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Research article

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Four new species of *Alloxysta* (Hym.: Cynipoidea: Figitidae: Charipinae) from Petr Starý's collection

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Abstract. After the revision of Petr Starý's Charipinae collection, four new species of *Alloxysta* Förster, 1869 have been found. This collection represents a good overview of the Charipinae fauna worldwide, although the best represented area is Central Europe. Here, we describe four new species of *Alloxysta*: *A. llumae* Ferrer-Suay sp. nov., *A. onae* Ferrer-Suay sp. nov., *A. poli* Ferrer-Suay sp. nov. and *A. staryi* Ferrer-Suay & Pujade-Villar sp. nov. Three of these new species are based on reared specimens. Diagnosis, distribution, and description of the new species are given and illustrated.

Keywords. Figitidae, Charipinae, *Alloxysta*, new species, description, taxonomy.

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Introduction

Current knowledge of the taxonomy and tritrophic associations of the Aphidiinae Haliday, 1833 (Hymenoptera: Baconidae) worldwide is deeply indebted to the long-term efforts by Petr Starý, a great naturalist and one of the best specialists. The Aphidiinae is a group of parasitoid wasps of aphids with great potential for use in the biological control of these important pests (Petrović 2022). Thanks to his work, including countless field collections, he managed to form a large collection of Charipinae Dalla Torre & Kieffer, 1910 (Hymenoptera: Figitidae), which are hyperparasitoids of aphids via Aphidiinae, their true hosts within aphids (Ferrer-Suay *et al*. 2012a, 2019, 2021).

The study of Charipinae is very important because they could potentially affect aphid biological control programs, manipulating the abundance of parasitoids and modifying their behavior (Sampaio *et al*. 2017). For this reason, the study of the core collections and material previously collected in the field is essential to understand the best way to study the biology and impacts of these species in the field. The Charipinae affect effectiveness of the primary parasitoids and as a result, may increase aphid populations which cause severe yield losses in some of the most important crops (Vázquez-Navarro *et al*. 2016; Zapata *et al*. 2016).

Part of the Charipinae (Hymenoptera: Cynipoidea: Figitidae) collection of Petr Starý was previously revised (Ferrer-Suay *et al*. 2017), 1439 specimens were identified and grouped in 36 species. In the previous work many new trophic associations were published, which is a valuable improvement on the knowledge of the ecological role of this important subfamily. This information was very useful to complete the host list of Charipinae and move forward to future specialization studies based on this subfamily (Ferrer-Suay *et al*. 2014). A review of Charipinae with all the relevant information about this subfamily was recently published by Ferrer-Suay *et al.* (2021).

Thanks to the study of this material four new species have been discovered: *Alloxysta llumae* Ferrer-Suay sp. nov., *Alloxysta poli* Ferrer-Suay sp. nov., *Alloxysta onae* Ferrer-Suay sp. nov. and *Alloxysta staryi* Ferrer-Suay & Pujade-Villar sp. nov. Their diagnoses, descriptions, biology, and illustrative plates are given. The material here described was established as undetermined in the previous work related to Starý's collection (Ferrer-Suay *et al*. 2017).

Material and methods

The main objective was to study the tritrophic associations (plant-aphid-parasitoid), for this reason many specimens were reared in different ecosystems and habitats. All studied material was collected through the following procedures (Petr Starý pers. com.): a piece of aphid-infested plant was gently cut with scissors and transferred into a plastic jar (250–500 cm^3) covered by nylon mesh. The plant was either identified at the spot or taken to an herbarium. Some of the aphids, and even the attending ants, were sampled in 70% ethanol for later identification in the laboratory. The jars were then transferred to the laboratory where they were kept at about room temperature or in a temperature-controlled room under +18–24°C and visited mostly daily to sample the emerged parasitoids. Samples were maintained for about the next two weeks, when the whole sample was re-visited to collect the other (hyper) parasitoids and, eventually, other natural enemies from the litter on the bottom. Each sample was numbered.

Specimens of Charipinae were studied using a stereo microscope (NIKON SMZ-1) and environmental scanning electron microscope (FEI Quanta 200 ESEM) belonging to the scientific technical services of the University of Barcelona. The field-emission gun environmental scanning electron microscope was used for high-resolution imaging without gold-coating of the specimens.

Morphological terms are taken from Paretas-Martínez *et al*. (2007). Measurements and abbreviations include F1–F12, first and subsequent flagellomeres. The width of the fore wing radial cell is measured from the margin of the wing to the beginning of the Rs vein. The transfacial line is measured as the distance between the inner margins of the compound eyes, measured across the face through the antennal sockets divided by the height of the eye. The malar space is measured by the distance from the lower part of the gena from the mouthparts to the ventral margin of the compound eye, divided by the height of the eye. Females and males have the same characters except where indicated.

Type material is deposited in the University of Barcelona collection (UB), Department of Evolutionary Biology, Ecology and Environmental Sciences.

