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A new species of the genus *Chrysotoxum* Meigen, 1803 (Diptera: Syrphidae) from Turkey

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A new species of the genus *Chrysotoxum* (Diptera: Syrphidae), *Chrysotoxum bozdagensis* Nedeljković, Vujić & Hayat sp. n., collected from Bozdağ Mt., İzmir Province, Turkey is described and illustrated. *Chrysotoxum bozdagensis* sp. n. can be distinguished from the similar *Ch. octomaculatum* Curtis, 1837 by the presence of a black pile on the mesonotum and the colour of the legs. It is also similar to *Ch. elegans* Loew, 1841, from which it can be distinguished by the colour of the pile on the vertical triangle and scutellum, as well from the structure of the male genitalia. Additionally, *Ch. bozdagensis* sp. n. can be clearly distinguished from the latter two species by DNA sequence data. This new species increases the total number of *Chrysotoxum* species in Turkey to 18.

http://www.zoobank.org/urn:lsid:zoobank.org:pub:7465AAEA-21E6-4F0F-984C-CD48BE75436F

Keywords: Hoverflies; *Chrysotoxum bozdagensis* sp. n.; COI; Bozdağ; ITS2, İzmir Province; Middle East

Introduction

With about 6000 described species, hoverflies (Diptera: Syrphidae) represent one of the most species-rich dipteran families. Syrphids play important ecological roles in nature, including plant pollination, predation of plant pests, phytophagy, and nutrient recycling (Rotheray & Gilbert, 2011).

The genus *Chrysotoxum* (Syrphinae: Syrphini) comprises large, wasp-mimicking species with elongated antennae, an abdomen strongly convex dorsally, with yellow fasciae on the terga, and yellow maculae on the thoracic pleurae (Thompson & Rotheray, 1998). *Chrysotoxum* species are present in all biogeographic regions except for Australasia and Antarctica (e.g. Thompson, Rotheray, & Zumbado, 2010). In the Palaearctic region, 71 species have been recorded, 26 of which are present in Europe (Violovitsh, 1974; Peck, 1988; Nedeljković, Ačanski, Đan, Obreht-Vidaković, Ricarte, & Vujić, 2015). With 17 *Chrysotoxum* species, Turkey is one of the most species-rich countries in the Middle East (Tóth, 2013; Sarıbıyık, 2014; Vujić, Nedeljković, Hayat, Demirözer, Mengual, & Kazerani, 2017).

Owing to subtle morphological differences (Nedeljković et al., 2015) and the high level of intraspecific variability (Sang-Wook & Ho-Yeon, 2013), clarification of the taxonomy of certain *Chrysotoxum* species has been significantly facilitated by the application of DNA sequence data. Although several taxonomic revisions of European and

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American species of this genus have been carried out, there is currently a great need for a further revision of the European species (Speight, 2016).

In an earlier paper, Vujić et al., (2017) described three *Chrysotoxum* species from North-East Turkey – *Chrysotoxum antennalis* Vujić, Nedeljković & Hayat, 2017, *Chrysotoxum clausseni* Vujić, Nedeljković & Hayat, 2017, and *Chrysotoxum persicum* Vujić, Nedeljković & Hayat, 2017 – and provided an identification key for Turkish *Chrysotoxum* species. The present work extends our taxonomic study of the genus *Chrysotoxum* in Turkey, resulting in the description of a new species.

Material and Methods

Morphology. The following references were used for species identification: Violovitsh (1974), Claussen & Vujić (unpublished key), and Vujić et al. (2017). We applied methods detailed in Vujić et al. (2017) to describe and diagnose species. Morphological terms follow Thompson (1999), except for "proepimeron" that follows van Veen (2004) and Speight (2014).

Molecular analyses. Extraction, PCR amplification and sequencing of DNA was performed as described in Šašić et al. (2016). We applied the same protocol for PCR amplification for both the 3' COI region and the ITS2 region. The universal primers C1-J-2183 (alias JERRY) and TL2-N-3014 (alias PAT) (Simon, Frati, Beckenbach, Crespi, Liu, & Flook, 1994) were used for amplification and sequencing of the 3' COI region. We used primers described in Beebe and Saul (1995) for amplification and sequencing of the ITS2 region.

