

# Two new morphologically interesting species of the genus *Ephedrus* Haliday (Hymenoptera, Braconidae, Aphidiinae)

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## Abstract

Here we describe two new *Ephedrus* species from the Biologiezentrum Linz's collection: *Ephedrus antennalis* **sp. nov.**, which possesses 12-segmented antennae, a unique character within the genus *Ephedrus*; and *E. carinatus* **sp. nov.**, which represents an additional member of the root aphid parasitoid group within the genus *Ephedrus*.

## Keywords

*Ephedrus*, new species, root aphid parasitoids

## Introduction

There are about 40 known species of the genus *Ephedrus* Haliday, 1833 around the world (Akhtar et al. 2011; Kocić et al. 2019). This genus is characterized by the presence of many plesiomorphic characters (e.g., antennae with 11 segments in

both sexes, which is a unique case within the subfamily, a fore wing venation pattern close to the braconid ancestor and long oviposition time), all of which suggest that it is probably one of the basal genera within the subfamily Aphidiinae (Gärdenfors 1986; Belshaw and Quicke 1997; Sanchis et al. 2001). Additionally, black parasitized aphids (“mummies”) are specific for *Ephedrus* and very few other genera (e.g., *Paralipsis* Förster, 1863, some species of *Pauesia* Quilis, 1931). A single species of the genus *Ephedrus*, known as an obligatory parasitoid of root aphids (*Ephedrus validus* (Haliday, 1833)), possesses accompanying adaptations to a subterranean mode of life. This species exhibits features such as small eyes and short and strong legs, along with a densely setose body as a protective trait against the honeydew of waxy root aphids. Interestingly, male specimens are less pubescent, and that character led Gärdenfors (1986) to suspect that males are not in contact with root aphids and that they probably do not follow females beneath the surface of the ground. It is known that *Ephedrus plagiator* (Nees, 1811), which is a broadly polyphagous species, also occasionally parasitizes the root aphids (Stary 1961; Gärdenfors 1986). Furthermore, while European, African and Central Asian populations of *Ephedrus persicae* Froggatt, 1904 are biparental (Takada 1979; Gärdenfors 1986), some Far Eastern, Australian and USA populations possess an asexual mode of reproduction (Stary and Schlinger 1967; Takada 1968; Gärdenfors 1986). Based on relevant literature, it is evident that numerous species from the genus *Ephedrus* possess a range of biologically and ecologically complex features.

Recently, the integrative systematic studies, that combine morphological and molecular methods of the subject group, revealed additional members of the genus *Ephedrus*, i.e. *E. tamaricis* Tomanović & Petrović, 2016 and *E. hyadaphidis* Kocić & Tomanović, 2019 (Petrović et al. 2016; Kocić et al. 2019).

After examination of the Biologiezentrum Linz’s collection, we discovered two *Ephedrus* species new to science with some unusual morphological traits. Here we describe *Ephedrus antennalis* sp. nov. and *E. carinatus* sp. nov. and discuss their relationships within the genus *Ephedrus*.

## Material and methods

Specimens were collected by sweeping from the Western Caucasus (Russia) and from Austria (before World War II – a historical record). Both specimens are slide-mounted with Berlese medium. Study of the external structure and the measurements was undertaken with a LEICA DM LS phase-contrast microscope (Leica Microsystems GmbH, Wetzlar, Germany). The terminology used in this paper regarding diagnostic characters is based on that of Sharkey and Wharton (1997).

## Results

### Description of two new species

#### *Ephedrus antennalis* Tomanović, sp. nov.

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**Diagnosis.** On the basis of fore wing venation (3SR vein shorter than 2SR vein), elongated pterostigma (Fig. 1C), and its short and broad petiole (Fig. 1D), *E. antennalis* sp. nov. belongs to the *persicae* species group (Gärdenfors, 1986). However, the long 12-segmented antennae (Fig. 1A) distinguish the new species from all the members of the *persicae* group, as well as from all other congeneric species.

