycidae) in tree oak, *Quercus* sp. (Madl 1990, Wall 1994). The reared beetle is polyphagous on deciduous trees and is endemic to Iran (Holzschuh 1974).

Remarks. The distribution of this species covers mainly the European area (see Turrisi 2011). It shows some

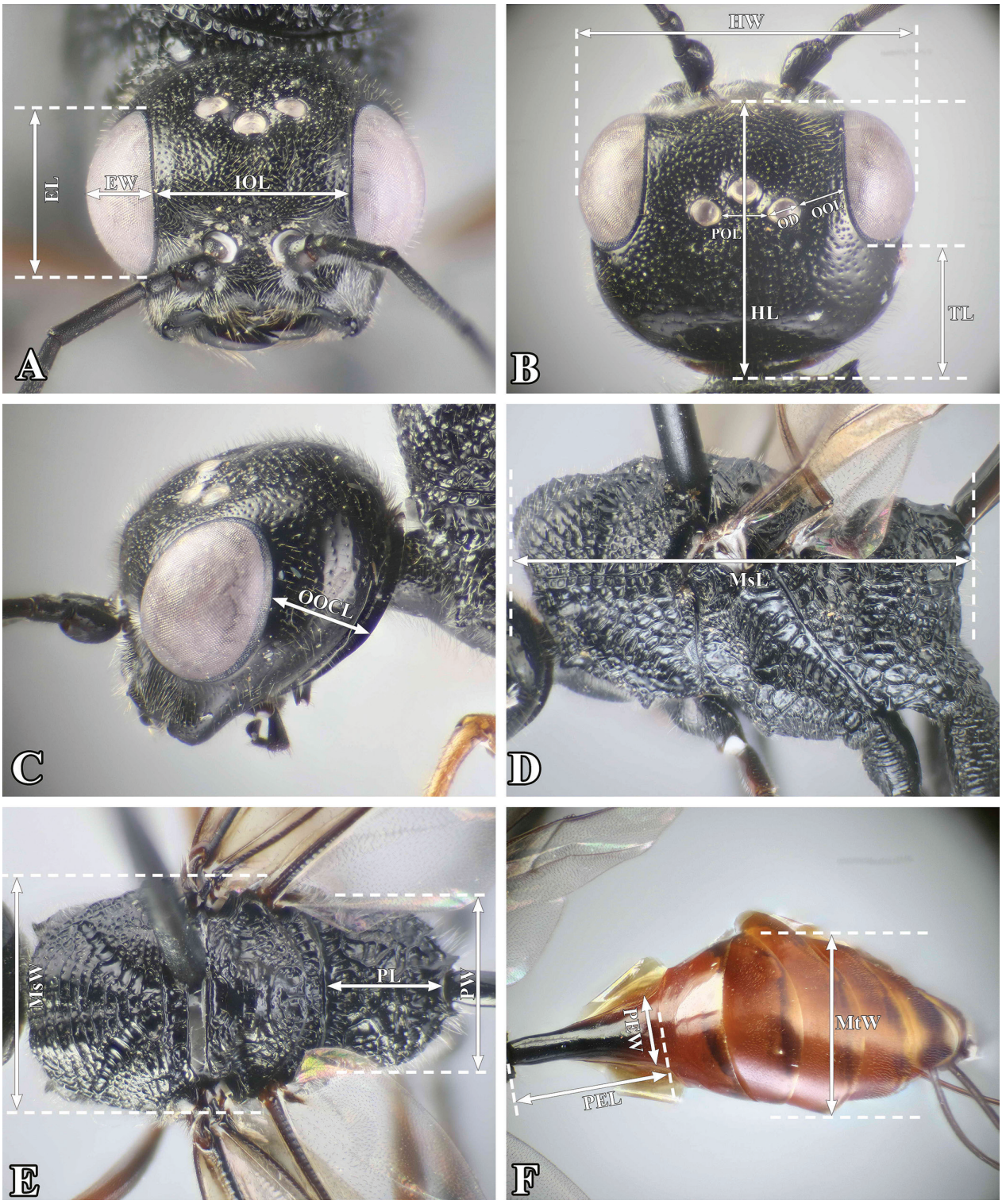


Figure 2. *Pristaulacus compressus* Spinola 1808. female (Iran): **A** face, frontal view; **B** head, dorsal view; **C** head, lateral view; **D** mesosoma, lateral view; **E** mesosoma, dorsal view; **F** petiole and metasoma, dorsal view.

intraspecific variation in colour and sculpture of some parts of the body (Turrisi 2007). The most similar species is *P. lindae* Turrisi, 2000, having hind tarsi blackish brown, metasoma more extensively red orange, different shape of mesosoma, sculpture of prescutum carinulate rugulose, a longer petiole and ovipositor (see Turrisi (2007, 2011 for more details). The head bears a coarser punctuation than European specimens of *P. compressus* and *P. lindae*, but less so than the other two similar species *P. samai* Turrisi, 2011 and *P. rapuzzii* Turrisi, 2011.