Results

Class Insecta Linnaeus, 1758
Order Hymenoptera Linnaeus, 1758
Suborder Apocrita Latreille, 1810
Superfamily Cynipoidea Billberg, 1820
Family Figitidae Thomson, 1862
Subfamily Charipinae Dalla Torre & Kieffer, 1910
Genus *Alloxysta* Förster, 1869

Alloxysta llumae Ferrer-Suay sp. nov.
urn:lsid:zoobank.org:act:F8118C7C-4796-409D-9629-95AA73D0D325
Fig. 1

Diagnosis

Alloxysta llumae sp. nov. is easily differentiated from all other species of *Alloxysta* by the R1 vein nearly touching Rs. It is morphologically similar to *A. salicicola* Belizin, 1973, but differs, in addition to the alar character mentioned, by the length of flagellomeres (F1 and F2) being longer in *A. salicicola* than in *A. llumae*. Also, the radial cell of *A. saliciola* is bigger (2.6) than in *A. llumae* (2.3).

Etymology

This species is dedicated to the daughter of the first author, Llum Garrido Ferrer.

Material examined

Only known from the holotype female.

Holotype
CZECH REPUBLIC • ♀; near Litoměřice; 24 Jun. 1957; P. Stary leg.; 57-i-287; UB.

Description

Length. Female: 1.4 mm. Male unknown.

Colouration. Head, mesosoma and metasoma brown. Scape, pedicel, F1–F2 dark yellow, F4–F11 yellowish brown. Legs yellow and veins yellowish brown.

Head. Transversally ovate, smooth, and shiny, slightly wider than high in frontal view. Few scattered setae above toruli. Scattered setae on vertex and many setae on face. Transfacial line 1.1 times the height of compound eye. Malar space 0.6 times the height of compound eye.

Antenna. Female: 13-segmented, filiform. All antennomeres covered with sparse setae. F1–F2 smooth and thinner than remaining flagellomeres, F3–F11 with placodeal sensilla and club shaped. Antennal formula: 2.5 (1.9); 4.0 (0.9); 2.8 (1.0); 2.7 (1.1); 3.0 (1.2); 2.7 (1.1), F5–F11 subequal in length, width, and shape (Fig. 1D).

Mesosoma. Pronotum completely covered by scattered setae, with two thin carinae sometimes difficult to see under the pubescence (Fig. 1B). Mesoscutum smooth and shiny, round in dorsal view with few scattered setae. Scutellum smooth and shiny with scattered setae, more abundant on apex of scutellum. Propodeum completely covered by abundant pubescence, without carinae present (Fig. 1C).

Fore wing. Longer than body, 1.4 times as long as mesosoma and metasoma together. Covered with dense pubescence; marginal setae present and very long (Fig. 1A). Partially open radial cell (nearly closed), 2.3 times as long as wide in female. R1 short and curved; Rs long and slightly curved nearly reachn R1 (Fig. 1F).

Metasoma. Anterior part with an incomplete ring of setae, glabrous at centre, wider laterally. Metasoma smooth and shiny, T3 and T4 clearly distinguished.

