

# A new species of the genus *Gaeolaelaps* (Acari, Mesostigmata, Laelapidae) from Iran

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## Abstract

The Genus *Gaeolaelaps* Evans & Till, 1966 is currently one of the largest genera of the family Laelapidae Berlese. The known representatives of this genus are active predators of small invertebrates such as other mites, insect eggs and nematodes. *Gaeolaelaps iranicus* Kavianpour & Nemati **sp. n.**, was collected from soil and litter in various parts of Iran. The description and figures of this species are given. A key to the *Gaeolaelaps* species of Iran is provided.

## Keywords

Taxonomy, Acari, Mesostigmata, Laelapidae, *Gaeolaelaps*

## Introduction

The mite family Laelapidae Berlese includes hundreds of species that are free-living predators in soil, as well as many others that have varying degrees of association with other animals, both vertebrates and invertebrates (Faraji and Halliday 2009). The genus *Gaeolaelaps* Evans & Till is currently one of the largest genera of the family Laelapidae. Some species of this genus, such as *Gaeolaelaps aculeifer* Canestrini, *G. oreithyiae* Walter and Oliver, and *G. gillesspiei* Beaulieu, are aggressive predators of nematodes and immature arthropods (Beaulieu 2009, Smiley et al. 2003, Trach 2012, Walter and Moser 2010).

*Gaeolaelaps* was considered at different taxonomic levels by authors: as a species group (Van Aswegen and Loots 1970); as a subgenus of *Hypoaspis* sens. lat. (Karg 1962, 1982, 1989, 1987, Faraji et al. 2008), and as a distinct genus (Lapina 1976, Ryke 1963, Hyatt 1964, Rosario 1981, Walter and Oliver 1989). We herein consider *Gaeolaelaps* as a genus. So far, a total of twelve species were reported from Iran: *G. aculeifer* (Canestrini), *G. nolli* (Karg), *G. kargi* (Costa), *G. queenslandicus* (Womersley), *G. angusta* (Karg), *G. angustiscutatus* (Willmann), *G. praesternalis* (Willmann), *G. minor* (Costa), *G. postreticulatus* (Xu & Liang), *G. deinos* (Zeman), *G. oreithyiae* (Walter & Oliver), and *G. glabrosimilis* (Hirschmann, Bernhard, Greim & Götz) (Mosaddegh 1997, Nemati et al. 2000, Kamali et al. 2001, Hadad Irani-Nejad et al. 2003, Mosavi et al. 2004, Noei 2007, Faraji et al. 2008, Babaeian et al. 2010, Nemati and Babaeian 2010, Ramezani and Nemati 2010). During our survey of soil and litter habitats in Iran we discovered a thirteenth species, new to science, which we describe in this paper.

## Materials and methods

Mites were collected from various soil and litter samples from different parts of Esfahan, Chaharmahal Va Bakhtiari and Khuzestan provinces in Iran. Mites were extracted from samples using Berlese funnels, placed in lactic acid at 55 °C for clearing and then mounted in Hoyer's medium on permanent microslides. All specimens were examined under a phase contrast microscope. Line drawings were made by use of a drawing tube and figures were performed with Corel X-draw software, based on the scanned line drawings. Seven specimens were used for most characters measurements. All the measurements are given in micrometers ( $\mu\text{m}$ ). The dorsal setae notation followed that of Lindquist and Evans (1965). The term lyrifissures and pore are used to refer to slit-shaped and circular or oval-shaped cuticular openings, respectively. We have attempted to identify all pore-like structures, but we acknowledge that some may have been overlooked. The holotype and some of the paratypes are deposited in the Acarological Laboratory, Department of Plant Protection, Agricultural College, Shahrekord University Shahrekord, Iran. Some paratypes are deposited in the Senckenberg Museum fur Naturkunde Gorkitz Am Museum 1 02826 Gorkitz Germany and Acarological Laboratory, Department of Plant Protection, Agricultural College, Shahid-Chamran University, Ahwaz, Iran.

## Results

### Genus *Gaeolaelaps* Evans & Till, 1966

**Type species:** *Laelaps aculeifer* Canestrini (1884), by original designation (Evans and Till 1966).

#### *Gaeolaelaps iranicus* Kavianpour & Nemati, sp. n.

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[http://species-id.net/wiki/Gaeolaelaps\\_iranicus](http://species-id.net/wiki/Gaeolaelaps_iranicus)

Figures 1–8

**Specimens examined.** Holotype, female, soil, Shahreza (32°03'N, 51°54'E, alt. 1777 m), Esfahan Province, Iran, 11 July 2010; coll., M. Kavianpour.

Paratypes: Females, soil from different parts of Shahreza, Esfahan province, and from different parts of Chaharmahal Va Bakhtiari and Khuzestan provinces, Iran, with the following data: Esfahan province, Shahreza: eight females (32°07'N, 51°55'E, alt. 1725 m), 22 August 2010; one female (32°06'N, 51°54'E, alt. 1747 m), 22 August 2010; three females (32°02'N, 51°53'E, alt. 1795 m), 1 September 2010; one female (32°01'N, 51°53'E, alt. 1799 m), 5 September 2010; seven females (32°01'N, 51°53'E, alt. 1800 m), 20 March 2011; five females (32°01'N, 51°53'E, alt. 1806 m), 4 April 2011; three females (32°02'N, 51°51'E, alt. 1827 m), 11 June 2011; three females (31°39'N, 51°55'E, alt. 2220 m), 9 July 2011; three females (32°00'20"N, 51°52'54"E, alt. 1823 m), 17 July 2011; one female (31°56'N, 51°44'E, alt. 1963 m), 4 August 2011.

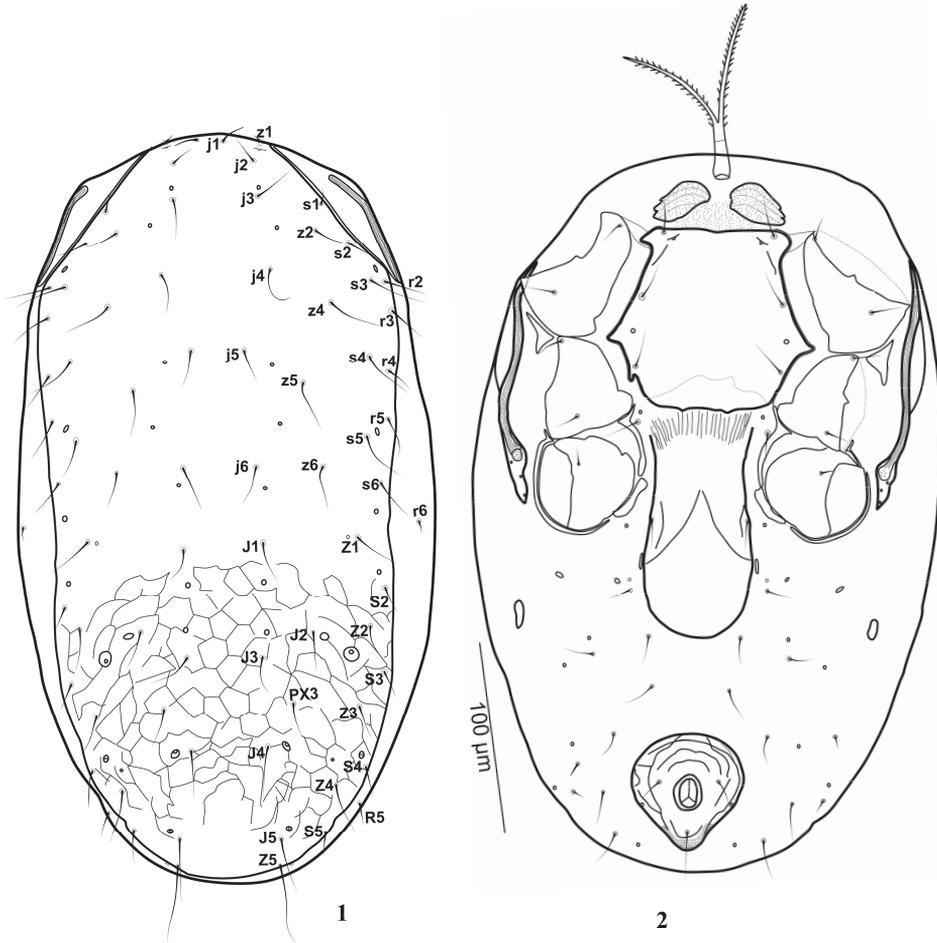
Chaharmahal Va Bakhtiari province, Shahrekord (32°19'N, 50°51'E, alt. 2206 m), three females, soil and litter, 2012, coll., A. Nemati.

Khuzestan province, Baghmalek (31°31'N, 49°53'E, alt. 707 m), two females, soil; Ghaletol (31°37'N, 49°53'E, alt. 885 m), two females, soil; Izeh (31°49'N, 49°52'E, alt. 845 m), two females, soil, 2012, coll., A. Nemati.

**Diagnosis.** Female; with small size (330–400); dorsal shield with 36 pairs of setae (*PX2* and *S1* missing), *PX3* setae present between *J* and *Z* series, only two pairs of marginal setae (*r6*, *R5*) in soft lateral cuticle, considerably shorter than dorsal shield setae; peritremes long, extending to anterior of setae *s1*; *leg IV*: tarsus (91–99: basitarsus + telotarsus), (*al1-3*, *av1-2*, *pl1-3* and *pv1-2* thickened, *ad2-3* and *pd2-3* slender and very elongate: *ad2-3* (0.55–0.57 and 0.66–0.69 × the length of tarsus IV respectively) and *pd2-3* (0.74–0.83 and 0.94–1.02 × the length of tarsus IV respectively).

**Description of the female** (n = 7). Figures 1–8.

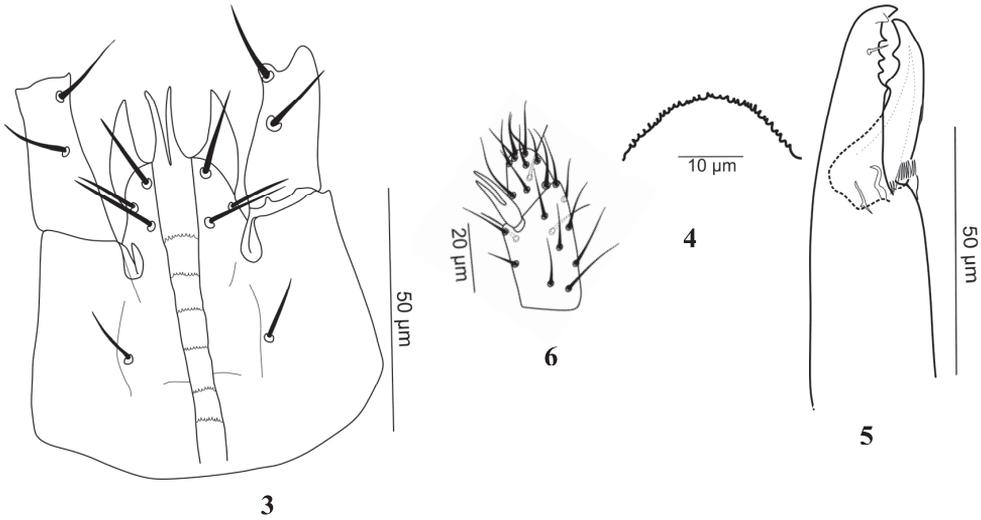
**Dorsal idiosoma.** Fig 1. Dorsal shield oval-shaped, 330–400 long, width at level of setae *r3* 170–195; reticulation more distinct posterior to setae *j6*; shield with 36 pairs of thin and simple setae, 21 pairs on podonotal region (*j1-6*; *z1*, *z2*, *z4-6*; *s1-6*; *r2-5*; *z3* missing) and 15 pairs on opisthonotal region (*J1-5*, *Z1-5*, *S2-5*), including *PX3* between *J* and *Z* series; *PX2* and *S1* missing. Dorsal setae vary in length, with



**Figures 1–2.** *Gaeolaelaps iranicus* Kavianpour & Nemati sp. n., Female. **1** Dorsum **2** Venter.

opisthonorotal setae generally slightly longer than podonotal setae: *j1* (14–20), *j2* (16–21), *j3* (20–33), *j4* (21–34), *j5* (20–28), *j6* (22–34); *z1* (8–14), *z2*, *z4*, *z5*, *z6* (22–34); *s1* (13–16), *s2* (15–26), *s3* (26–38), *s4–6* (27–36); *r2*, *r3*, *r4* and *r5* (21–31); *J1*, *J2* (21–28), *J3* (18–28), *J4* (25–34), *J5* (29–39); *Z1* (25–34), *Z2–Z3* (18–30), *Z4* (26–39), *Z5* longest (40–50), *S2–S4* (14–20), *S5* (18–25). Cuticle between dorsal and ventral side of body bearing *r6* (between *s6* and *Z1*) and *R5* (between *S4–S5*), length 8 and 12 µm long, respectively. Podonotal and opisthonorotal regions with 9 and 10 pairs of lyrifissures and pore-like structures, respectively, as shown in Fig. 1.

**Ventral idiosoma** (Fig 2). Tritosternum with tubular base (23–26) and pilose laciniae (70–75). Pre-sternal area granulated, with a pair of distinct, although poorly sclerotized plates. Sternal shield with smooth surface, 111–114 long, 114–118 wide (at level of projection between coxae II–III), with very small notch anteromedially; posterior margin irregular, almost straight. Sternal setae smooth, *st1*, *st2* and *st3* (26–29),

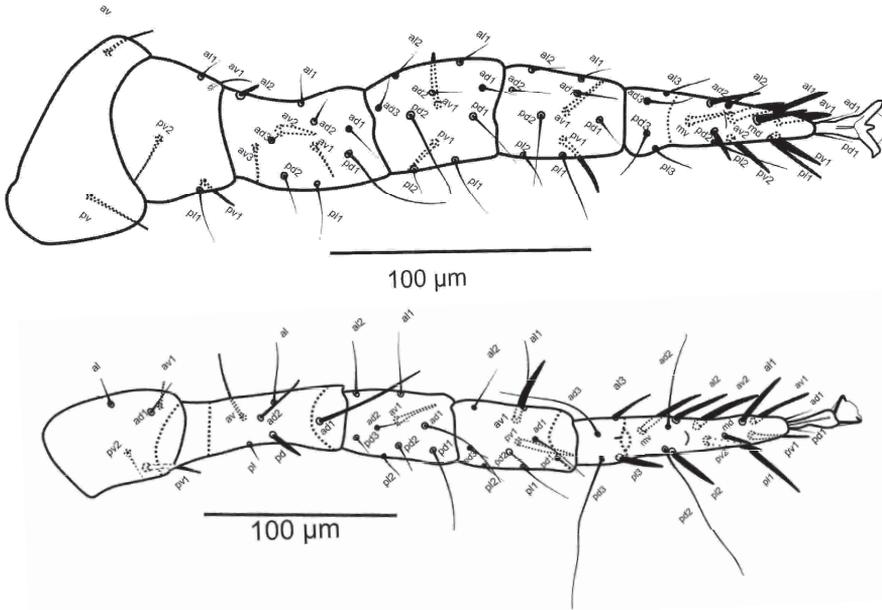


**Figures 3–6.** *Gaeolaelaps iranicus* Kavianpour & Nemati sp. n., Female. **3** Hypostome **4** Epistome **5** Chelicera **6** Apotele.

*iv1* slit-like, located slightly behind *st1*; *iv2* pore-like, between *st2*–*st3*. Setae *st4* (23–26) and pore-like *iv3* located on integument. Tongue-shaped genital shield 127–135 long (including hyaline flap at base of posterior margin of sternal shield), 57–60 wide, bearing 1 pair of setae (*st5* = 21–28) and a pattern of inverted v-shaped lines; paragenital pores (*iv5*) on soft integument near genital setae. Anal shield pyriform, reticulated, 65–70 long, 62–67 wide, post-anal seta (34–42) longer than paranal setae (18–22). Cribrum like a strip of teeth, extending laterally to level of post-anal seta. Opisthogastric surface with: 1 pair of suboval metapodal plates (12–15 × 3–6); 2 pairs of minute platelets (between metapodal plate and paragenital platelet); 1 pair of narrow, elongate paragenital platelets; 9 pairs of smooth setae, *ZVI-4* and *JVI-5* 16–29 long; and 7 pairs of pore-like structures, plus 1 pair on lateral margin of anal shield.

Stigma surrounded by short, narrow, pointed stigmatal plate, which extends posteriorly past level of mid-coxae IV (a distance ca. thrice diameter of stigma). Peritremes long, extending to anterior of setae *s1*. Narrow endopodal platelet present mesad coxae III–IV. Narrow exopodal plate surrounding coxae IV, and small exopodal plate between coxae II–III.

**Gnathosoma.** Hypostome (Fig. 3) with 3 pairs of similar smooth simple setae; *h1*, *h3* (20–26), *h2* (15–17). Palpcoxal setae 15–18 long. Deutosternal groove with 6 rows of 8–10 denticles; corniculi normal, horn-like. Epistome rounded with fine denticulations at anterior margin (Fig. 4). Chelicerae (Fig. 5) normal for genus, arthrochela processes developed, moveable digit (40–45) with 2 teeth, middle article (105–120), fixed digit with 4 teeth + offset tooth (gabelzahn), setaceous pilus dentilis small. Palp chaetotaxy normal (sensu Evans and Till 1965), with simple setae except *al* on femur thickened, spine-like, *al1* and *al2* of genu thickened, *al1* with tip rounded and *al2* spine-like; palp apotele two-tined (Fig. 6).



**Figures 7–8.** *Gaeolaelaps iranicus* Kavianpour & Nemati sp. n., Female. **7** Leg II **8** Leg IV.

**Legs.** Tarsi I–IV with claws and ambulacra. Legs I (432–442) and IV (382–397), longer than legs II (283–291) and III (255–270). Chaetotaxy of all leg segments normal for *Gaeolaelaps* (sensu Beaulieu 2009). Chaetotaxy of legs II and IV as shown in figures 7 and 8, respectively. Setae on legs I and III simple, slender; some setae on legs II and IV thickened or elongate, as follows. Leg II: femur (*al2* and *av2* short, slightly thickened, *pd1* elongate, slender), genu (setae *av1* and *pv1* slightly thickened), tibia (*av1* and *pv1* slightly thickened), tarsus (all setae thickened, except *al2*-3, *pl2*-3, *ad3* and *pd3*). Leg IV: trochanter (seta *pv2* thickened), femur (seta *pd* thickened, *ad1* elongate, slightly thickened), tibia (setae *al1*, *av1* and *pv1* thickened), tarsus (*al1*-3, *av1*-2, *pl1*-3 and *pv1*-2 thickened, *ad2*-3 and *pd2*-3 very elongate).

**Insemination structures.** Not seen.

**Male.** Unknown.

**Etymology.** The name of this new species refers to the currently known geographic range of the mite.

**Notes.** *Gaeolaelaps iranicus* sp. n. is differentiated by the following combination of characters: small size (330–400 long), the presence of four very long setae on tarsus IV (*ad2*, *ad3*, *pd2* and *pd3*), and 36 pairs of dorsal setae, with the absence of *PX2* and *S1* on the opisthonotal part of the dorsal shield, and the presence of two pairs of *r*-setae (*r6*, *R5*) on soft cuticle, which are considerably shorter than the dorsal shield setae.

The dorsal shield chaetotaxy is not always properly described, especially in older descriptions. However, species with as few as 36 pairs of setae appear to be rare, but some species do lack one pair of *PX* setae, as found in *G. iranicus*. Some specimens of

*G. fishtowni* (Ruf and Koehler 1993) appear to lack seta *PX3* but this species is larger than *G. iranicus* (565–653), has thickened spine or spur-like setae on the femur, genu, tibia and tarsus of leg II and tarsus IV, and the dorsal shield is posteriorly attenuated.

*G. vanpletzeni* (Van Aswegen and Loots 1970) has 38 pairs of setae on dorsal shield, lacking the *R* series, and has only one pair of *PX* setae (*PX2*), while *G. iranicus* sp. n. has 36 pairs of dorsal setae, with *R5* and *PX3* present. *G. spiniseta* (Barilo 1991) has 38 pairs of dorsal setae, with one pair of *PX* setae (*PX2*), a larger size (505–525), and with elongate spine-like setae on tarsus IV.

*Gaeolaelaps kargi* (Costa) has two elongate setae on tarsus IV, *S1* and *PX2-3* present, the postanal seta as long as the para-anal setae, and lacks elongate setae on genu IV. In contrast, *G. iranicus* sp. n. has four elongate setae on tarsus IV, lacks *S1* and *PX2*, the post-anal seta is considerably longer than the para-anal setae, and has two elongate setae (*ad1* and *pd1*) on genu IV.

*Gaeolaelaps nolli* (Karg) has two elongate setae on tarsus IV, a short peritreme (extending to the middle part of coxae II) and has *z3*, *PX2* and *S2*, while *G. iranicus* sp. n. has four elongate setae on tarsus IV, a longer peritreme and lacks *z3*, *PX2* and *S2*.

Some characters of *G. iranicus* sp. n. seem to be unique, but again poor descriptions hinder comparisons from the literature. For example, the presence of elongate setae on the femur, genu and tibia of leg IV (*ad1* on femur, *ad1* and *pd1* on genu, *ad2-3* and *pd2-3* on tarsus) is likely, in combination, to be unique in *Gaeolaelaps*. The length of leg segments and the relative lengths of the setae and their form may also be of taxonomic value. Hence we also report the following data relating to these characters: femur IV (80–82), *ad1* (0.77–0.87 × the length of femur); genu IV (55–57), *ad1* (0.77–0.91 × the length of genu), *pd1* (0.77–0.86 × the length of genu); tarsus IV (91–99: basitarsus + telotarsus), (*al1-3*, *av1-2*, *pl1-3* and *pv1-2* thickened, *ad2-3* and *pd2-3* slender and very elongate: *ad2-3* (0.55–0.57 and 0.66–0.69 × the length of tarsus IV respectively) and *pd2-3* (0.74–0.83 and 0.94–1.02 × the length of tarsus IV respectively).

### Key to the *Gaeolaelaps* of Iran (females)

- 1 Peritreme short, reaches to middle level of coxa II ..... ***G. nolli* (Karg, 1962) = *G. praesternalis* sensu Evans & Till, 1966\***
- Peritreme longer, reaches at least to anterior level of coxa I ..... **2**
- 2 Dorsal shield attenuated, with sudden constriction caudally ..... **3**
- Dorsal shield normal or less attenuated posteriorly ..... **5**
- 3 Leg II with thickened spines, especially a thick spine on femur II; moveable digit of chelicerae with 2 teeth; palp tarsal claw 3-tined ..... **4**
- Without thickened spines on leg II and femur II; movable digit of chelicerae with 2 larger and several smaller teeth; palp tarsal claw 2-tined ..... ***G. angustiscutatus* (Willmann, 1951)**
- 4 Leg I shorter than idiosoma; epistome with a row of equal denticles; dorsal shield without a curvature ..... ***G. angusta* (Karg, 1965)**

- Leg I longer than idiosoma; epistome with 2 teeth longer than the others; dorsal shield with a curvature in posterior part..... *G. queenslandicus* (Womersley, 1956)
- 5 Tarsus of leg IV with spine-like setae thicker than normal ..... 6
- Tarsus of leg IV without spine-like setae ..... 8
- 6 Some podonotal setae elongate, twice the length of opisthonotal setae, fixed digit of chelicerae with 12-14 teeth..... *G. aculeifer* (Canestrini, 1883)
- Podonotal setae not elongate, *Z5* approximately equal to *J5*; fixed digit of chelicerae with less than 12 teeth ..... 7
- 7 *iv2* slit-like; *al1* on femur IV short and spine-like ... *G. deinops* (Zeman, 1982)
- *iv2* pore-like; *al1* on femur IV elongate and simple..... *G. oreithyiae* (Walter & Oliver, 1989)
- 8 Seta *st1* located in presternal region off sternal shield... *G. minor* (Costa, 1968)
- Seta *st1* located on sternal shield ..... 9
- 9 Genital shield with diagonal parallel lines that meet together in the median area of the shield; sternal shield with concave posterior margin; with 3 unpaired setae between *J* series; seta *z3* present ..... *G. glabrosimilis* (Hirschmann, Bernhard, Greim & Gotz, 1969)
- Genital shield without diagonal parallel lines; sternal shield with relatively straight posterior margin; without unpaired setae between *J* series; without seta *z3*..... 10
- 10 Dorsal shield setae short, none of them reach to base of next setae; without elongate setae on tarsus IV ..... *G. praesternalis* (Willmann, 1949) after Karg (1971)\*\*
- Dorsal shield setae relatively long, some of them reach to the base of next setae; with elongate setae on tarsus IV..... 11
- 11 With setae *PX2-3* and *S1*; with 2 elongate setae on tarsus IV, para-anal setae slightly shorter than or as long as post-anal seta ..... *G. kargi* (Costa, 1968)
- Without setae *PX2* and *S1*; with 4 elongate setae on tarsus IV, post-anal seta considerably longer than para-anal setae ..... *G. iranicus* sp. n.

\* We suspect *G. postreticulatus* (Xu & Liang) recorded by Montazeri et al. (2011) from Iran is a junior synonym of *G. nollii*.

\*\* The second author has examined the following materials: Two females, soil, Izeh, Khuzestan province, Iran, 2010.

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# A preliminary checklist of the ants (Hymenoptera, Formicidae) of Andorra

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## Abstract

Within the last decade, checklists of the ant fauna of several European countries have been published or updated. Nevertheless, no ant checklists have hitherto been published for the principality of Andorra, a small landlocked country located in the eastern part of the Pyrenees. This work presents a critical list of the ant species of Andorra based on a review of the literature and on the biological material we collected during several field campaigns conducted in Andorra since the year 2005. Seventy-five species belonging to 21 genera of Formicidae were recorded. Nine species were recorded for the first time in Andorra: *Aphaenogaster gibbosa* (Latreille, 1798), *Camponotus lateralis* (Olivier, 1792), *Camponotus piceus* (Leach, 1825), *Formica exsecta* Nylander, 1846, *Lasius piliferus* Seifert, 1992, *Tapinoma madeirense* Forel, 1895, *Temnothorax lichtensteini* (Bondroit, 1918), *Temnothorax niger* (Forel, 1894), *Temnothorax nigriceps* (Mayr, 1855). The most speciose genera were *Formica* Linnaeus, 1758 and *Temnothorax* Forel, 1890 with 14 and 12 species, respectively. The ant fauna of Andorra is mostly dominated by Central European species (some are typical cold climate specialists); however species belonging to the Mediterranean ant fauna were also found. This can be explained by the particular geographic situation of Andorra which is characterized by a high mountain Mediterranean climate.

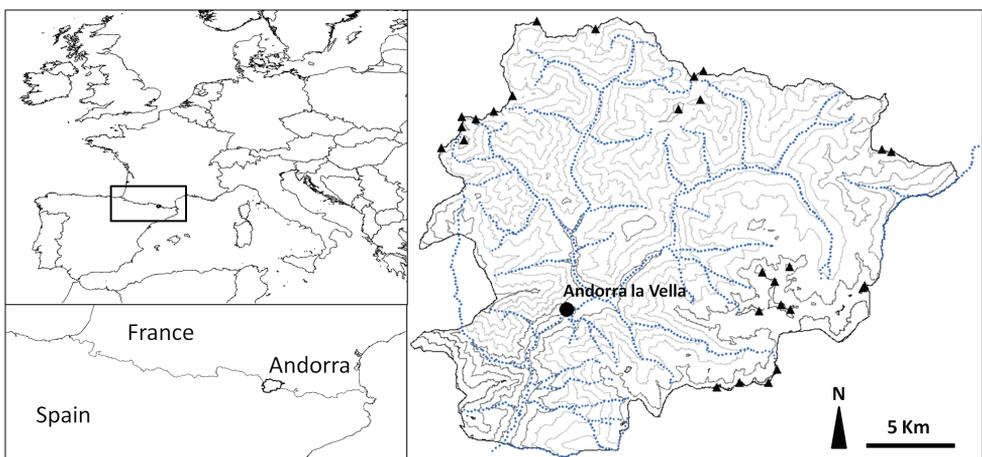
## Keywords

Hymenoptera, Formicidae, checklist, new records, Andorra, Pyrenees

## Introduction

Over the last decade, ant taxonomy has experienced a renewal in Europe due to the description of new species (Seifert 2005), the revision of genera or species groups (e.g. Radchenko and Elmes 2003, Rigato 2011) and the publication of checklists of the ant fauna of several European countries (e.g. Austria: Steiner et al. 2003, Benelux: Boer 2010, Bulgaria: Lapeva-Gjonova et al. 2010, Croatia: Bračko 2006; Romania: Markó et al. 2006, Montenegro: Karaman 2009, Poland: Czechowski et al. 2012, Slovenia: Bračko 2007). This renewal is also due to the publication of excellent taxonomic keys for ant identification (e.g. Seifert 2007, Boer 2010, Radchenko and Elmes 2010), the development of Internet databases accessible on-line (e.g. antbase.org: antbase.org; Ant Genera of the World: www.antmacroecology.org; AntWeb: www.antweb.org), as well as to the use of molecular approaches that have helped to resolve old and debated taxonomical problems (Bernasconi et al. 2011).

Despite the acknowledged importance of mountain ecosystems (Kollmair et al. 2005) in conservation issues, little information is available in the literature on the ant diversity of European mountains. A case in point is the Pyrenees. These mountains have always been of great interest for naturalists because they are characterized by a relatively high rate of endemism of both animal (e.g. Deharveng 1996, Brown et al. 2009) and plant species (Villar and Dendaletche 1994). The Pyrenees are particularly interesting for myrmecologists because they are located in a climatic zone which covers three different regions from a biogeographical point of view: Alpine, Mediterranean and Atlantic. The principality of Andorra (Figure 1) is a small landlocked country located in the heart of the Pyrenees which is bordered by Spain and France and covers an area of approximately 468 km<sup>2</sup> (Degage and Duro i Arajol 1998). Its relief mainly consists of fluvial valleys and rugged mountains spreading on an altitude ranging from



**Figure 1.** Map of Andorra (from light to dark grey: contour lines every 250 meters from low to high altitude, dotted lines: main Andorran rivers, triangles: peaks over 2800m).

840 to 2942 m. Andorra has a high mountain Mediterranean climate, characterized by cold temperatures in winter (mean monthly temperature in January  $-2^{\circ}\text{C}$ ) and mild temperatures in summer (mean monthly temperature in July  $19^{\circ}\text{C}$ ), although extreme peaks of  $-20^{\circ}\text{C}$  at Ransol and  $39^{\circ}\text{C}$  at Les Escaldes have been registered (Vilà-Valentí and Martín-Vide 1997). Although the ant fauna of France (Casevitz-Weulersse and Galkowski 2009) and Spain (Gómez 2012) are now relatively well known, the ant fauna of Andorra did not so far raise the interest of ant taxonomists. Except for some studies published in the grey literature or some scattered data collected during occasional samplings by Santschi (1919), Rösler (1937), Collingwood and Yarrow (1969), or Espadaler (1997) and Espadaler et al. (2008), there is little information available on the ant fauna of Andorra and no ant checklists for this country have been published to date. This paper presents a list of the ant species of Andorra based on a review of the literature and on material collected during several sampling campaigns conducted in Andorra since 2005.

## Methods

A preliminary checklist was assembled from a thorough and comprehensive review of the literature and from the information given by several databases available on the Internet (e.g. FORMIS 2011: [www.ars.usda.gov/saa/cmave/ifahi/formis](http://www.ars.usda.gov/saa/cmave/ifahi/formis), ScienceDirect: [www.sciencedirect.com](http://www.sciencedirect.com), Google Scholar: [www.scholar.google.com](http://www.scholar.google.com), etc.) using searching requests such as “Andorra + Formicidae”. This first checklist was compared with the material we collected during several sampling campaigns conducted in the last 8 years in different parts of Andorra: low and high altitude grasslands, low and high altitude forests, anthropized areas, etc. Ants were searched on the ground and on vegetation; potential nesting sites were also inspected: dead wood, underneath of stones / bark, grass stems, acorns. Ants were collected by hand and were placed in plastic vials filled with  $90^{\circ}$  ethanol. Once in the laboratory, they were sorted and identified to the species level. All the material collected was identified by Dr. Xavier Espadaler. As no identification keys exist for the ants of Andorra, keys created for other European countries (e.g. Czechowski et al. 2012, Seifert 2007) and for the taxonomic revisions of some ant genera (Seifert 1988, 1992, 2000, 2007) were used. Most of the material we collected is stored in the personal collection of Dr. Xavier Espadaler at the Department of Animal Biology, Plant Biology and Ecology, Autonomous University of Barcelona, Spain.

The final checklist was assembled based on every taxonomical/biodiversity papers related to Andorra as well as on other papers referring to data collected in Andorra (e.g. phylogeographical studies) and on the material collected by ourselves. The species list we present is arranged in alphabetic order by subfamily, genus and species. Nomenclature was checked following Bolton (2012). Only species with unambiguous taxonomic determinations were considered in the final checklist.