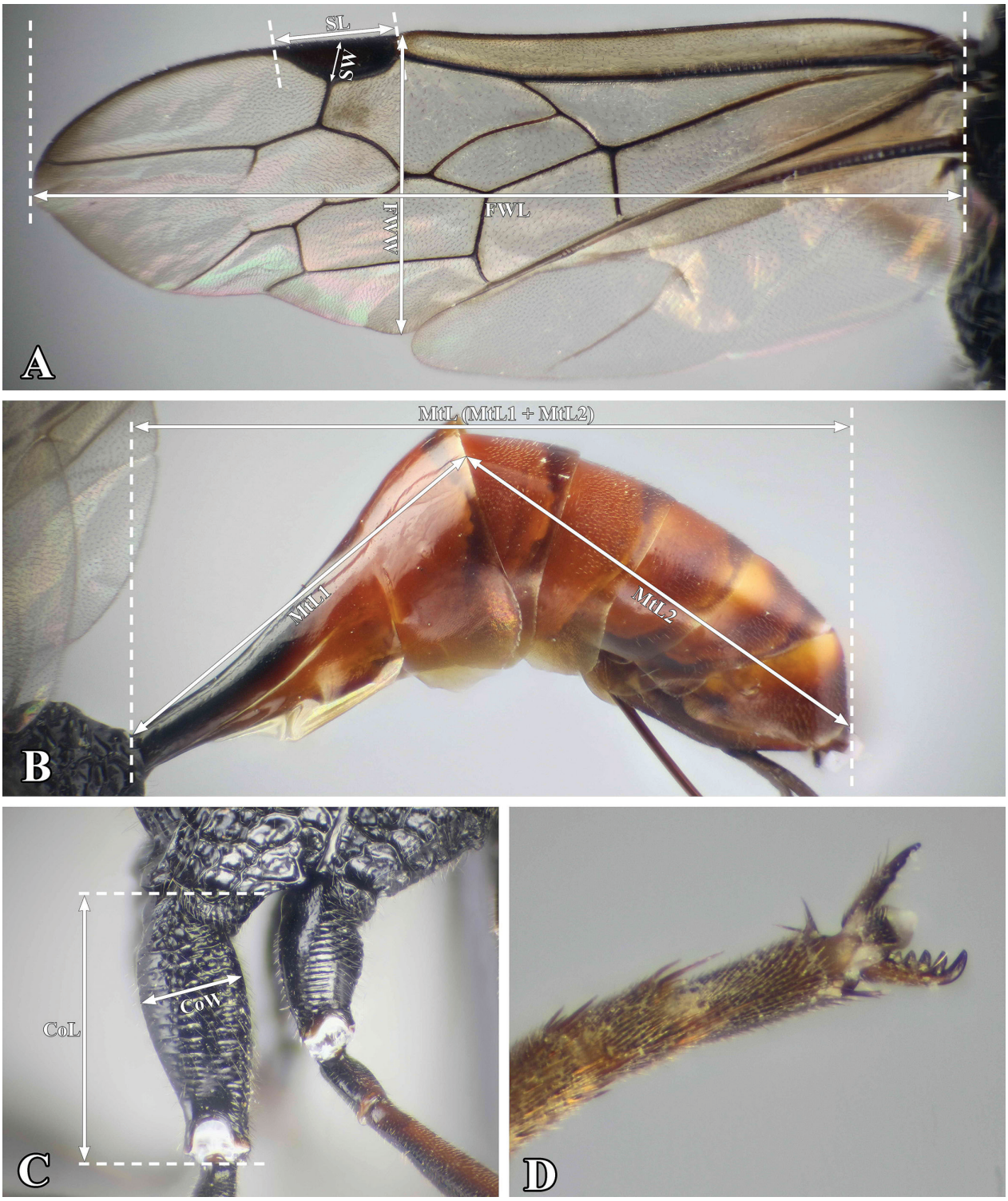


Figure 3. *Pristaulacus compressus* Spinola 1808. female (Iran): **A** fore and hind wing; **B** petiole and metasoma, lateral view; **C** hind coxa, lateral view; **D** hind claw, ventral view.