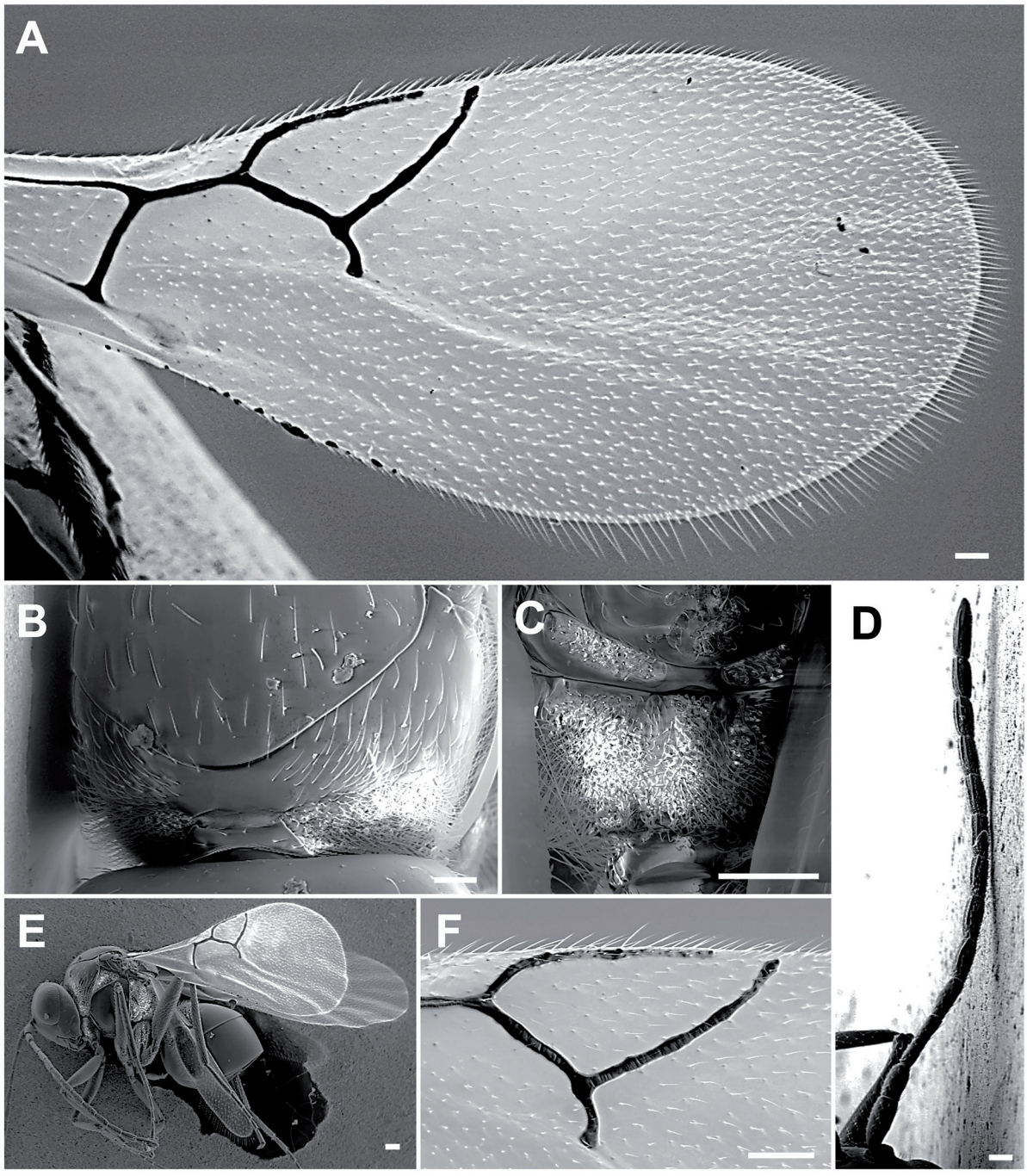

Fig. 1. *Alloxysta llumae* Ferrer-Suay sp. nov., holotype, ♀ (UB). **A**. Fore wing. **B**. Pronotum. **C**. Propodeum. **D**. Antenna. **E**. Body. **F**. Radial cell. Scale bars = 50 μm.

Distribution

Czech Republic (Litoměřice).

Host

Unknown.

Alloxysta onae Ferrer-Suay sp. nov.
urn:lsid:zoobank.org:act:691FD44B-6DDD-4663-BD2B-115F9515FCC8
Fig. 2

Diagnosis

Alloxysta onae sp. nov. is characterized by the partially open radial cell, pronotal carinae absent, propodeal carinae present, forming a plate and antennae with rhinaria beginning in F2 and club shape in F3, female with F1 longer than pedicel and F2, F2 longer than F3 and F3 subequal to F4. It is closely related to *A. longipennis* (Hartig, 1841) but they can be differentiated by the presence of pronotal carinae, absent in *A. onae* while they are present in *A. longipennis*.

Etymology

This species is dedicated to the daughter of the first author, Ona Garrido Ferrer.

Material examined

Known from one male and three females.

Holotype
SLOVAKIA • ♀; Vyšná hora, Čertovice, N Tatry; 22 Jun. 1963; Holman leg.; S*alix caprea*; *Pterocomma salicis*; 63/766; UB.

Paratypes
SLOVAKIA • 2 ♀♀, 1 ♂; same collection data as for holotype; UB.

Description

Length. Female: 1.4–1.7 mm. Male: 1.5 mm.

Colouration. Head, mesosoma and metasoma brown. Antennae yellow darkening towards the end. Legs yellow and veins yellowish brown.

Head. Transversally ovate, smooth, and shiny, slightly wider than high in front view. Setae below and between toruli, few scattered setae above toruli. Scattered setae on vertex and many setae on face. Transfacial line 1.0 times the height of compound eye. Malar space 1.0 times the height of compound eye.

Antenna. Female: 13-segmented, filiform. All antennomeres covered with sparse setae. F1 smooth and thinner than remaining flagellomeres, F2 with few sensilla present and F3–F11 with placodeal sensilla and club shaped. Antennal formula: 3.0 (1.9); 6.5 (1.2); 4.6 (1.5); 4.2 (1.7); 4.1 (2.0); 3.5 (2.1), F5–F11 subequal in length, width, and shape (Fig. 2E). Male: 14-segmented, filiform. All antennomeres covered with sparse setae. F1 smooth and thinner than remaining flagellomeres, F2–F12 with placodeal sensilla and club shaped. F2 with little bump on top side. Antennal formula: 2.8 (1.8); 5.3 (1.2); 4.3 (1.2); 3.8 (1.2); 3.8 (1.4); 3.0 (1.4), F5–F12 subequal in length, width, and shape (Fig. 2D).