## Results

The ant species recorded in Andorra are listed in Table 1. The list contains 75 species distributed across 21 genera belonging to 4 subfamilies (Dolichoderinae, Formicinae, Myrmicinae, Ponerinae). The most speciose subfamily was Myrmicinae and the most speciose genus was *Formica* Linnaeus, 1758 with 36 and 14 species respectively. We included in our checklist the species *Tetramorium pyrenaicum* Rösler, 1936. This species was first described in Andorra and elevated to species rank by Rösler (1951) (Güsten et al. 2006). However, because its morphological characters do not correspond to any European *Tetramorium* species currently described and because no biological material remains in their original depositories (Muzeul Brukenthal, Sibiu, Romania and Zoologisches Museum der Universität Hamburg, Germany), Güsten et al. (2006) consider that the validity of *T. pyrenaicum* as a taxonomically distinct species remains controversial. Nonetheless, we chose to retain this species in our list because the possibility exists that it could actually be a taxonomically distinct species, such as *Tetramorium D* or *Tetramorium E* described by Schlick-Steiner et al. (2006). We also decided to include *Solenopsis* sp. Westwood, 1840 in our checklist. Because of the absence of revised taxonomic keys on this genus however we did not attempt to identify the *Solenopsis* specimen we found to the species level. We agree with Casevitz-Weulersse and Galkowski (2009) that a thorough review of this genus based on new material would be necessary to clarify its situation in Europe. Indeed, between 1949 and 1977 Bernard (see Casevitz-Weulersse and Galkowski 2009) described many new species related to *Solenopsis fugax* (Latreille, 1798) using characters that turned out to be variable and irrelevant to correctly identify the different species of this genus. Therefore, we decided to only mention the presence of the *Solenopsis* genus in Andorra. Finally, *Monomorium pharaonis* (Linnaeus, 1758) was excluded from our checklist. In fact, this species was erroneously reported as present in Andorra by Passera (1994) citing Eichler (1978) as a source (see Wetterer 2010). In absence of new data on this species, we decided to exclude it from our list.

After comparing our material with the data available in the literature, we found that 9 species were new to Andorra:

*Aphaenogaster gibbosa* (Latreille, 1798), Sant Julià de Lòria: Bordes de la Juberrussa (42°26.41'N; 1°28.81'E - 950 m a.s.l), 15.VII.2007, leg. A. Bernadou, det. X. Espadaler, workers collected in a nest under a stone.

*Camponotus lateralis* (Olivier, 1792), Sant Julià de Lòria: Borda del Sabater (42°26.75'N; 1°28.83'E - 870 m a.s.l), 15.VII.2007, leg. A. Bernadou, det. X. Espadaler, workers collected.

*Camponotus piceus* (Leach, 1825), Sant Julià de Lòria: Coll de Jou, carretera de Fontaneda (42°27.50'N; 1°29.00'E - 1100 m a.s.l), 02.VIII.2008, leg. A. Bernadou, det. X. Espadaler, workers collected.

*Formica exsecta* Nylander, 1846, refugi de Sorteny (42°37.45'N; 1°34.56'E - 2100 m a.s.l.), 21.IX.2011, leg. det. X. Espadaler, workers collected.

*Lasius piliferus* Seifert, 1992, Sant Julià de Lòria: Coll de Jou, carretera de Fontaneda (42°27.50'N; 1°29.00'E - 1100 m a.s.l), 02.VIII.2008, leg. A. Bernadou, det. X. Espadaler, workers collected.

*Tapinoma madeirense* Forel, 1895, Sant Julià de Lòria: Coll de Jou, carretera de Fontaneda (42°27.50'N; 1°29.00'E - 1100 m a.s.l), 02.VIII.2008, leg. A. Bernadou, det. X. Espadaler, workers collected.

*Temnothorax lichtensteini* (Bondroit, 1918), Sant Julià de Lòria: Coll de Jou, carretera de Fontaneda (42°27.50'N; 1°29.00'E - 1100 m a.s.l), 02.VIII.2008, leg. A. Bernadou, det. X. Espadaler, workers collected.

*Temnothorax niger* (Forel, 1894), Sant Julià de Lòria: Coll de Jou, carretera de Fontaneda (42°27.50'N; 1°29.00'E - 1100 m a.s.l), 02.VIII.2008, leg. A. Bernadou, det. X. Espadaler, workers collected.

*Temnothorax nigriceps* (Mayr, 1855), Sant Julià de Lòria: Coll de Jou, carretera de Fontaneda (42°27.50'N; 1°29.00'E - 1100 m a.s.l), 02.VIII.2008, leg. A. Bernadou, det. X. Espadaler, workers collected.

**Table 1.** Checklist of the ant species of Andorra. The list is arranged alphabetically by subfamily, genus and species. Species names in bold characters refer to species recorded for the first time in Andorra. Bibliographic references are as follows: a = Bernadou et al. 2006a; b = Bernadou et al. 2006b; c = Espadaler et al. 2008 *Hypoponera eduardi* was misidentified with *Hypoponera punctatissima* in this study (Espadaler, pers. com.); d = Bernadou et al. 2010; e = Bernadou 2009; f = Seifert 1992; g = Santschi 1919; h = Espadaler 1997; i = Collingwood and Yarrow 1969; j = Leppänen et al. 2011; k = Cournault and Aron 2009; l = Bagherian et al. 2012; m = Rösler 1951.

Subfamilies	Scientific valid name		References
DOLICHODERINAE	<i>Dolichoderus quadripunctatus</i>	(Linnaeus, 1771)	c
	<i>Tapinoma erraticum</i>	(Latreille, 1798)	a, b, c, e, k
	<b><i>Tapinoma madeirense</i></b>	Forel, 1895	
FORMICINAE	<i>Camponotus aethiops</i>	(Latreille, 1798)	c
	<i>Camponotus cruentatus</i>	(Latreille, 1802)	c
	<i>Camponotus herculeanus</i>	(Linnaeus, 1758)	a, b, e
	<b><i>Camponotus lateralis</i></b>	(Olivier, 1792)	
	<i>Camponotus ligniperda</i>	(Latreille, 1802)	a, b, c, e, i
	<b><i>Camponotus piceus</i></b>	(Leach, 1825)	
	<i>Camponotus truncatus</i>	(Spinola, 1808)	c
	<i>Formica decipiens</i>	Bondroit, 1918	a, b, e
	<b><i>Formica exsecta</i></b>	Nylander, 1846	
	<i>Formica foreli</i>	Bondroit, 1918	a, b, e
	<i>Formica frontalis</i>	Santschi, 1919	a, b, e
	<i>Formica fusca</i>	Linnaeus, 1758	a, b, c, e, g
	<i>Formica genardi</i>	Bondroit, 1917	c
	<i>Formica lemani</i>	Bondroit, 1917	a, b, e
	<i>Formica lugubris</i>	Zetterstedt, 1838	a, b, e, i
	<i>Formica picea</i>	Nylander, 1846	a, b, e
<i>Formica pratensis</i>	Retzius, 1783	a, b, e	

Subfamilies	Scientific valid name	References		
	<i>Formica pressilabris</i>	Nylander, 1846	a, b, e	
	<i>Formica rufa</i>	Linnaeus, 1761	a, b, e, g	
	<i>Formica rufibarbis</i>	Fabricius, 1793	a, b, c, e, i	
	<i>Formica sanguinea</i>	Latreille, 1798	a, b, e	
	<i>Lasius alienus</i>	(Förster, 1850)	a, b, c, e	
	<i>Lasius brunneus</i>	(Latreille, 1798)	c, e	
	<i>Lasius distinguendus</i>	(Emery, 1916)	c, h	
	<i>Lasius flavus</i>	(Fabricius, 1782)	a, b, e	
	<i>Lasius fuliginosus</i>	(Latreille, 1798)	e	
	<i>Lasius grandis</i>	Forel, 1909	a, b, c, e, f	
	<i>Lasius mixtus</i>	(Nylander, 1846)	a, b, c, e	
	<i>Lasius niger</i>	(Linnaeus, 1758)	i	
	<i>Lasius paralienus</i>	Seifert, 1992	d, e	
	<b><i>Lasius piliferus</i></b>	Seifert, 1992		
	<i>Lasius platythorax</i>	Seifert, 1991	e	
	<i>Plagiolepis pygmaea</i>	(Latreille, 1798)	c	
	<i>Plagiolepis xene</i>	Stärcke, 1936	c	
	MYRMICINAE	<b><i>Aphaenogaster gibbosa</i></b>	(Latreille, 1798)	
		<i>Aphaenogaster subterranea</i>	(Latreille, 1798)	c
		<i>Crematogaster scutellaris</i>	(Olivier, 1791)	c
<i>Leptothorax acervorum</i>		(Fabricius, 1793)	a, b, e	
<i>Leptothorax muscorum</i>		(Nylander, 1846)	a, b, e	
<i>Messor structor</i>		(Latreille, 1798)	c	
<i>Myrmecina graminicola</i>		(Latreille, 1802)	c	
<i>Myrmica lobulicornis</i>		Nylander, 1857	a, b, e	
<i>Myrmica rubra</i>		(Linnaeus, 1758)	a, b, e, j	
<i>Myrmica ruginodis</i>		Nylander, 1846	a, b, e, i	
<i>Myrmica sabuleti</i>		Meinert, 1861	a, b, e	
<i>Myrmica scabrinodis</i>		Nylander, 1846	a, b, e, l	
<i>Myrmica schencki</i>		Emery, 1895	a, b, e	
<i>Myrmica specioides</i>		Bondroit, 1918	a, b, c, e	
<i>Myrmica spinosior</i>		Santschi, 1931	c	
<i>Myrmica sulcinodis</i>		Nylander, 1846	a, b, e	
<i>Myrmica wesmaeli</i>		Bondroit, 1918	a, b, e	
<i>Pheidole pallidula</i>		(Nylander, 1849)	c	
<i>Pyramica tenuipilis</i>		(Emery, 1915)	c, h	
<i>Solenopsis</i> sp.		Westwood, 1840	c	
<i>Stenammina striatulum</i>		Emery, 1895	c, h	
<i>Strongylognathus testaceus</i>		(Schenck, 1852)	a, b, e	
<i>Temnothorax affinis</i>		(Mayr, 1855)	a, b, c, e	
<i>Temnothorax gredosi</i>		(Espadaler & Collingwood, 1982)	a, b, e	
<i>Temnothorax krausseii</i>		(Emery, 1916)	c, h	
<b><i>Temnothorax lichtensteini</i></b>		(Bondroit, 1918)		
<i>Temnothorax nadigi</i>		(Kutter, 1925)	e	

Subfamilies	Scientific valid name		References
	<i>Temnothorax niger</i>	(Forel, 1894)	
	<i>Temnothorax nigriceps</i>	(Mayr, 1855)	
	<i>Temnothorax nylanderi</i>	(Förster, 1850)	a, b, e
	<i>Temnothorax parvulus</i>	(Schenck, 1852)	e
	<i>Temnothorax rabaudi</i>	(Bondroit, 1918)	c
	<i>Temnothorax tuberosum</i>	(Fabricius, 1775)	a, b, e
	<i>Temnothorax unifasciatus</i>	(Latreille, 1798)	a, b, c, e
	<i>Tetramorium impurum</i>	(Förster, 1850)	a, b, c, e, h
	<i>Tetramorium pyrenaicum</i>	Rösler, 1936	m
	PONERINAE	<i>Hypoponera punctatissima</i>	(Roger, 1859)
<i>Ponera coarctata</i>		(Latreille, 1802)	c

## Discussion

With 75 species recorded, the ant fauna of Andorra can be considered as highly diverse, especially in view of the size of the country (Figure 1). The number of ant species collected represents more than one third of the number of species found in France (213 species, see Casevitz-Weulersse and Galkowski 2009) and about a quarter of the total number of species recorded in the Iberian Peninsula (299 species, Gómez 2012). When considered at the scale of the Pyrenees, Andorra contains about 88% of the ant species recorded in these mountains above an altitude of 1,000 m (about 85 species, Espadaler 1979, updated). Based on these results, we consider this first checklist as satisfactory. Nevertheless, we suspect that the total number of species could actually be somewhat higher for two reasons. First, we found very few parasitic species and one can imagine that they could probably be found with a higher sampling effort. And second, based on what is known from the ant fauna of France and Spain, some genera can be expected to be richer (e.g. *Temnothorax* Forel, 1890, *Camponotus* Mayr, 1861).

What could be the causes of the ant species richness observed in Andorra? Our data are interesting to compare with those obtained by Iserbyt et al. (2008) in a study of Pyrenean bumblebees in the Eyne valley, a small valley located in the eastern part of the Pyrenees. The number of species of bumblebees reported in this valley corresponds to 72% of the bumblebee species found in continental France. The authors explain this species richness by the high diversity of plants and habitat found in the Eyne valley. The same ecological factors probably contribute to the high ant biodiversity recorded for Andorra. In fact, with an altitudinal range of 2100 m condensed on a strong vertical gradient (Figure 1), Andorra presents a great diversity of microclimates and vegetation (e.g. sclerophyllous forest, mixed deciduous forests or mountain pine forests) that are potentially able to promote ant diversity. In addition to its relief, Andorra - because of its geographic situation on the south side of the Pyrenees - has a Mediterranean mountain climate (Degage and Duro i Arajol 1998). As a consequence, boreal ant species (e.g. *Camponotus herculeanus* (Linnaeus, 1758)) are listed jointly with species belonging to the Mediterranean fauna (e.g. *Camponotus cruentatus* (Latreille, 1802)). Such results have already been reported in other studies investigating the diversity of

other insect orders in Andorra, e.g. Heteroptera (Gessé et al. 1994) and Sphecidae (González et al. 2000). The fact that this region is influenced by both an Alpine and a Mediterranean climate gives an additional interest to the study of the natural heritage of Andorra and makes the Pyrenees an ideal natural laboratory to study the influence of ecological factors on arthropod species diversity.

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# ***Barucynips panamensis*, a new genus and species of oak gallwasps (Hymenoptera, Cynipidae, Cynipini) from Panama, and description of one new species of *Coffeikokkos***

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## **Abstract**

*Barucynips panamensis* Medianero & Nieves-Aldrey, a new genus and species of oak gallwasps (Hymenoptera: Cynipidae: Cynipini), is described from adults reared from galls on *Quercus bumelioides* in Panama. The new genus is taxonomically close to the recently described *Coffeikokkos* from Costa Rica, but differs from it and all of the described genera of Cynipini, by the shape and setation of the projecting part of the ventral spine of the hypopygium and by the sculpture of the propodeum. A new species of *Coffeikokkos* is also described from the same area, the Volcán Barú in Panama. Diagnostic characters, gall description, distribution, and biological data of the new genus and the two new species are given. The new genus is the first genus of oak gallwasps of the tribe Cynipini described in Panama.

## **Keywords**

Cynipidae, *Barucynips*, *Coffeikokkos*, oak gall wasps, *Quercus*, Chiriqui, Volcán Barú, Panama

## Introduction

Gall wasps (Hymenoptera, Cynipidae) are part of a quirky family inside Cynipoidea, with a majority of species being highly specialized phytophages that are able to induce complex galls on plants, although the family also contains representatives that inhabit the galls induced by other cynipids (Nieves-Aldrey 2001, Melika 2006, Liljeblad et al. 2011). The known biological diversity of the Cynipidae has recently been enlarged with the discovery that the family also includes parasitoids or lethal inquilines of gall-inducing chalcids of the family Pteromalidae on *Nothofagus* species (Nieves-Aldrey et al. 2009). The family Cynipidae is divided into eight tribes: Aylacini (157 species), Diplolepidini (58 species), Eschatocerini (3 species), Cynipini (936 species), Pediaspidini (2 species), Paraulacini (6 species), Synergini (176 species) and the recently described tribe Qwaqwaiini (1 species) (Liljeblad et al. 2011). The oak gall wasps (tribe Cynipini) is the most species-rich group of cynipid gall wasps, with the majority of its species distributed in the Holarctic region (Nieves-Aldrey 2001, Csóka et al. 2005, Liljeblad et al. 2008), although recent studies have also found a rich diversity of those insects in the Neotropical and Oriental regions (Medianero and Nieves-Aldrey 2011a, b, Tang et al. 2011).

Morphological analyses support the monophyly of the tribe Cynipini, grouping it together with the Diplolepidini, Eschatocerini and Pediaspidini into a large group of cynipid gall-inducers restricted to woody representatives of the eudicot subclass Rosidae (Kinsey 1920, Liljeblad and Ronquist 1998, Liljeblad et al. 2008). Recent molecular analyses, while confirming the monophyly of the Cynipini, failed to support the grouping with the above-mentioned tribes (Nylander 2004). Taxonomic and classificatory problems still exist in the study of the Cynipini, particularly with regard to a sound and consistent definition of the genera, especially from the rich Nearctic fauna and from the also rich, but poorly studied, neotropical and oriental faunas. The use of few and sometime inconsistent morphological characters for the separation of Cynipini genera, especially with reference to some Nearctic genera of that tribe, have often caused instability in the classification within this tribe. Morphological studies suggest that characteristics such as the shape of the ventral spine of the hypopygium and its pilosity, the shape and sculpturing of the mesosoma, the structure of the propodeum and the shape of the radial cell and Rs of the forewing can have significant potential for distinguishing genera or groups of genera (Melika and Abrahamson 2000). Other characteristics—such as the width of the head relative to the mesosoma, presence or absence of a malar sulcus, and presence, shape, depth and sculpture of scutellar foveae—are useful to complement the generic location of the species.

Recent studies have unveiled a rich diversity of Cynipidae in the high mountains of western Panama (see Medianero and Nieves-Aldrey 2011b for a synthesis). However, much of this fauna requires a more thorough taxonomic study. In line with this need, the objective of this work was to describe a new genus and species of Cynipini (Cynipidae) of the oak gall wasp fauna of Panama as well as a second species of the recently described genus *Coffeikokkos*. The new genus represents the first endemic genus of oak gall wasps in Panama.

## Materials and methods

**Study material.** The adults studied were reared from galls collected on *Quercus bumeioides* Liebm. Samplings were made and material was collected from December 2007 to August 2010 at Volcán Barú, Chiriqui Province, Panama. The adult insects emerged from the galls in rearing cages under laboratory conditions. Voucher specimens and their galls were deposited in the entomology collections of the Museo Nacional de Ciencias Naturales, Madrid (Spain) and Maestria en Entomología, Universidad de Panama (MEUP). The identification of the *Quercus* species was based on several key references (Burger 1977, D'Arcy 1987, Breedlove 2001) as well as on comparison with materials from the collection of the University of Panama and the Smithsonian Tropical Research Institute.

**Specimen preparation.** For observation under a scanning electron microscope (SEM), adult cynipids were dissected in 70% ethanol, air dried, mounted on a stub and coated with gold. Micrographs were taken with an FEI QUANTA 200 microscope (high vacuum technique) for several standardized views. Forewings were mounted in Euparal on slides and later examined under a Wild MZ8 stereo microscope. Images of adult habitus and gall dissections were taken with a NIKON Coolpix 4500 digital camera attached to a Wild MZ8 stereo microscope. Measurements were made with a calibrated micrometer scale attached to an ocular of the light microscope. The images will be deposited in the "morphbank.com" databank. Terminology of morphological structures and abbreviations follow Ronquist and Nordlander (1989), Ronquist (1995), Nieves-Aldrey (2001), and Liljeblad et al. (2008). For cuticular sculpture we follow Harris (1979). Measurements and abbreviations used include: POL (post-ocellar distance) is the distance between the inner margins of the posterior ocelli; OOL (ocellar-ocular distance) is the distance from the outer edge of a posterior ocellus to the inner margin of the compound eye.

## Results

### *Barucynips Medianero & Nieves-Aldrey, gen. n.*

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<http://species-id.net/wiki/Barucynips>

Figs 1, 2, 3, 5

**Type species.** *Barucynips panamensis* Medianero & Nieves-Aldrey, sp. n., by present designation and monotype.

**Etymology.** From Barú (the name of the volcano in Panama where the new genus was collected) and Cynips, referring to Cynips-groups, inside the tribe Cynipini.

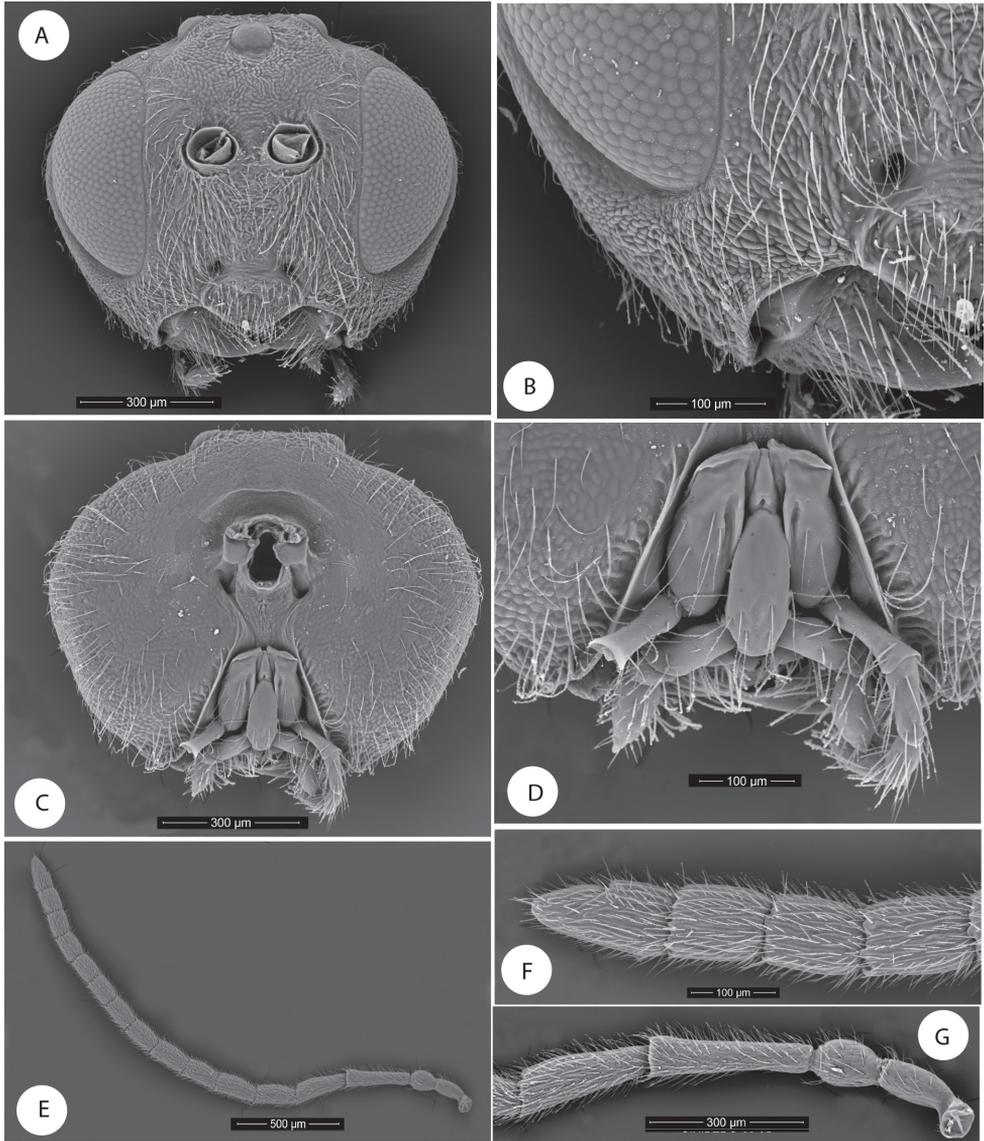
**Gender.** Masculine

**Diagnosis and identification.** By the 16 segmented antennae, head and mesosoma shape and sculpture, forewing venation and the association with *Quercus bumei-*

*lioides*, a tree common in the mountains of Central America, the new genus resembles the recently described genus *Coffeikokkos* Pujade-Villar & Melika, from Costa Rica. *Barucynips* differs, however, from that genus in some important characteristics which clearly separate the two genera. The main diagnostic characteristic that clearly allows the separation of *Barucynips* and *Coffeikokkos* is the shape of the hypopygial spine. The shape and setosity of the ventral spine of hypopygium of *Barucynips* is completely distinctive among all the exhibited by the described cynipids (Fig. 3). The projecting part of the hypopygial spine is lanceolate, pointed apically, and at least 4.0 times as long as broad, with a basal group of long setae, which reach the apex of the spine, forming a tuft, while *Coffeikokkos* present a projecting part of the hypopygial spine only 2.5 times as long as wide, uniformly broad, with parallel sides, rounded distally, with tuft of long supapical setae, reaching far beyond apex of spine. The new genus also differs from *Coffeikokkos* in the propodeal sculpture. The lateral carinae of the propodeum are subparallel in the anterior half and strongly divergent posteriorly in *Coffeikokkos*, without a median longitudinal carina, while the lateral propodeal carinae are much less strongly divergent posteriorly and a median longitudinal carina is present in *Barucynips*. Furthermore, the metatarsal claws of *Coffeikokkos* present a strong basal obtuse lobe, while the claws of *Barucynips* are toothed, with a small acute basal tooth. Other discriminant characteristics are as follows: the ventral margin of clypeus is strongly projected on mandibles (only slightly so in *Coffeikokkos*); the malar area has a strong alutaceous sculpture (Fig. 1B) and lacks irradiating striae from the clypeus (a few but clearly impressed striae are present in *Coffeikokkos*). The new genus is also taxonomically close to the genera of the *Cynips* group, *Cynips* Linnaeus (= *Antron* Kinsey, *Besbicus* Kinsey), *Atrusca* Kinsey, *Philonix* Fitch, *Acraspis* Mayr and *Biorhiza* Westwood (= *Sphaeroteris* Ashmead) but can easily be distinguished by the following character states: antenna with 16 antennomeres (Fig. 1E); projecting part of the ventral spine of the hypopygium is long, lanceolate, and at least 4.0 times as long as broad; from the point where the spine narrows, a dense group of long setae arises, which reach the apex of the spine, forming a tuft, (Fig. 3B–D); lateral propodeal carinae poorly defined, fragmented, widely divergent posteriorly, with a median propodeal area bare, and narrower anteriorly, and a fragmented median longitudinal carina present (Fig. 2E); lateral propodeal area densely pubescent and forewing hyaline.

Of the genera included into the *Cynips* group, the new genus resemble the genus *Atrusca*, primarily because of the long ventral spine of the hypopygium, but it differs in the position, direction and length of the setae on the spine, which are subapical, reaching beyond the apex of the spine. Additionally, the species of genus *Atrusca* possesses, on the forewing, dark spots or dark stripes along veins, the radial cell is 2.0 – 2.5 times as long as broad and the Rs is strongly angulate. More diagnostic characters are given in the generic key and the description below.

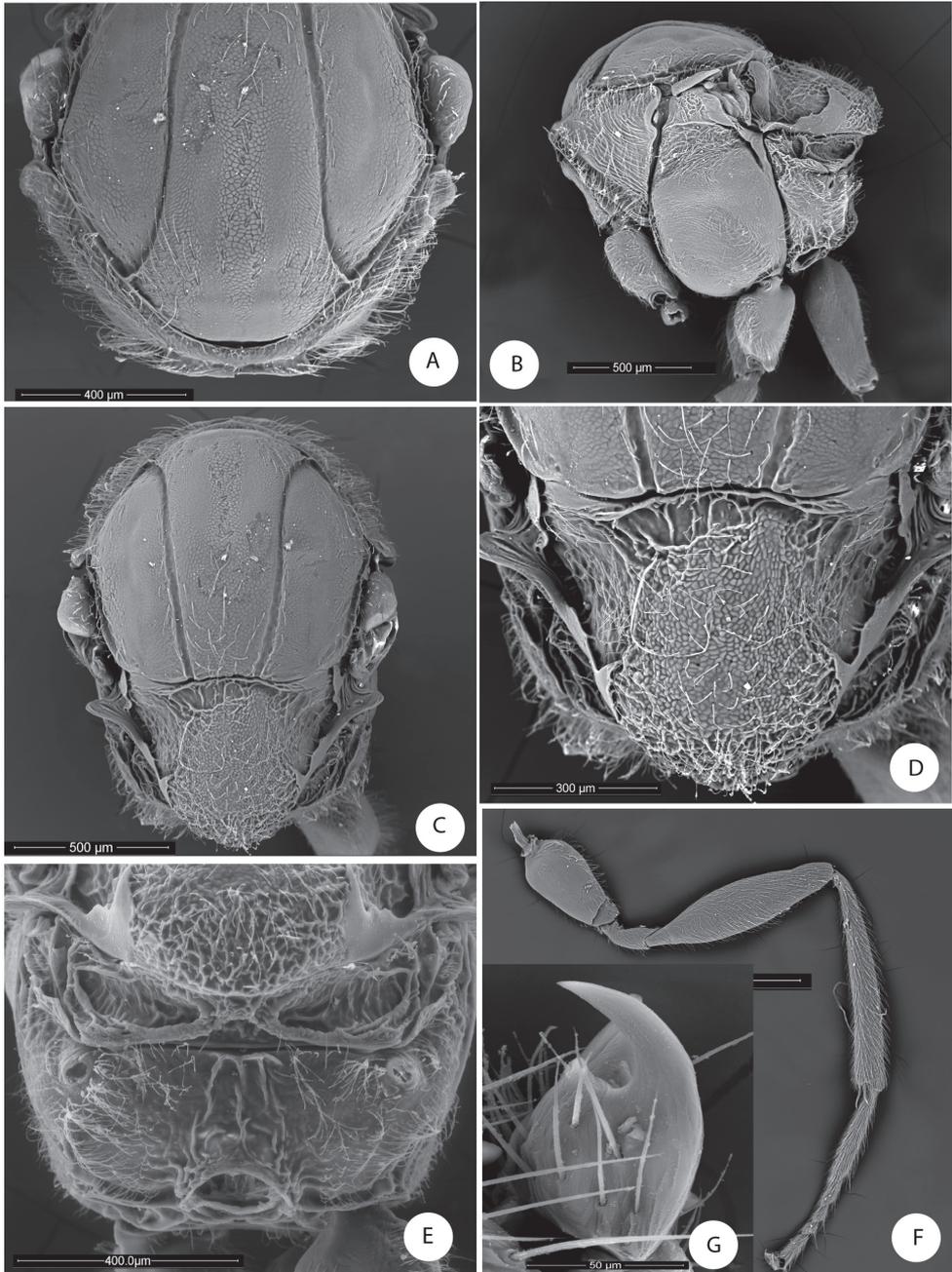
**Description.** Description of this genus is based in the asexual generation of the only known species. The eventual discovery of a sexual generation would imply the revision of the generic limits.



**Figure 1.** *Barucynips panamensis*: **A** Head anterior view **B** Detail of malar space **C** Head posterior view **D** Mouthparts **E** Female antenna **F** Detail of last flagellomeres **G** Detail of basal flagellomeres.

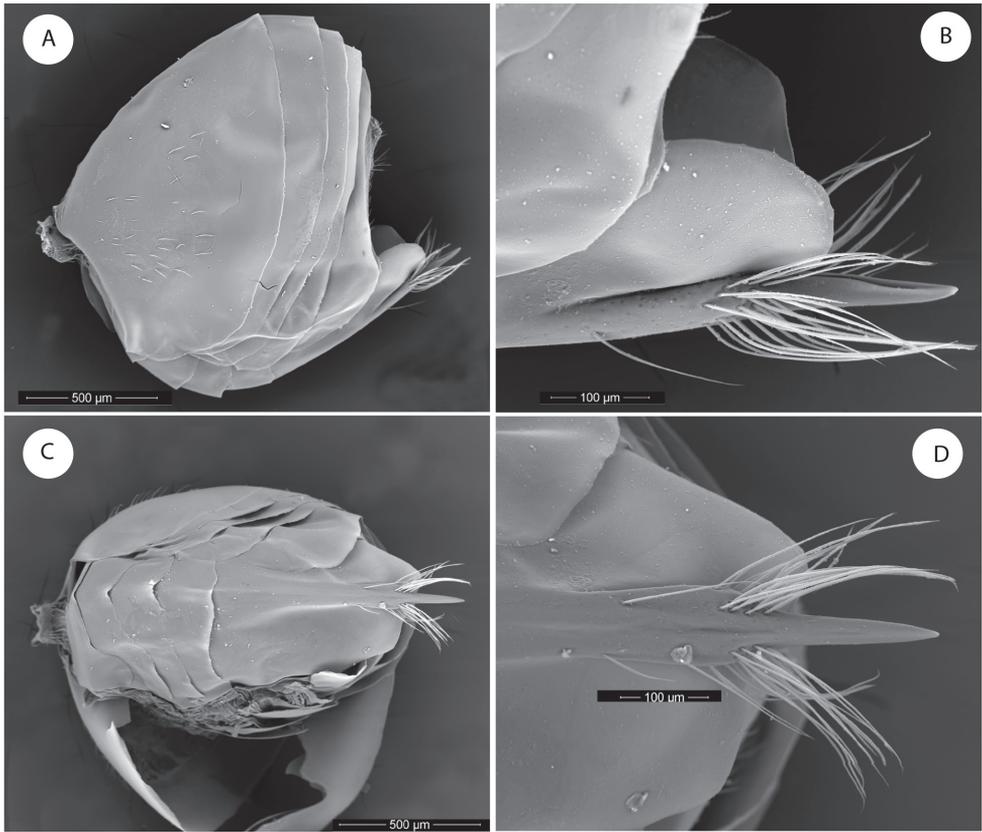
Asexual female densely pubescent. Head (Figs 1A–C), with genae slightly expanded behind eyes. Clypeus with ventral margin sinuate, moderately projecting over mandibles. Malar space without malar sulcus. Head, posterior view (Fig. 1C) without occipital carina. Gula short, distance between occipital and oral foramina as high as occipital foramen (Fig. 1C). Hypostomal sulci well separated at oral fossa.

Antenna (Fig. 1E–G) with 16 antennomeres; flagellum not broadening towards apex.



**Figure 2.** *Barucynips panamensis*: **A** Pronotum antero-dorsal view **B** Mesosoma lateral view **C** Mesosoma dorsal view **D** Scutellum **E** Propodeum **F** Hind leg **G** Metatarsal claw.

Mesosoma. Pronotum short medially, densely pubescent, lateral surface of pronotum with longitudinal wrinkles; pronotal plate indistinct dorsally (Fig. 2A). Mesoscutum alutaceus, barely pubescent with scattered setae anteriorly and posteriorly.



**Figure 3.** *Barucynips panamensis*: **A** Metasoma lateral view **B** Detail of ventral spine of hypopygium, lateral view **C** Metasoma ventral view **D** Detail of ventral spine of hypopygium.

Notauli percurrent, smooth, well impressed along entire length, reaching pronotum, separated posteriorly, with an indistinct median mesoscutal impression. Scutellar foveae not well differentiated, shallow, confluent medially, with some longitudinal striae and indistinct margins posteriorly.