Pristaulacus galitae (Gribodo, 1879)

Aulacus galitae Gribodo, 1879: 339, Holotype ♀. — Tunisia, Galita Island (CPTO).

Distribution. Algeria, Austria, Bulgaria, Canary Islands (Tenerife), Croatia, Cyprus, Czech Republic, France, Germany, Greece (including Crete and Rhodos), Hungary, Iran, Italy (including Sardinia and Sicily), Morocco, Poland, Romania, Russia (westernmost area), Slovakia, Spain, Tunisia (including Galita Island), Turkey, Ukraine and former Yugoslavia (Turrisi 2007, 2013a, Ghahari 2012, Huflejt and Wiśniowski 2012).

Distribution in Iran. East Azarbaijan province (Ghahari 2012: DU).

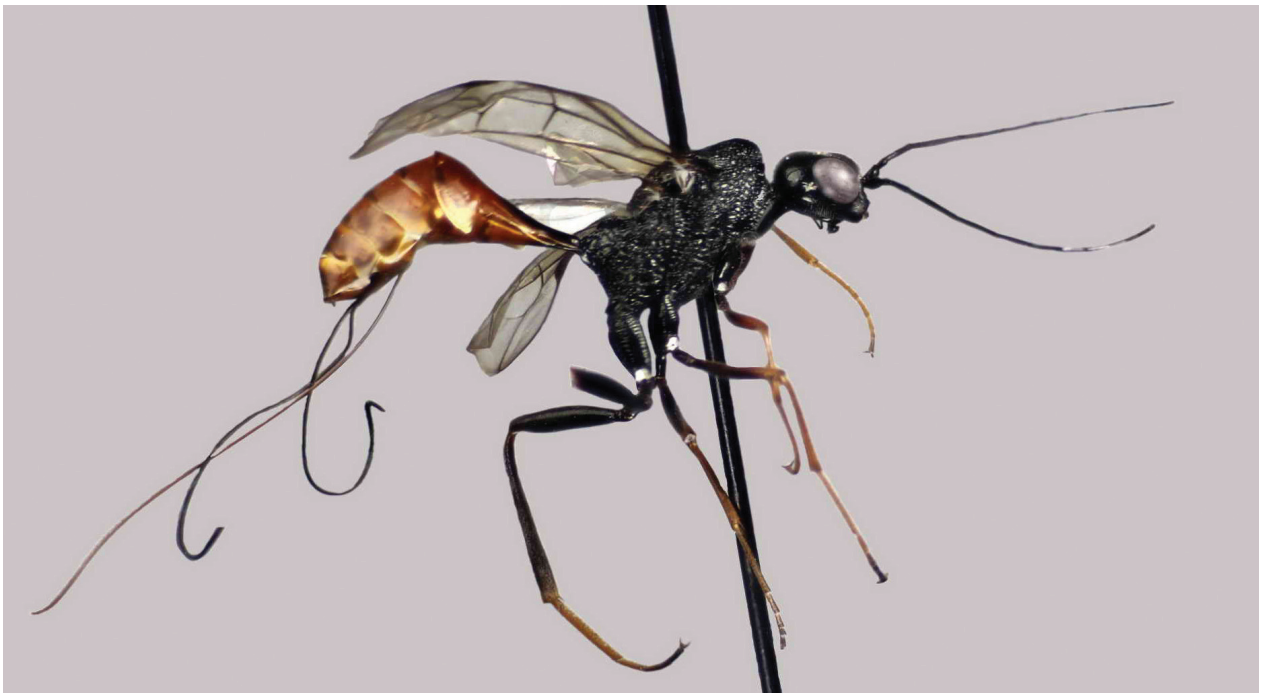


Figure 4. *Pristaulacus compressus* Spinola 1808. female (Iran): lateral habitus.