The resulting DNA sequences were edited for base-calling errors using BioEdit version 7.2.5. (Hall, 1999). COI sequences were aligned manually, whereas ITS2 sequences were aligned using MAFFT (Katoh & Standley, 2013) available on the EMBL-EBI bioinformatics framework platform (McWilliam et al., 2013). The two sequence matrices were combined and analysed using NONA (Goloboff, 1999), spawned with the aid of Winclada ASADO (Nixon, 2008) using the heuristic search algorithm with 1000 random addition replicates (mult_1000), holding 100 trees per round (hold/100), maxtrees set to 100,000 and applying tree-bisection–reconnection branch swapping. Nodal support for branches was assessed using non-parametric bootstrapping with 1000 replicates. *Melanostoma mellinum* (Linnaeus, 1758) was used as outgroup (NCBI accession numbers: KJ848101 for COI, KJ848059 for ITS2). Our DNA analysis included representatives of the following *Chrystoxum* species: *Ch. festivum* (Linnaeus, 1758); *Ch. tomentosum* Giglio-Tos, 1890; *Ch. elegans* Loew, 1841; *Ch. vernale* Loew, 1841; *Ch. montanum* Nedeljković & Vujić, 2015; *Ch. octomaculatum* Curtis, 1837; and *Ch. bozdagensis* sp. n. (Table S1).

Acronyms

FSUNS, Entomological Collection of the Department of Biology and Ecology, Faculty of Sciences, University of Novi Sad, Serbia. – LSF, Museo Zoologico La Specola, Firenze, Italy. – NHMUK, Natural History Museum, London, United Kingdom. – NMVM, Museums Victoria, Melbourne, Australia. – ZISP, Zoological Museum, Academy of Sciences, Russian Academy of Sciences, St. Petersburg, Russia.

Results

***Chrysotoxum bozdagensis* Nedeljković, Vujić & Hayat sp. n.**
(Figures 1, 2A, 3)

Type material. Holotype: Male, TURKEY: İzmir province, Bozdağ Ski Centre (38.332°N, 28.108°E), 25.vi.2016, leg. A. Vujić [12132, FSUNS]. – Paratype: 1♀, same location, 24.vi.2016, leg. A. Vujić [12075, FSUNS].

Comparative material of other species. Three females that most probably belong to type material of *Chrysotoxum octomaculatum* Curtis, 1837 [NMVM], because the type material has not been designated by the author of the species (Curtis, 1823–1840). –