Lateral propodeal carinae moderately divergent ventrally, the median propodeal area narrow, bare, with a median longitudinal carina present (Fig. 2E). Metatarsal claws with an acute basal lobe. Forewing (Fig. 5B) hyaline, without fuscate spots or stripes, radial cell open along anterior margin; areolet triangular, closed and distinct. Apical margin of wing with short hair fringe. Metasoma with second metasomal tergite covering about two thirds of metasoma, with a patch of setae laterally in its anteromedial area. Projecting part of hypopygial spine long, lance shaped, at least 4.0 times as long as broad, with dense, long basal setae that reach the apex of the spine and form a dense tuft (Fig. 3B–C).

**Distribution.** Based on our data, the new genus is found only to 2515–3045 m a.s.l. at Volcán Barú, Chiriquí, Panama, around the upper limit of the growth of *Quercus* species in Panama.

### Key for the identification of the genus *Barucynips* from related genera

- 1 Antennae with 16–17 segments. Projecting part of the ventral spine of hypopygium long or short. Forewings without dark spots or stripes along veins ..... **2**
- Antennae with 13–14 segments. Projecting part of the ventral spine of the hypopygium short, not more than 2 times as long as broad (Fig. 4A–E, 4G–H), if projecting part of the ventral spine of the hypopygium is long (Fig. 4F), then the forewing possesses dark spots and/or dark stripes along veins and the Rs is strongly angulate; setae on the spine are subapical, reaching beyond the apex of the spine ..... **genera *Cynips*, (= *Antron*, *Besbicus*), *Philonix*, *Acraspis*, *Biorhiza* (= *Sphaeroterax*), *Kinseyella* and *Atrusca***
- 2 Projecting part of hypopygial spine long, lanceolate, at least 4.0 times as long as broad, with dense long basal setae that reach the apex of the spine forming a tuft (Fig. 3B–C). Female antenna with 16 segments (Fig. 1E). Metatarsal claws toothed, with a small basal lobe or tooth, 1/3 as long as main tooth. Median propodeal carina present. Malar area without irradiating striae ..... ***Barucynips***
- Projecting part of the hypopygial spine short, at most 2.5 times as long as wide, uniformly broad, with tuft of long supapical setae reaching far beyond apex of spine. Female antenna with 17 segments. Metatarsal claws simple, with an obtuse rounded basal lobe. Median propodeal carina absent. Malar area with some irradiating striae ..... ***Coffeikokkos***

#### ***Barucynips panamensis* Medianero & Nieves-Aldrey, sp. n.**

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[http://species-id.net/wiki/Barucynips\\_panamensis](http://species-id.net/wiki/Barucynips_panamensis)

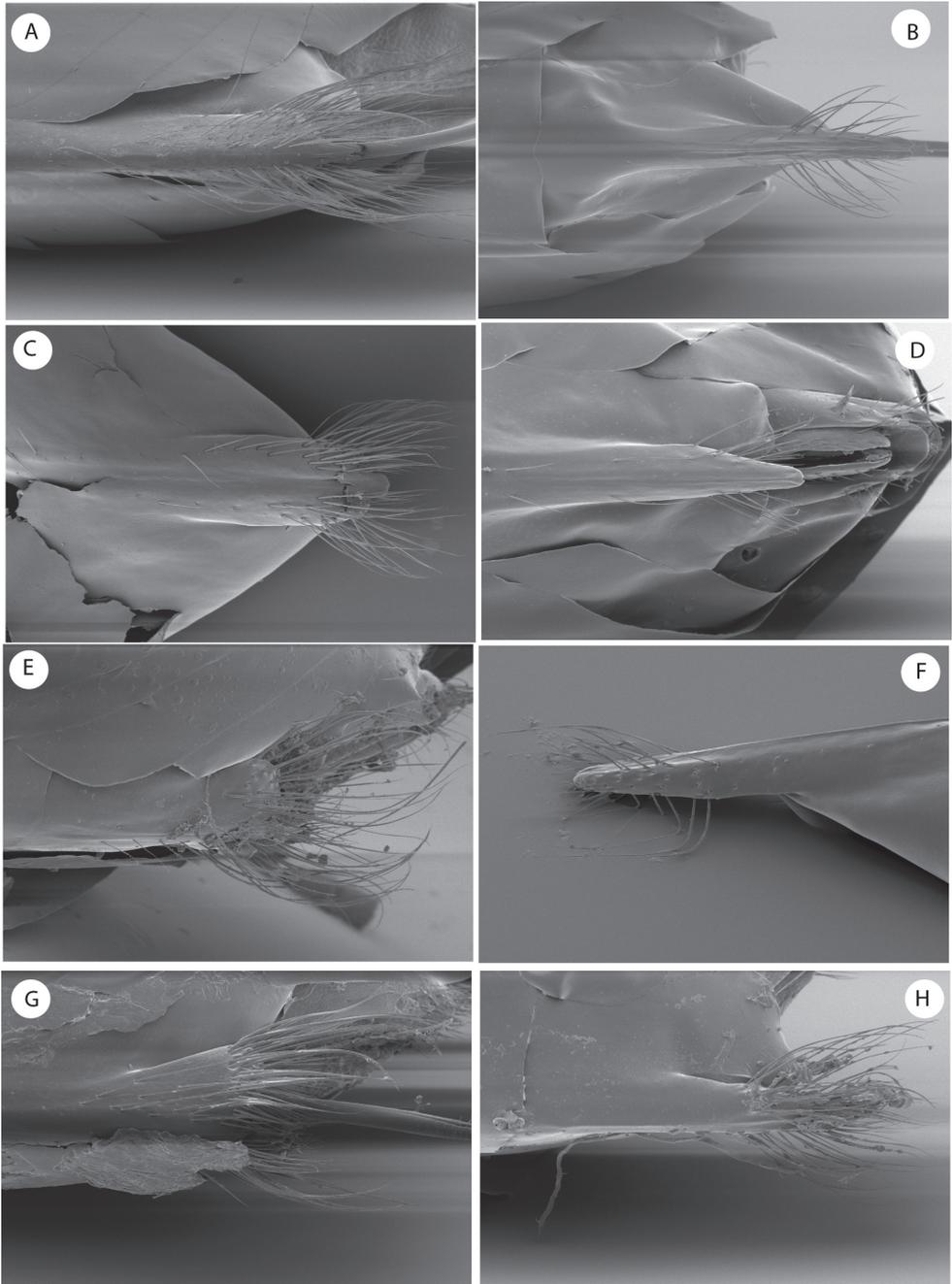
Figs 1, 2, 3, 5

**Type material.** Holotype ♀ (Fig. 5A) (in Museo Nacional de Ciencias Naturales, Madrid, Spain (MNCN), card-mounted. Cat. n° 2315). PANAMA, Chiriquí, Volcán Barú 8°46'36.8"N, 82°31'39.3"W, 2515–3045 m; from galls on leaves of *Quercus bumelioides* Liebm. (Fagaceae), gall collected 16.vi.2008, insect emerged vii.08, E. Medianero leg. Paratypes: 1♀ same data as holotype, 2♀ same data as holotype but collected 15.iii.2008, insect emerged iv.08, 1♀ same data as holotype but collected 24 i.2009, insect emerged ii.09. Three paratypes in MNCN, one paratype in Maestría en Entomología, Universidad de Panamá (MEUP).

Additionally, 1♀ paratype of the type series was dissected for SEM observation (in MNCN).

**Etymology.** Named after the country where the new species was collected.

**Description.** Asexual female. Body length 2.9 mm (range 2.59–3.42; N = 4). Head and mesosoma black. Metasoma, flagellomeres and tarsi brownish; hypopygium



**Figure 4.** Detail of ventral spine of hypopygium of females of species of the Cynips group: **A** *Cynips divisa*, asexual generation **B** *C. divisa*, sexual generation **C** *Acraspis erinacei*, asexual generation **D** *Acraspis erinacei*, sexual generation **E** *Cynips* = *Antron douglasi* **F** *Atrusca emergens* **G** *Philonix gigas* **H** *Biorhiza* = *Sphaeroteris mellea*. [after Liljeblad *et al.* 2008 <http://www.morphbank.net/>].

yellowish. Mandibles yellowish with black teeth. Antennal scape and pedicel yellowish in part. Half basal of coxae black; coxae apically, femora and tibiae ventrally yellowish. Forewing hyaline, slightly and uniformly darkened; veins dark brown.

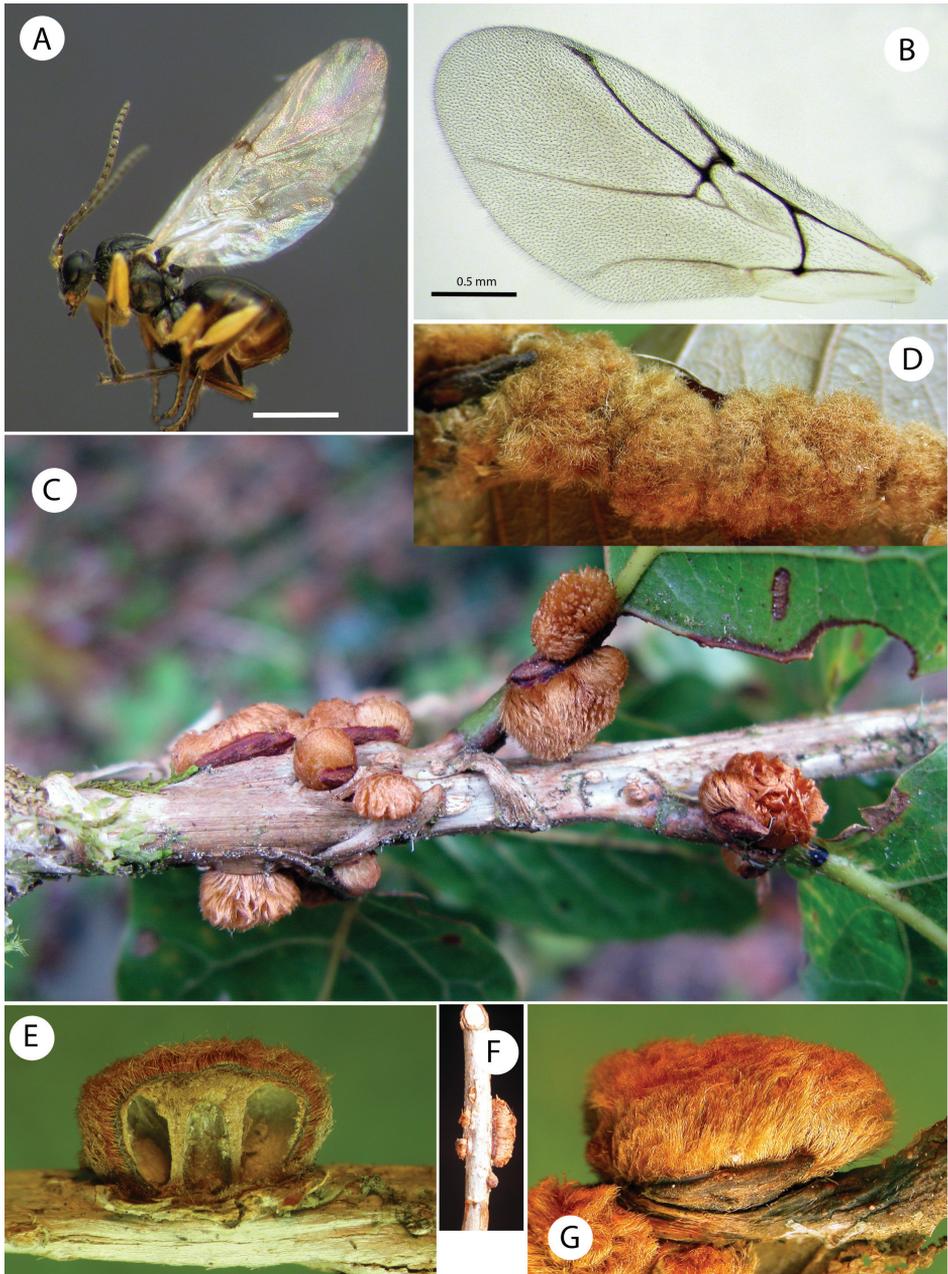
Head alutaceous-reticulate, moderately pubescent, with relatively long white setae, except on vertex, upper frons and gena, in dorsal view about 2.7 times wider than long. POL 1.8 times longer than OOL, posterior ocellus separated from inner orbit of eye by 2.0 times its longest diameter. Head in anterior view (Fig. 1A) 1.2 times wider than high. Genae slightly expanded behind eyes, strongly alutaceous-reticulate (Fig. 1B). Clypeus more or less trapezoidal, 1.7 times wider than high moderately pubescent, ventral margin sinuate, moderately projecting over mandibles. Anterior tentorial pits visible; epistomal sulcus not visible, clypeo-pleurostomal lines visible. Malar space 0.2 times height of compound eye, without malar sulcus strongly alutaceous-reticulate, without irradiating striae from clypeus (Fig. 1B). Toruli situated slightly above mid-height of compound eye; distance between antennal rim and compound eye 0.8 times width of antennal socket including rim. Ocellar plate slightly raised. Head, posterior view (Fig. 1C) without occipital carina. Gula short; distance between occipital and oral foramina as high as occipital foramen (Fig. 1C). Hypostomal sulci well separate at oral fossa.

Mouthparts (Figs 1D): mandibles exposed; with dense setae in base, right mandible with three teeth; left with two teeth. Cardo of maxilla visible, maxillary stipes long, about 2.3 times longer than wide. Maxillary palp five-segmented. Labial palp three-segmented, both moderately pubescent (Fig. 1D).

Antenna (Fig. 1E–G) of moderate length, as long as 1/2 body length, with 16 antennomeres; flagellum not broadening towards apex; with relatively long, erect setae, and visible elongate placodeal sensilla (Fig. 1F). Relative lengths of antennal segments: 19:12:32:25:20:21:17:18:16:15:13:12:13:12:11:16. Pedicel, globose, 0.6 as long as scape (Fig. 1G). F1 1.3 times as long as F2. F14 2.1 times longer than wide, 1.5 times as long as F13 (Fig. 1F). Placodeal sensillae on F2–F14 disposed in one row of 8–9 sensillae in half dorsal area of each flagellomere.

Mesosoma. Uniformly alutaceous, moderately pubescent, in lateral view 1.2 times as long as high, slightly convex dorsally (Fig. 2B). Pronotum, densely pubescent; lateral surface of pronotum with longitudinal wrinkles; with long and dense white setae (Fig. 2A–B). Pronotum short medially, ratio of length of pronotum medially/laterally = 0.2. Pronotal plate indistinct dorsally (Fig. 2A).

Mesonotum (Fig. 2C). Mesoscutum coriaceous-alutaceous, only slightly pubescent medially and along notauli, slightly broader than long in dorsal view. Notauli percurrent, smooth, well impressed along entire length, reaching pronotum, not quite convergent, well separated posteriorly, median mesoscutal impression not visible. Anteroadmedian and parapsidal signa visible. Transscutal fissure narrow, well-visible, deeply impressed, slightly sinuate. Scutellar foveae not well differentiated, shallow, confluent medially, with some longitudinal striae and indistinctly margined posteriorly. Mesoscutellum (Fig. 2D) rounded from above moderately pubescent, about 0.6 as long as mesoscutum, strongly alutaceous-reticulate, in lateral view extending posteriorly slightly



**Figure 5.** Habitus, forewings and galls of *Barucynips panamensis* **A** Habitus, female **B** Forewing of female **C–G** Mature galls **C** Galls on stems **D** Cluster of galls on midrib of leaves **E** Section of a gall showing larval cells **F** Galls on stems **G** Detail of a single gall.

over the dorsellum. Axillula slightly pubescent, their anterior margins marked and posterior indistinctly. Mesopleuron alutaceus, slightly pubescent with mesopleural triangle densely pubescent (Fig. 2B).

Metanotum (Fig. 2E). Metapectal-propodeal complex. Metapleural sulcus reaching posterior margin of mesopectus at about two thirds height (Fig. 2B). Lateral propodeal carinae poorly defined, fragmented, slightly divergent posteriorly and reaching nucha. Median propodeal area narrow, bare, with a median longitudinal carina fragmented but well visible (Fig. 2E); lateral propodeal area densely pubescent, with relatively long white setae, nucha rugose.

Legs (Fig. 2F). Densely pubescent, metatarsal claws with an acute basal lobe or short tooth (Fig. 2G).

Forewing (Fig. 5B) 1.2 times as long as body, without smoky spots or stripes and densely pubescent; basal cell pubescent; radial cell 4.2 times longer than wide, open along anterior margin; areolet large, triangular, closed. R1, Rs and M nearly straight not reaching wing margin. R1 forming a quite acute angle with anterior margin of wing; Rs+M not reaching basalis. Basalis slightly curved, 2r well pigmented. Apical margin of wing with moderately long hair fringe.

Metasoma (Fig. 3A) large, as long as head and mesosoma combined, in lateral view as wide as high. Second metasomal tergite covering about two thirds of metasoma, with a patch of setae in its lateral anteromedial area. Projecting part of hypopygial spine long, lanceolate, tapering from the base to apex, at least 4.0 times as long as broad, with dense long basal setae arising in the base of the projected part which reach the apex of the spine forming a tuft (Fig. 3B–C).

**Gall** (Fig. 5C–G). Irregular small formations (up to 4–9 mm) arising from crevices on the stems and on the petiole and midribs of leaves. The gall is displayed as a dense mass covered with light brown hairs, solitary, containing a single larval cell or more frequently forming clusters, and then appearing as polythalamous. Inside, the gall has a highly lignified core enclosing the larva (Fig. 5E).

**Host plant.** *Quercus bumelioides* Liebm. (section *Quercus* of *Quercus*; white oaks (Fagaceae), a species distributed from Mexico to Panama (Breedlove 2001). The gall resembles that of the species of the Nubila complex, established by Kinsey within the subgenus *Acraspis* of *Cynips* (Kinsey 1936), all known from Mexico. These galls were described as a mass of coarse hairs containing a spherical hard core, attached to mid-veins, on or under the surfaces of leaves. However, the insects are quite different in important characteristics such as the number of antennal segments and the shape of the hypopygial spine.

**Distribution.** *Barucynips panamensis* was found between 2515–3045 m a.s.l. at Volcán Barú, Chiriquí, Panama. Although currently known only at this locality, it is a species that is relatively abundant at the higher elevations of Volcán Barú.

**Biology.** Only the asexual generation is known, inducing galls on *Quercus bumelioides* Liebm (section *Quercus*). The galls are common and can be found at every time of year in different grades of maturation on stems and leaves. The galls frequently are found growing together with galls of the new species, also described in this paper, *Coffeikokkos korytkowskii*. The insects studied emerged from January to July.

**Inquiline and parasitoid associated community.** From the gall of *Barucynips panamensis*, two species of inquilines were reared, *Synergus elegans* Nieves-Aldrey & Medianero, and one indeterminate species similar to *S. luteus* Nieves-Aldrey & Medi-

anero or *S. gabrieli* Nieves-Aldrey & Medianero (Nieves-Aldrey and Medianero 2011). Additionally, the parasitoid species *Ormyrus venustus* Hanson 1992 (Chalcidoidea, Ormyridae) was also reared.

***Coffeikokkos korytkowskii* Medianero & Nieves-Aldrey, sp. n.**

urn:lsid:zoobank.org:act:D8B6DD27-E6CB-44A4-9598-BBCD51D7E3F5

http://species-id.net/wiki/Coffeikokkos\_korytkowskii

Figs 6–8

**Type material.** Holotype ♀ (Fig. 8A) (in Museo Nacional de Ciencias Naturales, Madrid, Spain (MNCN), card-mounted. Cat. n° 2316). PANAMA, Chiriquí, Volcán Barú 8°46'36.8"N, 82°31'39.3"W, 3079 m; ex gall on stems of *Quercus bumelioides* Liebm. (Fagaceae), gall collected 23.x.2008, insect emerged xi.08, E. Medianero leg. Paratypes: 12♀ same data as holotype. Seven paratypes in MNCN, five paratypes in Maestría en Entomología, Universidad de Panamá (MEUP).

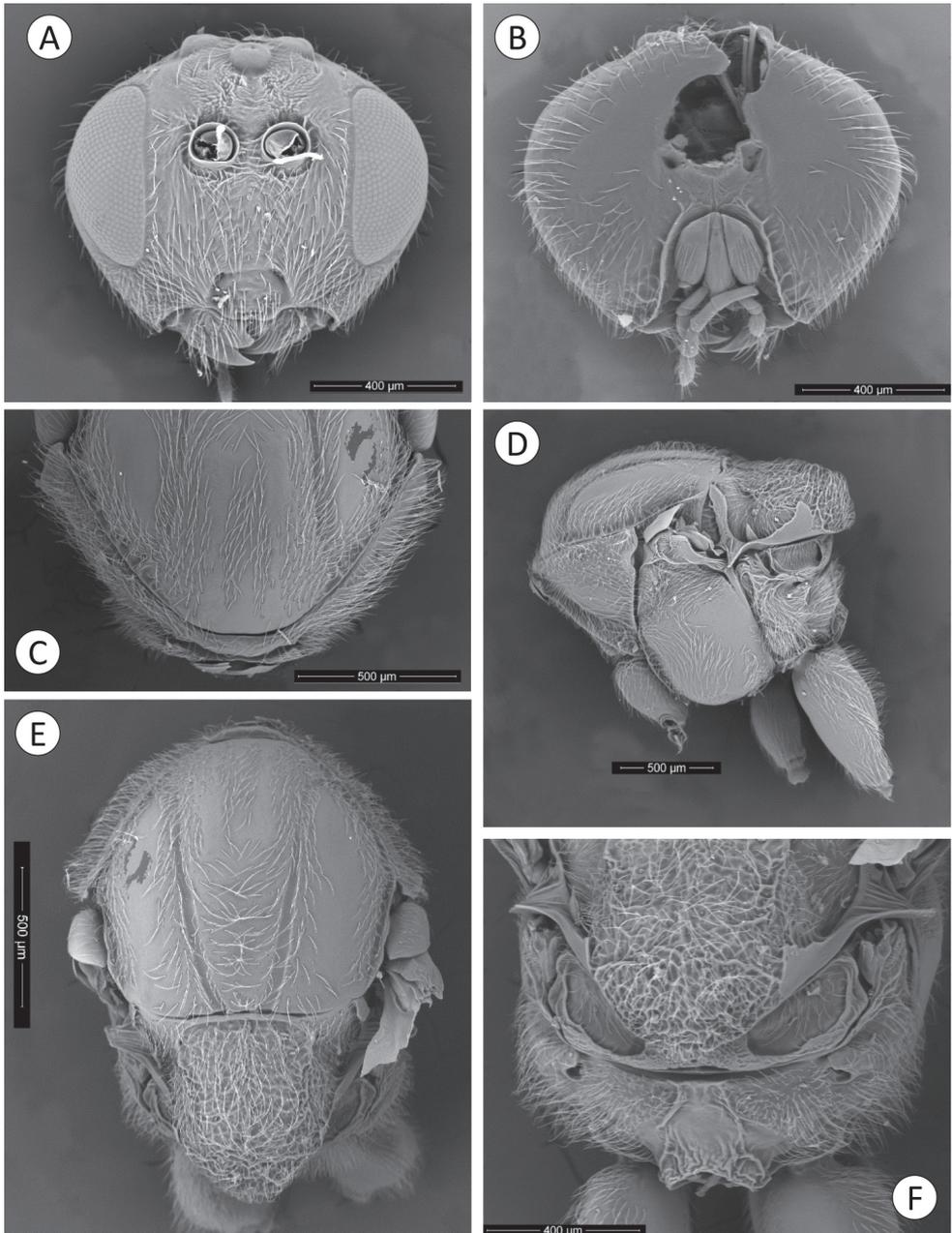
Additionally, 1♀ paratype of the type series was dissected for SEM observation (in MNCN).

**Etymology.** Named after Dr. Cheslavo A. Korytkowski for his contribution to the development of entomology in Panama.

**Diagnosis and comments.** The new species represents the second species of the genus *Coffeikokkos*, which was recently described in Costa Rica. The species is closely related to *C. copeyensis* Pujade-Villar & Melika, 2012, being similar in color and a majority of morphological characteristics. The species differ in the pubescence of mesosoma, the shape of the mesoscutellum, propodeal sculpture and gall shape. *C. korytkowskii* has a moderately pubescent mesosoma with piliferous punctures, whereas the mesosoma is smooth in *C. copeyensis*. The new species has a more elongate mesoscutellum, clearly longer than is wide, and the propodeal carinae are complete, reaching the nucha, whereas in *C. copeyensis*, the mesoscutellum is as long as is wide or only slightly longer than wide, and the propodeal carinae is incomplete, not reaching the nucha. Additionally, the basal cell of the forewing in the new species is hairy, whereas the basal cell of *C. copeyensis* is bare. The new species induces a regular spherical gall (5 mm diameter) with a spotty surface, while the galls induced by *C. copeyensis* are similar in size, but irregular or slightly ovate and uniformly colored.

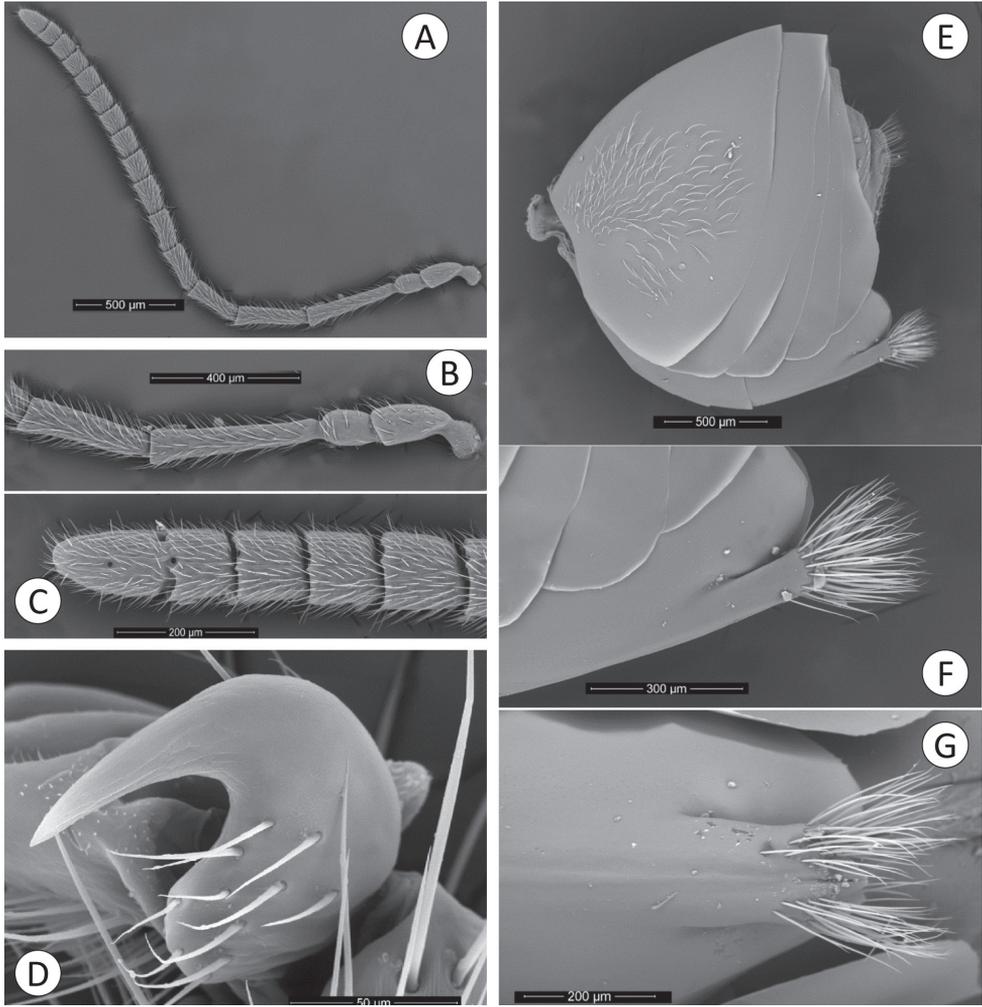
**Description.** Body length 3.62 mm (range 3.3–4.2; N = 5) for females. Body uniformly reddish brown and shiny; the toruli area, flagellomeres of antenna, area above clypeus, occiput, dorsolateral margin of pronotum, anteroadmedian signa area, parapsidal signa, mesopleuron, metapectal-propodeal complex and anteromedial area of scutellum dark brown to black. Legs with all coxae and femora yellowish; tibia and tarsomeres dark brown to black. Forewing hyaline with some very light infumation; veins dark brown to black.

*Asexual female.* Head moderately pubescent with piliferous punctures, in dorsal view about 3.5 times wider than long. POL 1.5 as long as OOL, posterior ocel-



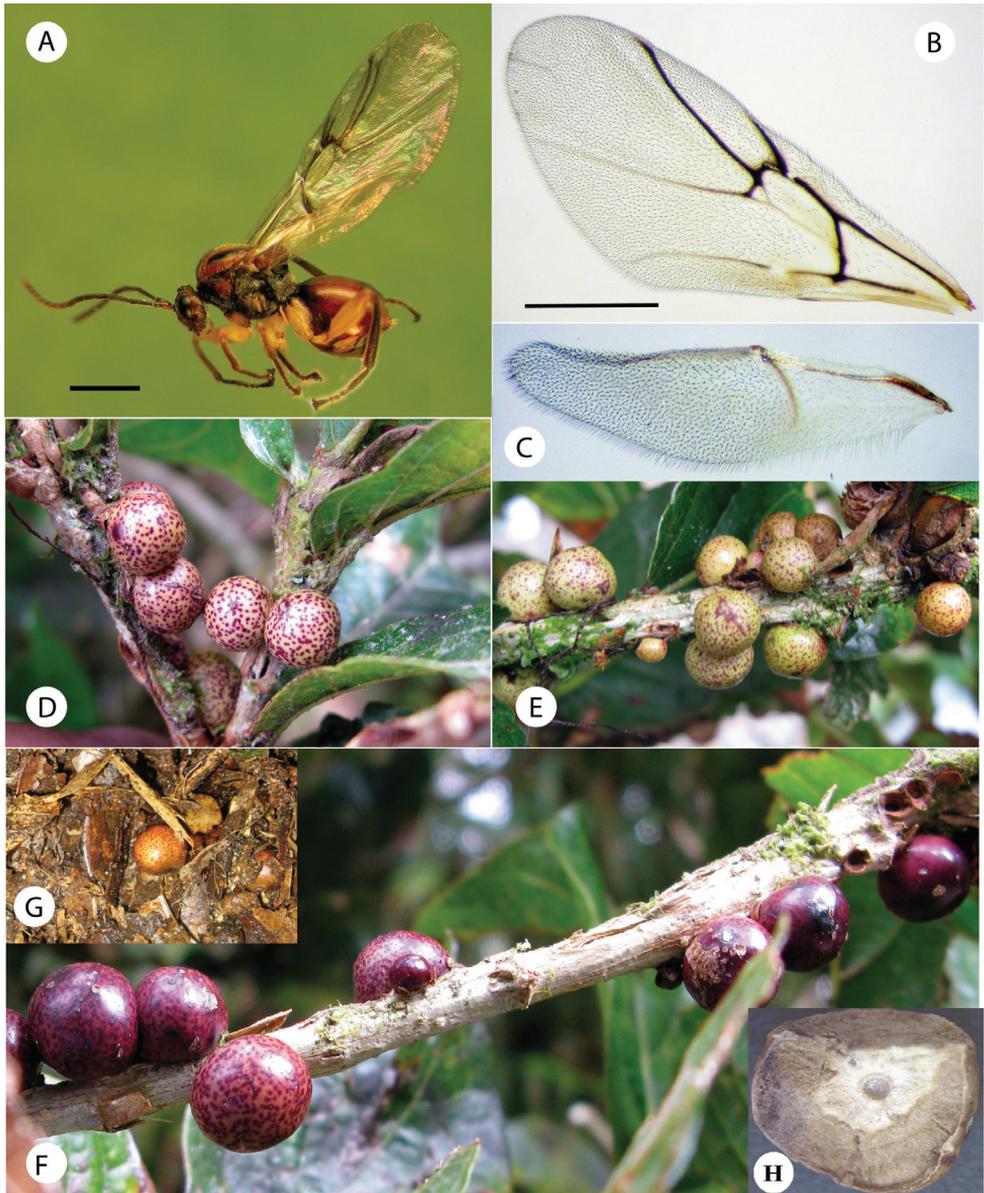
**Figure 6.** *Coffeikokkos korytkowskii*: **A** Head anterior view **B** Head posterior view **C** Pronotum antero-dorsal view **D** Mesosoma lateral view **E** Mesosoma dorsal view **F** Propodeum.

lus separated from inner orbit of eye by 1.7 times its longest diameter. Head in anterior view (Fig. 6A) transversely ovate, 1.15 times wider than high, gena not expanded behind eyes. Vertex frons and gena slightly alutaceous. Head moderately



**Figure 7.** *Coffeikokkos korytkowskii*: **A** Female antenna **B** Detail of basal flagellomeres **C** Detail of last flagellomeres **D** Metatarsal claw **E** Metasoma lateral view **F** Detail of ventral spine of hypopygium, lateral view **G** Detail of ventral spine of hypopygium.

pubescent, with relatively long white setae, except vertex, frons with sparse, shorter setae. Clypeus more or less trapezoidal, 1.6 times wider than high, mostly smooth and moderately pubescent; ventral margin sinuate, slightly projecting over mandibles. Anterior tentorial pits visible; epistomal sulcus indicated, clypeo-pleurostomal lines visible. Malar space 0.3 times height of compound eye, without malar sulcus; some irradiating striae from clypeus present, reaching ventral margin of compound eye, absent medially above clypeus. Toruli situated slightly above mid-height of compound eye; distance between antennal rim and compound eye 1.1 times width of antennal socket including rim. Ocellar plate not raised. Head, posterior view (Fig. 6B) without occipital carina. Gula short; distance between occipital and oral



**Figure 8.** *Coffeikokkos korytkowskii*: **A** Habitus, female **B** Fore wing **C** Hind wing **D–F** Galls **G** A gall on the ground **H** Section of a gall showing larval cells.

foramina 0.5 times height of occipital foramen (Fig. 6B). Hypostomal sulci well separate at oral fossa.