**Female. Head.** Malar index equal to approximately 0.20 of the longitudinal eye diameter. Clypeus oval with eight long setae. Tentorial index approximately 0.35. Maxillary palps with four, labial palps with two palpomeres. Antennae 12-segmented, filiform, with semierect setae which are shorter than half of the segments' diameter (Fig. 1A). F1 and F2 elongated, 4.25 and 3.6 times as long as wide, respectively (Fig. 1B). F1 subequal to F2. F1 with two, F2 with three (Fig. 1B), F3 and F4 with five longitudinal placodes. Antennae not thickened towards apex, F9 well separated from F10 (whereas in *E. persicae* F8 and F9 are not well separated and form a kind of club).

**Mesosoma.** Mesoscutum with notaulices distinct in anterior half. Mesoscutal fovea not developed. Propodeum areolated, with seven setae on upper areola and five setae on lower areola. *Fore wing.* Pterostigma approximately 5.7 times as long as wide (Fig. 1C). Vein ratio 3SR/2SR about 0.9 (Fig. 1C).

**Metasoma.** Petiole subquadrate, 1.33 times as long as wide (Fig. 1D). Ovipositor sheaths elongated, with two long setae on dorsal margin (Fig. 1E).

**Colouration.** Head light-brown. Mouthparts light-brown. Scape brown, pedicel and F1 yellow to light-brown, remaining parts of antennae brown. Legs brown with light-brown tarsi. Petiole brown, remaining parts of metasoma light-brown to brown. Ovipositor sheath brown.

**Body length.** 1.8 mm.

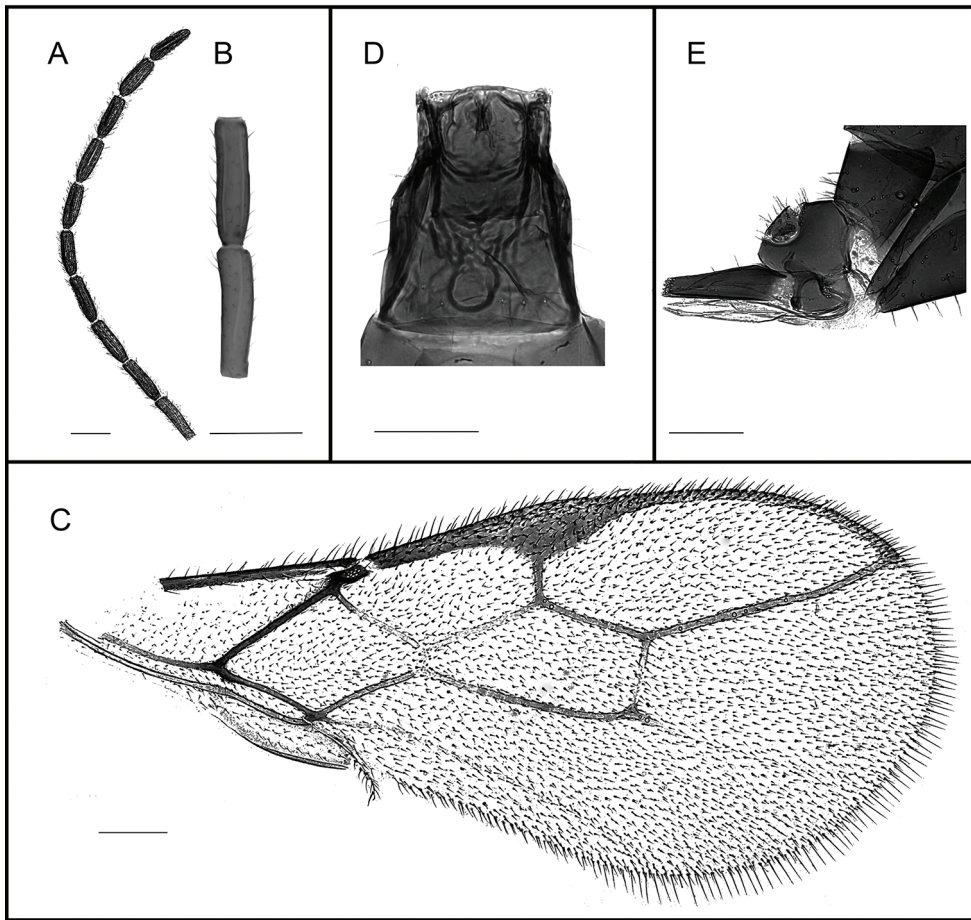
**Male.** Unknown.

**Type material. Holotype:** 1 ♀, Russia, Western Caucasus, E. Krasnaya Polyana, Aibga mt. VII 2000, collected by sweeping, leg. Gurko. Deposited in the Biologiezentrum Linz's collection, Austria.