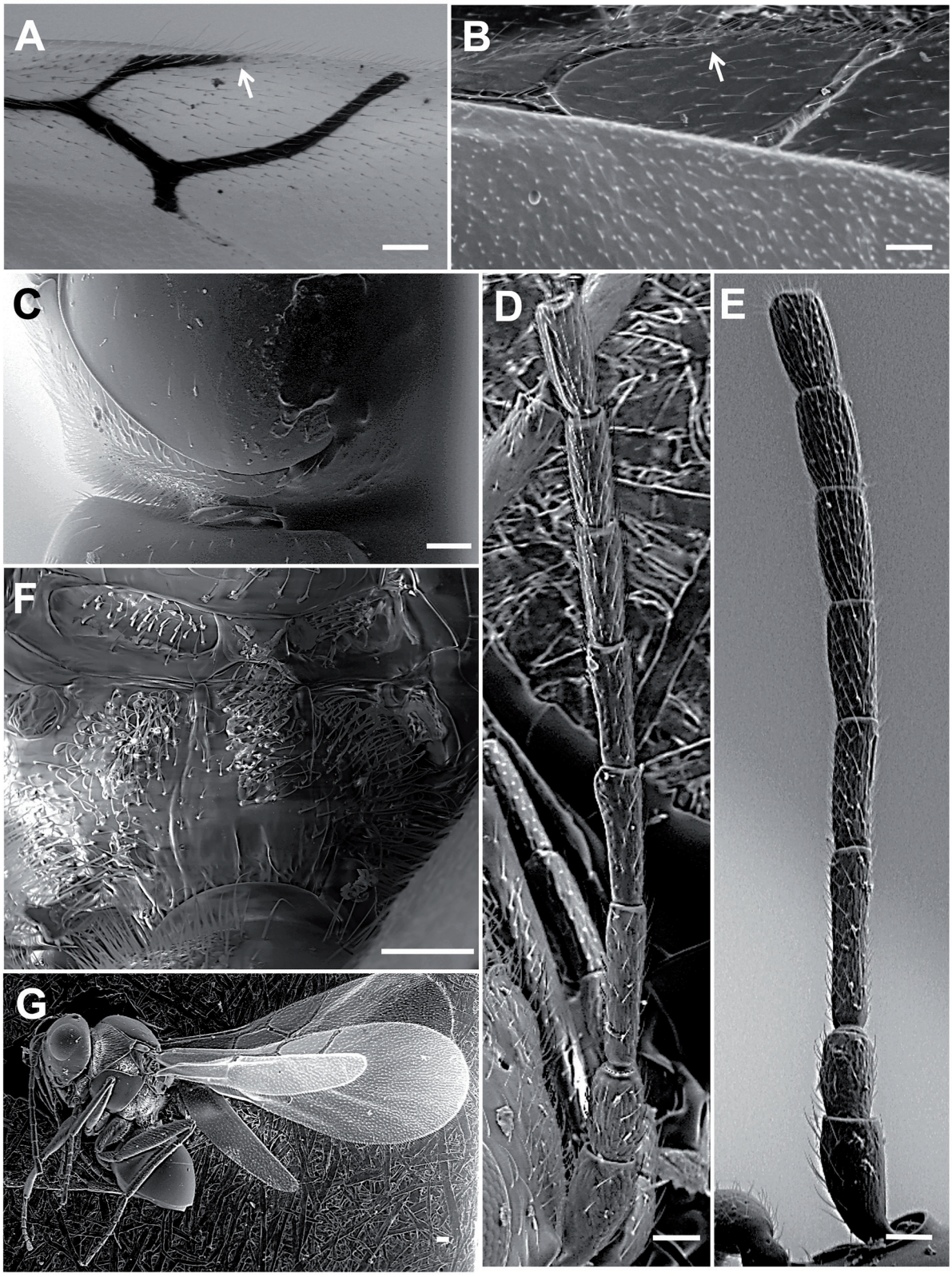

Fig. 2. *Alloxysta onae* Ferrer-Suay sp. nov. **A**. Female radial cell. **B**. Paratype, ♂ (UB), radial cell. **C**. Pronotum. **D**. Paratype, ♂ (UB), antenna. **E**. Female antenna. **F**. Propodeum. **G**. Body. Arrows mark the limit of R1 vein, which determine the partially open radial cell. Scale bars = 50 µm.

Mesosoma. Pronotum nearly completely covered by abundant setae, without carinae (Fig. 2C). Mesoscutum smooth and shiny, round in dorsal view with few scattered setae. Scutellum smooth and shiny with scattered setae, more abundant on apex of scutellum. Propodeum covered by abundant long pubescence, with two carinae joining forming plate, this plate has many setae on first half and curved sides (Fig. 2F).