Mouthparts (Figs 6A–B): mandibles exposed, with dense setae in base, right mandible with three teeth, left with two teeth. Cardo of maxilla not visible, maxillary stipes about 2.3 times longer than wide. Maxillary palp five-segmented. Labial palp three-segmented.

Antenna (Fig. 7A-C) of moderate length, as long as 1/2 body length, with 15 flagellomeres, but F15 only partially separated from F14 dorsally (Fig. 7C); flagellum not broadening towards apex; with relatively long, erect setae, and elongate placodeal sensilla well visible (Fig. 7C). Relative lengths of antennal segments: 16:12:43:32:24:20:19:17:13:12:11:11:10:9:9:8:14. Pedicel sub-globose, 0.8 as long as scape; F1-F9, gradually decreasing in length. F1 1.34 times as long as F2. F10-F13 short and wide, F15 1.8 times longer than wide, 1.7 as long as F14 (Fig. 7C). Placodeal sensillae on F4-F15 disposed in one row of 5–6 sensillae in half dorsal area of each flagellomere.

Mesosoma. Smooth, moderately pubescent with piliferous punctures, in lateral view 1.3 times as long as high, slightly convex dorsally. Pronotum, moderately pubescent; lateral surface of pronotum with some longitudinal wrinkles dorsally; with long and dense setae (Fig. 6D). Pronotum short medially, ratio of length of pronotum medially/laterally = 0.16. Pronotal plate indistinct dorsally (Fig. 6C).

Mesonotum (Fig. 6E). Mesoscutum smooth, moderately pubescent with piliferous punctures medially and along notauli; slightly broader than long in dorsal view. Notauli complete, smooth, broad, deep and convergent posteriorly, without median mesoscutal impression, anteroadmedian signa and parapsidal signa indistinct. Transscutal fissure narrow, clearly visible, deeply impressed, and slightly sinuate. Scutellar foveae shallow, confluent, indistinctly margined posteriorly and rugose. Mesoscutellum (Fig. 6E), about 0.7 times length of mesoscutum, 1.2 times as long as wide, strongly reticulate-rugose and moderately pubescent, in lateral view extended posteriorly over dorsellum. Axillula moderately pubescent, their anterior margins marked and posterior margins indistinct. Mesopleuron smooth, moderately pubescent except in speculum (Fig. 6D).

Metanotum (Fig. 6F). Metapectal-propodeal complex. Metapleural sulcus reaching posterior margin of mesopectus at about mid-height of metapectal-propodeal complex (Fig. 6D). Lateral propodeal carinae moderately divergent posteriorly, reaching the nucha; median propodeal area longer than broad, smooth, with some setae anteriorly; lateral propodeal area densely pubescent (Fig. 6F). Nucha rugose.

Legs. Densely pubescent; metatarsal claws with a large obtuse basal lobe (Fig. 7D).

Forewing (Fig. 8B) slightly longer than body, strongly pubescent; basal cell with some rows of setae; radial cell 4.0 times longer than wide; open along anterior margin; areolet triangular, closed and distinct. R1 and Rs nearly straight, not quite reaching wing margin; R1 forming an acute angle with anterior margin of wing. Rs+M reaching basalis at its mid-height. 2r well pigmented, angulate and slightly projected medially. Apical margin of wing with moderately long hair fringe.

Metasoma (Fig. 7E) large, as long as head and mesosoma combined, in lateral view as wide as high. Second metasomal tergite covering about 2/3 of metasoma, with a patch of dense setae in its anteromedial area. Projecting part of hypopygial spine short (Fig. 7F–G), shorter than basal height of spine (Fig. 7F); with parallel sides and pointed apically, with dense long subapical setae forming a patch, extending far beyond apex of spine.

**Gall** (Fig. 8D–H). Similar in location, shape, and size to the galls of *C. copeyensis* Pujade-Villar & Melika. However, the galls of this new species are much more regu-

larly spherical and its surface is not uniformly colored, but spotty. Diameter of gall measures 5 to 8 mm. They are formed, solitary or more frequently in groups, in stems of *Quercus bumelioides* Liebm. The surface of the gall is smooth and shiny; whitish, green or yellowish when fresh with red spots, becoming brown when mature. Monothalamic, with compact woody tissue internally containing the single larval cell (Fig. 8H). Similar spherical and spotty galls are also induced by the Nearctic *Cynips* (= *Besbicus*) *mirabilis* (Kinsey 1922), but this galls are larger, pubescent, formed in leaves and with an internal structure of irradiant filaments (Kinsey 1930).

**Distribution.** *Coffeikokkos korytkowskii* was found between 2515–3045 m a.s.l. at Volcán Barú, Chiriquí, Panama.

**Biology.** Only the asexual generation is known, inducing galls on *Quercus bumelioides* Liebm. (section *Quercus*). The galls are common and can be found at every time of year in different grades of maturation on stems. They often develop jointly with the galls of *Barucynips panamensis*, also described here. When the gall is mature, it falls to the ground (Fig. 8G), from which the adult emerges after a couple of months. The studied insects emerged in November.

### Key for the identification of species of genus *Coffeikokkos*

- 1 Temples only slightly expanded behind eyes. Mesosoma conspicuously pubescent; mesoscutum medially setose with piliferous punctures. Mesoscutellum elongate, longer than wide. Propodeal carinae moderately divergent posteriorly, complete, reaching the nucha. Basal cell of forewing with some setae. Areolet small, measuring less than 1/3 length of Rs+M. Gall regularly spherical, with colored spotty surface..... *C. korytkowskii*
- Temples more clearly expanded behind eyes, being visible in anterior view of head. Mesosoma slightly pubescent; mesoscutum medially smooth, shiny, with only sparse setae laterally and along notauli. Mesoscutellum as long as wide. Propodeal carinae strongly divergent posteriorly, incomplete not reaching the nucha. Basal cell of forewing almost bare. Areolet large, measuring about 1/2 of length of Rs+M. Galls irregular, with uniform red colour, without colored spots..... *C. copeyensis*

### Discussion

The majority of the morphological characters of *Coffeikokkos* and the new proposed genus *Barucynips* indicate their close affinity with the “*Cynips* group” of genera (Kinsey 1930, 1936, Liljeblad et al. 2008). Their association only with *Quercus bumelioides*, a species of “white oaks” (*Quercus* section *Quercus*), reinforce the morphological evidence. The genera of the *Cynips* group, which is represented primarily in the Nearctic Region, have had an unstable taxonomic status. Kinsey (1930, 1936), in his revision of the genus *Cynips*, divided it into six subgenera: *Cynips* (European species) *Antron*,

*Besbicus*, *Atrusca*, *Philonix*, and *Acraspis* (American species). Under the “mellea” species complex in the *Acraspis* subgenus, he included also all known *Sphaeroterus* species (Melika and Abrahamson 2002). Weld (1952) gave the status of genus to all subgenera of Kinsey, but Melika and Abrahamson (2002) consider *Antron* and *Besbicus* synonyms of *Cynips*, and *Sphaeroterus* a synonym of *Biorhiza*. Liljeblad et al. (2008) in one analysis of 308 characters, 283 from morphology and 25 from biology and distribution, suggested that these last synonymizations were unfortunate, as they showed the close and unresolved phylogenetic relationships between the taxa forming the *Cynips* group, including the *Trigonaspis*, *Belocnonema* and *Biorhiza* species. However, because of the relatively poor taxon sampling in their analysis and the lack of convincing support values for the clades within the *Cynips* group, they refrained from proposing formal taxonomic changes in *Cynips* group. Pujade-Villar et al. (2010) described one new genus from Mexico (*Kinseyella*) related to *Cynips* group and suggested that the nearctic genera *Antron* and *Besbicus* were erroneously synonymized to *Cynips* by Melika and Abrahamson (2002).

Despite the unstable taxonomic status of this group of genera and the clear need for a complete revision, mainly in the Nearctic fauna, the new genus proposed herein, as with the recently described *Coffeikokkos*, present clearly distinctive morphological characters that justify its establishment. Both genera are closely related and share a unique synapomorphy within the Cynipini, namely, the antenna with 14–15 flagellomeres. However, *Barucynips* is well distinguished from *Coffeikokkos* and from all known Cynipini genera by one distinctive morphological character, the shape and pubescence of the projecting part of the ventral spine of the hypopygium. Furthermore, a combination of other morphological character, such as the presence of a median propodeal carina and a weakly toothed metatarsal claw lend further support to the status of this proposed new genus. In Panama, we have found more species clearly included in the *Cynips* group of taxa but that are doubtfully assigned to any described genus. Future studies should clarify whether these species should be attributed to the genus *Cynips* (*sensu lato*) or to one or more new genera. These facts clearly show the taxonomic complexity of this fauna and note the necessity of more complete revisional studies.

The southern boundaries of distribution of the oak gall wasps in America (the Cynipidae associated with Fagaceae) are revealing an unexpectedly great taxonomic richness and phylogenetic diversity. As evidenced by gall diversity in Panama alone, we have demonstrated that a rich fauna of 45–65 species of Cynipidae do exist in this country, contrasting with the single species previously recorded (Nieves-Aldrey and Medianero 2011, Medianero and Nieves-Aldrey 2011b). Furthermore, many genera previously known only in the Nearctic region, such as *Amphibolips*, *Disholcaspis*, *Odontocynips*, *Bassetia*, and *Loxaulus*, have been found in recent years in the Neotropical region from Costa Rica to Colombia (Medianero and Nieves-Aldrey 2010a, 2010b, 2011a, 2011b, Medianero et al. 2011a, 2011b), while representatives of undescribed species related to *Neuroterus*, *Dryocosmus*, *Cynips*, *Trigonaspis* and *Callirhytis* have also been found but have been not yet published (Medianero and Nieves-Aldrey unpub.). More interesting is the discovery of new genera such as *Agastoroxenia* (Nieves-Aldrey

and Medianero 2010) from Panama, *Coffeikokkos* (Pujade-Villar et al. 2012a) and *Zapatella* (Pujade et al. 2012b) from Costa Rica and Colombia, and the new genus *Barucynips* from Panama described here, demonstrating that the phylogenetic diversity is high in this region. All of these data support Kinsey's (1936) hypothesis, which postulated America as the center of origin and radiation of the Cynipini, and challenges the more recent hypothesis that postulates that gall wasp lineages diverged in Asia (Stone et al. 2008). New data collected in the Eastern Palearctic and oriental biogeographic region, as well as ongoing phylogenetic and biogeographical studies, will shed more light on this problem. Current data on the richness and diversity of oak gall wasps in the Neotropic clearly indicate that this fauna reflects the result of the population dynamics along Pleistocene glaciations (circa 2.0 million to 12,000 years before present), with the high peaks of Neotropical mountains playing the role of postglacial refugees for the gall wasp fauna and their host plants.

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# On the *Lathrobium* fauna of the Emei Shan, Sichuan, China (Coleoptera, Staphylinidae, Paederinae)

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## Abstract

Six species of *Lathrobium* Gravenhorst, 1802 from the Emei Shan, Sichuan, are described and illustrated: *L. iunctum* Assing & Peng **sp. n.**, *L. coniunctum* Assing & Peng **sp. n.**, *L. conexum* Assing & Peng **sp. n.**, *L. ensigerum* Assing & Peng **sp. n.**, *L. hastatum* Assing & Peng **sp. n.**, and *L. bisinuatum* Assing & Peng **sp. n.** Based on their primary and secondary sexual characters, they represent two distinct lineages, each of them comprising three species. A key to the species recorded from the Emei Shan is provided.

## Keywords

Coleoptera, Staphylinidae, taxonomy, *Lathrobium*, new species, description, key to species, species groups, endemism, Emei Shan, Sichuan, China

## Introduction

According to a recent checklist, 90 species of the speciose paederine genus *Lathrobium* Gravenhorst, 1802 have been recorded from mainland China (Assing in press). With few exceptions, they are micropterous, endemic to particular mountains or mountain

ranges, and inhabit the leaf litter layer of intermediate to high-altitude forest or shrub habitats. Nine species have been reported from Sichuan, one from the Gongga Shan, two from the Labahe Natural Reserve, one from the Daxue Shan, four from the environs of Songpan in northern Sichuan (Min Shan and adjacent mountains), and one from the border region with Shaanxi (Micang Shan) (Assing in press; Peng et al. 2012; Schülke 2002). Not a single species was previously known from the Emei Shan. The geographically closest localities from where *Lathrobium* species were described are the Gongga Shan (approximately 140 km) and the Labahe Natural Reserve (approximately 120 km).

Covering an area of 154 km<sup>2</sup>, the Emei Shan, one of the four sacred Buddhist mountains of China, is situated at the western rim of the Sichuan Basin and forms the southernmost part of the Qionglai range (Fig. 1), without being separated from adjacent mountains of this range by deep valleys. Geologically, the higher parts of the Emei Shan are dominated by igneous rock (basalt). The highest peak is the Wanfoding at 3,099 m. Below 1,800 m, the Emei Shan is subject to subtropical climate, at 1,800–2,200 m the climate is warm temperate, at 2,200–2,600 m it is medium temperate, and above 2,600 m it is cool temperate (Liu 1992). According to Li (1984) four vertical zones of forest vegetation can be distinguished: an evergreen broad-leaved forest zone at elevations below 1,900 m, a mixed evergreen and deciduous forest zone



**Figure 1.** Geographic position of the Emei Shan in China.

at 1,500–2,000 m, a mixed broad-leaved and coniferous forest zone at 2,000–2,500 m, and a cold-temperate coniferous forest zone at altitudes above 2,500 m. The Emei Shan is known to host numerous endemic plants and animals, among them at least three species of Paederinae, one of them in the genus *Nazeris* Fauvel, 1873 and two in *Rugilus* Leach, 1819 (Assing 2012a–b; Zheng 1992). One species of *Lobrathium* Mulsant & Rey, 1878 was described from the Emei Shan, too, but as the description is based on a single female, the species and its distribution are of doubtful status (Assing 2012c; Zheng 1988).

A study of recently collected *Lathrobium* material from the Emei Shan revealed a remarkable diversity. As many as six undescribed species were recognized; they represent the first records of the genus from this mountain.

## Material and methods

The material treated in this paper is deposited in the following public and private collections:

- CAS** Chinese Academy of Sciences, Beijing  
**SNUC** Insect Collection of Shanghai Normal University, Shanghai  
**cAss** private collection Volker Assing, Hannover  
**cSme** private collection Aleš Smetana, Ottawa

The morphological studies were conducted using Stemi SV 11 (Zeiss Germany) and Olympus CX31 microscopes, and a Jenalab compound microscope (Carl Zeiss Jena). The images were prepared using Nikon Coolpix 995, Canon EOS 40D (with an MP-E 65 macrolens), and Canon G9 cameras. The map was created using MapCreator 2.0 (primap) software.

Body length was measured from the anterior margin of the mandibles (in resting position) to the abdominal apex, the length of the forebody from the anterior margin of the mandibles to the posterior margin of the elytra, head length from the anterior margin of the frons to the posterior margin of the head, elytral length at the suture from the apex of the scutellum to the posterior margin of the elytra, and the length of the aedeagus from the apex of the ventral process to the base of the aedeagal capsule. The “parameral” side (i.e., the side where the sperm duct enters) is referred to as the ventral, the opposite side as the dorsal aspect.

The labels are cited in the original spelling; different labels are separated by slashes.

## Results

Six new species are reported from the Emei Shan. All of them are micropterous (hind wings completely reduced) and most likely endemic to this mountain range.

## Species groups

The *Lathrobium* species of the Emei Shan undoubtedly belong to two distinct lineages, both of which are represented by three species.

One lineage is represented by the *L. iunctum* group and includes *L. iunctum*, *L. coniunctum*, and *L. conexum*. It is constituted by two evident synapomorphies, a male sternite VII with an obliquely asymmetric impression with numerous strongly modified short and stout black setae, as well as the asymmetric and fused ventral process and dorsal plate of the aedeagus. In addition, this group is characterized by dark coloration, moderately large size, a broad head (at least as long as broad), a broad pronotum (approximately 1.2 times as long as broad), the absence of a noticeable sexual dimorphism of the protarsomeres I–IV, a small basal portion of the aedeagus, a relatively short and posteriorly only weakly produced female sternite VIII, an anteriorly undivided and short median portion of the female tergite IX, and the long postero-lateral processes of the female tergite IX. This species group also includes *L. acutissimum* Peng et al., 2012 from the Labahe Natural Reserve in Sichuan and an undescribed species from the Qincheng Shan. For illustrations of *L. acutissimum* see Peng et al. (2012).

The second lineage is represented by the *L. ensigerum* group and comprises *L. ensigerum*, *L. hastatum*, and *L. bisinuatum*. This group is constituted particularly by the presence of a more or less distinctly sclerotized apical internal sclerite and by the shape of the dorsal plate of the aedeagus (apical portion strongly developed, distinctly sclerotized and long; basal portion reduced, very short). Additional characters characterizing this group are the oblong head, a moderately to very slender pronotum, small eyes, symmetric male sternites VII and VIII, a male sternite VIII with shallow posterior excision and with clusters of modified setae posteriorly, an aedeagus with a slender ventral process (at least in ventral view), a long and undivided median portion of the female sternite VIII (at least approximately as long as tergite X), and a posteriorly distinctly produced female sternite VIII. Although vastly different in size, *L. ensigerum* and *L. hastatum* apparently represent adelphotaxa, as is suggested by the synapomorphic presence of a long sclerotized spine in the internal sac of the aedeagus, by the similarly shaped dorsal plate of the aedeagus, by the derived shape of the male sternite VIII (presence of a posterior pair of impressions; posterior excision with median projection), as well as by the similarly slender pronotum.

## Natural history

The *Lathrobium* material from the Emei Shan was sifted from the leaf litter and soil beneath broad-leaved trees, bushes, bamboo, and rhododendron. One species was collected at an altitude of 1,100 m, the remaining species at altitudes of 1,700–2,500 m, one of them primarily at high elevations from approximately 2,500 up to about 3,000 m. The labels attached to the material suggest that up to four species may have been found syntopically.

## Descriptions

### *Lathrobium iunctum* Assing & Peng, sp. n.

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[http://species-id.net/wiki/Lathrobium\\_iunctum](http://species-id.net/wiki/Lathrobium_iunctum)

Figs 2A, 3, 9

**Type material.** Holotype ♂: 'CHINA: Sichuan, Prov. Emeishan City, Mt. Emeishan, 29°33'N, 103°20'E, 23.vii.2012, alt. 2,000–2,300 m, Dai, Peng & Yin leg. / Holotypus ♂ *Lathrobium iunctum* sp. n., det. Assing & Peng 2012' (SNUC). PARATYPES: 10♂♂, 13♀♀: 'P. R. CHINA, Sichuan, Emei Shan, N29°33.6', E103°20.6', 27.vi.–5.vii.2009, 1800–2400 m, siftings 11–17, V. Grebennikov'; 1♂: 'P. R. CHINA, Sichuan, Emei Shan, N29°32.932', E103°20.466', 2310 m, 01.vii.2009, sifting 14, V. Grebennikov'; 1♂, 3♀♀: 'P. R. CHINA, Sichuan, EmeiShan, N29°32'56.0", E103°20'28.0"', 2310 m, 20.vi.2010, sifting 38, V. Grebennikov'; 1♀: 'P. R. CHINA, Sichuan, EmeiShan, N29°33'36.3"', E103°20'38.0"', 1947 m, 15.vi.2010, sifting 33, V. Grebennikov'; 10♂♂, 9♀♀: 'CHINA Sichuan, Emei Shan, Leidongping, 2500 m, 18.VII.1996, 29°32'N 103°21'E C65 / collected by A. Smetana, J. Farkač and P. Kabátek' (Paratypes in CAS, cSme, and cAss).

**Etymology.** The specific epithet (Latin, adjective: connected, fused) alludes to the merged ventral process and dorsal plate of the aedeagus.

**Description.** Species of moderately large and somewhat variable size, without sexual size dimorphism. Body length 8.0–9.5 mm; length of forebody 3.4–4.2 mm. Habitus as in Fig. 2A. Coloration: body blackish-brown to black, abdominal apex indistinctly paler; legs reddish-brown to dark-brown with pale-reddish tarsi; antennae reddish.

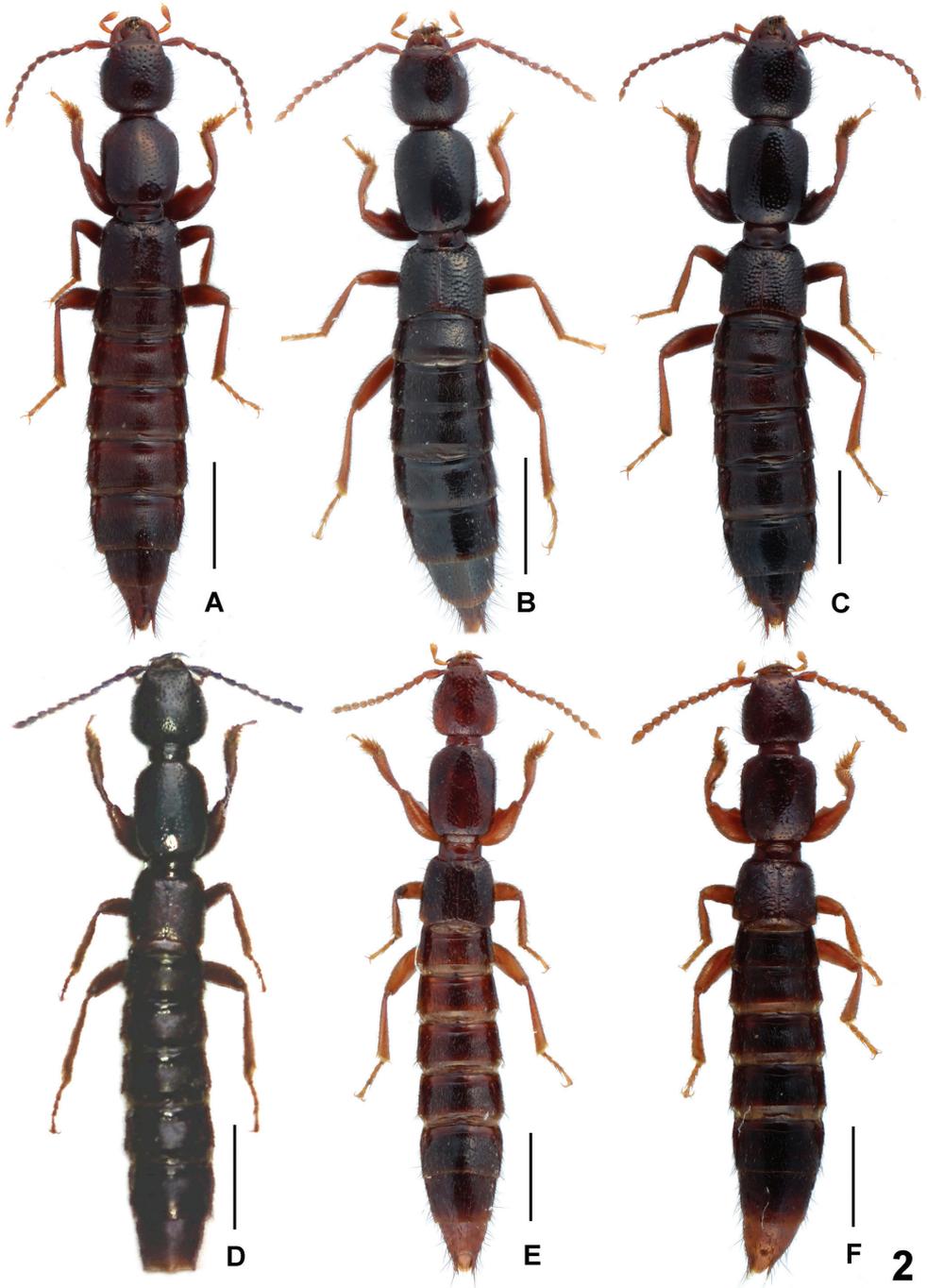
Head usually weakly transverse, 1.00–1.05 times as broad as long; punctuation variable, moderately coarse to coarse and moderately dense to dense, sparser in median dorsal portion; interstices with fine but distinct microreticulation. Eyes weakly convex and rather large, approximately half the length of postocular region in dorsal view, or nearly so, and composed of numerous (> 50) ommatidia. Antenna 2.0–2.3 mm long.

Pronotum relatively broad, approximately 1.2 times as long as broad and 1.05–1.10 times as broad as head; punctuation similar to that of head or somewhat finer; impunctate midline moderately broad; interstices without microsculpture.

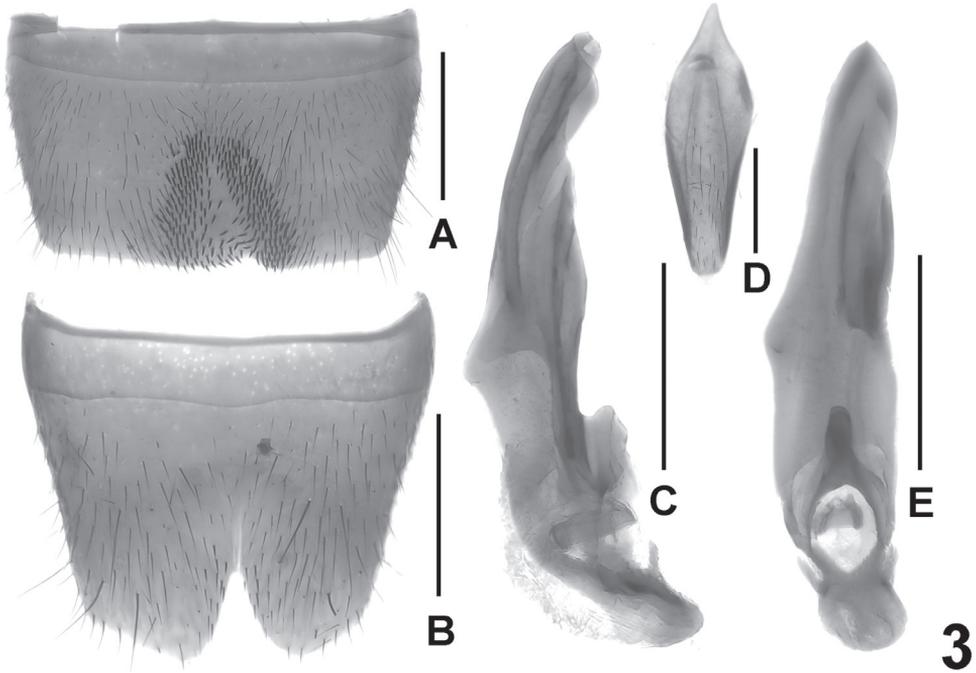
Elytra short and broad, distinctly dilated posteriorly, approximately 0.55 times as long as pronotum, and at posterior margin approximately 1.6–1.7 times as broad (combined width) as long; punctuation somewhat variable, usually shallow and moderately defined. Hind wings completely reduced. Protarsi without evident sexual dimorphism, moderately dilated in both sexes.

Abdomen with fine and rather dense punctuation, that of tergite VII only slightly sparser than that of anterior tergites; interstices with fine microsculpture; posterior margin of tergite VII without palisade fringe; tergite VIII without sexual dimorphism, with truncate to weakly convex posterior margin.

Male. Sternites III–VI unmodified. Sternite VII strongly transverse, with asymmetric, somewhat oblique median impression posteriorly, this impression with pronounced



**Figure 2.** Habitus of *Lathrobium* spp., **A** *L. iunctum* **B** *L. coniunctum* **C** *L. conexum* **D** *L. ensigerum* **E** *L. bastatum* **F** *L. bisinuatum*. Scale bars: **A–C** 1.5 mm; **D** 2.0 mm; **E–F** 1.0 mm.



**Figure 3.** *Lathrobium iunctum*. **A** male sternite VII **B** male sternite VIII **C** aedeagus in lateral view **D** male sternite IX **E** aedeagus in ventral view. Scale bars: 0.5 mm.

and extensive cluster of numerous distinctly modified, short and stout black setae; posterior margin bisinuate or with shallow excision in asymmetric position (Fig. 3A). Sternite VIII transverse, pubescence unmodified; posterior excision almost symmetric, narrowly V-shaped and rather deep, its depth approximately  $1/4$ – $2/5$  the length of sternite (Fig. 3B). Sternite IX as in Fig. 3D. Aedeagus (Figs 3C, E) approximately 1.5 mm long, slender, distinctly asymmetric, and with rather small basal portion; ventral process and dorsal plate fused; internal sac with small and weakly sclerotized basal sclerite.

Female. Sternite VIII approximately as long as broad and with distinctly convex posterior margin, its shape similar to that of *L. coniunctum* (cf. Fig. 4B). Tergite IX undivided in the middle, with short median portion, and with long posterior processes; tergite X more than twice as long as tergite IX in the middle.

**Comparative notes.** In external characters, *L. iunctum* is highly similar to the closely related *L. coniunctum* and *L. conexum* (see comparative notes in the following section), from which it is reliably distinguished only by the male sexual characters (shape and chaetotaxy of the male sternite VII; deep and narrow posterior excision of the male sternite VIII; shape of the aedeagus).

**Distribution and natural history.** This species is most likely endemic to the Emei Shan, where the type specimens were sifted from leaf litter at elevations from approximately 1,800 to 2,500 m, together with *L. coniunctum*, *L. hastatum*, and *L. bisinuatatum*. The locality where the holotype was collected is illustrated in Fig. 9.

***Lathrobium coniunctum* Assing & Peng, sp. n.**

urn:lsid:zoobank.org:act:15495984-54B5-4B11-9EF0-384631577BA6

[http://species-id.net/wiki/Lathrobium\\_coniunctum](http://species-id.net/wiki/Lathrobium_coniunctum)

Figs 2B, 4, 10

**Type material.** Holotype ♂: 'CHINA: Sichuan Prov., Emeishan City, Mt. Emeishan, 29°33'N, 103°21'E, 21.vii.2012, alt. 1,700–1,900 m, Dai, Peng & Yin leg. / Holotypus ♂ *Lathrobium coniunctum* sp. n., det. Assing & Peng 2012'. Paratypes: 2♂♂: same label data as holotype; 2♀♀: same data, but '29°33'N, 103°20'E, 23.vii.2012, alt. 2,000–2,300 m' (SNUC); 1♂, 2♀♀: 'P. R. CHINA, Sichuan, Emei Shan, N29°33.6', E103°20.6', 27.vi.–5.vii.2009, 1800–2400 m, siftings 11–17, V. Grebennikov'; 1♀: 'P. R. CHINA, Sichuan, Emei Shan, N29°32.932', E103°20.466', 2310 m, 01.vii.2009, sifting 14, V. Grebennikov' (paratypes in SNUC, CAS, cSme, cAss).

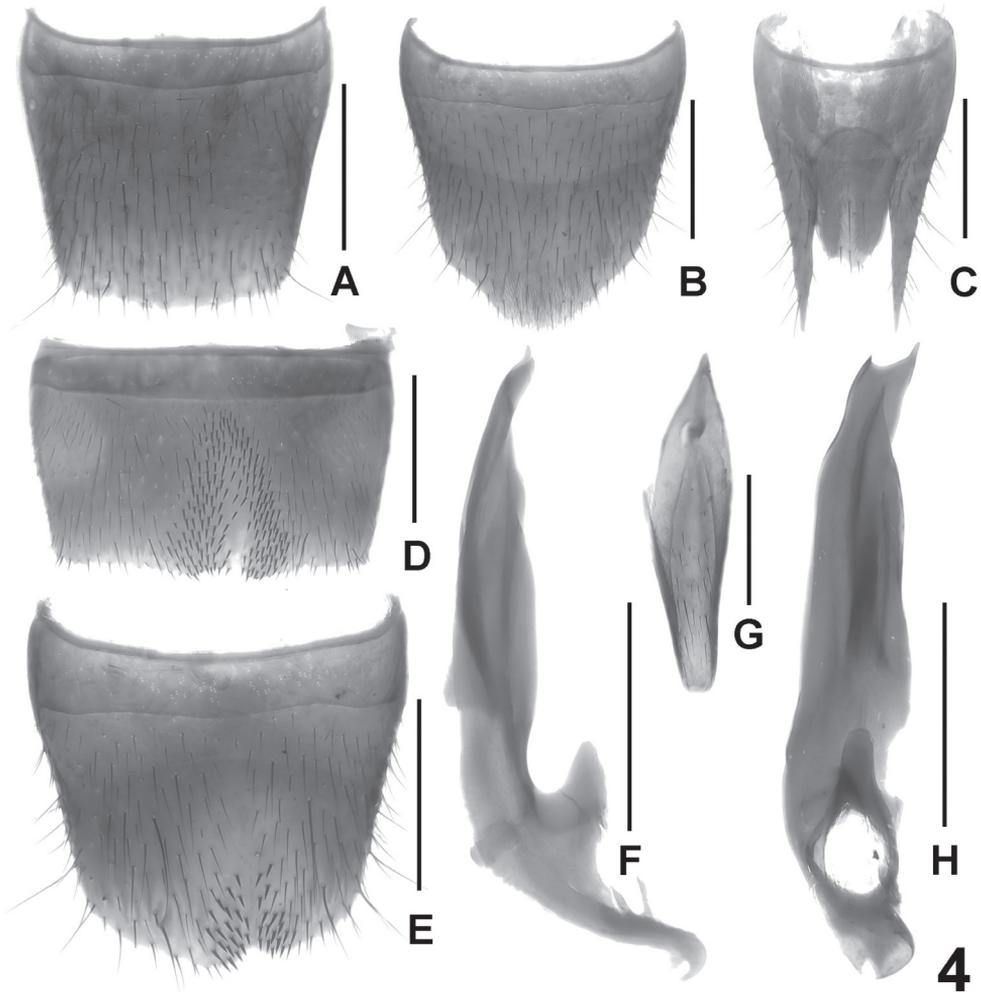
**Etymology.** The specific epithet (Latin, adjective: connected, fused) alludes to the merged ventral process and dorsal plate of the aedeagus and emphasizes the hypothesized close relationship of *L. coniunctum* to *L. iunctum* and the following species.