**Distribution and biology.** *Ephedrus antennalis* sp. nov. was collected in the Western Caucasus Mountains of Russia, and that is the only locality where the species has been found to date.

**Aphid host.** Unknown (collected by sweeping).

**Etymology.** The new species takes its name from an unusual number of antennal segments (12), unique within the genus *Ephedrus*.

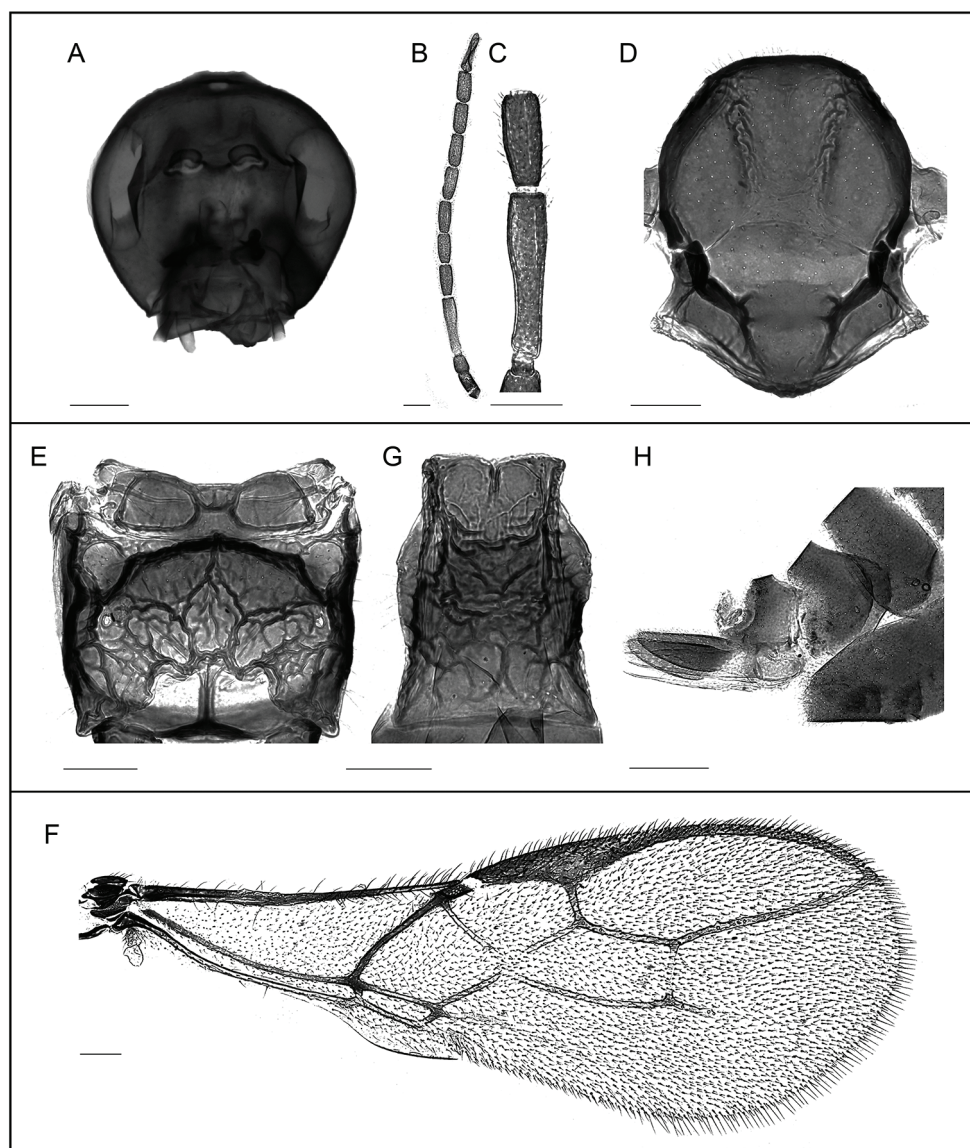


**Figure 1.** *Ephedrus antennalis* sp. nov. Tomanović **A** antenna **B** first and second flagellar segment **C** fore-wing **D** petiole – dorsal aspect **E** ovipositor sheaths – lateral aspect. Scale bars: 100  $\mu$ m.