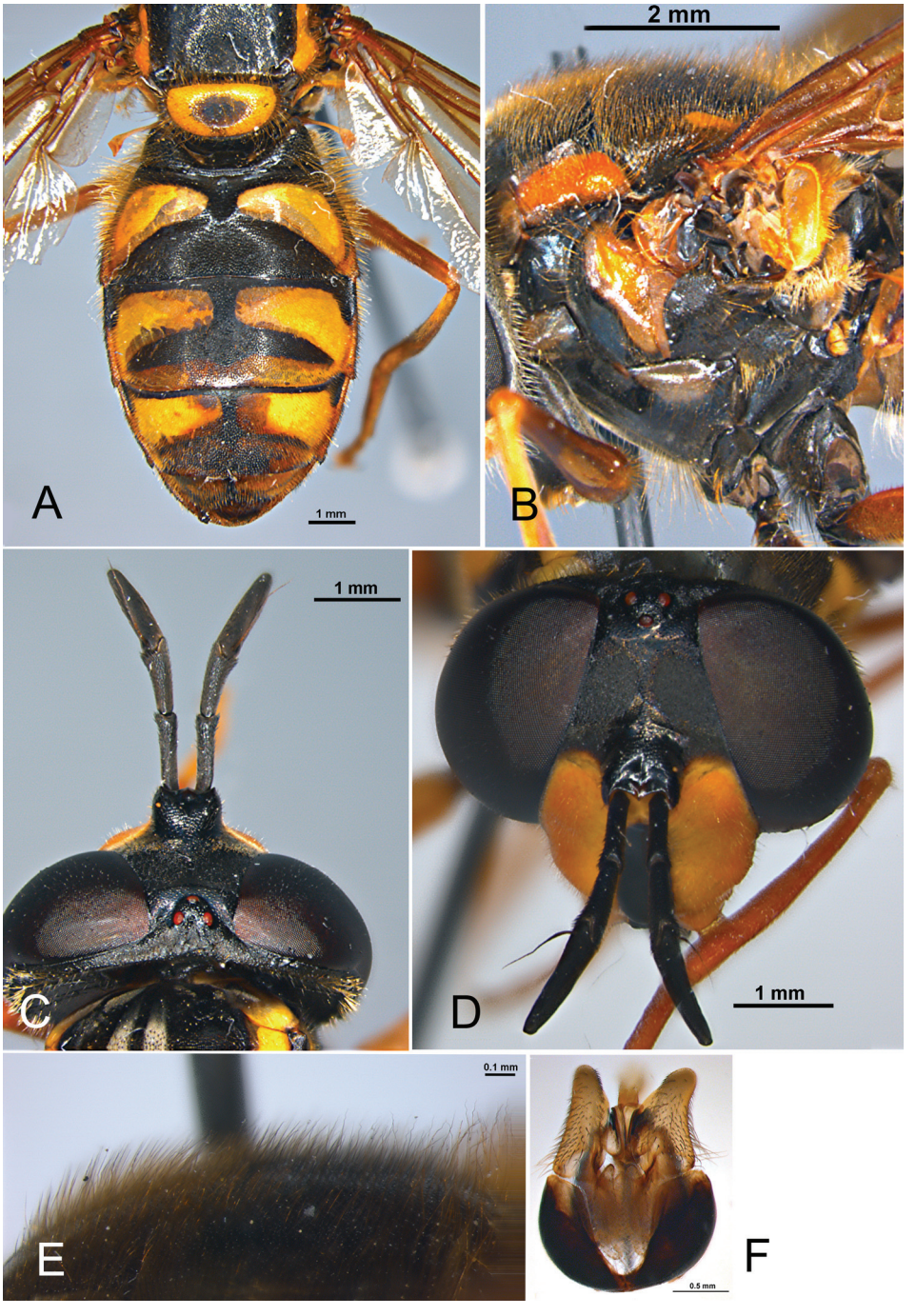

Figure 1. *Chrysotoxum bozdagensis* sp. n.: A. abdomen of male, dorsal view. B. pleuron of male, lateral view. C. antennae, dorsal view. D. frons of female, frontal view. E. thoracic scutum of male, lateral view. F. male genitalia, dorsal view.

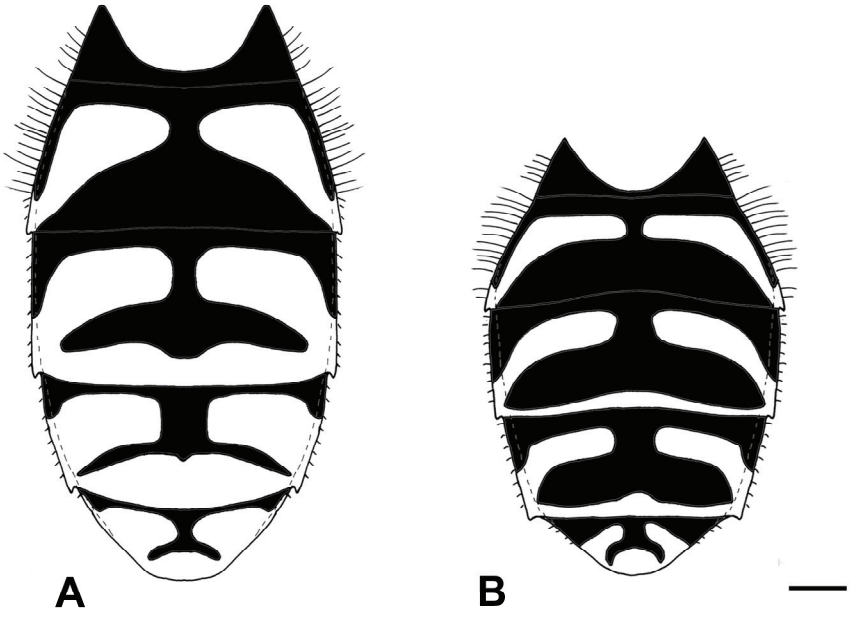

Figure 2. Abdomen, dorsal view: A. *Chrysotoxum bozdagensis* sp. n. (male holotype). B. *Ch. elegans*. – Scale bar = 1 mm.