**Description.** Body length 7.1–9.0 mm; length of forebody 3.4–3.8 mm. Habitus as in Fig. 2B. Legs reddish to reddish-brown. Other external characters as in *L. iunctum*.

Male. Sternites III–VI unmodified. Sternite VII distinctly transverse, with slightly asymmetric, somewhat oblique, and relatively extensive median impression, this impression with defined and extensive cluster of numerous distinctly modified, short and stout black setae; posterior margin bisinuate, with shallow excision in asymmetric position (Fig. 4D). Sternite VIII weakly transverse, with small and shallow, somewhat asymmetrically oblique median impression posteriorly, this impression with a cluster of distinctly modified, short and stout black setae on either side of middle; posterior excision shallow and in asymmetric position (Fig. 4E). Sternite IX as in Fig. 4G. Aedeagus (Figs 4F, H) approximately 1.4 mm long (from base of capsule to apex of dorsal plate), slender, distinctly asymmetric, and with small basal portion; ventral process and dorsal plate fused; dorsal plate apically obliquely bifid in ventral view; internal sac with small and weakly sclerotized basal sclerite.

Female. Sternite VIII approximately as long as broad and with distinctly convex posterior margin (Fig. 4B). Tergite IX undivided in the middle, with short median portion, and with long posterior processes; tergite X more than twice as long as tergite IX in the middle (Fig. 4C).

**Comparative notes.** *Lathrobium coniunctum* is undoubtedly closely related to *L. iunctum*. This conclusion is supported by the similarly derived structure of the aedeagus (ventral process and dorsal plate fused, asymmetric, and slender; basal portion small; internal sac with small and weakly sclerotized basal sclerite); the similarly derived shape and chaetotaxy of the male sternite VII (median impression obliquely asymmetric and with defined, extensive cluster of distinctly modified setae), by the



**Figure 4.** *Lathrobium coniunctum*. **A** female tergite VIII **B** female sternite VIII **C** female tergites IX–X. **D** male sternite VII **E** male sternite VIII **F** aedeagus in lateral view **G** male sternite IX **H** aedeagus in ventral view. Scale bars: 0.5 mm.

similar female secondary sexual characters (sternite VIII relatively short; tergite IX with short median portion and with long postero-lateral processes), as well as by the extremely similar external characters. Both species are best distinguished by the completely different shape and chaetotaxy of the male sternite VIII and by the differently shaped apex of the aedeagus.

**Distribution and natural history.** Like *L. iunctum*, *L. coniunctum* is probably endemic to the Emei Shan, where the type specimens were sifted from leaf litter at elevations from approximately 1,700 to 2,310 m, partly together with *L. iunctum*. One of the collecting sites is illustrated in Fig. 10.

***Lathrobium conexum* Assing & Peng, sp. n.**

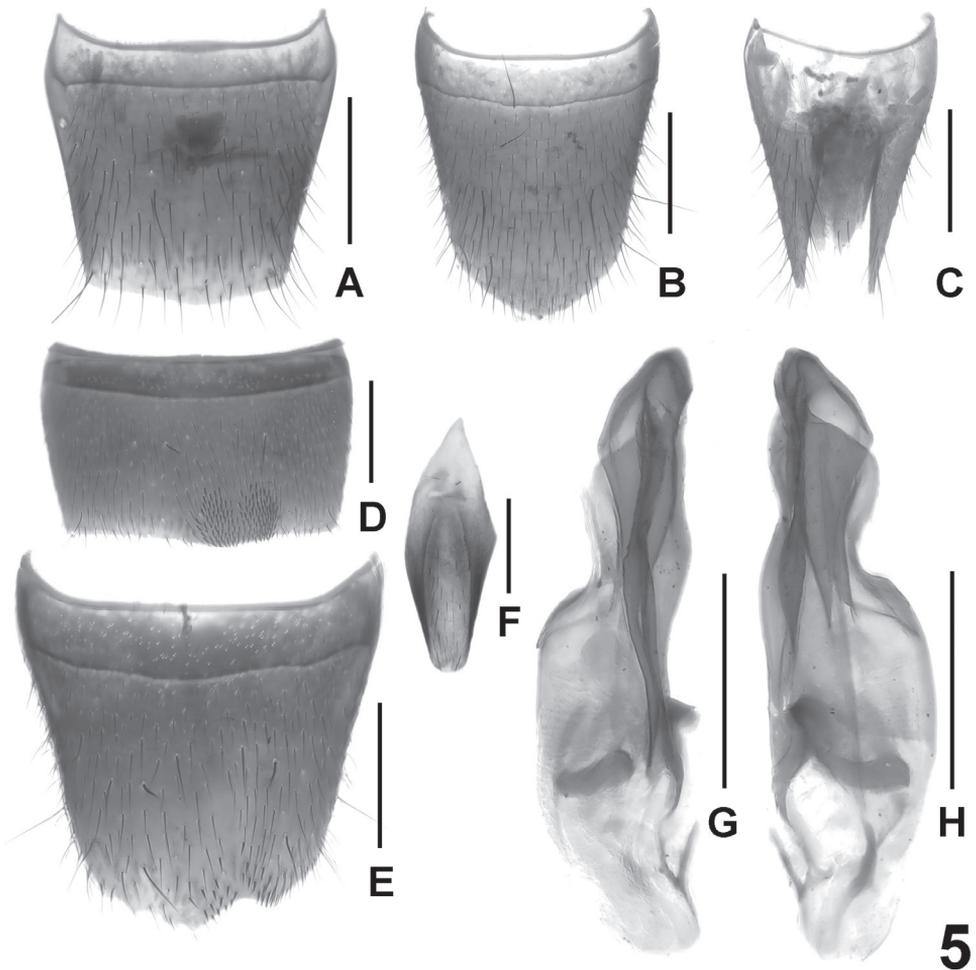
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[http://species-id.net/wiki/Lathrobium\\_conexum](http://species-id.net/wiki/Lathrobium_conexum)

Figs 2C, 5, 11

**Type material.** Holotype ♂: 'CHINA: Sichuan Prov., Emeishan City, Mt. Emeishan, 29°33'N, 103°23'E, 27.vii.2012, alt. 1,100 m, Dai, Peng & Yin leg. / Holotypus ♂ *Lathrobium conexum* sp. n., det. Assing & Peng 2012' (SNUC). PARATYPES: 2♂♂, 2♀♀: same data as holotype (SNUC).

**Etymology.** The specific epithet (Latin, adjective: connected) refers to the merged ventral process and dorsal plate of the aedeagus and emphasizes the hypothesized close relationship of *L. conexum* to *L. iunctum* and *L. coniunctum*.



**Figure 5.** *Lathrobium conexum*. **A** female tergite VIII **B** female sternite VIII **C** female tergites IX–X **D** male sternite VII **E** male sternite VIII **F** male sternite IX **G** aedeagus in lateral view **H** aedeagus in ventral view. Scale bars: 0.5 mm.

**Description.** Body length 8.8–10.0 mm; length of forebody: 4.1–4.5 mm. Habitus as in Fig. 2C. Head noticeably transverse, 1.05–1.10 times as broad as long. Other external characters as in *L. iunctum*.

Male. Sternite VII (Fig. 5D) distinctly transverse and with relatively small, sublentic, and shallow posterior impression in asymmetric position, this impression with defined and extensive cluster of numerous distinctly modified, short and stout black setae; posterior margin weakly convex. Sternite VIII (Fig. 5E) weakly transverse, with small and shallow impression in asymmetric position posteriorly, this impression with few short black setae; posterior excision shallow and in distinctly asymmetric position. Sternite IX as in Fig. 5F. Aedeagus (Figs 5G, H) approximately 1.4 mm long (from base to apex of dorsal plate) and distinctly asymmetric; ventral process and dorsal plate fused; basal portion of aedeagus small; internal sac with weakly sclerotized basal sclerite.

Female. Sternite VIII (Fig. 5B) oblong, its posterior margin strongly convex. Tergite IX with short and undivided median portion and with moderately long postero-lateral processes; tergite X approximately 2.3 times as long as tergite IX in the middle (Fig. 5C).

**Comparative notes.** As can be inferred from the similarly derived morphology of the aedeagus (ventral process and dorsal plate fused and distinctly asymmetric; small basal portion; internal sac with weakly sclerotized basal sclerite), the similar modifications of the male sternite VII (posterior impression in asymmetric position and with cluster of distinctly modified setae), the similar female secondary sexual characters, and the practically identical external characters, *L. conexum* is closely allied to *L. iunctum* and *L. coniunctum*. The similar modifications of the male sternite VIII would suggest that it may be most closely related to the latter.

**Distribution and natural history.** This species is currently known only from the type locality. The specimens were collected by sifting leaf litter and humus from the floor of hardwood forest with *Kalopanax* at an altitude of 1,100 m (Fig. 11).

***Lathrobium ensigerum* Assing & Peng, sp. n.**

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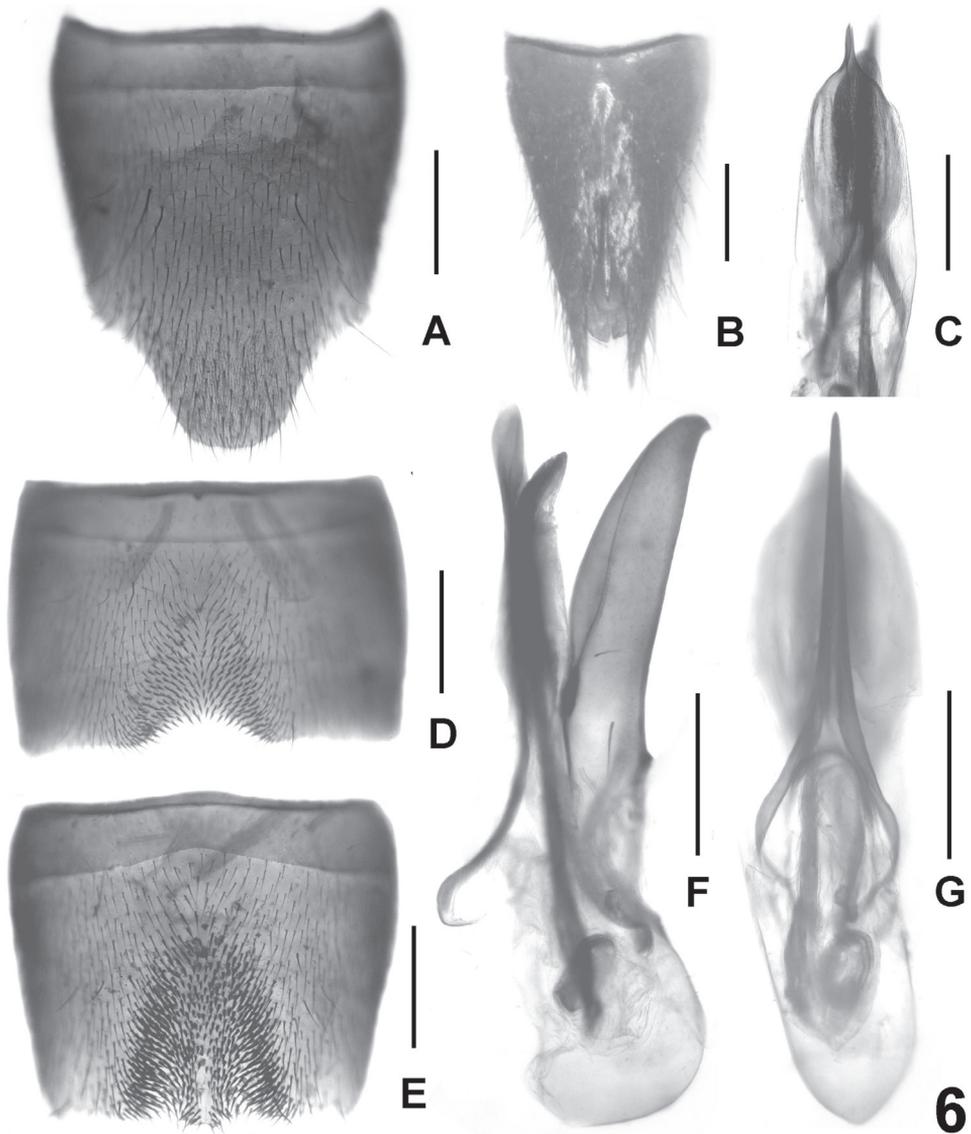
[http://species-id.net/wiki/Lathrobium\\_ensigerum](http://species-id.net/wiki/Lathrobium_ensigerum)

Figs 2D, 6

**Type material.** Holotype ♂: 'P. R. CHINA, Sichuan, EmeiShan, N29°32'57.2", E103°20'37.7", 16.vi.2010, 2289 m, sifting35, V. Grebennikov, Holotypus ♂ *Lathrobium ensigerum* sp. n., det. V. Assing 2012' (CAS). PARATYPE ♀: same data as holotype (cAss).

**Etymology.** The specific epithet (Latin, adjective: carrying a sword) alludes to the shape of the ventral process of the aedeagus.

**Description.** Large species; body length 11.0–13.0 mm; length of forebody 5.5–5.8 mm. Habitus as in Fig. 2D. Coloration: head and pronotum blackish-brown to black; elytra reddish-brown; abdomen brown to dark-brown, apex (posterior margin of segment VII; segments VIII–X) slightly paler; legs and antennae reddish-brown, antennomere I somewhat infusate.



**Figure 6.** *Lathrobium ensigerum*. **A** female sternite VIII **B** female tergites IX-X **C** apical portion of aedeagus in dorsal view **D** male sternite VII **E** male sternite VIII **F** aedeagus in lateral view; **G** aedeagus in ventral view. Scale bars: 0.5 mm.

Head weakly oblong, approximately 1.05 times as long as broad; punctation not particularly coarse and moderately dense, sparser in median dorsal portion; interstices with fine but distinct microreticulation. Eyes weakly convex and rather small, less than one third or even only one fourth as long as postocular region in dorsal view. Antenna 3.2–3.3 mm long.

Pronotum slender, approximately 1.35–1.40 times as long as broad and 0.95 times as broad as head; punctation similar to that of head or somewhat finer; impunctate midline broader posteriorly than anteriorly; interstices without microsculpture.

Elytra short, not distinctly dilated posteriorly (i.e., lateral margins subparallel in dorsal view), approximately 0.50–0.55 times as long as pronotum; punctuation shallow and dense. Hind wings completely reduced. Protarsi with weakly pronounced sexual dimorphism.

Abdomen with fine and rather dense punctuation, that of tergite VII slightly sparser than that of anterior tergites; interstices with fine microsculpture; posterior margin of tergite VII without palisade fringe; tergite VIII without sexual dimorphism, in both sexes with weakly convex posterior margin.

Male. Sternites III–VI unmodified. Sternite VII (Fig. 6D) strongly transverse, with median impression of triangular shape posteriorly, this impression with numerous distinctly modified, short and stout black setae; posterior margin distinctly concave in the middle. Sternite VIII (Fig. 6E) moderately transverse, with pair of posteriorly diverging impressions posteriorly, these impressions with numerous modified short black setae; posterior margin bisinuate, i.e., the shallow median excision with projection in the middle. Aedeagus (Figs 6C, F, G) 2.1 mm long and symmetric; ventral process blade-shaped, laterally compressed; dorsal plate with apical portion large, distinctly curved in lateral view, and apically acute in dorsal view; basal portion very short and thin; internal sac with long sclerotized spine and apically with additional, weakly sclerotized structure.

Female. Sternite VIII 1.7 mm long, distinctly oblong, posterior margin strongly produced in the middle (Fig. 6A). Tergite IX undivided in the middle, with long median portion, and with moderately long posterior processes; tergite X sharply keeled along the middle and approximately as long as tergite IX in the middle (Fig. 6B).

**Comparative notes.** *Lathrobium ensigerum* is readily distinguished from all other species known from the Emei Shan by its much larger size alone. In addition, it is characterized by the slender pronotum, as well as the distinctive male and female sexual characters. For details regarding its phylogenetic affiliations see the comparative notes in the following section.

**Distribution and natural history.** The type locality is situated in the Emei Shan. The specimens were sifted from leaf litter at an altitude of nearly 2,300 m.

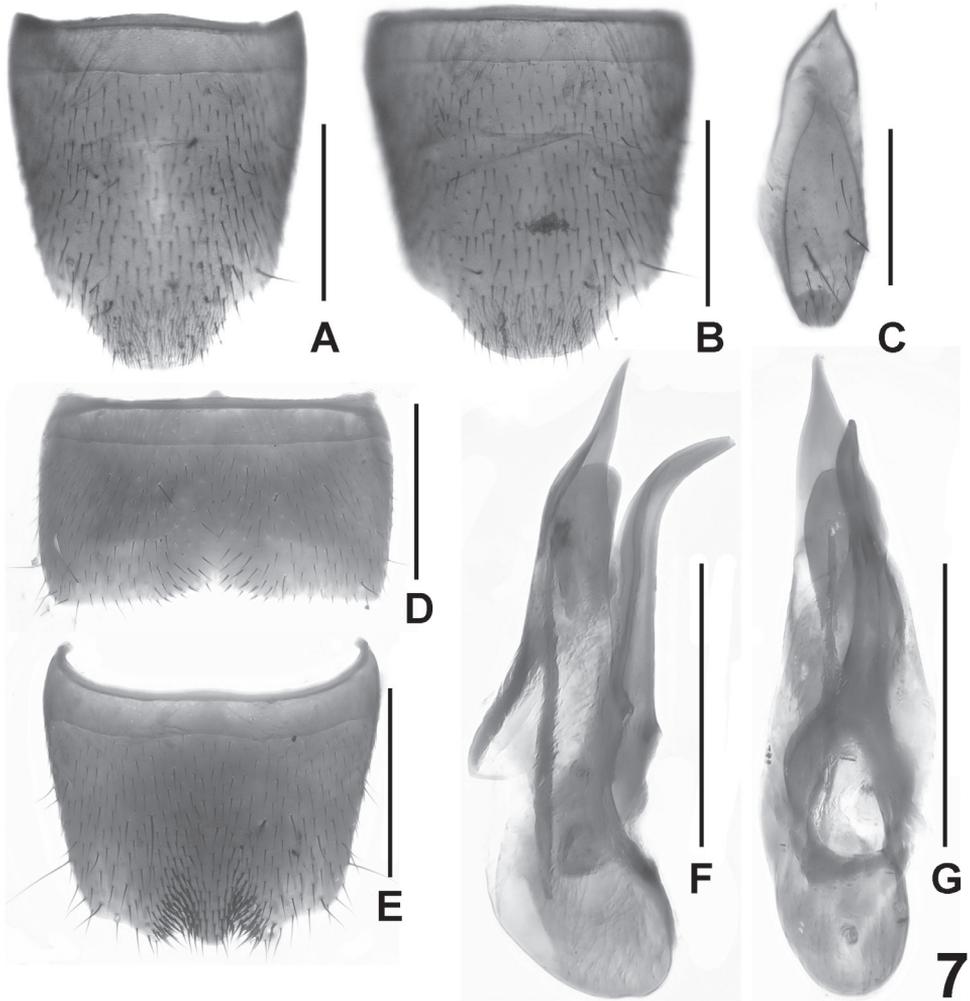
***Lathrobium hastatum* Assing & Peng, sp. n.**

urn:lsid:zoobank.org:act:1AB56ED6-2A42-4768-B208-0B558633890A

[http://species-id.net/wiki/Lathrobium\\_hastatum](http://species-id.net/wiki/Lathrobium_hastatum)

Figs 2E, 7, 9

**Type material.** Holotype ♂: 'CHINA: Sichuan Prov., Emeishan City, Mt. Emeishan, 29°33'N, 103°20'E, 21.vii.2012, alt. 2,000–2,300 m, Dai, Peng & Yin leg. / Holotypus ♂ *Lathrobium hastatum* sp. n., det. Assing & Peng 2012' (SNUC). Paratypes: 6♂♂, 11♀♀: 'P. R. CHINA, Sichuan, Emei Shan, N29°33.6', E103°20.6', 27.vi.–5.vii.2009, 1800–2400 m, siftings 11–17, V. Grebennikov'; 1♂, 2♀♀: 'P. R. CHINA, Sichuan, EmeiShan, N29°32'56.0", E103°20'28.0", 2310 m, 20.vi.2010, sifting 38, V. Gre-



**Figure 7.** *Lathrobium hastatum*. **A–B** female sternite VIII **C** male sternite IX **D** male sternite VII **E** male sternite VIII **F** aedeagus in lateral view **G** aedeagus in ventral view. Scale bars: 0.5 mm.

bennikov'; 4♀♀: 'P. R. CHINA, Sichuan, EmeiShan, N29°33'36.3", E103°20'38.0", 1947 m, 15.vi.2010, sifting 33, V. Grebennikov'; 1♀: 'CHINA Sichuan, Emei Shan, Leidongping, 2500 m, 18.VII.1996, 29°32'N, 103°21'E C65 / collected by A. Smetana, J. Farkač and P. Kabátek' (Paratypes in CAS, SNUC, cSme, and cAss).

**Etymology.** The specific epithet (Latin, adjective: armed with a spear) alludes to the presence of a long spine in the internal sac of the aedeagus.

**Description.** Species of relatively small and somewhat variable size, without sexual size dimorphism. Body length 6.3–7.6 mm; length of forebody 2.9–3.3 mm. Habitus as in Fig. 2E. Coloration: body brown to blackish-brown, abdominal apex indistinctly paler; legs and antennae reddish.

Head weakly oblong, approximately 1.05 times as long as broad; punctation variable, relatively fine to moderately coarse and moderately sparse to moderately dense, sparser in median dorsal portion; interstices with fine but distinct microreticulation. Eyes weakly convex and small, approximately one fourth as long as postocular region in dorsal view and composed of approximately 20 weakly defined ommatidia. Antenna 1.6–1.8 mm long.

Pronotum slender, approximately 1.35 times as long as broad and approximately 1.05 times as broad as head; punctation similar to that of head or somewhat finer; impunctate midline moderately broad; interstices without microsculpture.

Elytra short, weakly dilated posteriorly, little more than 0.50 times as long as pronotum; punctation somewhat variable, usually shallow and moderately defined. Hind wings completely reduced. Protarsi with weakly pronounced sexual dimorphism.

Abdomen with fine and rather dense punctation, that of tergite VII slightly sparser than that of anterior tergites; interstices with fine microsculpture; posterior margin of tergite VII without palisade fringe; tergite VIII without sexual dimorphism, with truncate to weakly concave posterior margin.

Male. Sternites III–VI unmodified. Sternite VII strongly transverse, symmetric, with shallow median impression posteriorly, this impression with sparse and weakly modified dark setae (Fig. 7D). Sternite VIII moderately transverse, symmetric, with pair of small impressions posteriorly, these impressions with numerous distinctly modified, stout and dark setae; posterior margin bisinuate, i.e., the shallow posterior excision with median projection (Fig. 7E). Sternite IX as in Fig. 7C. Aedeagus (Figs 7F, G) approximately 1.1 mm long; ventral process subapically strongly curved and apically acute in lateral view; apical portion of dorsal plate large, long, apically very acute, and distinctly sclerotized; basal portion of dorsal plate very short; internal sac with long and straight sclerotized spine and with additional lamellate apical structure.

Female. Sternite VIII 0.9–1.0 mm long, weakly oblong, of slightly variable shape; posterior margin distinctly produced, middle weakly to distinctly convex (Figs 7A, B). Tergite IX undivided in the middle, with long median portion, and with relatively short postero-lateral processes; tergite X much shorter than tergite IX in the middle.

**Comparative notes.** The similarly derived shape and chaetotaxy of the male sternite VIII (posteriorly with pair of impressions, these impressions with modified setae; posterior excision with median projection), the similarly derived morphology of the aedeagus (apical portion of dorsal plate large, apically acute, and distinctly sclerotized; basal portion of dorsal plate very short; internal sac with long sclerotized spine and apically with additional sclerite), the similar shape of the female sternite VIII, and the similarly slender pronotum suggest that, among the described species recorded from the Emei Shan, *L. hastatum* is most closely related to *L. ensigerum*. It is at once distinguished from this species by much smaller body size and by the sexual characters.

**Distribution and natural history.** *Lathrobium hastatum* is probably endemic to the Emei Shan. The specimens were sifted from leaf litter at elevations between 1,800 and 2,500 m, together with *L. iunctum*, *L. coniunctum*, and/or *L. bisinuatatum*. The locality where the holotype was collected is illustrated in Fig. 9. The ovaries of one of the dissected females contained a mature egg.

***Lathrobium bisinuatatum* Assing & Peng, sp. n.**

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[http://species-id.net/wiki/Lathrobium\\_bisinuatatum](http://species-id.net/wiki/Lathrobium_bisinuatatum)

Figs 2F, 8, 12

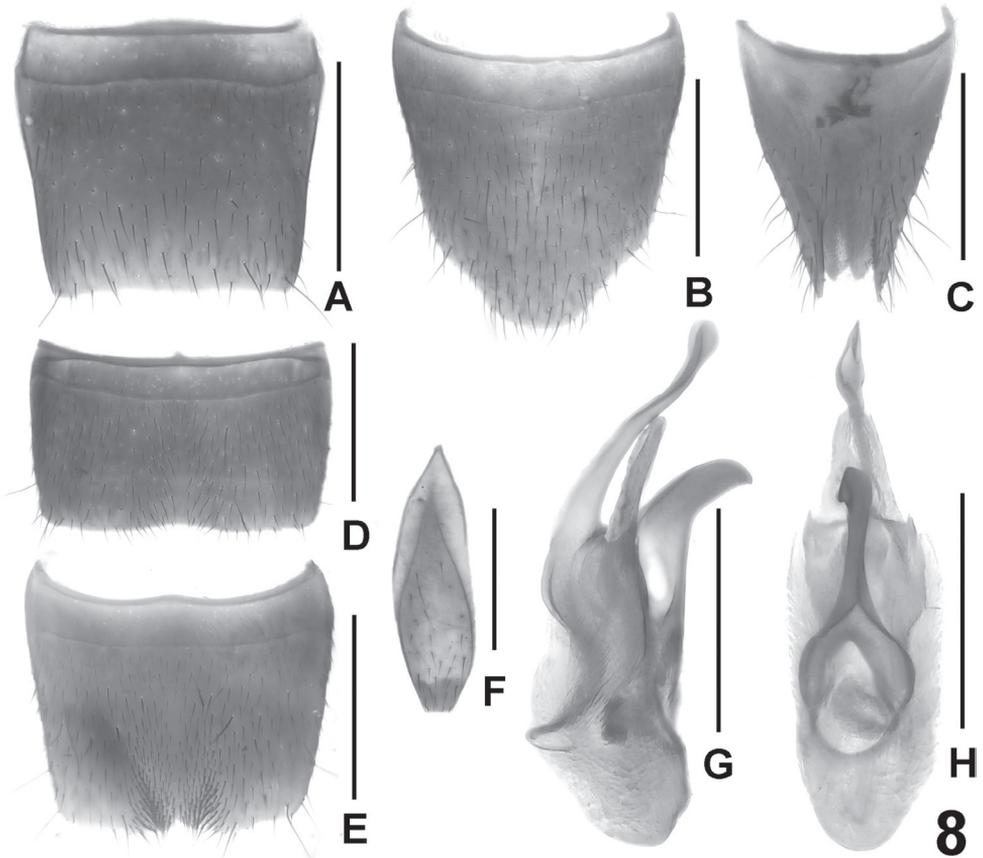
**Type material.** Holotype ♂: 'CHINA: Sichuan Prov., Emeishan City, Mt. Emeishan, 29°31'N, 103°20'E, 28.vii.2009, alt. 3,000 m, He & Tang leg. / Holotypus ♂ *Lathrobium bisinuatatum* sp. n., det. Assing & Peng 2012' (SNUC). Paratypes: 5♀♀: same data as holotype; 1♂, 3♀♀: same data, but '17.vii.2009, alt. 3,000 m, Li-Zhen Li leg.'; 2♂♂, 3♀♀: same data, but '29°32'N, 103°20'E, 18.vii.2012, alt. 2,500–2,600 m, Dai, Peng & Yin leg.'; 9♂♂, 5♀♀: same data, but '19.vii.2012, alt. 2,800–3,000 m, Dai, Peng & Yin leg.'; 4♂♂, 1♀: same data, but '20.vii.2012, alt. 2,800–3,000 m, Dai, Peng & Yin leg.'; 1♂, 1♀: 'P. R. CHINA, Sichuan, EmeiShan, N29°31'36.8", E103°19'52.1", 15.vi.2010, 2926 m, sifting 30, V. Grebennikov'; 4♀♀: 'P. R. CHINA, Sichuan, Emei Shan, N29°33.6', E103°20.6', 27.vi.–5.vii.2009, 1800–2400 m, siftings 11–17, V. Grebennikov'; 3♀♀: 'P. R. CHINA, Sichuan, EmeiShan, N29°30'46.5", E103°19'47.0", 14.vi.2010, 3035 m, sifting 28, V. Grebennikov'; 3♂♂, 3♀♀: 'CHINA Sichuan, Emei Shan, Leidongping, 2500 m, 18.VII.1996, 29°32N, 103°21E C65 / collected by A. Smetana, J. Farkač and P. Kabátek' (Paratypes in CAS, SNUC, cSme, and cAss).

**Etymology.** The specific epithet (Latin, adjective) alludes to the bisinuate posterior margin and the bisinuate dorsal plate (lateral view) of the aedeagus.

**Description.** Small species without sexual size dimorphism. Body length 5.2–6.5 mm; length of forebody 2.6–2.8 mm. Habitus as in Fig. 2F. Coloration: body dark-brown to blackish-brown, abdominal apex indistinctly paler; legs and antennae reddish. Pronotum moderately slender, 1.21–1.26 times as long as broad. Posterior margin of tergite VIII truncate to weakly convex in both sexes. Other external characters as in *L. hastatum*.

Male. Sternites III–VI unmodified. Sternite VII strongly transverse, symmetric, with shallow median impression posteriorly, this impression with sparse and unmodified pubescence; posterior margin weakly and broadly concave (Fig. 8D). Sternite VIII moderately transverse, symmetric, shallowly impressed along the middle, this impression posteriorly with cluster of dense modified black setae on either side of middle; posterior excision very shallow, posterior margin on either side of this impression weakly concave (Fig. 8E). Sternite IX as in Fig. 8F. Aedeagus (Figs 8G, H) 0.9–1.0 mm long; ventral process laterally compressed, rather short, subapically curved, and apically acute; apical portion of dorsal plate of conspicuous shape, very long and slender, bisinuate in lateral view, and considerably projecting beyond apex of ventral process apically; basal portion of dorsal plate very short; internal sac with small and weakly sclerotized basal sclerite and with additional, semi-transparent apical sclerite.

Female. Sternite VIII 0.8–0.9 mm long, weakly oblong, posterior margin distinctly produced in the middle, apex of this projection truncate to weakly convex (Fig. 8B). Tergite IX undivided in the middle, with long median portion, and with relatively short postero-lateral processes; tergite X much shorter than tergite IX in the middle (Fig. 8C).



**Figure 8.** *Lathrobium bisinuatum*. **A** female tergite VIII **B** female sternite VIII **C** female tergites IX–X. **D** male sternite VII **E** male sternite VIII **F** male sternite IX **G** aedeagus in lateral view **H** aedeagus in ventral view. Scale bars: 0.5 mm.

**Comparative notes.** Among the *Lathrobium* species known from the Emei Shan, *L. bisinuatum* is most closely related to the species pair *L. ensigerum* + *L. hastatum*, a conclusion supported particularly by the structure of the aedeagus (presence of an apical internal sclerite; strongly developed apical portion and reduced basal portion of the dorsal plate) and additionally by the similar female secondary sexual characters (shape of sternite VIII; relative length and shapes of tergites IX and X), the somewhat similar shape and chaetotaxy of the male sternite VIII (posteriorly with shallow excision and with clusters of modified black setae), and the similar external characters. In external characters, *L. bisinuatum* is most similar to *L. hastatum*, from which it is distinguished by smaller size, darker average coloration, the less slender pronotum, as well as by the male sexual characters.

**Distribution and natural history.** Like the other species described above, *L. bisinuatum* is probably endemic to the Emei Shan, where it was found primarily at high altitudes (2,500–3,000 m). In one locality at 2,500 m, *L. bisinuatum* was found together



**Figures 9–12.** Collecting sites on the Emei Shan. **9** type localities of *Lathrobium iunctum* and *L. hastatum* (2,000–2,300 m) **10** site where *Lathrobium coniunctum* was collected (1,700–1,900 m) **11** type locality of *Lathrobium conexum* (1,100 m) **12** site where *Lathrobium bisinuatum* was collected (2,800–3,000 m).

with *L. iunctum* and *L. hastatum*. Four females were collected somewhere between 1,800–2,400 m; they have the same label data as specimens of *L. iunctum*, *L. coniunctum*, and/or *L. hastatum*, suggesting that they were collected syntopically. Some of the specimens were sifted from rhododendron litter and humus in a rhododendron forest on a west slope near the mountain summit at an altitude of 2,800–3,035 m (Fig. 12).