Fore wing. Longer than body, 1.4 times as long as mesosoma and metasoma together. Covered with dense pubescence; marginal setae present and very long. Partially open radial cell, 3.2 times as long as wide in female (Fig. 2A) and 2.7 times in male (Fig. 2B). R1 short and curved; Rs long and slightly curved.

Metasoma. Anterior part with an incomplete ring of setae, glabrous at centre, wider laterally. Metasoma smooth and shiny, T3 and T4 clearly distinguished.

Distribution

Slovakia (Čertovice, N Tatry).

Host

Emerged from *Pterocomma salicis* (Linnaeus, 1758) (Hemiptera: Aphididae) on *Salix caprea* L. (Salicaceae).

Alloxysta poli Ferrer-Suay sp. nov.
urn:lsid:zoobank.org:act:FD5BACE6-9E86-4FB2-AA01-2C90E9BCF8AC
Fig. 3

Diagnosis

Alloxysta poli sp. nov. is characterized by the presence of pronotal carinae and a propodeal plate, radial cell partially open, 2.3 times as long as wide, rhinaria and club begin on F2, F1 longer than pedicel and subequal to F2, F2 longer than F3. It is closely related to *A. macrophadna* (Hartig, 1841) but they can be differentiated by the short radial cell, 3.0 times as long as wide in *A. macrophadna* while it is 2.3 times as wide in *A. poli*.

Etymology

This species is dedicated to the son of the first author, Pol Garrido Ferrer.

Material examined

Known from seven males and twenty-eight females.

Holotype

CUBA • ♂; La Guirra, Pinar del Río; 30 Mar. 1968; *Psidium guyava*; *Aphis gossypii*; 65/111; UB.

Paratypes

CUBA • 3 ♂♂; same collection data as for holotype; UB.

CZECH REPUBLIC • 18 ♀♀; Zhoř; B. m.; Aug. 1962; Satry; akraj lesa; *Betula*; 62/388; UB • 1 ♂; Ztana; sit.SSR; 16 Jul. 1963; Ruipais; *Betula verrucosa*; 13 chilapis 4- lisurcutate; UB.

SLOVAKIA • 1 ♂; Bct Tatry; 20 Jun. 1974; P. Stary leg.; *Betulaphis* sp.; *Euceraphis* sp.; *Betula*; 74.156; UB • 1 ♂, 10 ♀♀; [handwriting is not understood]; 31 Aug. 1962; *Picea canadensis*; *Liosomaphis abiefinum*; UB.

Description

Length. Female: 0.8–0.9 mm. Male: 0.7–0.9 mm.

Colouration. Head yellowish brown, mesosoma and metasoma brown. Scape, pedicel, F1–F3 dark yellow, F4–F11 yellowish brown. Legs yellow and veins yellowish brown.

Head. Transversally ovate, smooth, and shiny, slightly wider than high in front view. Setae below and between toruli, few scattered setae above toruli. Scattered setae on vertex and many setae on face. Transfacial line 1.2 times the height of compound eye. Malar space 0.3 times the height of compound eye.