Chrysotoxum elegans (Villers, 1789) "is regarded as homonymous with *Musca eligans* Harris, 1780 (*elegans* in Index)" (Peck, 1988), so the authors believed that it was not necessary to review the type material. The depository of Villers' type material is unknown and may have been destroyed or lost (Nigel Wyatt, pers. comm.). The description provided by Villers (1789) is very poor, but indicates that abdominal fasciae are interrupted in the median part ("…obliqui in medio interrupti"). – Photos (dorsal and lateral views) were examined of the syntypus of *Chrysotoxum chrysopolitum* Rondani, 1845 (356, Museo La Specola, coll. Rondani, SYNTYPUS). Photos (dorsal and lateral views) of the holotype of *Ch. verae* Violovitsh, 1974 were examined [ZISP].

Diagnosis. Robust species (L=19 mm); x:y= 1:1 (Figure 1C); frontal triangle with yellow pile; face with black vitta occupying 1/6–1/7 of the facial width; proepimeron with faint yellow macula; katepisternum with yellow macula; scutellum with long yellow pile; legs mainly yellow and only black in the basal 1/10 of femora; T2 with yellow triangular maculae reaching the lateral margin; T3−T5 with a pair of broad yellow maculae (occupying almost 1/2 of the tergal height), reaching the lateral margins of terga in its posterior part and with yellow fasciae along posterior margins of terga; surstylus short and broad (about two times longer than wide); frons of female with broad rectangular maculae.

Chrysotoxum bozdagensis sp. n. is similar to *Ch. octomaculatum*, but can easily be distinguished by the black pile on the posterior part of the mesonotum. In *Ch. octomaculatum*, the mesonotum is covered only with yellow pile. In *Ch. bozdagensis* sp. n., the femora are black in the basal 1/10, whereas in *Ch. octomaculatum* they are completely yellow. Generally, *Ch. bozdagensis* sp. n. is more robust than *Ch. octo-*

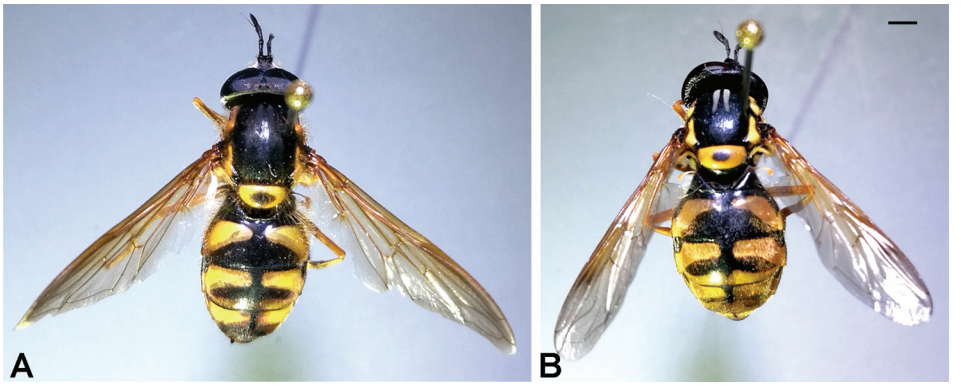

Figure 3. *Chrysotoxum bozdagensis* sp. n., dorsal view. A. male, holotype; B. female, paratype. – Scale bar = 1 mm.

maculatum. Furthermore, the surstyli are much thinner and longer in *Ch. octomaculatum* (Figure 8D in Vujić et al., 2017) than that of *Ch. bozdagensis* sp. n. (Figure 1F).