Diagnosis. *P. galitae* is a medium-sized species with a body length of 8.0–11.2 mm (excluding ovipositor), fore wing length 4.5–7.8 mm. It is distinguished by the combination of the following features: shape of the head, with rounded profile of temple, occipital carina moderately wide (0.5× OD), one anterior tooth-like process on each side of latero-ventral margin of pronotum, ovipositor length 1.0–1.2× fore wing length.

Hosts. Ghahari (2012) mentioned specimens reared in Iran from *Trichoferus griseus* # (Fabricius, 1792) (Coleoptera, Cerambycidae) feeding on common fig, *Ficus carica* L. (Moraceae).

Pristaulacus gloriator (Fabricius, 1804)

Bassus gloriator Fabricius, 1804: 99, Holotype ♀. — Germany, Habitat in Germ. Dom. Smidt (ZMUC).

Distribution. Albania, Austria, Czech Republic, Germany, Greece, Hungary, Iran, Italy, Poland, Romania, Russia (European and central areas), Slovakia, Turkey, former Yugoslavia (Turrisi 2007, 2013a, Huflejt and Wiśniowski 2012).

Distribution in Iran. Guilan province (Madl 1990: 114–115, NHMW; Turrisi 2007).

Diagnosis. *P. gloriator* is a medium to moderately large-sized species with a body length of 10.2–15.0 mm (excluding ovipositor), fore wing length 8.2–11.8 mm. It can be easily identified by the shape of the head with a narrow cerciniform occipital carina (width 0.2× OD), a rugulose-carinulate frons, latero-ventral margin of pronotum rounded without tooth-like processes, four tooth-like processes on the inner margin of tarsal claw, and light yellow tarsi.

Hosts. This species was reared from *Paraclytus reitteri* (Ganglbauer, 1881) (Coleoptera, Cerambycidae) feeding on alder, *Alnus* sp. The reared beetle is polyphagous in deciduous trees i.e. *Acer*, *Alnus*, *Carpinus* and *Quercus* (Miroshnikov 2014).

Remarks. This species was previously recorded as *P. holzschuhi* Madl, 1990 from Bandar-e Pahlavi (now called: Bandar-e Anzali - Anzali Port), Assalem, Guilan, Iran (Madl 1990), and is considered as a synonym of *P. gloriator* (Turrisi 2007) (type material examined and deposited in NHMW).

Pristaulacus mourguesi Maneval, 1935 *

Figs 5, 6, 7

Pristaulacus mourguesi Maneval, 1935: 66, Holotype ♀. — France, Pont-Ravatgers (MNHN).

Specimens examined. 2♀, DPPZ. Iran, Kermanshah province, Dudan, 35°01′00″N, 46°11′32″E, 1155m, 20.II.2016, BM-MTF-TS mounted in orchard, leg.: M. Zardouei Heidari; 1♀, DPPZ. same locality label, 05.VI.2016, BM-MTF-TS mounted among Oak forest - *Quercus brantii* Lindley, leg.: M. Zardouei Heidari.

Distribution. Croatia, France, Greece, Hungary (Turrisi 2007, 2013a), Iran (**new record**).