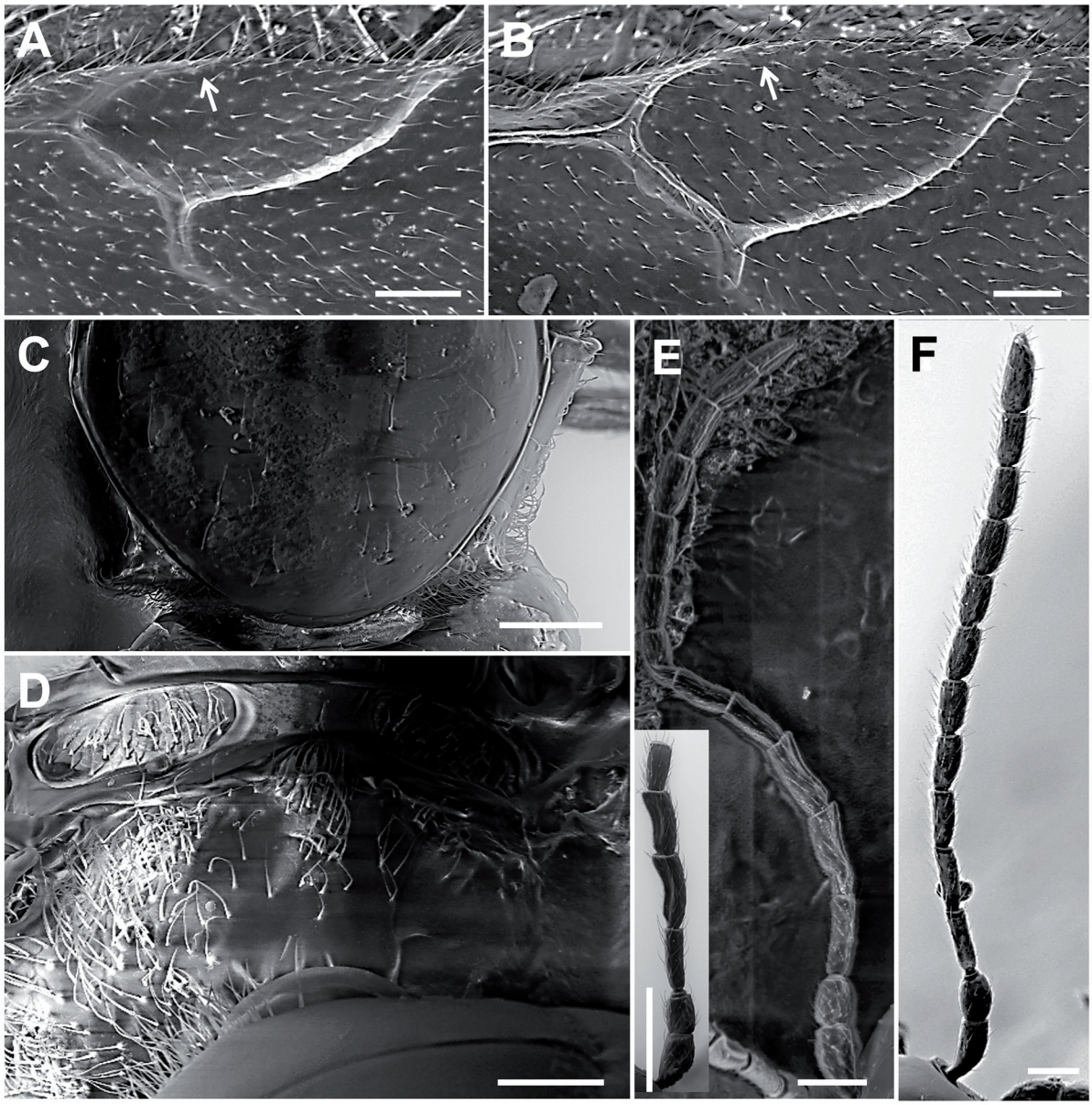

Fig. 3. *Alloxysta poli* Ferrer-Suay sp. nov. **A**. Female radial cell. **B**. Male radial cell. **C**. Pronotum. **D**. Propodeum. **E**. Male antenna. **F**. Female antenna. Arrows mark the limit of R1 vein. Scale bars = 50 μm.

Antenna. Female: 13-segmented, filiform. All antennomeres covered with sparse setae. F1–F3 smooth and thinner than remaining flagellomeres, F4–F11 with placodeal sensilla and club shaped. Antennal formula: 2.0 (1.3); 2.6 (0.7); 2.8 (0.8); 2.5 (0.8); 2.4 (1.0); 2.4 (1.1), F5–F12 subequal in length, width, and shape (Fig. 3F). Male: 14-segmented, filiform. All antennomeres covered with sparse setae. F1 smooth and thinner than remaining flagellomeres, F2–F12 with placodeal sensilla and club shaped, F2 and F3 bowed. Antennal formula: 2.0 (1.5); 3.0 (1.0); 3.5 (1.2); 3.2 (1.2); 2.5 (1.1); 2.5 (1.1), F5-F12 subequal in length, width, and shape (Fig. 3E).

Mesosoma. Pronotum covered by sparse setae, being less in the distolateral corners and abundant in the anterior margins, with two long and think carinae clearly visible (Fig. 3C). Mesoscutum smooth and shiny, round in dorsal view with few scattered setae. Scutellum smooth and shiny with scattered setae, more abundant on apex of scutellum. Propodeum covered by abundant setae, without carinae and without setae where carinae usually present (Fig. 3D).

Fore wing. Longer than body, 1.5 times as long as mesosoma and metasoma together. Covered with dense pubescence; marginal setae present and very long. Partially open radial cell, 2.3 times as long as wide in female paratypes (Fig. 3A), 2.8 times in male, type and paratypes (Fig. 3B). R1 short and curved; Rs long and slightly curved.

Metasoma. Anterior part with an incomplete ring of setae, glabrous at centre, wider laterally. Metasoma smooth and shiny, T3 and T4 clearly distinguished.

Distribution

Pinar del Río (Cuba), Zhoř (Czech Republic) and Tatry (Slovakia).

Host

Emerged from *Aphis gossypii* Glover, 1877 (Hemiptera: Aphididae) on *Psidium guyava* L. (Myrtaceae) and, *Betulaphis* sp. and *Euceraphis* sp. (Hemiptera: Aphididae) on *Betula* L. (Betulaceae).