***Ephedrus carinatus* Tomanović, sp. nov.**

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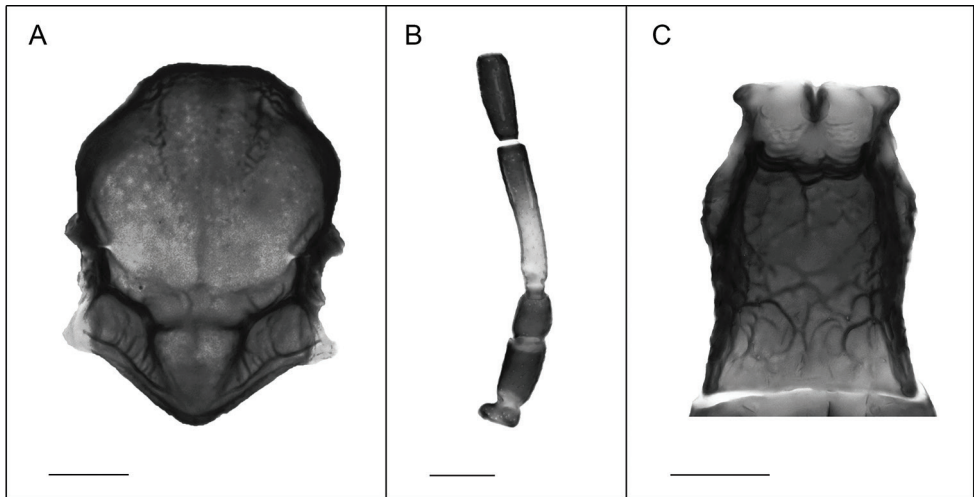
**Diagnosis.** On the basis of fore wing venation (3SR vein longer than 2SR vein) (Fig. 2F), this species belongs to the *plagiator* species group. The new species morphologically resembles *E. validus* in possessing a reticulated petiole (Fig. 2G) and propodeum (Fig. 2E) and a densely setose ovipositor sheath (Fig. 2H), features that point to a subterranean habitat where it probably parasitizes root aphids. However, it differs clearly from *E. validus* in having wide and rugose notaulices along the dorsal side of the mesoscutum (Fig. 2D) (vs. shorter notaulices reaching the first third of the mesoscutum in *E. validus* (Fig. 3A)), second flagellomere approximately 3.2 times as long as wide (Fig. 2C) (vs. 2.7–2.8 times as long as wide in *E. validus* (Fig. 3B)) and a petiole approximately 1.35 times as long as wide at the spiracle level (Fig. 2G) (vs. a more elongated petiole, 1.4–1.6 times as long as wide at the spiracle level in *E. validus* (Fig. 3C)).



**Figure 2.** *Ephedrus carinatus* sp. nov. Tomanović **A** head **B** antenna **C** first and second flagellar segment **D** mesoscutum – dorsal aspect **E** propodeum – dorsal aspect **F** forewing **G** petiole – dorsal aspect **H** ovipositor sheaths – lateral aspect. Scale bars: 100  $\mu$ m.

**Female. Head.** Malar space equal to approximately 0.32 of longitudinal eye diameter. Clypeus oval, densely setose with over 20 long setae. Tentorial index approximately 0.48. Maxillary palps with four palpomeres, labial palps with two. Head approximately 1.3 times wider than mesoscutum (Fig. 2A). Antennae 11-segmented, filiform, slightly tickened towards apex, with semierect setae which are shorter than half of diameter of the segments (Fig. 2B). F1 elongated, with a constriction in the





**Figure 3.** *Ephedrus validus* **A** mesoscutum – dorsal aspect **B** first and second flagellar segments **C** petiole – dorsal aspect. Scale bars: 100  $\mu$ m.

first half, approximately 5.8 times as long as wide and approximately 1.8 times longer than F2 (Fig. 2C). F2 approximately 3.2 times as long as wide. F1 and F2 with two or three longitudinal placodes (Fig. 2C), F3 and F4 with four longitudinal placodes. F8 and F9 well separated.

**Mesosoma.** Mesoscutum with notaulices almost reaching the scutellum (Fig. 2D). Mesoscutal fovea absent. Propodeum very rugose, areolated and densely setose (Fig. 2E), with more than 15 and 20 setae on the upper areola and lower areola, respectively (Fig. 2E). Central areola wide and pentagonal.