### Key to the *Lathrobium* species of the Emei Shan

- 1 Large species; body length > 10 mm; length of forebody > 5 mm. Head slightly broader than pronotum (Fig. 2D). ♂: aedeagus 2.1 mm long, with sword-shaped ventral process (Figs 6C, F, G); sternites VII and VIII of distinctive shapes and chaetotaxy (Figs 6D, E). ♀: tergite X sharply keeled along the middle, approximately as long as tergite IX in the middle (Fig. 6B) .....*ensigerum*
- Distinctly smaller species; body length < 10 mm; length of forebody < 4.5 mm. Head slightly narrower than pronotum. ♂: aedeagus much smaller and with ventral process of different shape; sternites VII and VIII of different

- shape and chaetotaxy. ♀: tergite X not keeled, either distinctly shorter or distinctly longer than tergite IX in the middle ..... **2**
- 2 Larger species; body length > 7.7 mm; length of forebody > 3.3 mm. Head as broad as long or weakly transverse. Eyes larger, approximately half as long as postocular region in dorsal view, or nearly so, and composed of > 50 ommatidia. Pronotum broad, approximately 1.2 times as long as broad. Elytra broad and distinctly dilated posteriorly. ♂: sternite VII with median impression of obliquely asymmetric shape, this impression with extensive cluster of short and stout black setae; aedeagus asymmetric and with small basal portion, ventral process and dorsal plate fused. ♀: sternite VIII weakly oblong at most, posterior margin convex, not strongly produced in the middle; tergite IX with short median portion and long postero-lateral processes; tergite X much longer than tergite IX in the middle..... **3**
- Smaller species; body length < 7.6 mm; length of forebody < 3.4 mm. Head weakly oblong. Eyes smaller, less than one third as long as postocular region in dorsal view, and composed of approximately 20 ommatidia. Pronotum more slender, > 1.2 times as long as broad. Elytra only weakly dilated posteriorly. ♂: sternite VII with symmetric impression, this impression with sparse unmodified or weakly modified setae; aedeagus symmetric or weakly asymmetric and with large basal portion, ventral process and dorsal plate not fused. ♀: sternite VIII distinctly oblong, posterior margin distinctly produced in the middle; tergite IX with long median portion and relatively short postero-lateral processes; tergite X much shorter than tergite IX in the middle..... **5**
- 3 ♂: sternite VIII with deep and symmetric posterior excision, pubescence unmodified (Fig. 3B); sternite VII as in Fig. 3A; aedeagus as in Figs 3C, E..... *iunctum*
- ♂: sternite VIII with small and shallow posterior excision in asymmetric position, posteriorly with modified setae; aedeagus of different shape..... **4**
- 4 ♂: sternite VII with weakly convex posterior margin and with less extensive impression (Fig. 5D); sternite VIII with broader posterior excision and with fewer, weakly modified setae posteriorly (Fig. 5E); sternite IX less oblong (Fig. 5F); aedeagus stouter, dorsal plate not bifid apically in ventral view (Figs 5G, H). ♀: sternite VIII weakly oblong (Fig. 5B) ..... *conexum*
- ♂: sternite VII with shallow posterior excision and with more extensive impression (Fig. 4D); sternite VIII with smaller posterior excision and with more numerous and more distinctly modified setae posteriorly (Fig. 4E); sternite IX more slender (Fig. 4G); aedeagus more slender, dorsal plate bifid apically in ventral view (Figs 4F, H). ♀: sternite VIII approximately as long as broad (Fig. 4B) ..... *coniunctum*
- 5 Body larger; length of forebody 2.9–3.3 mm. Pronotum more slender, approximately 1.35 times as long as broad. ♂: sternite VII with weakly modified setae in posterior impression, posterior margin more distinctly concave

- in the middle (Fig. 7D); sternite VIII with median projection in the middle of the posterior excision; aedeagus approximately 1.1 mm long, with longer and more slender ventral process in lateral view, with broad and shorter dorsal plate, and with long sclerotized spine in internal sac (Figs 7F, G) .... *bastatum*
- Body smaller; length of forebody 2.6–2.8 mm. Pronotum less slender < 1.30 times as long as broad. ♂: sternite VII with unmodified pubescence in posterior impression and with weakly concave posterior margin (Fig. 8D); posterior margin of sternite VIII with small posterior excision, this excision without median projection (Fig. 8E); aedeagus 0.9–1.0 mm long with shorter and broader ventral process in lateral view, with conspicuously long, slender, and bisinuate (lateral view) dorsal plate, internal sac only with small basal sclerite in internal sac (Figs 8G, H) ..... *bisinquatum*

## Acknowledgements

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# Two sympatric new species of woodlizards (Hoplocercinae, *Enyalioides*) from Cordillera Azul National Park in northeastern Peru

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## Abstract

We report the discovery of two sympatric new species of *Enyalioides* from a montane rainforest of the Río Huallaga basin in northeastern Peru. Among other characters, the first new species is distinguishable from other *Enyalioides* by the combination of the following characters: strongly keeled ventral scales, more than 37 longitudinal rows of dorsals in a transverse line between the dorsolateral crests at midbody, low vertebral crest on the neck with vertebrals on neck similar in size to those between hind limbs, projecting scales on body or limbs absent, 96 mm maximum SVL in both sexes, and caudals increasing in size posteriorly within each autotomic segment. The second new species differs from other species of *Enyalioides* in having strongly keeled ventral scales, scales posterior to the superciliaries forming a longitudinal row of strongly projecting scales across the lateral edge of the skull roof in adults of both sexes, 31 or fewer longitudinal rows of strongly keeled dorsals in a transverse line between the dorsolateral crests at midbody, vertebrals on neck more than five times the size of vertebrals between hind limbs in adult males, projecting scales on body or limbs absent, and caudals increasing in size posteriorly within each autotomic segment. We also present an updated molecular phylogenetic tree of hoplocercines including new samples of *E. rudolfarndti*, *E. rubrigularis*, both species described in this paper, as well as an updated identification key for species of Hoplocercinae.

## Resumen

Reportamos dos nuevas especies simpátricas de *Enyalioides* provenientes de los bosques lluviosos montañosos de la cuenca del Río Huallaga. La primera especie nueva se distingue de las demás especies de *Enyalioides* por la combinación de los siguientes caracteres: ventrales fuertemente quilladas, más de 37 filas longitudinales de dorsales (contadas en línea transversal entre las crestas dorsolaterales a la mitad del cuerpo), cresta dorsal muy baja con las vertebrales del cuello de una talla similar a las vertebrales que se encuentran entre las piernas, falta de escamas proyectadas sobre el cuerpo o miembros, talla pequeña (con una longitud máxima de hocico a cloaca de 96 mm en ambos sexos) y caudales que aumentan en tamaño posteriormente en cada segmento autotómico. La segunda especie nueva se diferencia del resto de especies de *Enyalioides* por tener ventrales fuertemente quilladas, escamas posteriores a las superciliares formando una fila longitudinal de escamas fuertemente proyectadas a lo largo del borde lateral del techo del cráneo (en ambos sexos), 31 o menos filas longitudinales de dorsales fuertemente quilladas (contadas en línea transversal entre las crestas dorsolaterales a la mitad del cuerpo), vertebrales sobre el cuello más de cinco veces la talla de las vertebrales que se encuentran entre las piernas en machos adultos, ausencia de escamas proyectadas sobre el cuerpo o miembros y caudales que aumentan en tamaño posteriormente en cada segmento autotómico. Además, presentamos un árbol filogenético molecular de hoplocercinos actualizado que incluye nuevas muestras de *E. rudolfarndti*, *E. rubrigularis*, las nuevas especies reportadas aquí, así como una clave de identificación actualizada para las especies de Hoplocercinae.

## Keywords

Cordillera Azul, *Enyalioides*, Hoplocercinae, new species, Peru, systematics

## Palabras clave

Cordillera Azul, *Enyalioides*, especie nueva, Hoplocercinae, Perú, sistemática

## Introduction

Woodlizards (*Enyalioides*) are represented by ten currently recognized extant species that occur between 0–2000 m on both sides of the Andes from Panama to Bolivia (Torres-Carvajal et al. 2011). Eight species, the largest number for a single country, occur in Ecuador followed by Peru (7), Colombia (5), Brazil (2), Panama (1), and Bolivia (1) (Torres-Carvajal et al. 2011; Venegas et al. 2011). Although *Enyalioides* has been regarded as a group of low species diversity, recent fieldwork combined with taxonomic analyses has revealed a previous underestimation of species diversity. Three of the ten species, *E. touzeti*, *E. rubrigularis*, and *E. rudolfarndti*, have been described since 2008 (Torres-Carvajal et al. 2008, 2009; Venegas et al. 2011). These species were discovered in recent expeditions to poorly explored areas on both sides of the Andes in Ecuador and Peru, suggesting that more species might be awaiting discovery in other unexplored areas close to the Andes.

The 1.3 million ha Cordillera Azul National Park (CAZNP) is the third largest National Park in Peru and protects the largest extent of montane rainforest in the country. This national park is located between the Huallaga and Ucayali rivers, and includes some of the least explored forests of four Regions of Peru (i.e., Huánuco, Loreto, San Martín, and Ucayali). Rodríguez et al. (2002) reported 58 species of amphibians and 26 species of reptiles from the basins of the rivers Pisqui and Pauya in

CAZNP (Loreto). In recent surveys at CAZNP in the San Martín Region we collected specimens of *Enyalioides* that are inferred to represent two new species, based on morphological and molecular evidence, and are reported on in this paper. This discovery increases the number of species of woodlizards known to occur in Peru to nine, making it the country with the highest known species diversity in this clade.

## Materials and methods

The type series of the new species reported on in this paper were deposited in the herpetological collection of the Centro de Ornitología y Biodiversidad (CORBIDI) in Lima, Peru. Specimens of other *Enyalioides* species from CORBIDI, the Museo de Historia Natural San Marcos (MUSM) in Lima, Peru, and the Museo de Zoología, Pontificia Universidad Católica del Ecuador (QCAZ) in Quito, Ecuador were examined for comparative purposes and are listed in Appendix 1. Snout-vent length (SVL) and tail length (TL) measurements were made with a ruler and recorded to the nearest millimeter. All other measurements were made with digital calipers and recorded to the nearest 0.1 mm. Sex was determined by noting the presence/absence of hemipenes. We followed the terminology of Avila-Pires (1995) and Torres-Carvajal et al. (2011) for scutellational characters and measurements.

## Phylogenetic analyses

Torres-Carvajal and de Queiroz (2009) sampled two nuclear genes (BDNF, RAG1) and a continuous fragment of mitochondrial DNA (mtDNA) that extends from the protein-coding gene ND1 (subunit one of NADH dehydrogenase) through the genes encoding tRNA<sup>ILE</sup>, tRNA<sup>GLN</sup>, tRNA<sup>MET</sup>, ND2 (subunit two of NADH dehydrogenase), tRNA<sup>TRP</sup>, tRNA<sup>ALA</sup>, tRNA<sup>ASN</sup>, the origin of light-strand replication, tRNA<sup>CYS</sup>, tRNA<sup>TYR</sup>, to the protein-coding gene COI (subunit I of cytochrome c oxidase) to examine phylogenetic relationships among hoplocercine species. Following similar laboratory protocols, we sequenced the mtDNA fragment for five specimens of the new species reported herein (CORBIDI 6772, 8825–28), as well as three specimens of *Enyalioides rudolfarndti* (CORBIDI 7209–10, 7212) and one of *E. rubrigularis* (QCAZ 8454). GenBank accession numbers are KC588838–KC588846, respectively. We added these new sequences to the mtDNA dataset of Torres-Carvajal and de Queiroz (2009), and followed their alignment and model selection protocols. Phylogenetic relationships were assessed under a Bayesian approach using MrBayes 3.2.0 (Ronquist and Huelsenbeck 2003) after partitioning the data (tRNAs, 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> codon positions of protein coding genes). To reduce the chance of converging on a local optimum, four runs were performed. Each consisted of five million generations and four Markov chains with default heating values. Trees were sampled every 1000 generations resulting in 5000 saved trees per analysis. Stationarity was confirmed by plotting the  $-\ln L$  per

generation in the program Tracer 1.2 (Rambaut and Drummond 2003). Additionally, the standard deviation of the partition frequencies and the potential scale reduction factor (Gelman and Rubin 1992) were used as convergence diagnostics for the posterior probabilities of bipartitions and branch lengths, respectively. Adequacy of mixing was assessed by examining the acceptance rates for the parameters in MrBayes and independence of samples was assessed by examining the effective sample sizes (ESS) in Tracer. After analyzing convergence, mixing, and sampling, the first 500 trees in the sample were discarded as “burn-in” from each run. We then confirmed that the four analyses reached stationarity at a similar likelihood score and that the topologies were similar, and used the resultant 18,000 trees to calculate posterior probabilities (PP) for each bipartition in a maximum clade credibility tree in TreeAnnotator 1.6.1 (Rambaut and Drummond 2010).

## Results

### *Enyalioides azulae* sp. n.

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[http://species-id.net/wiki/Enyalioides\\_azulae](http://species-id.net/wiki/Enyalioides_azulae)

Figs 1–4

**Holotype.** CORBIDI 06772 (Fig. 1), an adult male from Chambirillo close to Checkpoint 16 of the CAZNP (07°04'8.9"S, 76°00'51.2"W, 1122 m), Provincia de Picota, Región San Martín, Perú, collected on 1 May 2010 by P. J. Venegas.

**Paratypes.** CORBIDI 8825, 8826, adult females collected on 30 October 2010 by P. J. Venegas; CORBIDI 08786, 08790, 08791, adult male, juvenile female, and juvenile male, respectively, collected on 21 January 2011 by P. J. Venegas and V. Duran; CORBIDI 09213, 09214, juvenile male and female, respectively, collected on 8 May 2011 by P. J. Venegas and V. Duran. All paratypes are from the type locality.

**Diagnosis.** *Enyalioides azulae* can be distinguished from other species of *Enyalioides*, except *E. microlepis* and *E. cofanorum*, by the combination of the following characters: (1) strongly keeled ventral scales; (2) more than 37 longitudinal rows of dorsals in a transverse line between the dorsolateral crests at midbody; and (3) absence of superciliary flaps projecting over each orbit (present only in *E. palpebralis*). *Enyalioides azulae* differs from *E. cofanorum* and *E. microlepis* in having more gulars (45–57, mean =  $51.13 \pm 4.05$ , versus 34–41, mean =  $36.13 \pm 2.00$  in *E. cofanorum* and 34–49, mean =  $37.88 \pm 3.44$  in *E. microlepis*), a smaller body size (maximum SVL = 96 mm in both males and females, versus 107 mm in males and 109 mm in females of *E. cofanorum*, and 127 mm in males and 116 mm in females of *E. microlepis*), a lower vertebral crest on the neck, a narrower snout in dorsal view, and in lacking blue on the gular region in males. Additionally, *E. azulae* has a marked sexual dichromatism, with males having greenish and females brownish background coloration (Fig. 2), whereas the other two species have brownish background coloration in both sexes. *Enyalioides azulae* further



**Figure 1.** Holotype of *Enyalioides azulae* sp. n. (CORBIDI 06772, adult male, SVL = 96 mm). Top: lateral view; middle: close-up of head; bottom: ventral view. Photographs by P.J. Venegas.

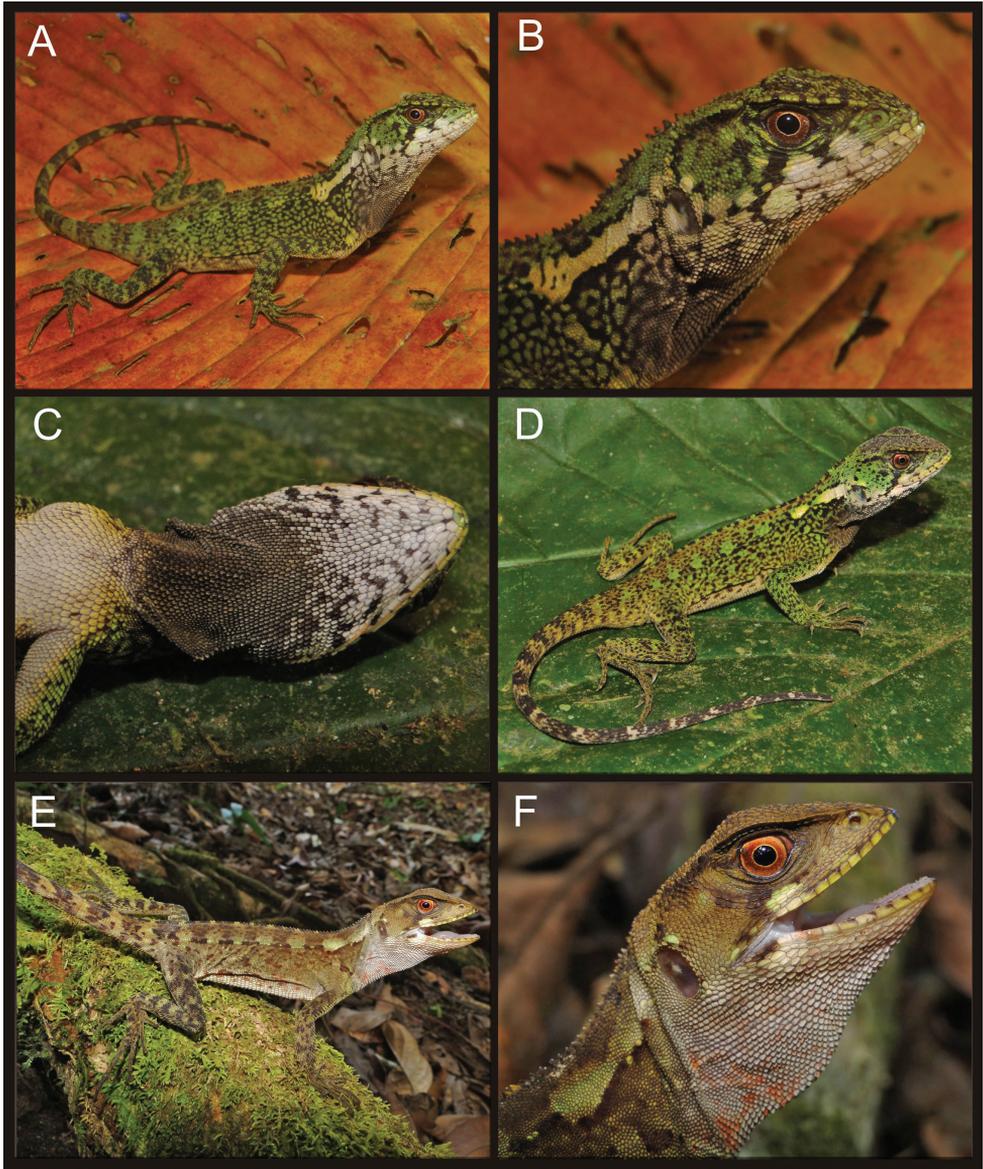


**Figure 2.** Male (top, CORBIDI 09213) and female (bottom, CORBIDI 09214) of *Enyalioides azulae* sp. n. Photograph by P.J. Venegas.

differs from *E. cofanorum* in lacking scattered enlarged scales on the dorsum, well-developed dorsolateral crests between the hind limbs, and a dark gular patch in females.

**Description of holotype.** Male (Fig. 1); SVL = 96 mm; TL = 140 mm; maximum head width = 21.28 mm; head length = 26.35 mm; head height = 17.95 mm; dorsal head scales uni- or multicarinate, those on parietal region projected dorsally; parietal eye present; scales immediately posterior to superciliares conical and as dorsally projected as adjacent parietals and temporals; temporal scales small, granular and multicarinate; one enlarged pretympenic scale; 14 superciliares; six canthals; five postrostrals; 11 (left or right) supralabials counted to a point below middle of eye; rostral (2.57 × 1.16 mm) about twice as wide as adjacent supralabials; two longitudinal rows of lorilabials between suboculars and supralabials at level of middle of eye, 3–4 longitudinal rows of lorilabials anterior to this point; loreal region broken into small, multicarinate, and juxtaposed scales; nasal at level of supralabials III–IV; 10 (left or right) infralabials counted to a point right below middle of eye; mental (2.51 × 1.53 mm) wider and longer than adjacent infralabials; two postmentals; gulars ventrally projected; gular fold complete midventrally, extending dorsally and posteriorly to form antehumeral fold; neck with several oblique folds and a dorsolateral row of enlarged scales.

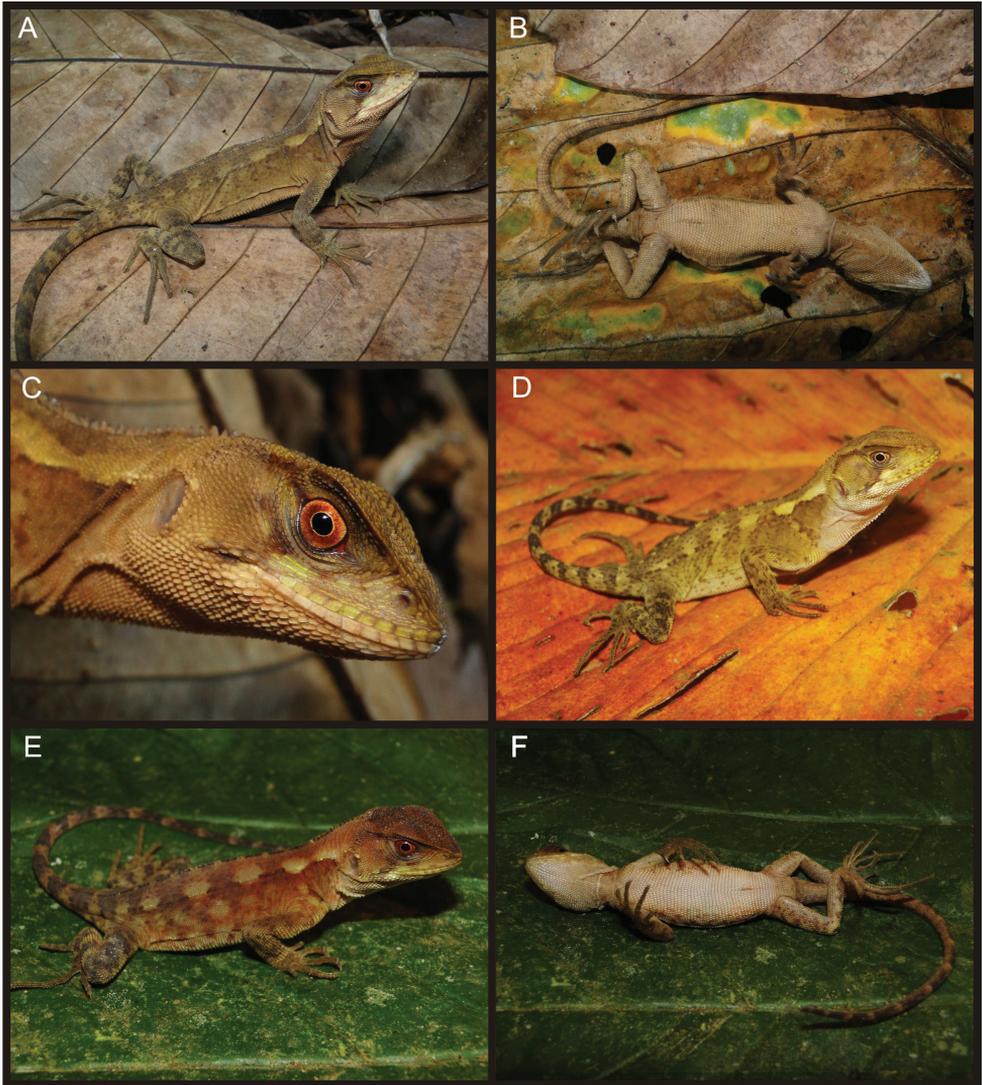
Vertebral crest not strongly projected, with vertebrae on neck similar in size to those between hind limbs; crest bifurcates posteriorly and extends onto tail less than ¼ its length; body flanks between fore and hind limbs without folds; irregular dorsolateral row of 1–2 keeled, enlarged scales (i.e., approximately twice as large as adjacent scales); dorsal scales between dorsolateral scale rows and vertebral crest small, keeled and subimbricate towards vertebral crest, granular towards dorsolateral scale rows;



**Figure 3.** Adult male (**A, B, C** CORBIDI 08786), juvenile male (**D** CORBIDI 09213), and adult female (**E, F** CORBIDI 08826) of *Enyalioides azulae*. Photographs by P.J. Venegas.

scales on flanks similar in size to lateralmost dorsal scales; ventral scales subimbricate, keeled, subrectangular, with a posterolateral mucron; ventrals more than twice the length of dorsals.

Limb scales keeled and imbricate dorsally and ventrally; scales on dorsal and posterior aspects of thighs keeled and imbricate, with most scales less than half the size of those on anterior and ventral aspects; 19 subdigitals on manual digit



**Figure 4.** Adult (**A, B, C** CORBIDI 08825) and juvenile (**D** CORBIDI 08791 **E, F** CORBIDI 09214) females of *Enyalioides azulae*. Photographs by P.J. Venegas.

IV; 26 subdigitals on pedal digit IV; one femoral pore on each side; tail laterally compressed and gradually decreasing in relative height towards tip; caudal scales strongly keeled and imbricate, moderately increasing in size posteriorly on lateral and dorsal aspects of each autotomic segment; ventral caudals larger than dorsal caudals, with individual vertebral segments three scales long ventrally and six scales long dorsally.

**Color in life of holotype** (Fig. 1). Dorsal surface of head dark brown with light green flecks; lateral surface of head green with lorilabial and pretympanic regions turquoise and a black narrow supratemporal stripe; a black oblique stripe extending from

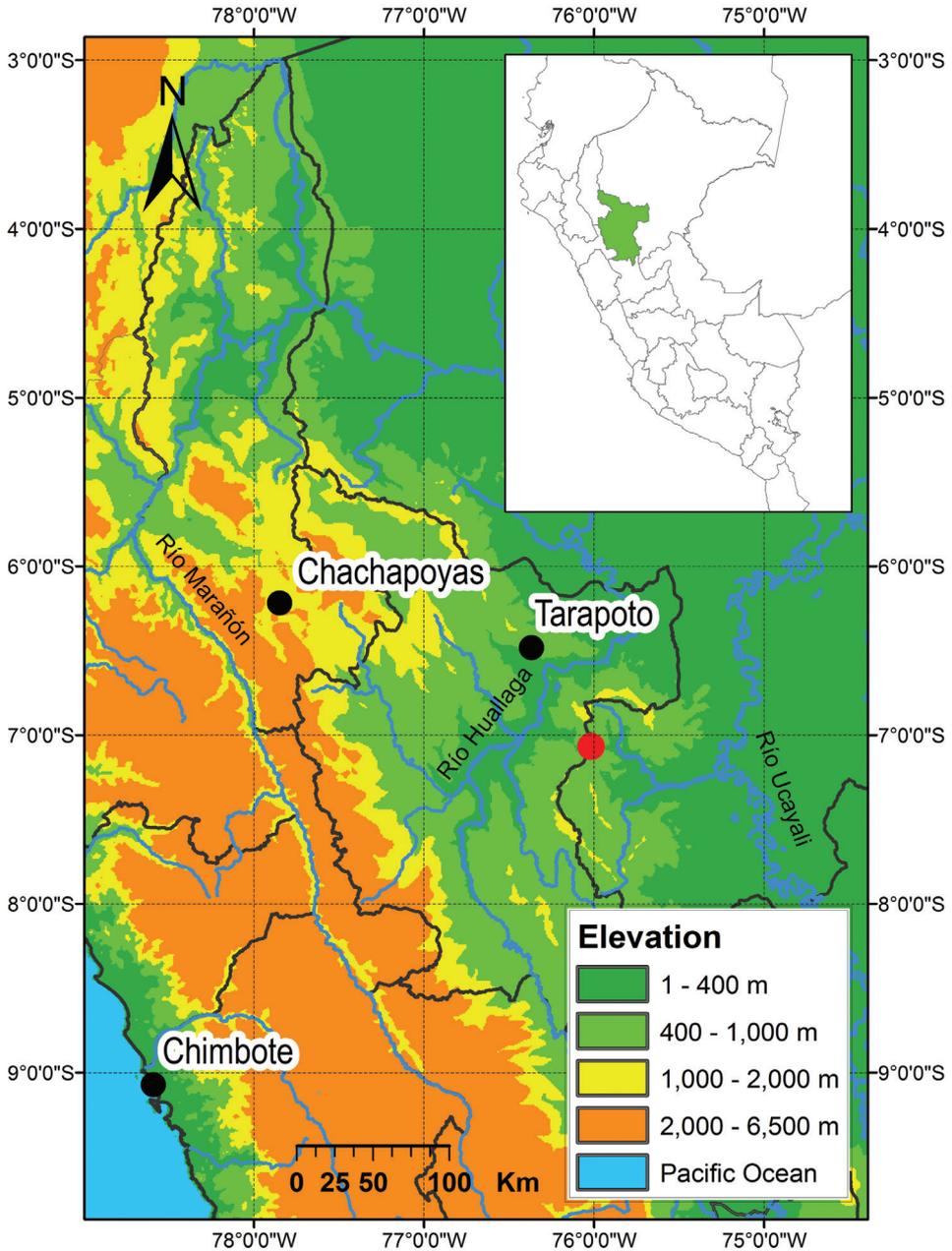


**Figure 5.** Habitat at the type locality of *Enyalioides azulae* sp. n. and *E. binzayedii* sp. n. The photo shows the montane rainforest on the top of the mountain ridge that forms the boundary between Region de San Martín and Region de Loreto. Photograph by A. Del Campo.

eye to commissure of the mouth; an orange cream oblique stripe on suboculars, posterior labials and adjacent gulars; labials cream; rostral and mental light green; wide, cream longitudinal stripe extending from above tympanum to scapular region; gular region dirty cream with dark spots and flecks; dark brown patch on medial aspect of gular fold; dorsal background green with diffuse, transverse dark brown bars on body, limbs, and tail; flanks covered with dark brown reticulations; ventral surface of body, limbs and tail tan with diffuse darker brown spots on thighs; iris reddish copper with a fine golden ring around the pupil.

**Intraspecific variation.** Meristic and morphometric characters of *E. azulae* are summarized in Table 1. Male paratypes (CORBIDI 08786, 09213) are very similar in coloration to the holotype (Fig. 3A–D). The dark patch on the gular region of adult males is also present in juvenile male specimens.

Adult (CORBIDI 08825–08826) and juvenile (CORBIDI 08791, 09214) females share similar color patterns (Figs. 3E–F, 4): head brown with a narrow dark brown supratemporal stripe; broad subocular dark stripe extending from eye to commissure of mouth, with a parallel, conspicuous white or cream stripe immediately anterior to it; pale, wide longitudinal stripe extending from tympanum to scapular region; gular region pale brown without dark markings, or white with faint reddish brown reticulation as in specimen CORBIDI 08826; dorsal background light brown, with a greenish tone in CORBIDI 08826 (Fig. 3E–F) and coppery tone in CORBIDI 09214



**Figure 6.** Distribution of *Enyalioides azulae* sp. n. and *E. binzayedii* sp. n. in Peru. The red circle indicates the type (and only currently known) locality of both species.

(Fig. 4E); transverse dark brown bars on dorsal aspect of body, limbs, and tail; ventral surface of body, limbs and tail light brown (CORBIDI 08825; Fig. 4B) or white (CORBIDI 08826; Fig. 4F); iris reddish brown.

Although this species seems to have a marked sexual dichromatism in background colors (green in males, brown in females, see Fig. 2), one male specimen (the holotype) exhibited metachromatism consisting of dark brown tones being replaced by green tones.

**Distribution and natural history.** *Enyalioides azulae* is known only from its type locality in the montane rainforest of the Río Huallaga basin (Fig. 5) in northeastern Peru at an elevation of 1100 m. This locality lies within the CAZNP, on a mountain ridge between the Región San Martín and Región Loreto (Fig. 6). Seven of the eight individuals of *E. azulae* reported in this paper were collected at night sleeping on low vertical stems of bushes 15–80 cm above the ground. One adult male (the holotype) was collected during the day on a narrow trail after a rain; when approached, it fled and hid under a fallen log. This species is found in sympatry and possibly syntopy with *E. binzayedii* sp. n. (see below) and *E. laticeps*. The smallest individuals (CORBIDI 08790–08791, SVL = 61 and 62 mm, respectively) were collected in January. Other species of squamate reptiles collected at the same locality include *Alopoglossus angulatus*, *Anolis fuscoauratus*, *A. transversalis*, *Cercosaura manicata*, *Potamites ecleopus*, *P. strangulatus*, *Potamites* sp., *Chironius fuscus*, *Dipsas indica*, *Imantodes cenchoa*, *I. lentiferus*, *Micrurus obscurus*, *Oxyrhopus petola*, and *Xenopholis scalaris*.

**Etymology.** The specific epithet is a noun derived from the Spanish word “azul” (blue) in the genitive case; it refers to the Cordillera Azul, the mountain range after which the National Park where this species was discovered is named. Although the word “azul” in “Cordillera Azul” is an adjective, and the Spanish noun “azul” is masculine, we are here treating “azulae” as a feminine noun that is an abbreviation for “Cordillera Azul” and is therefore to be interpreted as meaning “of the [Cordillera] Azul.”

***Enyalioides binzayedii* sp. n.**

urn:lsid:zoobank.org:act:01F81E7A-E9CF-42DA-88F9-6EB2A4EE3EFC

[http://species-id.net/wiki/Enyalioides\\_binzayedii](http://species-id.net/wiki/Enyalioides_binzayedii)

Figs 7–9

**Holotype.** CORBIDI 08828 (Fig. 7), an adult male from Chambirillo close to the Checkpoint 16 of the CAZNP (07°04'8.9"S, 76°00'51.2"W, 1122 m), Provincia de Picota, Región San Martín, Perú, collected on 30 October 2010 by P. J. Venegas.

**Paratypes.** CORBIDI 08827, an adult female collected on 2 November 2010 by P. J. Venegas; CORBIDI 08786, 08787, 08788, 08789, adult females collected on 21 January 2011 by P. J. Venegas and V. Duran; CORBIDI 09215, 09216, a juvenile male and adult female, respectively, collected on 6 May 2011 by P. J. Venegas and V. Duran. All paratypes are from the same locality as the holotype.