Alloxysta staryi Ferrer-Suay & Pujade-Villar sp. nov.
urn:lsid:zoobank.org:act:7D3238EA-F499-4FEC-896F-E81A1EF0962B
Fig. 4

Diagnosis

Alloxysta staryi sp. nov. is characterized by the presence of pronotal carinae and propodeal plate, radial cell partially open being 2.3 times as long as wide, rhinaria and club begin on F2, F1 longer than pedicel and subequal to F2, F2 longer than F3. It is similar to *A. melanogaster* (Hartig, 1840) male but they can be differentiated by the beginning of rhinaria and club: F2 in *A. staryi* but F3 in *A. melanogaster*; and the proportion between flagellomeres: F1 longer than pedicel and subequal to F2, F2 longer than F3 in *A. staryi* while pedicel-F3 subequal in length in *A. melanogaster*.

Etymology

This species is named after Petr Starý, collector of the material, and without whom this material would not have been possible to be studied.

Material examined

Known only from one male.

Holotype

CZECH REPUBLIC • ♂; Byšice, Bc; 16 Jun. 1959; Hosman leg.; *Salix* sp.; *Aphis farinosa*; *Aphidius salicis*; 59/132; UB.

Description

Length. Female unknown. Male: 1.0 mm.

Colouration. Head yellow, mesosoma and metasoma brown. Scape, pedicel, F1–F3 dark yellow, F4–F11 yellowish brown. Legs yellow and veins yellowish brown.

Head. Transversally ovate, smooth and shiny, slightly wider than high in front view. Setae below and between toruli, few scattered setae above toruli. Scattered setae on vertex and many setae on face. Transfacial line 0.87 times the height of compound eye. Malar space 0.3 times the height of compound eye.