**Fore wing.** Pterostigma approximately 4.6 times as long as wide (Fig. 2F). Vein ratios 3SR/2SR and 1SR/3SR approximately 1.30 (Fig. 2F).

**Metasoma.** Petiole subquadrate, approximately 1.35 times as long as wide at the spiracle level (Fig. 2G). Ovipositor sheaths elongated, densely setose and straight on the dorsal margin (Fig. 2H).

**Colouration.** Head black. Scape and pedicel yellow to light-brown. F1 yellow, remaining part of antennae brown. Mouthparts light-brown. Petiole light-brown to brown. Legs light-brown with dark apices. Metasoma brown. Remaining body parts brown to black.

**Body length.** 2.0 mm.

**Male.** Unknown.

**Type material.** **Holotype:** 1 ♀, Austria, Oberösterreich, Lichtenberg, 01 IX 1933., collected by sweeping, leg. J. Kloiber. Deposited in the collection of the Biologiezentrum Linz's collection, Austria.

**Distribution and biology.** *Ephedrus carinatus* sp. nov. is known only from a historical record from Austria. We assume that it is a parasitoid of root aphid species.

**Etymology.** The new species takes its name from the developed notaulices on the mesoscutum.

## Discussion

Stary (1959) established the subgenus *Lysephedrus* Stary, 1959, with the nominative species *Ephedrus* (*Lysephedrus*) *validus*. Later on, in a taxonomic and biological revision of Palaearctic species Gärdenfors (1986) divided the genus *Ephedrus* into three subgenera – *Ephedrus* Haliday, 1833, *Breviephedrus* Gärdenfors, 1986 and *Lysephedrus* Stary, 1958. Davidian (2007; 2018) considers the subgenus *Lysephedrus* as a separate genus. However, on the basis of molecular markers and morphology, in an integrative study, Kocić et al. (2019) established *Ephedrus* (*Lysephedrus*) *validus* to be nested within species of the subgenus *Ephedrus* and assigned it a status of junior synonym of the subgenus *Ephedrus*. Here we describe a new *Ephedrus* species morphologically related to *E. validus*, with a reticulated propodeum, petiole, and densely pubescent ovipositor sheaths, features which imply that it is another species of root aphid parasitoids within the genus *Ephedrus*. Long notaulices along the mesoscutum represent a plesiomorphic character absent in almost all other congeneric species, except in *E. validus* and sometimes *E. persicae* where they remain shorter, maximally reaching the first third of the mesoscutum. This was confirmed by examination of several available specimens of *E. validus*, all of which possessed shorter notaulices (Fig. 3A). All these specimens share almost the same cytochrome c oxidase subunit I (COI) gene barcoding sequences (Kocić et al. 2019).

Possession of 11-segmented antennae in both sexes represents a plesiomorphic character state in *Ephedrus*. Gärdenfors (1986) mentioned that in some “extremely rare” cases some specimens can possess 12-segmented antennae. However, in communication with the author (Gärdenfors, personal communication), we were informed that 12-segmented antennae are present only in specimens where terminal segments are elongated and semi-divided due to developmental instability of these individuals. We also found specimens with the terminal 10<sup>th</sup> segment elongated and undivided (e.g., aberrant specimens of *E. laevicollis* (Thomson, 1895)). However, with clearly 12-segmented antennae, our Russian specimen of *Ephedrus* that was discovered in the Biologiezentrum Linz’s collection changes diagnostic characters for the genus *Ephedrus* (from 11-segmented antennae to 11–12-segmented antennae). Possession of 12-segmented antennae represents an apomorphic and very unusual character that was until now unknown for the genus *Ephedrus*. On the basis of the short fore wing 3SR vein, it can be concluded that *E. antennalis* sp. nov. belongs to subgenus *Fovephedrus* Chen, 1986 (recently revised by Kocić et al. 2019) and “*persicae*” species group. For details of diagnosis and biology, see Gärdenfors (1986), Žikić et al. (2009) and Kocić et al. 2019.

The phylogenetic position of the two species newly described here is unclear and integrative research on them in the future could provide insight about their taxonomic and phylogenetic status and suggest a possible subtribal classification of the genus *Ephedrus*.

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