**Diagnosis.** *Enyalioides binzayedii* can be distinguished from other species of *Enyalioides* by the combination of the following characters: (1) scales posterior to the superciliaries forming a longitudinal row of strongly projecting scales across the lateral edge of the skull roof in adults of both sexes; (2) 31 or fewer longitudinal rows of strongly keeled dorsals in a transverse line between the dorsolateral crests at midbody; (3) ven-

tral scales strongly keeled; (4) caudals increase in size posteriorly within each autotomic segment; (5) projecting scales on body or limbs absent; (6) vertebrales on neck more than five times the size of vertebrales between hind limbs in adult males.

A longitudinal row of strongly projecting scales along the lateral edge of the skull posterior and continuous with the superciliaries is also present in *E. oshaughnessyi*, which occurs west of the Andes in Ecuador and Colombia and differs from *E. binzayedii* in having smooth or slightly keeled dorsals. Species of *Enyalioides* occurring east of the Andes that share strongly keeled ventrals with *E. binzayedii* are *E. azulae*, *E. cofanorum*, *E. microlepis*, *E. palpebralis*, and *E. rudolfarndti*. All of these species either lack strongly projecting scales along the lateral edge of the skull roof (although they are slightly projecting in *E. rudolfarndti*) or have such scales but with a gap separating them from the superciliaries (*E. palpebralis*). *Enyalioides azulae*, *E. cofanorum* and *E. microlepis* differ further from *E. binzayedii* (character states in parentheses) in having more than 33 dorsal scales in a transverse line between the dorsolateral crests at mid-body (31 or fewer), a low vertebral crest (high, with vertebrales on neck more than four times the size of vertebrales between hind limbs in both sexes), and a black gular patch (absent). The new species can be also distinguished from *E. palpebralis* by lacking both a superciliary triangular flap that projects posterolaterally over each eye and a small gap in the vertebral crest in the neck region, and by having femoral pores. From *E. rudolfarndti* (character states in parentheses), *E. binzayedii* also differs in having a prominent medial keel on each dorsal scale (medial keel weak or absent), dorsals nearly homogeneous in size (dorsals heterogeneous in size), and in lacking a round orange blotch in the antehumeral region (orange blotch present in adult males).

**Description of holotype.** Male (Fig. 7); SVL = 118 mm; TL = 180 mm; maximum head width = 25.14 mm; head length = 30.46 mm; head height = 23.70 mm; dorsal head scales uni- or multicarinate, those in parietal region strongly projected dorsally; parietal eye present; scales immediately posterior to superciliares conical and dorsolaterally projected, forming longitudinal row of seven scales that extends posteriorly over supratemporal region, with fifth anteriormost scale more than twice the size of other scales in row; temporal scales small, multicarinate, juxtaposed; two large, projected conical temporal scales dorsal to tympanum, the dorsal one in contact with the supratemporal crest, and the ventral one in contact with an enlarged pretympanic scale; 14 superciliares; four canthals; three postrostrals; 12 (left or right) supralabials counted to a point right below middle of eye; rostral (2.27 × 1.27 mm) slightly wider than adjacent supralabials; single longitudinal row of lorilabials between suboculars and supralabials at level of middle of eye, two longitudinal rows of lorilabials immediately anterior to this point; loreal region broken into small, multicarinate, and juxtaposed scales; nasal at level of supralabials III–IV; 11 (left) or 10 (right) infralabials counted to a point right below middle of eye, respectively; mental (2.47 × 1.89 mm) twice as wide and high as adjacent infralabials; postmentals three; gulars ventrally projected, those immediately anterior to gular fold keeled, mucronate, and imbricate; gular fold complete midventrally, extending dorsally and posteriorly to form antehumeral fold; neck with several longitudinal and oblique folds, and a dorsolateral row of enlarged scales.



**Figure 7.** Holotype of *Enyalioides binzayedii* sp. n. (CORBIDI 08828, adult male, SVL = 118 mm). Top: lateral view; middle: close-up of head; bottom: ventral view. Photographs by P.J. Venegas.

Vertebral crest strongly projected and decreasing in size posteriorly, with vertebrals on neck at least four times higher than those between hind limbs; crest bifurcates posteriorly and extends onto tail less than  $\frac{1}{4}$  its length; body between fore and hind limbs with dorsolateral crests and without folds; dorsal scales heterogeneous in size, prominently keeled, and subimbricate; scales on flanks more homogeneous in size than dorsals and less than half their size; ventral scales imbricate, keeled, subrectangular, and mucronate; ventrals as large as largest dorsals.

Limb scales keeled and imbricate dorsally and ventrally; most scales on dorsal and posterior aspects of thighs homogeneous in size, less than half the size of scales on anterior and ventral aspects; 19 subdigitals on manual digit IV; 24 subdigitals on pedal digit IV; femoral pores on each side two; tail laterally compressed and gradually decreasing in relative height towards tip; caudal scales strongly keeled and imbricate, slightly increasing in size posteriorly on lateral and dorsal aspects of each vertebral segment; ventral caudals larger than dorsal caudals, with individual autotomic segments three scales long ventrally and four scales long dorsally.

**Color in life of holotype** (Fig. 7). Dorsal and lateral surface of head dark brown or black, with scattered light green scales (especially on the dorsal surface) and a dark longitudinal supratemporal stripe; supralabials greenish white intercalated with dark brown, infralabials greenish white; rostral and mental light green; gulars white, with greenish-white margins; skin between gulars dark gray; dorsal background of body, limbs, and tail light green, with a dark brown reticulation; a white blotch posterior to tympanum followed by five diffuse pale brown dorsolateral blotches extending from the neck to the base of the tail; ventral surface of body, limbs, and tail white, with a longitudinal row of 4–5 dark gray squarish marks between flanks and venter; iris coppery with a fine brown reticulation; pupil round with pale green margin.

**Intraspecific variation.** Meristic and morphometric characters of *Enyalioides binzayedii* are summarized in Table 1. The holotype is the only adult male specimen available; it differs from female and subadult male paratypes in having projecting scales on each side of the vertebral crest on the neck. Additionally, female paratypes CORBIDI 08789 and 09216 are unique in having a double vertebral crest from midbody to pelvic region.

A subadult male specimen (CORBIDI 09215; Fig. 8) differs from the holotype in having scattered black spots on the ventral surface of body. All females differ from the holotype in having dorsal, broad transverse bars arranged longitudinally along the vertebral line, larger dark marks on the ventrolateral surface of body, and well defined postocular and supratemporal stripes. Dorsal background of body, limbs, and tail can be dark greenish brown (CORBIDI 08827 and 08787), as in the holotype, dark green (CORBIDI 08789), or dark brown (CORBIDI 08788) speckled with light green flecks. Females CORBIDI 08787 and 08827 have light dorsolateral blotches intercalating with dark transverse bars, which are well defined dorsolaterally and diffuse laterally (Fig. 9). Female paratypes CORBIDI 08789 and 09216 have a pale blotch behind the tympanum similar to the holotype, whereas CORBIDI 08787, 08827, and 08788 have a larger pale blotch connected to first pale dorsolateral blotch forming a continuous posttympanic stripe extending from the tympanum to the scapular region. Ventrally females are white (CORBIDI 08788; Fig.

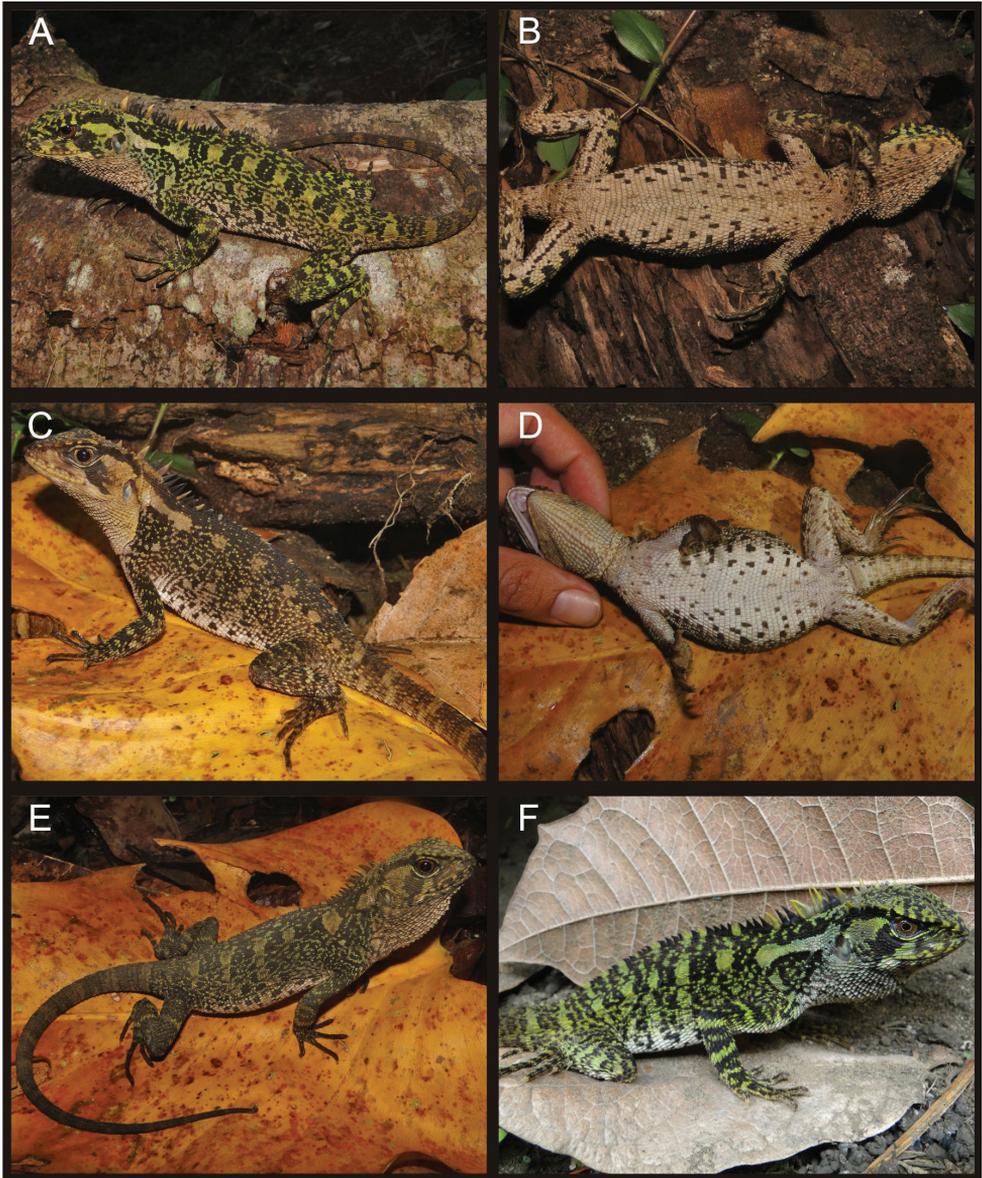
**Table 1.** Summary of counts and measurements (mm) for *Enyalioides azulae* and *E. binzayedii*. Range (first line) and mean  $\pm$  standard deviation (second line) are given. Sample size is given in parentheses if different from that in the column heading.

Character	<i>E. azulae</i> <i>n</i> = 8	<i>E. binzayedii</i> <i>n</i> = 7
Vertebrae from occiput to base of tail	62–69 65.88 $\pm$ 2.70	40–55 48.00 $\pm$ 5.51
Dorsals in transverse row between dorsolateral crests at midbody	37–47 41.63 $\pm$ 3.20	22–31 27.57 $\pm$ 3.64
Ventrals in transverse row at midbody	27–33 28.75 $\pm$ 1.91	26–32 28.14 $\pm$ 2.12
Transverse rows of ventrals between fore and hind limb	36–44 40.38 $\pm$ 2.45	30–39 35.29 $\pm$ 2.81
Gulars	45–57 51.13 $\pm$ 4.05	27–31 29.14 $\pm$ 1.77
Infralabials	10–13 11.38 $\pm$ 1.30	10–14 11.29 $\pm$ 1.50
Supralabials	10–14 11.75 $\pm$ 1.28	11–15 12.00 $\pm$ 1.41
Canthals	4–6 4.63 $\pm$ 0.74	4–6 4.43 $\pm$ 0.79
Superciliaries	12–18 15.38 $\pm$ 2.07	13–14 13.57 $\pm$ 0.53
Subdigitals Manual Digit IV	15–22 19.25 $\pm$ 1.98	17–22 19.86 $\pm$ 1.68
Subdigitals Pedal Digit IV	25–28 26.50 $\pm$ 1.07	24–30 27.14 $\pm$ 2.48
Femoral pores in males	1 ( <i>n</i> = 4) —	1–2 ( <i>n</i> = 2) —
Femoral pores in females	1–2 ( <i>n</i> = 4) 1.13 $\pm$ 0.35	1–3 ( <i>n</i> = 5) 2.20 $\pm$ 0.79
Head length/head width	1.23–1.32 ( <i>n</i> = 4) 1.26 $\pm$ 0.04	1.21–1.41 1.26 $\pm$ 0.07
Head width/head height	1.15–1.27 ( <i>n</i> = 4) 1.20 $\pm$ 0.05	1.04–1.16 1.10 $\pm$ 0.05
Rostral width/rostral height	1.55–2.22 ( <i>n</i> = 4) 1.79 $\pm$ 0.30	1.51–2.56 1.79 $\pm$ 0.36
Mental width/mental height	1.18–1.64 ( <i>n</i> = 4) 1.41 $\pm$ 0.21	1.20–1.63 1.40 $\pm$ 0.17
Fore limb length/SVL	0.49–0.53 ( <i>n</i> = 4) 0.51 $\pm$ 0.02	0.47–0.53 0.52 $\pm$ 0.02
Hind limb length/SVL	0.75–0.84 ( <i>n</i> = 4) 0.80 $\pm$ 0.04	0.69–0.80 0.75 $\pm$ 0.04
Tail length/total length	0.57–0.59 ( <i>n</i> = 5) 0.58 $\pm$ 0.01	0.56–0.60 0.58 $\pm$ 0.02
Maximum SVL (mm) males	96 ( <i>n</i> = 4)	118 ( <i>n</i> = 2)
Maximum SVL (mm) females	96 ( <i>n</i> = 4)	122 ( <i>n</i> = 5)

9D) or tan (CORBIDI 08787, 08789; Fig. 9B) with scattered dark brown spots or flecks. The throat in females is brown or light brown with dark flecks or diffuse reticulations, except one female (CORBIDI 08789), which has an immaculate tan throat.

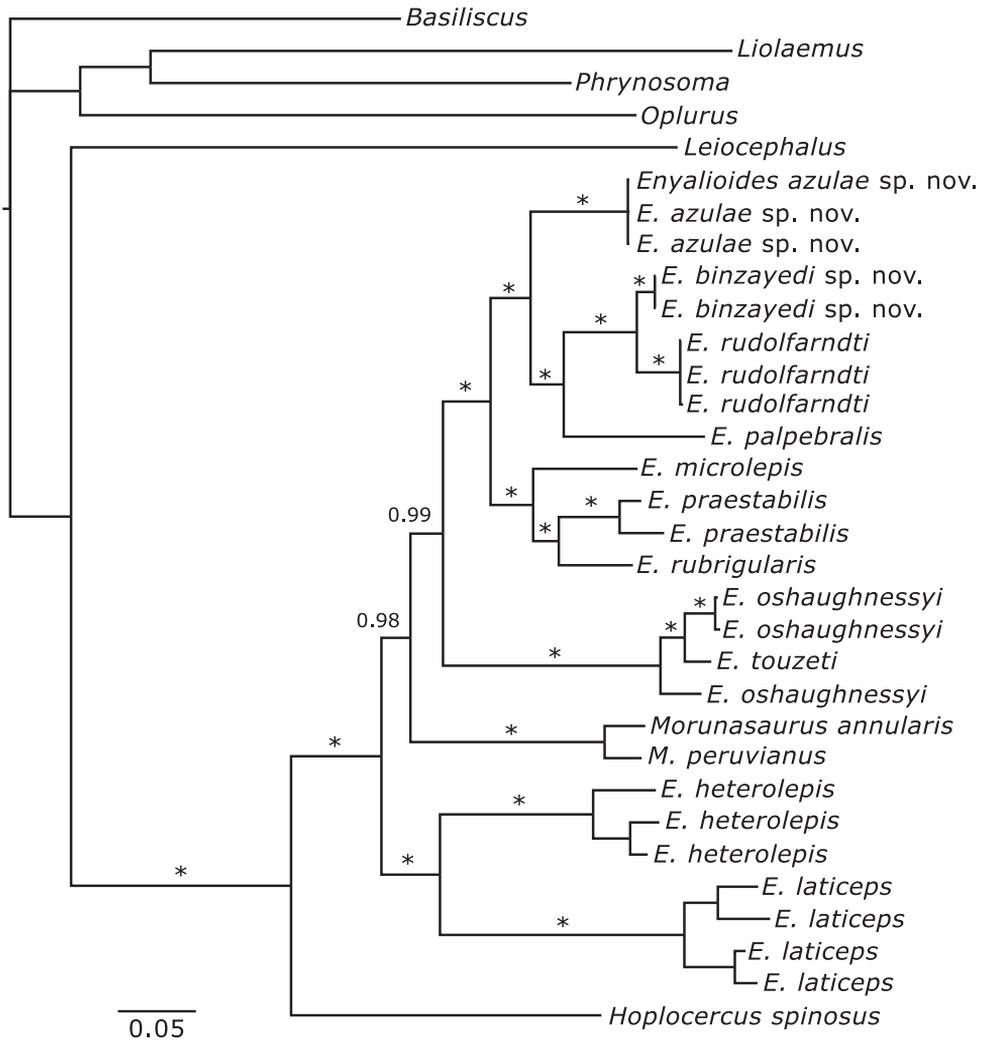


**Figure 8.** Juvenile male of *Enyalioides binzayedii* sp. n. (CORBIDI 09215). Top: lateral view; bottom: ventral view. Photographs by P.J. Venegas.



**Figure 9.** Four adult females of *Enyalioides binzayedi* sp. n. (**A, B** CORBIDI 08787 **C, D** CORBIDI 08788 **E** CORBIDI 08789 **F** CORBIDI 08827). Photographs by P.J. Venegas.

**Distribution and natural history.** *Enyalioides binzayedi* is known only from its type locality in the montane rainforest of the Río Huallaga basin (Fig. 6) in northeastern Peru at an elevation of 1080 m. This locality lies within the CAZNP, in a mountain ridge between the Región San Martín and Región Loreto (Fig. 5). All individuals reported here were collected at night sleeping on vertical stems of bushes 30–230



**Figure 10.** Maximum clade credibility tree of hoplocercine lizards based on a Bayesian analysis of mtDNA sequences. Posterior probabilities are indicated next to branches, with asterisks denoting values > 0.99.

cm above the ground. One female (CORBIDI 08788) collected on 21 January 2011 had two maturing eggs in each oviduct. *E. binzayedii* occurs in sympatry and possibly syntopy with *Enyalioides azulae* sp. n. (see above) and *E. laticeps*. Other species of squamate reptiles collected in the same locality include *Alopoglossus angulatus*, *Anolis fuscoauratus*, *A. transversalis*, *Cercosaura manicata*, *Potamites ecleopus*, *P. strangulatus*, *Potamites* sp., *Chironius fuscus*, *Dipsas indica*, *Imantodes cenchoa*, *I. lentiferus*, *Micrurus obscurus*, *Oxyrhopus petola*, and *Xenopholis scalaris*.

**Etymology.** The specific name is a noun in the genitive case and is a patronym honoring Sheikh Mohamed bin Zayed Al Nahyan, Crown Prince of Abu Dhabi and

Deputy Supreme Commander of the UAE, who created the Mohamed bin Zayed Species Conservation Fund (MBZSCF) to support species conservation projects around the globe. Field surveys leading to the discovery of the two species reported on in this paper were supported by a grant from the MBZSCF.

**Phylogenetic relationships**

Using a phylogenetic definition (de Queiroz and Gauthier 1990, 1992), Torres-Carvajal and de Queiroz (2009) applied the name *Enyalioides* to the crown clade originating in the most recent common ancestor of *Enyalioides cofanorum* Duellman 1973, *E. heterolepis* (Bocourt 1874), *E. laticeps* (Guichenot 1855), *E. microlepis* (O’Shaughnessy 1881), *E. oshaughnessyi* (Boulenger 1881), *E. palpebralis* (Boulenger 1883), *E. praestabilis* (O’Shaughnessy 1881), and *E. touzeti* Torres-Carvajal et al. 2008. The phylogenetic tree inferred in this study (Fig. 10) is consistent with Torres-Carvajal and de Queiroz’s (2009) phylogenetic hypothesis in that species of *Enyalioides* are split into two primary subclades. One contains *E. heterolepis* and *E. laticeps* as sister taxa, and the other includes all remaining species of *Enyalioides*, as well as possibly *Morunasaurus*. *Enyalioides azulae* sp. n. is sister to the clade (*E. palpebralis*, (*E. binzayedii* sp. n., *E. rudolfarndti*)) with strong support (PP = 1.00), whereas *E. binzayedii* sp. n. is sister to *E. rudolfarndti* with strong support (PP = 1.00). Both species reported on in this paper, as well as *E. rudolfarndti*, are strongly supported (PP = 1.00) as monophyletic groups (Fig. 10). Thus, the phylogenetic tree presented here strongly supports both referral of the new species to *Enyalioides* and their status as different species from those recognized previously, except that the divergence between *E. binzayedii* and *E. rudolfarndti* is less than that observed within some currently recognized species (*E. heterolepis* and *E. laticeps*), which is at least partly attributable to the geographic separation of the samples. Differences in morphology and color patterns presented above provide additional evidence for recognizing *E. binzayedii* sp. n. and *E. rudolfarndti* as separate species.

**Key to the species of Hoplocercinae**

The following key is artificial in the sense that its structure does not necessarily reflect the order of branching in the phylogeny.

- 1 Dorsal head scales flat, smooth, juxtaposed; vertebral crest absent or composed of a discontinuous row of enlarged scales that are longer than tall ..... **2**
- Dorsal head scales conical; vertebral crest present, composed by projecting scales that are taller than long ..... **5**
- 2 Tail depressed, short (tail length < snout-vent length), with enlarged spiny scales dorsally and laterally ..... ***Hoplocercus spinosus***
- Tail nearly round, moderate (tail length > snout-vent length), with rings of enlarged spiny scales ..... **3**

- 3 Vertebral region of trunk without enlarged scales; tail with three scale rows separating the spiny whorls ventrally.....***Morunasaurus groi***
- Some vertebral scales in trunk region enlarged forming a discontinuous longitudinal row; tail with two scale rows separating the spiny whorls ventrally ....4
- 4 Usually two femoral pores on each leg; two postmentals; females without streaks on throat .....***M. annularis***
- Femoral pores 3–4 on each leg; usually four postmentals; females with dark streaks on throat ..... ***M. peruvianus***
- 5 Caudal scales homogeneous in size within each autotomic segment...***E. laticeps***
- Caudal scales increase in size posteriorly within each autotomic segment .... 6
- 6 Laterally projecting superciliary flap present; vertebral crest usually discontinuous (absent on posterior part of neck).....***E. palpebralis***
- Laterally projecting superciliary flap absent; vertebral crest continuous .....7
- 7 Scattered, projecting, tetrahedral large scales on dorsum, flanks, and hind limbs present ..... ***E. heterolepis***
- Scattered, projecting, tetrahedral large scales on dorsum, flanks, and hind limbs absent..... 8
- 8 Ventrals smooth or slightly keeled ..... 9
- Ventrals conspicuously keeled..... 10
- 9 Gulars in males cream or yellow without black margins; usually one femoral pore on each leg.....***E. praestabilis***
- Gulars in males bright orange or red, with black margins; usually two femoral pores on each leg.....***E. rubrigularis***
- 10 Dorsals heterogeneous in size, with scattered, tetrahedral, projecting scales (sometimes absent in males or juveniles); dorsolateral crests well developed between hind limbs..... ***E. cofanorum***
- Dorsals homogeneous in size, without projecting scales; dorsolateral crests inconspicuous or absent between hind limbs ..... 11
- 11 Dorsals smooth or slightly keeled; iris bright red in adult males; dark gular patch, if present, restricted to gular fold in males ..... ***E. oshaughnessyi***
- Dorsals conspicuously keeled, iris grey, reddish brown or copper in adult males; dark gular patch, if present, covering gular region in males ..... 12
- 12 Dorsals in transverse row between dorsolateral crests at midbody 31 or fewer..... 13
- Dorsals in transverse row between dorsolateral crests at midbody more than 31 ..... 14
- 13 Scales along the lateral edge of the skull roof strongly projected; dorsal scales homogeneous in size, with prominent median keel; antehumeral orange blotch in adult males absent.....***E. binzayedii***
- Scales along the lateral edge of the skull roof slightly projected; dorsal scales heterogeneous in size, without prominent median keel; distinct antehumeral orange blotch in adult males ..... ***E. rudolfarndti***

- 14 White or cream spot posterior to tympanum usually present; 41–54 (mean =  $45.96 \pm 3.49$ ) dorsals in transverse row between dorsolateral crests at mid-body; gular background in adult males light blue..... *E. microlepis*
- White or cream spot posterior to tympanum absent; 37–47 (means =  $41.63 \pm 3.20$  in *E. azulae*,  $40.50 \pm 1.90$  in *E. touzeti*) dorsals in transverse row between dorsolateral crests at midbody; gular background in adult males cream or black..... **15**
- 15 Vertebral scales in neck region in adult males similar in size as vertebrales in pelvic region; 45–57 (mean =  $51.13 \pm 4.05$ ) gulars ..... *E. azulae*
- Vertebral scales in neck region in adult males more than twice as high as vertebrales in pelvic region; 42–48 (mean =  $44.40 \pm 2.22$ ) gulars ..... *E. touzeti*

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## Appendix I

### Specimens examined

- Enyalioides cofanorum*.-ECUADOR: *Orellana*: Vía Pompeya-Iro, 66 Km from Pompeya, QCAZ 08035; *Sucumbíos*: La Selva lodge, 0°24'0"S, 76°39'0"W, QCAZ 03953, 03521.
- Enyalioides microlepis*.-PERÚ: *Loreto*: Pozo Runtusapa, MUSM 22264; Datem del Marañón; Andoas, 3°42'15.6"S, 77°18'46.2"W, 273 m, CORBIDI 01506, 01575; Capahuari Norte, 02°39'51.3"S, 76°30'4.42"W, 270 m, CORBIDI 04804; San Jacinto 02°19'51.0"S, 75°51'49.3", 160 m, CORBIDI 05120.
- Enyalioides palpebralis*.-PERÚ: *Cusco*: Camisea, 11°35'0"S, 72°57'0"W, 431 m, MUSM 14661; Echarate, 12°50'0"S, 72°39'0"W, 1133 m, MUSM 24663, 26114; 12°34'1.30"S, 73°5'24.9"W, 1300 m, CORBIDI 06042; La Convención 12°11'18.7"S, 73°00'3.31"W, 725 m, CORBIDI 06646, 06752, 06756, 08347; *Loreto*; Requena; Sierra del Divisor, 6°55'7.4"S, 73°50'46"W, 205 m, CORBIDI 02298.
- Enyalioides rudolfarndti*.-PERÚ: *Pasco*: Huampal 10°11'03"S, 75°34'27"W, 1050 m (Parque Nacional Yanachaga-Chemillen), CORBIDI 07209 (holotype), CORBIDI 07210, 07213, 07212 (paratypes).

# Alien molluscan species established along the Italian shores: an update, with discussions on some Mediterranean “alien species” categories

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## Abstract

The state of knowledge of the alien marine Mollusca in Italy is reviewed and updated. *Littorina saxatilis* (Olivi, 1792), *Polycera hedgpethi* Er. Marcus, 1964 and *Haminoea japonica* Pilsbry, 1895 are here considered as established on the basis of published and unpublished data, and recent records of the latter considerably expand its known Mediterranean range to the Tyrrhenian Sea. COI sequences obtained indicate that a comprehensive survey of additional European localities is needed to elucidate the dispersal pathways of *H. japonica*. Recent records and interpretation of several molluscan taxa as alien are discussed both in light of new Mediterranean (published and unpublished) records and of four categories previously excluded from alien species lists. Within this framework, ten taxa are no longer considered as alien species, or their records from Italy are refuted. Furthermore, *Trochocochlea castriotae* Bellini, 1903 is considered a new synonym for *Gibbula albida* (Gmelin, 1791). Data provided here leave unchanged as 35 the number of alien molluscan taxa recorded from Italy as well as the percentage of the most plausible vectors of introduction, but raise to 22 the number of established species along the Italian shores during the 2005–2010 period, and backdate to 1792 the first introduction of an alien molluscan species (*L. saxatilis*) to the Italian shores.

## Keywords

Alien Mollusca, natural entries, translocations, state of knowledge, Italy

## Introduction

Although marine invasions have been well documented all over the world, they are particularly conspicuous in the Mediterranean Sea, mainly due to the high number of vectors of introduction (Galil 2009, 2012; Zenetos et al. 2010, 2012). Moreover, the complex geological history of the region, and the fact that the basin was almost entirely re-colonized naturally by the Atlantic Ocean fauna (Harzhauser et al. 2007) - and this natural interference is still in progress - makes the situation in the Mediterranean even more complex, with the possibility that relatively recent natural dispersals can be interpreted as human-mediated introductions. In this paper we examine some molluscan species from the Mediterranean Sea that appear to be the result of human introductions, with special emphasis on Italy. The previously published state of knowledge of Italian alien molluscan species for the period 2005-2010 (see Crocetta 2011, 2012) is updated based on both molecular data and faunal observations. Additionally, discussions of several taxa belonging to four categories previously excluded by Crocetta (2012) from alien species lists [1- species recorded on the basis of empty shells only; 2- possible cryptogenic or vagrant species (here listed as “Deep-water species, natural dispersers or species with a plausible Atlanto-Mediterranean distribution”); 3- species with a complex/unclear taxonomy; 4- translocations of native Mediterranean species to an area where they previously did not occur], but recently recorded from Italy or included among “Mediterranean aliens” by other authors, are relevant to the entire Mediterranean basin.

## Materials and methods

### Alien species definition and establishment status

The inclusion (or not) of the taxa listed as aliens in the Mediterranean is based on strict accordance to the definition of alien species by the International Union for Conservation of Nature:

‘[non-native, non-indigenous, foreign, exotic] means a species, subspecies, or lower taxon occurring outside of its natural range (past or present) and dispersal potential (i.e., outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes any part, gametes or propagule of such species that might survive and subsequently reproduce.’

Four categories previously excluded (Crocetta 2012), but included by other authors, are discussed. Additionally, an alien species is considered as “established” if, during the surveyed period, at least one self-maintaining population is currently known to occur in the wild (see Crocetta 2012). The definition of cryptogenic species follows Carlton (1996): ‘a species that cannot be included with confidence among native nor among introduced ones.’

## Taxonomy, nomenclature, published and unpublished data collection

A survey of published Mediterranean records of the taxa listed in the present paper was conducted and, where necessary, a full list of synonyms for Mediterranean records is provided. Unpublished records, when available, are listed under each species and come from the examination of preserved specimens, photographs and personal observations obtained from different research projects conducted in several sites along the Italian coasts. Updated taxonomy and nomenclature used follow WoRMS (World Register of Marine Species: last accessed 30 January 2013), unless clearly specified [see *Gibbula albida* (Gmelin, 1791) for the new synonymy proposed].

## DNA extraction, PCR sequencing and data analysis

A total of 8 specimens of *Haminoea japonica* Pilsbry, 1895 from two populations in Italy (Lago Fusaro and Lago di Sabaudia) were sequenced for the cytochrome c oxidase I (COI) mitochondrial gene, following methods used in Hanson et al. (2013). Specimens were preserved in 99.8% ethyl alcohol. DNA was extracted from a small foot sample using a hot Chelex<sup>®</sup> protocol, then amplified by polymerase chain reaction (PCR) using the HCO2198/LCO1490 universal primers for COI (Folmer et al. 1994). PCRs were performed in a 50  $\mu$ L reaction volume containing 0.25  $\mu$ L 5U/ $\mu$ L taq polymerase, 5.00  $\mu$ L 10x buffer, 5.00  $\mu$ L 25 mM MgCl<sub>2</sub>, 1.00  $\mu$ L 40 mM dNTPs, 1.00  $\mu$ L each 10 mM primer, 34.75  $\mu$ L H<sub>2</sub>O, and 2.00  $\mu$ L extracted DNA. Reaction conditions involved an initial denaturation of 95°C for 3 min, 35 cycles of 94°C for 45 s, 45°C for 45 s, and 72°C for 2 min, followed by a final elongation step of 72°C for 10 min. PCR products were run on gel electrophoresis to confirm the presence of DNA fragments of appropriate size (700 bp), and positive products were cleaned using Montage PCR Cleanup Kit (Millipore). The DNA concentration of purified samples was then determined using a NanoDrop 1000 spectrophotometer (Thermo Scientific). Sequencing was outsourced to the City of Hope DNA Sequencing Laboratory (Duarte, California, USA) using sequencing buffer BigDye V3.1. Sequences were assembled and edited using the software GENEIOUS PRO 4.7.4 (Biomatters Ltd.). Geneious also was used to extract the consensus sequences and to align the sequences using the default parameters. In order to determine the relationships between the haplotypes found in Lago Fusaro and Lago di Sabaudia and other haplotypes found in the non-native range of *H. japonica*, a haplotype network was constructed using TCS 1.21 (Clement et al. 2000) with a fixed connection limit of 100 steps. Sequence data have been submitted to the GenBank databases with accession numbers JX679598-JX679605. Data for non-Italian haplotypes were obtained from Hanson et al. (2013).

## Results and discussion

### Alien molluscan species established along the Italian shores

In order to verify the presence or absence of alien species, a continuous monitoring effort is necessary. Only field surveys may provide such evidence, and the new records of the two species reported below ensure that they fit well into the category of established species.