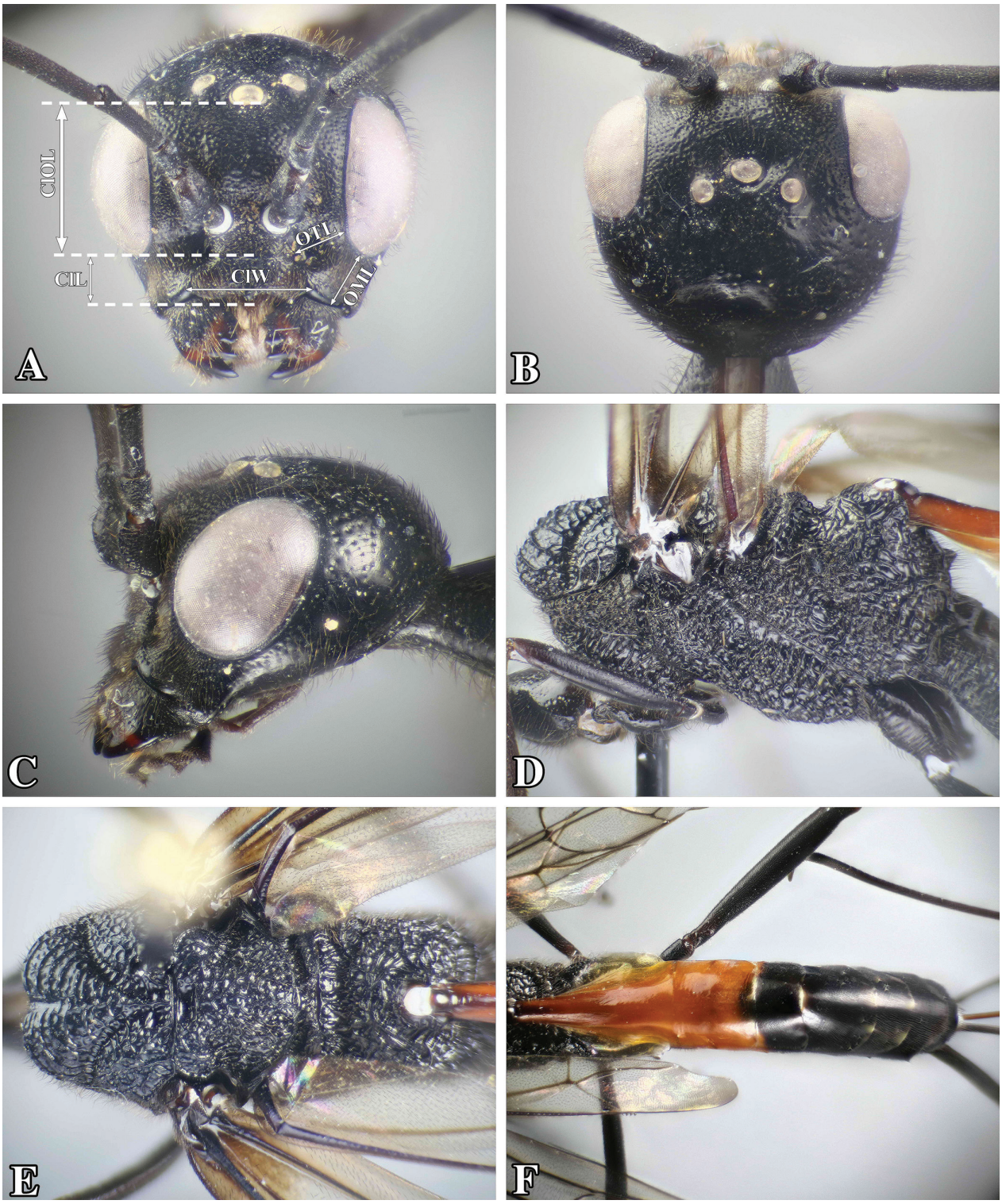


Figure 5. *Pristaulacus mourguesi* Maneval, 1935. female (Iran): **A** face, frontal view; **B** head, dorsal view; **C** head, lateral view; **D** mesosoma, lateral view; **E** mesosoma, dorsal view; **F** petiole and metasoma, dorsal view.

Distribution in Iran. Kermanshah province.

Diagnosis. *P. mourguesi* is one of the largest species among the Palaearctic *Pristaulacus* with a body length varying from 16.5 to 18.5 mm (excluding ovipositor), and fore wing length of 8.8–13.0 mm (♀). It is distinguished by the shape of the head, narrow cerciniform occipital carina (width 0.2× ocellus diameter), hind basitarsus long and slightly curved, 1.5× length of tarsomeres 2-5, and long ovipositor, 1.4–1.6× fore wing length.

Morphometric ratios. ClOL/ClL: 1.21; ClL/ClW: 2.75; ClW/OML: 0.78; CoL/CoW: 2.71; EL/EW: 2.65; EL/OML: 2.72; EW/OOCL: 0.58; EW/OTL: 1.14; FWL/