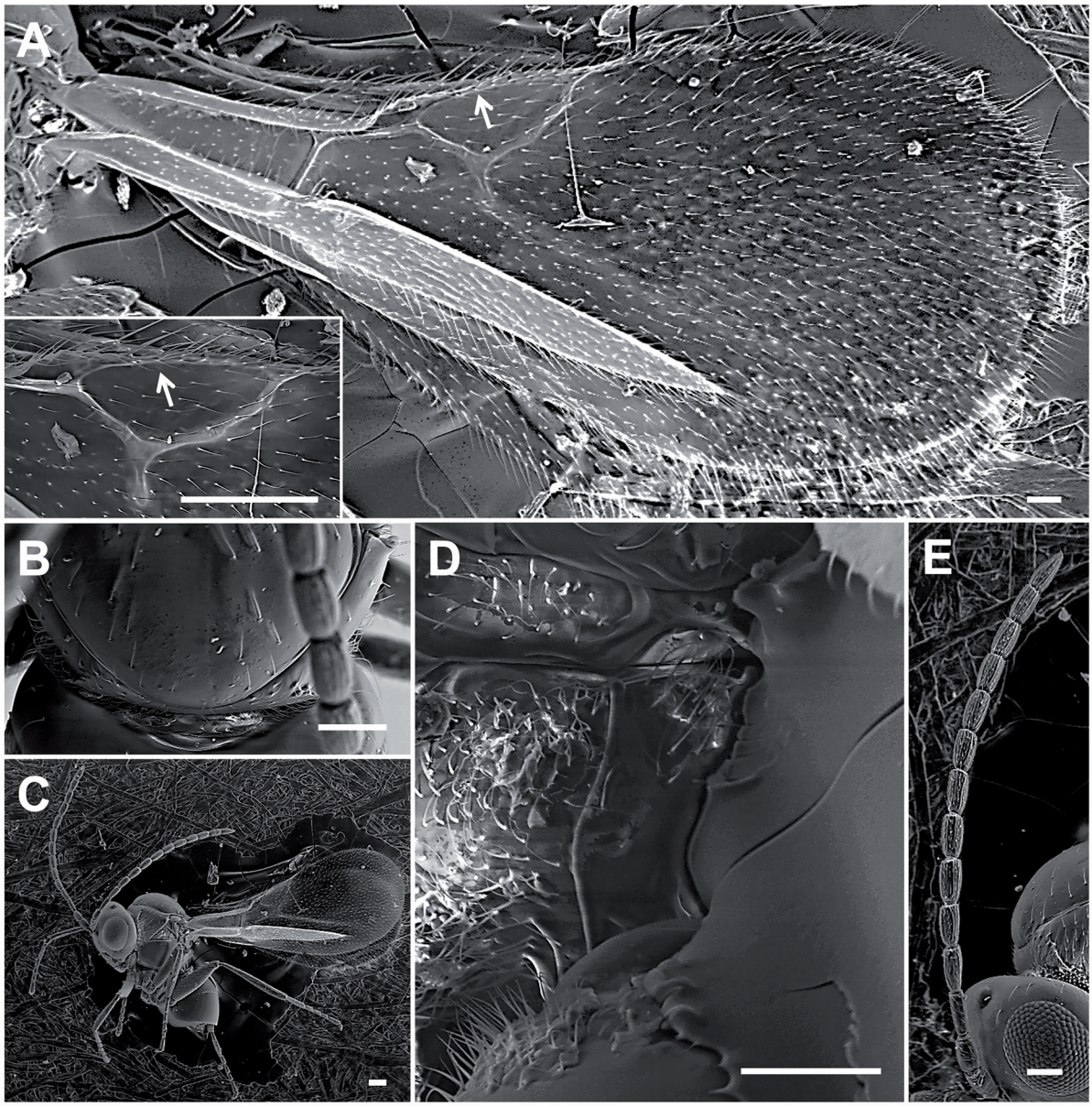

Fig. 4. *Alloxysta staryi* Ferrer-Suay & Pujade-Villar sp. nov., holotype, ♂ (UB). **A**. Fore wing. Inset: detail of radial cell; arrow marks the limit of R1 vein. **B**. Pronotum. **C**. Body. **D**. Propodeum. **E**. Antenna. Scale bars = 50 μm.

Antenna. Male: 14-segmented, filiform. All antennomeres covered with sparse setae. F1 smooth and thinner than remaining flagellomeres, F2–F12 with placodeal sensilla and club shaped. Antennal formula: 2.0 (1.2); 2.5 (0.9); 2.5 (1.1); 2.3 (1.1); 2.5 (4.3); 2.5 (1.3), F5–F12 subequal in length, width, and shape (Fig. 4E). Female unknown.

Mesosoma. Pronotum covered by disperse setae, being less in the distolateral corners and abundant in the anterior margins, with two small carinae present (Fig. 4B). Mesoscutum smooth and shiny, round in dorsal view with few scattered setae. Scutellum smooth and shiny with scattered setae, more abundant on apex of scutellum. Propodeum covered by abundant long pubescence, with protruding plate, this plate has a few setae on first half and curved sides (Fig. 4D).

Fore wing. Longer than body, 1.4 times as long as mesosoma and metasoma together. Covered with dense pubescence; marginal setae present and very long (Fig. 4A). Partially open radial cell, 2.3 times as long as wide. R1 short and curved; Rs long and slightly curved (Fig. 4A).

Metasoma. Anterior part with an incomplete ring of setae, glabrous at centre, wider laterally. Metasoma smooth and shiny, T3 and T4 clearly distinguished.

Distribution

Obec Byšice (Czech Republic).

Host

Emerged from *Aphis farinose* Gmelin, 1790 (Hemiptera: Aphididae) via *Aphidius salicis* Haliday, 1834 (Braconidae: Aphidiidae) on *Salix* L. (Salicaceae).

Discussion

The group of Hymenoptera Parasitica is hyper diverse and there are many species waiting to be discovered. As is well known, the study of entomological collections could give us the opportunity to find new species and in this way improve our knowledge about this subfamily with data about their distribution patterns as well as their host relationships. Especially in Charipinae, there are few data about their trophic relations, most of the material originating from field catches or by Malaise traps. There is also very limited information about the grade of specialization of species of Charipinae; this should be addressed in future work on this subfamily, for example by dedicated rearing efforts, documenting species and their ecology.

Petr Starý collected many specimens, being a specialist of the subfamily Aphidiinae, and usually he collected mummies. Sometimes, instead of Aphidiinae, Charipinae appear, because they are parasitoids of the aphidiines. This collection has around 1500 specimens from around the world; in Ferrer-Suay *et al*. (2017) Central European material was studied, but there is also material collected from other geographical regions (Ferrer-Suay *et al*. in prep.).

Thanks to the study of this collection, we have found four new species of *Alloxysta* here described, three from Czech Republic (*A. llumae* sp. nov., *A. onae* sp. nov. and *A. staryi* sp. nov.) and another from the Czech Republic, Slovakia and Cuba (*Alloxysta poli* sp. nov.).

Although type material is scarce for the new species described from Czech Republic, we have no doubt that they are new species since the distinctive characters are different from any of the *Alloxysta* known species (Ferrer-Suay *et al*. 2018).

Alloxysta poli sp. nov. has a Holarctic distribution having been collected in the Czech Republic and Cuba. It is not uncommon in Charipinae for this to happen, similar cases having been cited in other species,

for example *Phaenoglyphis americana* Baker, 1896 was described from the Nearctic region, and has been cited from the Palaearctic (France and Spain) by Ferrer-Suay *et al*. (2012b, 2015). Globalization, with transport of aphids, and the fact that its host associations are not very specific, can result in a very extensive distribution.

With these species described here, there are now 109 described *Alloxysta* (61 in Europe, 34 in America and 14 on both continents).

The study of the Petr Starý collection has so far provided a multitude of biological data and an extension of the distribution areas of many species of Charipinae (Ferrer-Suay *et al*. 2017). Additionally, with the description of the new species, we are still investigating possible new records from other countries.

Acknowledgements

We are very grateful to Petr Starý, for his careful and continuous work collecting mummies and aphid parasitoids, which provided the scientific community with an important reference collection.

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