#### Family LITTORINIDAE Children, 1834

##### *Littorina saxatilis* (Olivi, 1792)

**Unpublished material examined.** *Italy - Veneto:* Malamocco (45°20.35'N, 12°18.80'E), under and on rocks and in crevices at tidal level. Voucher specimens: 05/2009, approx. 50 sps., *legit* F. Crocetta and F. Favero; 06/2009, approx. 100 sps., *legit* F. Crocetta and F. Favero; 03/2010, approx. 20 sps., *legit* F. Crocetta.

**Remarks.** *Littorina saxatilis* (Olivi, 1792) was originally described from the Venice Lagoon (Italy); its disjunct distribution in the eastern and western Atlantic Ocean, Barents Sea, White Sea and Mediterranean (see Panova et al. 2011) led several authors to discuss whether the northern Adriatic population of this species should be considered a recent anthropogenic introduction from northern Europe or a remnant of an earlier wider distribution in the Mediterranean Sea (see Crocetta 2011 and references therein). Only recently, Panova et al. (2011) have shown that the Italian population is a recent introduction, using sequence data from a fragment of the mitochondrial cytochrome b gene. This taxon is now known from the Gulf of Trieste and the Venice area in Italy; a recent record from Monopoli (de Jong 2006) has been questioned (Crocetta et al. 2008). The previously unpublished records listed above confirm the establishment of this alien species along the Italian shores. In addition, *L. saxatilis* constitutes the earliest confirmed introduction of an alien species to the Mediterranean Sea; this date was considered to be 1865 (Galil 2012), but is here backdated to at least 1792, confirming alien spreading into the Mediterranean Sea even before completion of the Suez Canal in 1869. Paradoxically, the description date also constitutes the date of its first sighting.

#### Family HAMINOEIDAE Pilsbry, 1895

##### *Haminoea japonica* Pilsbry, 1895

Published Mediterranean records

*Haminaea callidegenita* Gibson and Chia, 1989 (sic!) - Alvarez et al. 1993: 59–65 (figures 1–10).

*Haminoea callidegenita* (Gibson & Chia, 1989) - Delongueville and Scaillet 2007: 52–53 (figure 8).

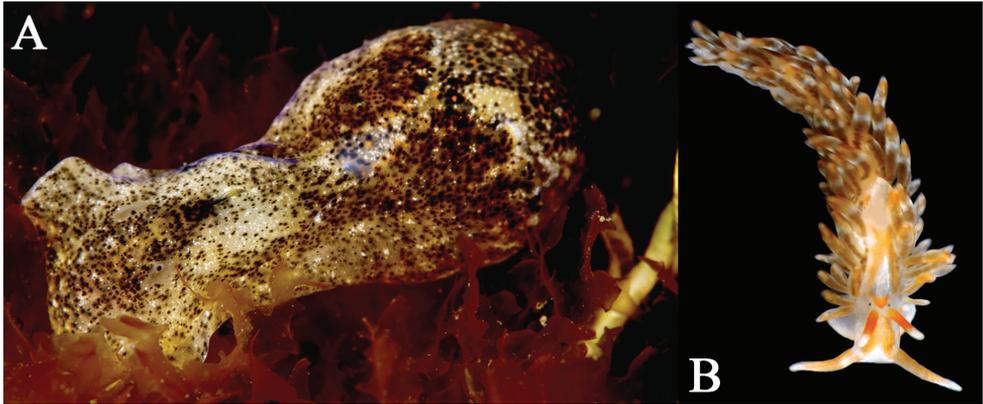
*Haminoea* cf. *japonica* - Cossignani and Ardovini 2011: 375 (figures a, b).

**Unpublished material examined.** *Italy - Latium:* Lago di Sabaudia (S2: 41°17.58'N, 13°1.06'E; S3: 41°17.58'N, 13°1.21'E; S4: 41°16.13'N, 13°2.23'E; S5: 41°15'N, 13°2.33'E), low depth on mud and amidst algae. Very common in the area during observations and samplings held from April 2007 to May 2012 (A. Macali, pers. obs) - Voucher specimens: 29/05/2007, approx. 30 sps. and egg masses, *legit* A. Macali; 05/02/2008, around 50 sps. and egg masses, *legit* A. Macali; 06/05/2008, approx. 50 sps. and egg masses, *legit* A. Macali; 24/11/2009, approx. 50 sps. and egg masses, *legit* A. Macali; 24/05/2010, approx. 100 sps. and egg masses, *legit* A. Macali; 21/04/2012, approx. 100 sps. and egg masses, *legit* A. Macali and C. Smriglio (4 sps. used for molecular analysis - JX679602-JX679605).

*Italy - Campania:* Casina Vanvitelliana, Lago Fusaro (FuI: 40°49.16'N, 14°3.53'E), low depth on mud and amidst algae. Voucher specimens: 27/01/2012, approx. 100 sps. and egg masses, *legit* F. Crocetta; 17/02/2012, 12 sps. and egg masses, *legit* F. Crocetta and G. Villani (Fig. 1A); 25/02/2012, approx. 200 sps. and egg masses, *legit* F. Crocetta (4 sps. used for molecular analysis - JX679598-JX679601); 29/03/2012, approx. 50 sps. and egg masses, *legit* F. Toscano.

**Remarks.** According to Hanson et al. (2013) *Haminoea japonica* Pilsbry, 1895 is native to Japan and Korea. This species has recently spread to the Pacific coast of North America (Gosliner and Behrens 2006; Hanson et al. 2013) as well as into Europe (Atlantic coasts of France and Spain and the Venice-Ravenna area in the northern Adriatic Sea), presumably with imports of bivalves for commercial aquaculture (Cervera et al. 2004; Zenetos et al. 2010; Occhipinti-Ambrogi et al. 2011; Crocetta 2012; Hanson et al. 2013), whilst the record previously reported by Cervera et al. (2004) and Tempelado et al. (2011) from the Straits of Gibraltar is based on a bibliographic misreading of Álvarez Orive (1994) and is not included here. To date, non-native populations of *H. japonica* are known from areas with relatively cold winter water temperatures, and Hanson et al. (2013) suggested the possibility that the potential spread of *H. japonica* to other regions with exotic bivalve aquaculture facilities (such as southern California and the Hawaiian Islands) might be hampered by warm winter temperatures. That would confirm the temporary nature of the populations of this species in the Mediterranean Sea, where it has been considered as not established, the Venice-Ravenna area populations being considered extinct in 2001–2002 (Crocetta 2012).

However, the recently discovered populations from Lago di Sabaudia (Latium, Tyrrhenian Sea) since 2007 and from Lago Fusaro during 2012 (Figure 1A) considerably expand its known Mediterranean distribution to the Tyrrhenian Sea, and suggest that non-native genotypes can become established in areas warmer than previously thought. Sequence data obtained from Italian specimens are similar to those obtained for other specimens found in the non-native range of *H. japonica*: two distinct haplotypes for COI were detected in Italy, H20 and H25 (according to the haplotype nomenclature by Hanson et al. 2013). H20 was found only in Lago di Sabaudia, whereas H25 in both Lago di Sabaudia and Lago Fusaro (Figure 2). Hanson et al. (2013) also found H20 in north-eastern Japan (the source of the non-native populations), the Pacific coast of North America and France, whereas H25 was previously known only from Spain. This



**Figure 1.** A. *Haminoea japonica* Pilsbry, 1895 from Lago Fusaro, 17/02/2012, approx. 15 mm. Photo: Guido Villani. B. *Anteaolidiella foulisi* (Angas, 1864) from Lago di Sabaudia, April 2009, 13 mm. Photo: Paolo Mariottini.

suggests the possibility that *H. japonica* is still spreading and could potentially colonize other areas in the Mediterranean, but it can also suggest that the species is already widespread in the region but remains undetected due to scarcity of faunal studies and experts in opisthobranch taxonomy in areas where mariculture is practiced.

## Discussions on previously excluded categories

### Species recorded on the basis of empty shells only

The durable composition of molluscan shells, primarily made of calcium carbonate, often allow the study of local assemblages without sacrificing living animals, offering reliable data on taxa distributions and the ability to study populations qualitatively. Data obtained from the study of empty shells, however, should always be complemented by a very critical approach, and the three taxa cited below are a good example of this. They have been recorded on the basis of worn empty shells only, found in bioclastic sediments trawled at depths of 400–500 m off Latium in 2007 (Perna 2012; E. Perna, pers. comm.). The presence of three Lessepsian shallow water species in the central Tyrrhenian Sea, at such depths, is indeed puzzling. However, because contamination of the samples cannot be excluded, we hereby prefer to exert caution and exclude them from the alien species list until further findings, including that of living specimens, confirm their presence in Italy.

### Family SCALIOLIDAE Jousseume, 1912

#### *Finella pupoides* A. Adams, 1860

**Remarks.** *Finella pupoides* Adams, 1860 is an Indo-Pacific taxon well established along the eastern Mediterranean shores up to Turkey (Zenetos et al. 2004). A recent record

from Italy, based on a shell sampled in 1999 in the Gulf of Taranto, has never been followed by further records either of shells or living specimens (Trono 2006; Crocetta 2012; D. Trono, pers. comm.). It has been recently recorded from Latium, also on the basis of eight shells (Perna 2012; E. Perna, pers. comm.).

#### **Family CERITHIIDAE Fleming, 1822**

*Clathrofenella ferruginea* (A. Adams, 1860) *sensu* Perna (2012)

**Remarks.** Four empty shells of a taxon belonging to Cerithiidae have been recently recorded for the first time from Italy (off Latium) as *Clathrofenella ferruginea* (A. Adams, 1860) (Perna 2012; E. Perna, pers. comm.). However, these worn specimens may belong to *Cerithidium diplax* (Watson, 1886) (J.J. Van Aartsen, pers. comm.), one of the two Mediterranean Lessepsian immigrants previously misidentified as *C. ferruginea* (see Van Aartsen 2006), but due to the state of the specimens a positive identification is unlikely.

#### **Family VENERIDAE Rafinesque, 1815**

*Timoclea roemeriana* (Issel, 1869) *sensu* Perna (2012)

**Remarks.** Two loose valves of a bivalve belonging the genus *Timoclea* have been recently recorded for the first time from Italy (off Latium) as *Timoclea roemeriana* (Issel, 1869) (Perna 2012; E. Perna, pers. comm.). This is a Lessepsian species recently reported both as *T. marica* (Mienis 2004, Cecalupo et al. 2008, Zenetos et al. 2010) and *T. roemeriana* (Huber 2010), known from the Mediterranean basin only from the deep eastern shores and from Tunisia (see Cecalupo et al. 2008).

#### **Deep-water species, natural dispersers or species with a plausible Atlanto-Mediterranean distribution**

After the complete re-establishment of the Atlanto-Mediterranean connection, dating approximately 5.33 million years ago, no evidence of further closing of the Strait of Gibraltar exists (Loget and Van Den Driessche 2006), and most of the Mediterranean fauna and flora migrated from the Atlantic Ocean throughout the Gibraltar Strait by natural dispersal. Species widespread in the Atlantic Ocean, or originally described from that area but subsequently recorded from the Mediterranean Sea, have often been interpreted as alien species by some authors (see discussions in Galil 2009, 2012). Unless human-induced activity is clearly involved, many of these records are most likely the result of natural dispersal and their inclusion among aliens can only be justified relative to time, with older records labelled as “native.” However, there are major limitations with this approach: i) it is problematic to determine what constitutes an old or a new introduction, as well as developing objective criteria to establish a temporal boundary between them;

ii) it forces researchers to consider biological processes as static, as opposed to the ongoing complex dynamics of populations and ecosystems. Additional biases may be caused by difficulties in the determination of a correct introduction date. Even if it may be relatively straightforward for easy-to-identify, conspicuous, shallow water species, it can be very challenging for pelagic, bathyal or taxonomically difficult species. The five taxa discussed below were recently considered alien species, both deliberately and by mistake.

### **Family CIMIDAE Warén, 1993**

#### ***Cima apicisbelli* Rolán, 2003**

**Remarks.** *Cima apicisbelli* Rolán, 2003 has been recently described from Dakar (Senegal, Atlantic Ocean) on the basis of differences in shell and protoconch sculpture with the closely related *Cima cylindrica* (Jeffreys, 1856) (see Rolán 2003). Its presence in the Mediterranean Sea has been first reported from the Gulf of Valencia (Oliver Baldoví 2007, Cossignani and Ardovini 2011) and then from Acitrezza (eastern Sicily, Italy), where Scuderi and Criscione (2011) interpreted it as an alien species, presumably introduced by the discard of marine market animals. However, Gofas (2011), reporting additional specimens from Andalusia where the species is distributed throughout the region, provided additional data to clarify this issue, or rather to cast doubt on the inclusion of *C. apicisbelli* in the list of alien species. It is, in fact, impossible to determine whether: i) it is native to the Mediterranean Sea and naturally spread into the Atlantic Ocean; ii) it is native of the Atlantic Ocean, but might have an older Atlanto-Mediterranean distribution, overlooked in the Mediterranean Sea until recently due to small size and similarities with other local similar species; or iii) is native of the Atlantic Ocean, but has been introduced into the Mediterranean by human activities. With the available data, *C. apicisbelli* better fits the definition of a cryptogenic species rather than an alien one.

### **Family SEPIOLIDAE Leach, 1817**

#### ***Stoloteuthis leucoptera* (A.E. Verrill, 1878)**

and

### **Family CYCLOTEUTHIDAE Naef, 1923**

#### ***Cycloteuthis sirventi* Joubin, 1919**

**Remarks.** The deep water sepiolid *Stoloteuthis leucoptera* (A.E. Verrill, 1878), described from the Gulf of Maine and then recorded from the eastern Atlantic Ocean and the Mediterranean Sea (Degner 1925; Orsi Relini and Massi 1991; Villanueva and Sánchez 1993), as well as the teuthoid squid *Cycloteuthis sirventi* Joubin, 1919, a taxon described from off Madeira (Joubin 1919), have been recently listed as Mediterranean aliens by

Bello (2011), following the definition of alien species used by Relini (2008) (natural range expansions + human mediated introductions). As a “natural range expansion” in the Mediterranean Sea is more likely than an introduction throughout a human-induced activity, also suggested by Bello (2011), who considered Mediterranean records as “natural range expansion” and “stray specimens,” they are here excluded from alien species.

### Species with a complex/unclear taxonomy

#### Family AEOLIDIIDAE Gray, 1827

#### *Anteaeolidiella foulisi* (Angas, 1864)

Published Mediterranean records

*Aeolidiella takanosimensis* Baba, 1949 (sic!) - Schmekel 1968: 122, 145.

*Aeolidiella orientalis takanosimensis* Bergh, 1888 (sic!) - Schmekel and Portmann 1982: 226-228, 352-352 (figures 3–4), 376-377 (figure 10).

*Aeolidiella indica* Bergh, 1888 - Sammut and Perrone 1998: 232, 237; García-Gómez 2002: 258 (figure 130).

**Unpublished material examined.** *Italy - Latium:* Canale Romano, Lago di Sabaudia (S6: 41°15.03'N, 13°2.35'E; S7: 41°14.9'N, 13°2.35'E), 2.5 m depth under stones. Very common in the area during samplings conducted from April 2009 to September 2011 (Fig. 1B) (A. Macali, pers. obs). Voucher specimens: April 2011: 3 sps. and egg masses, *legit* A. Macali; 16/11/2011: 5 sps. and egg masses, *legit* A. Macali.

*Italy - Campania:* Canale Est di Maremorto di Miseno (40°47.55'N, 14°4.68'E), low depth under stones, 30/09/2011: 5 sps. and egg masses, *legit* G. Villani; 04/10/2011: 29 sps. and egg masses, *legit* G. Villani; 01/01/2012: 6 sps., *legit* G. Villani.

**Remarks.** *Anteaeolidiella foulisi* (Angas, 1864) - senior synonym of *Anteaeolidiella indica* (Bergh, 1888), following Burn (2006) - is found throughout the tropical Indo-West Pacific and as far south as northern New Zealand. However, it also occurs in the Atlantic Ocean (e.g. see Marcus and Marcus 1967) and in the Mediterranean Sea, where it is known on the basis of three records (a total of approx. 10 specimens), supposedly introduced by shipping transport (Zenetos et al. 2004, García-Gómez et al. 2011, Crocetta 2012) or via an unknown vector (Sciberras and Schembri 2007, Occhipinti-Ambrogi et al. 2011).

Records from Maremorto di Miseno (Campania, Tyrrhenian Sea) confirm the presence of this species at the same sampling site after approximately 40 years after the last records from Italy, while those from Lago di Sabaudia (Latium, Tyrrhenian Sea) constitute the first record from the area and the only other known Italian site where the species has been reported. Unpublished Italian records reported here, as well as recent records from the Atlantic Ocean (Domínguez et al. 2008, Padula et al. 2011), cast doubts on its inclusion in the list of alien species. According to Willan and Coleman (1984), the widespread distribution of this species is likely due to shipping introductions, but the intraspecific external colour pattern variation recently noted within its

wide distributional range, as well as extreme differences between egg masses reported from different localities (Nudi-Pixel web-based identification tool: last accessed 30 January 2013) suggest that *A. foulisi* could constitute a complex of several distinct species. Additionally, the striking similarities between Atlantic and Mediterranean animals versus other worldwide populations suggest that Mediterranean specimens may simply belong to a species with a conceivably Atlanto-Mediterranean range.

### **Family CRANCHIIDAE Prosch, 1849**

#### ***Megalocranchia* sp.**

**Remarks.** The genus *Megalocranchia* includes several species widespread all over the world (Voss 1980). The taxon listed here as *Megalocranchia* sp. has been recorded in the Mediterranean Sea only on the basis of a photograph of a single adult specimen, which unfortunately was not preserved, and, therefore, cannot be positively identified (Bello 2011). Despite this, it has been recently listed as a Mediterranean alien by Bello (2011). The possibility that this record actually represents an undescribed Mediterranean species is high (as well as a natural range expansion within the Mediterranean Sea of a yet-to-be-described species), and its inclusion among alien species (whatever definition is used) is entirely speculative.

### **Translocations of native Mediterranean species to an area where they previously did not occur**

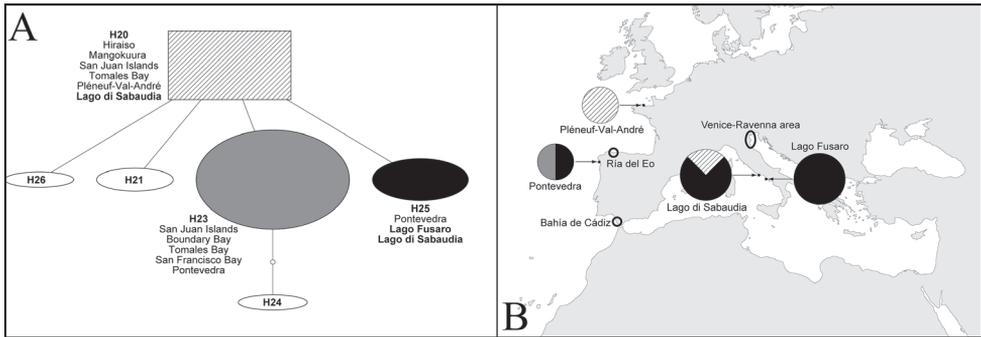
Mediterranean translocations (species introduced from elsewhere within the Mediterranean) have been recently listed as alien species when the introduction event was unmistakable (Zenetos et al. 2010, 2012). With regard to Mediterranean molluscan species, three species were first considered as such by Zenetos et al. (2010): *Siphonaria pectinata* (Linnaeus, 1758), *Gibbula albida* (Gmelin, 1791) and *Echinolittorina punctata* (Gmelin, 1791). These were reduced to two species with the exclusion of *E. punctata* by Zenetos et al. (2012); among these, only *G. albida* is known from Italy.

### **Family TROCHIDAE Rafinesque, 1815**

#### ***Gibbula albida* (Gmelin, 1791)**

( = *Trochocochlea castriotae* Bellini, 1903, new synonym)

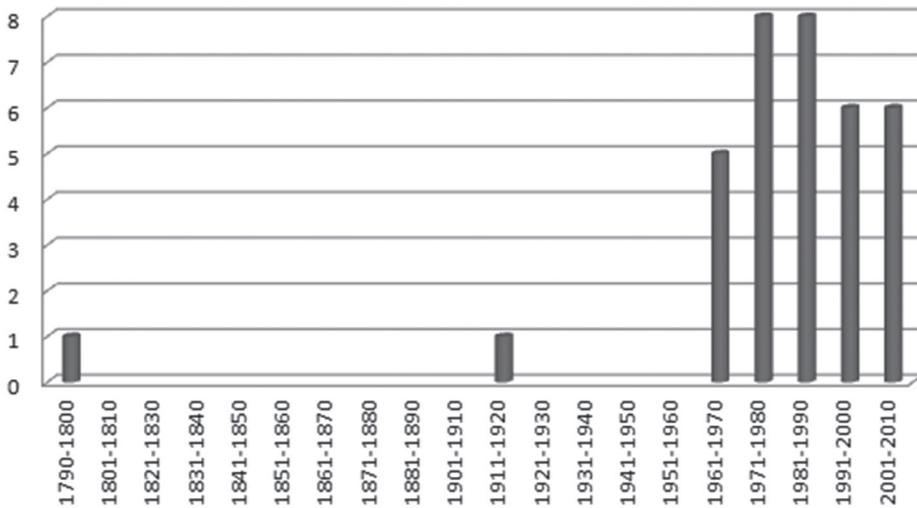
**Remarks.** *Gibbula albida* (Gmelin, 1791) has been considered a native species to the Adriatic Sea, but an alien in the western Mediterranean Sea due to recent introductions into the Ebro Delta (Spain) and the French Mediterranean lagoons (see Zenetos et al. 2010). In Italy, it has been considered a translocated species through aquaculture into Laguna



**Figure 2.** A. Haplotype network of non-native haplotypes of *Haminoea japonica* Pilsbry, 1895 (haplotypes IDs from Hanson et al. 2013). Rectangular haplotype (H20) is most ancestral. Sizes of the haplotype icons are proportional to the total number of individuals sequenced (data from Hanson et al. 2013 and present paper). B. Known European records of *H. japonica*, including new collection localities. Sizes of the pie charts are proportional to the number of individuals sequenced from the locality. Pie charts and patterns within indicate the proportion of different haplotypes found in each locality.

di Caprolace (Italy, Latium, Tyrrhenian Sea) (see Bini 1983), thus suggesting that the western Mediterranean shores may have really been only recently colonized by this species.

This taxon, however, was originally described with no type locality (Gmelin 1791), and has been known for centuries to occur commonly in the Adriatic Sea (e.g. Cantaine 1835 as *Trochus bornii* sp. n., Nardo 1847 as *Trochus clodianus* sp. n.), as suggested by Zenetos et al. (2010). It currently ranges from the Black Sea to the North Atlantic Ocean (whether native or introduced), including several old and recent confirmed sightings from the eastern Mediterranean, as well as fossil records from the area (e.g. Deshayes 1833 as *Trochus magulus* sp. n., Rolán et al. 1985, Tenekides 1989, Bachelet et al. 1990, Delamotte and Vardala-Theodorou 1994, Delemarre and Le Neuthiec 1995, Grossu 1999, Morhange et al. 2000, Demir 2003, Anistratenko 2005, Ateş et al. 2007, Stiner 2010). In addition to early records from the Black Sea area and the deep eastern Mediterranean shores, the presence of this species in the Italian Ionian Sea and several western Mediterranean sites also dates back centuries (e.g.: Leghorn: Philippi 1836 as *Trochus biasoletti* sp. n.; Acì Trezza: Aradas and Benoit 1876; Antibes and Nice: Granger 1884 as *Trochus magulus*). Additionally, the taxon *Trochocochlea castriotae* Bellini, 1903 was described by Bellini (1903) on the basis of abundant live material collected from Maremorto di Miseno (Italy, Campania, Tyrrhenian Sea). Although no type material of this species is known to occur in Museo Zoologico, Centro Museale Università degli Studi di Napoli Federico II (Naples, Italy) (N. Maio, pers. comm.), nor in the Museum of the Stazione Zoologica Anton Dohrn di Napoli (Naples, Italy) (A. Travaglini, pers. comm.), and every attempt to trace it was unsuccessful (F. Crocetta, unpublished data), “the canaliculate suture and turruculated whorls,” as well as the image included in the original description (page 23, figs 3a and 3b), allow us to determine with confidence that *T. castriotae* Bellini, 1903 is a junior synonym of *Gibbula albida* (Gmelin, 1791).



**Figure 3.** The rate of reporting (as number of species per decade) of alien molluscan species from the Italian territorial seawaters.

Although a translocation into the western Mediterranean from the Adriatic is possible, but may have happened earlier than the recent records from France and Spain cited by Zenetos et al. (2010), and taking into account previous reports, we hereby prefer to exclude it from the Italian alien species list. Molecular data is necessary to elucidate whether past and current western Mediterranean distributions of *G. albida* are due to human activities.

## Conclusions

The last decades have seen an ever-increasing worldwide scientific emphasis on biological pollution. Marine alien species feature among the qualitative descriptors of good environmental status in the EU's Marine Strategy Framework Directive. In this view, alien species inventories play important roles in informing regional policy and management decisions, as well as in identifying resource priorities. The scientific community is called upon to pay particular attention to their accuracy and veracity (Galil 2012). A first attempt to monitor alien molluscan species recorded along the Italian shores, based on the examination of fresh material combined with a critical bibliographic review, was only recently conducted (Crocetta 2012: data obtained until 2010), stating the number of confirmed recorded live alien species to be 35 taxa, and the number of established ones 19 taxa. Data presented here leave unchanged the number of alien molluscan taxa recorded from Italy as 35 - one species, *Littorina saxatilis* (Olivi, 1792) is added but one, *Anteaeolidiella foulisi* (Angas, 1864) is removed - as well as the percentage of the most plausible vectors of introduction, but raise to 22 the number of established species along the Italian shores during the 2005–2010 period (60% of

**Table 1.** Alien Mollusca established from the territorial seawaters of Italy during the 2005-2010 period - data after Crocetta (2011, 2012), Keppel et al. (2012) and present paper.

Taxa
<i>Cerithium scabridum</i> Philippi, 1848
<i>Littorina saxatilis</i> (Olivi, 1792)
<i>Rapana venosa</i> (Valenciennes, 1846)
<i>Haminoea cyanomarginata</i> Heller & Thompson, 1983
<i>Haminoea japonica</i> Pilsbry, 1895
<i>Aplysia dactylomela</i> Rang, 1828
<i>Syphonota geographica</i> (Adams & Reeve, 1850)
<i>Bursatella leachii</i> Blainville, 1817
<i>Polycera hedgpethi</i> Er. Marcus, 1964
<i>Melibe viridis</i> (Kelaart, 1858)
<i>Godiva quadricolor</i> (Barnard, 1927)
<i>Anadara transversa</i> (Say, 1822)
<i>Anadara kagoshimensis</i> (Tokunaga, 1906)
<i>Brachidontes pharaonis</i> (P. Fischer, 1870)
<i>Arcuatula senhousia</i> (Benson in Cantor, 1842)
<i>Limnoperna securis</i> (Lamarck, 1819)
<i>Pinctada imbricata radiata</i> (Leach, 1814)
<i>Crassostrea gigas</i> (Thunberg, 1793)
<i>Fulvia fragilis</i> (Forsskål, 1775)
<i>Theora lubrica</i> Gould, 1861
<i>Venerupis philippinarum</i> (Adams & Reeve, 1850)
<i>Mya arenaria</i> Linnaeus, 1758

the confirmed recorded ones), and backdates to at least 1792 the first introduction of an alien molluscan species to the Italian shores (see Table 1 and Figure 3). The establishment and maintenance of a comprehensive network of observatories across the Mediterranean is the only viable mechanism with which to monitor changes in species composition taking place all over the basin. In particular, molluscs are currently known to make the largest contribution to the number of documented alien species in the Mediterranean (31% of approx. 660 species: Galil 2012), but this number is expected to increase due to the constant monitoring by researchers, amateur malacologists and diver-photographers, who can potentially detect the presence of new alien species misidentified as native ones in their databases, samples or private collections. Finally, our knowledge on Mediterranean bioinvasions is likely to increase with the use of molecular tools to elucidate population structures of cryptogenic species and to confirm identifications of taxonomically difficult species.

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# Nomenclatural changes in Cicadellidae: Typhlocybinae and Delphacidae (Homoptera)

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## Abstract

New replacement names are proposed for seven species of the subfamily Typhlocybinae; one new synonym is recognized in the family Delphacidae. The following changes are proposed: *Empoasca* (*Empoasca*) *angustata* **nom. nov.** for *Empoasca angusta* Linnavuori & DeLong (not Dworakowska); *Empoasca* (*Empoasca*) *chilensis* **nom. nov.** for *Empoasca diversa* Linnavuori & DeLong (not Vilbaste); *Austroasca verdensis* **nom. nov.** for *Empoasca artemisiae* Lindberg (not Lethierry); *Kropka vidanoi* Dworakowska for *Erythroneura unipunctata* Dlabola (not Cerutti); *Zyginella vietnamica* **nom. nov.** for *Zyginella melichari* Dworakowska (not Kirkaldy); *Eupteryx* (*Eupteryx*) *dlabolai* **nom. nov.** for *Eupteryx octonotata* Dlabola (not Hardy); *Baaora ahmedi* **nom. nov.** for *Baaora spinosa* (Ahmed) (not Beamer); *Paradelphacodes insolitus* Dmitriev is synonymized with *Paradelphacodes gvosdevi* (Mitjaev), **syn. nov.**

## Keywords

Typhlocybinae, Delphacidae, leafhopper, planthopper, systematics, homonym, synonym

## Introduction

Use of the 3i software package (Dmitriev 2006) helped to reveal several junior homonyms in the leafhopper subfamily Typhlocybinae, which need publication of replacement names. The nomenclatural changes proposed in this paper are necessary to bring

the classification of the subfamily Typhlocybinae into compliance with the International Code of Zoological Nomenclature (ICZN 1999). In addition, a new synonym in the family Delphacidae is recognized.

## Nomenclatural changes and notes

### Family Cicadellidae

#### Subfamily Typhlocybinae

***Empoasca (Empoasca) angustata* nomen novum** for *Empoasca angusta* Linnavuori & DeLong

*E. angusta* Linnavuori & DeLong, 1977:17, described from Chile, is a junior primary homonym of *Empoasca (Buhria) angusta* Dworakowska, 1976:26, described from Cameroon.

Eymology: The original species name in modified spelling is used.

***Empoasca (Empoasca) chilensis* nomen novum** for *Empoasca diversa* Linnavuori & DeLong

*E. diversa* Linnavuori & DeLong, 1977:179, described from Chile, is a junior primary homonym of *Empoasca (Matsumurasca) diversa* Vilbaste, 1968:87, an eastern Palearctic and Oriental species.

Eymology: The species is named for the country, from which it was originally described.

***Austroasca verdensis* nomen novum** for *Empoasca artemisiae* Lindberg

*Austroasca artemisiae* (Lindberg), Dworakowska 1970b: 712

*Empoasca artemisiae* Lindberg, 1958: 208, described from Cape Verde, is a junior primary homonym of *Empoasca artemisiae* Haupt, 1924:294 (= *Austroasca vittata* (Lethierry, 1884:65)), a wide spread Palearctic and Oriental species.

Eymology: The species named for the country of the original description.

***Kropka vidanoi* Dworakowska, 1970a: 619 nomen revived**

= *Erythroneura unipunctata* Dlabola, 1957:119

*E. unipunctata* Dlabola, described from southern Europe, is a junior primary homonym of *E. tithide* var. *unipunctata* Cerutti, 1939:85 (= *Zygina (Zygina) tithide* Ferrari, 1882:159), another European species. Dworakowska (1981) recognized *Kropka vidanoi* Dworakowska as junior synonym of *Kropka unipunctata* (Dlabola). We restore *K. vidanoi* Dworakowska as a valid name for the species.

***Zyginella vietnamica* nomen novum** for *Zyginella melichari* Dworakowska

*Z. melichari* Dworakowska, 1977:24, described from Vietnam, is a junior secondary homonym of *Z. melichari* (Kirkaldy, 1906:315, *Eupteryx*), a species known from Sri Lanka.

Etymology: The species is named for the country, from which it was originally described.

***Eupteryx (Eupteryx) dlabolai* nomen novum** for *Eupteryx (Eupteryx) octonotata* Dlabola

*E. octonotata* Dlabola, 1974:51, described from Iran, is a junior secondary homonym of *E. octonotata* (Hardy, 1850:419, *Typhlocyba*) (= *Eupteryx (Eupteryx) urticae* (Fabricius, 1803: 77)), a wide spread Palaearctic species.

Etymology: The species is named for the author of the replaced name.

***Baaora ahmedi* nomen novum** for *Typhlocyba spinosa* Ahmed

*Baaora spinosa* (Ahmed), Dworakowska, 1982:104

*T. spinosa* Ahmed, 1971:195, described from Pakistan, is a junior primary homonym of *Empoa (Empoa) spinosa* (Beamer, 1943:131, *Typhlocyba*), a wide spread Nearctic species.

Etymology: The species is named for the author of the replaced name.

***Typhlocyba rubrasvulva* var. *bifasciata* Osborn, 1898:12 nom.nud.**

The name is a primary homonym of *Zonocyba bifasciata* (Boheman, 1851:212) (Original genus *Typhlocyba*). However, the name does not need a replacement, since it is not available.

## Family Delphacidae

***Paradelphacodes vosdevi* (Mitjaev, 1980)**

*Chloriona vosdevi* Mitjaev, 1980: 36

*Paradelphacodes vosdevi* Mitjaev, 2002: 104

= *Paradelphacodes insolitus* Dmitriev, 2000: 281 **syn.n.**

Dmitriev (2002) described *Paradelphacodes insolitus* from Southern Russia, not far from the type locality of the *C. vosdevi* Mitjaev in Northern Kazakhstan. In 2002, Mitjaev compared his material to the illustrations of Dmitriev (2000) and transferred *C. vosdevi* Mitjaev to the genus *Paradelphacodes* without formally synonymizing both species. In this paper the synonymy of the two species is confirmed.

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