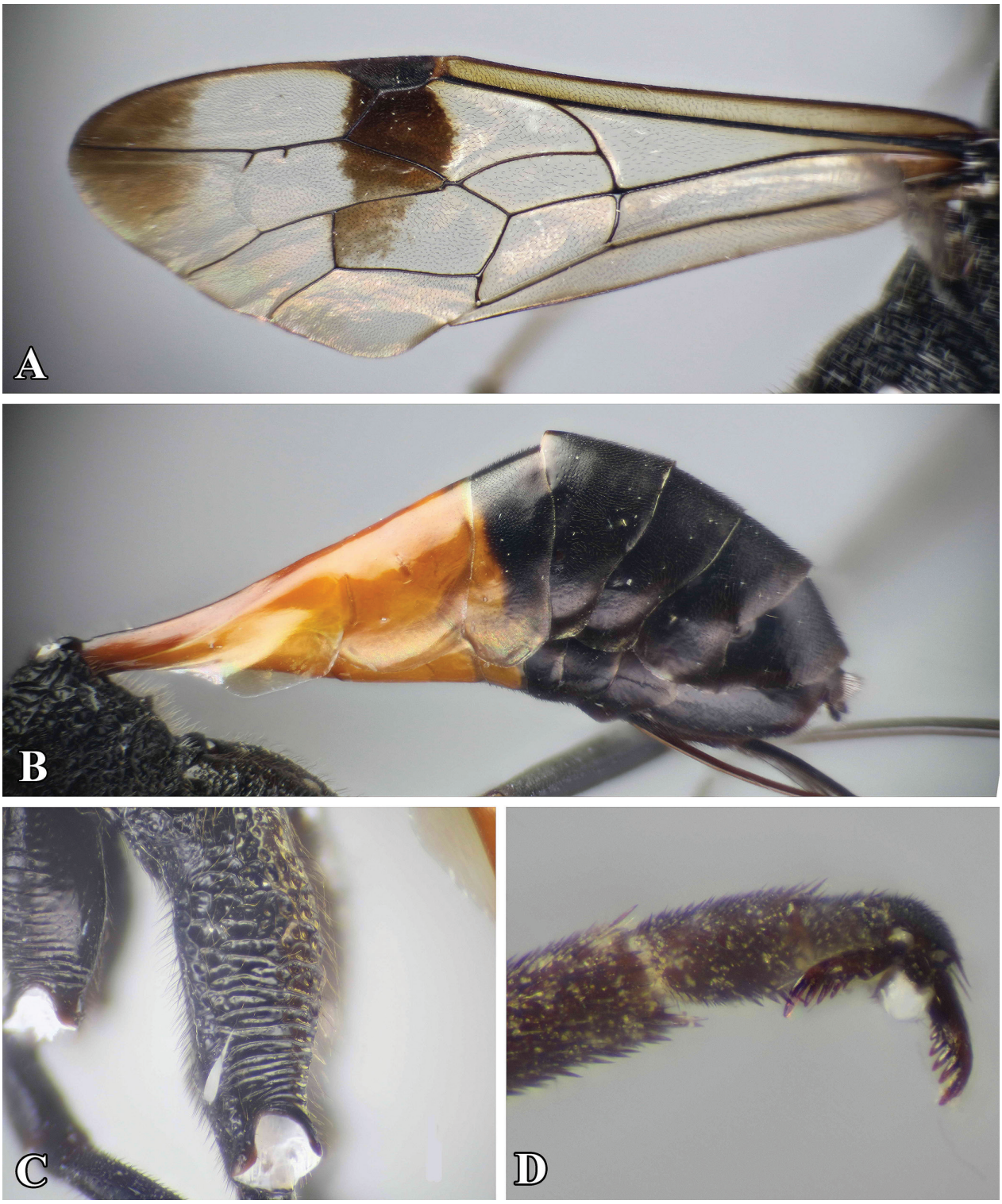


Figure 6. *Pristaulacus mourguesi* Maneval, 1935. female (Iran): **A** fore and hind wing; **B** petiole and metasoma, lateral view; **C** hind coxa, lateral view; **D** hind claw, ventral view.

FWW: 3.02; HL/ClL: 2.01; HL/TL: 1.97; HW/EW: 5.40; HW/HL: 1.27; IOL/CIOL: 1.27; IOL/EW: 3.26; IOL/HW: 0.60; IOL/OML: 3.35; MsL/MsW: 1.91; MtL/MtW: 6.39; PEL/PEW: 2.39; PL/PW: 0.55; POL/OD: 2.08; POL/OOL: 1.33; SL/SW: 2.62; TL/EL: 0.80.

Hosts. Unknown (Turrisi 2007).

Remarks. This species was previously recorded only from Europe (Turrisi 2007, 2013a). There is a possible record for the Near East without source material (Madl 2012). The closest species is *P. morawitzi* (Semenow, 1892) being medium sized, punctures of head very fine, superficial, and scattered, metasoma pyriform, strongly compressed, nearly entirely reddish orange. See Turrisi (2007) for more details.

Figure 7. *Pristaulacus mourguesi* Maneval, 1935. female (Iran): lateral habitus.

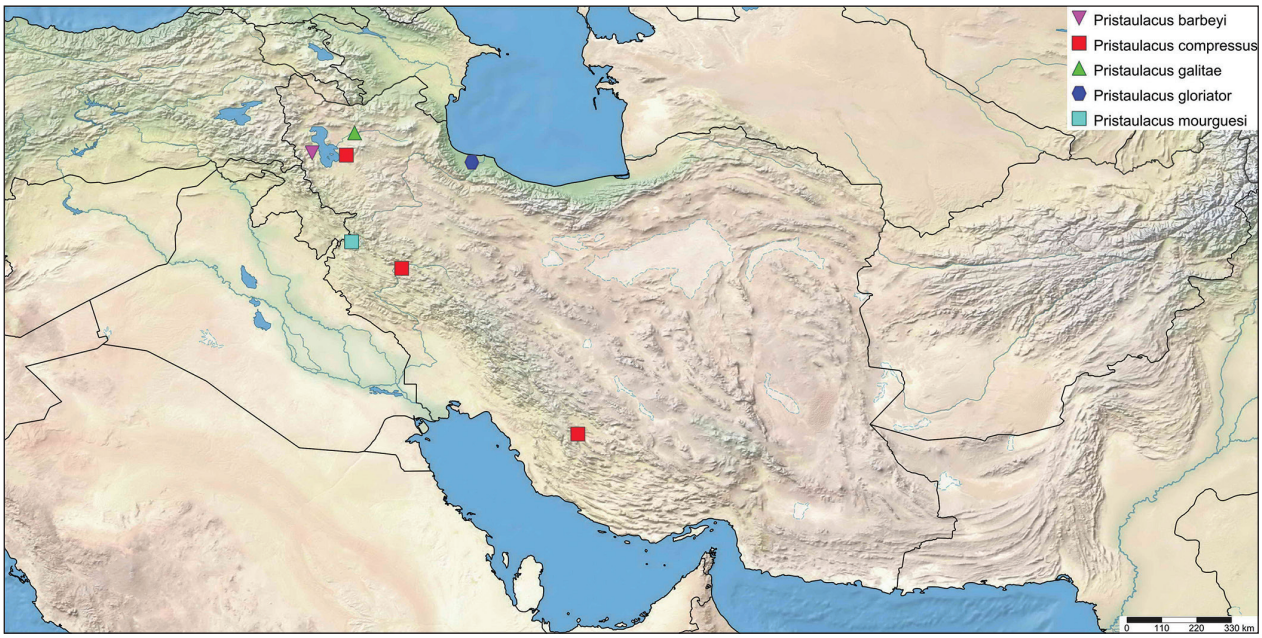


Figure 8. Distribution map of aulacid species in some provinces of Iran.

Discussion

The number of Iranian Aulacidae is raised to five, all within a single genus (*Pristaulacus*). All these species have been collected in Northern and Northwestern (forest habitat) regions, except *P. compressus*, which is recorded from Southern (subdesertic habitat) region.

Jennings et al. (2004) stated that remnant stands of forest are an ideal habitat for their wood-boring hosts. These wasps can be locally abundant in areas undergoing log-

ging or forest fires. The rich fossil record of Aulacidae indicates they were quite abundant in the Mesozoic (Jennings and Austin 2004, Turrisi et al. 2009).

The new specimens have been collected in Zagros forests, which have an area of about 6 million hectares (3.5 percent of Iran), located in the west of Iran with a semi-arid to temperate climate. This wide territory is also referred to as western oak forests (oak-woodland), due to the dominancy of oak species (*Quercus* spp.). The species composition of the woodland vegetation depends on the climatic conditions (Zohary 1973, Kwandrans 2007).

The five species reported in this paper are distributed only in the Western part of the Palearctic region. The results of the present study clearly show the improved efficiency of modern collecting methods for Hymenoptera that are rarely collected with most conventional methods. In addition, the best collecting period seems to be June and this is consistent with those reported in Lotfalizadeh et al. (2017).

Although the research suggests a higher number of species in the Western territories of Iran we predict that the Eastern and Southern parts should also be quite species-rich. Further investigation, especially in poorly collected regions will probably increase the number of known species (Turrisi 2014). The species reported from Iran have ranges included in the Western part of the Palaearctic region. Given the poorly known faunistic situation, it is premature to discuss possible relationships among faunas of Iran and adjacent territories.

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