Chrysotoxum bozdagensis sp. n. is also similar to *Ch. verae* Violovitsh, 1973 described from Armenia, with this latter species having triangular maculae on T2 and broad somewhat trapezoid fasciae on T3 and T4. However, these two species can be distinguished by the fact that the legs are completely yellow in *Ch. verae*, whereas the basal 1/10 of the femora are black in *Ch. bozdagensis* sp. n., and by the fact that the posterior margins of T3 and T4 are black in *Ch. verae* whereas they are yellow in *Ch. bozdagensis* sp. n.

Chrysotoxum bozdagensis sp. n. can be distinguished from the similar *Chrysotoxum elegans* Loew, 1841 by the colour of the pile on the vertical triangle and scutellum; these are black in *Ch. elegans,* but yellow in *Ch. bozdagensis* sp. n. In addition, *Chrysotoxum elegans* has narrow yellow fasciae on T2 (Figure 2B), whereas *Ch. bozdagensis* sp. n. possesses broad rectangular yellow maculae on T2 (Figure 2A). The yellow fasciae on T2-T5 are much thinner in *Ch. elegans* (Figure 2B) than in *Ch. bozdagensis* sp. n. (Figure 2A). Finally, the surstyli are much thinner and longer in *Ch. elegans* (Figure 8F in Vujić et al., 2017) than that in *Ch. bozdagensis* sp. n. (Figure 1F).

Description. Male (Figure 3A). L=19 mm. − *Head.* Eye pile straight and yellow, denser and longer in the dorsal half; frontal triangle black with silver pollinosity and long yellow pile; vertical triangle black with black pollinosity in the anterior part and silver pollinosity in the posterior part, and with two patches of golden pollinosity in the posterior-lateral parts, with yellow pile; ocellar triangle black with silver pollinosity and wavy black pile in the anterior part and long yellow pile in the posterior part; face yellow with long yellow pile and black vitta extending from the antennal bases to the genae, occupying 1/5-1/6 of the facial width; genae dark yellow with yellow pile; antennae black; scape and pedicel almost the same length (x:y=1:1); arista bare, dark-brown; occiput white pollinose with intermixed long yellow and black pile. − *Thorax.* Scutum black with two longitudinal, silvery pollinose vittae extending for two-thirds of its length, covered with long yellow pile in the anterior part and black pile in the posterior part, section near the scutellum only with long yellow pile (Figure 1E); scutellum yellow except for central part that has light brown macula, blackish at lateral corners, covered with long yellow pile (some black pile can be present); katepisternum with small yellow macula (Figure 1B); proepimeron with faint yellow macula; posterior anepister-

num with yellow macula in the posterior part; legs yellow except for the basal 1/10 of femora that are dark brown, covered with yellow pile; wing membrane extensively microtrichose; wing cells R_1 and R_{2+3} with dark yellow maculae in the apical part. − *Abdomen* (Figures 1A, 2A). Elongated, parallel sides; shiny black with short black pile, except for T1 and the anterior part of T2 that have long yellow pile; fasciae with yellow pile; T2 with broad triangular fasciae reaching the lateral margins of the posterior part; T3 with rectangular fasciae reaching the lateral margins of its posterior half; posterior margin of T3 with yellow fascia covered with short black pile; T4 with broad rectangular fasciae reaching the lateral margin of its posterior half; lateral margin yellow along its length; posterior margin of T4 with broad yellow fascia covered with short black pile and connected with the central fascia in the posterior corner; T5 with broad rectangular fasciae; posterior margin with yellow macula; lateral margin yellow along its length. S1 yellow with small black macula on the median part; S2 black with narrow yellow fascia in the anterior part and two yellow maculae on the posterior part; S3 black with two yellow maculae on the anterior part and yellow fascia in the posterior part; S4 black with two yellow maculae in the anterior part and yellow fascia in the posterior part; S1, S2 and lateral parts of S3 and S4 with yellow pile, other parts of sterna and fasciae have black pile. −*Male genitalia* (Figure 1F). Surstylus short and broad (about two times longer than its width) with long pile; hypandrium short and broad.

Female (Figure 3B). Scutum with intermixed short black and yellow pile in the anterior part and only black pile in the medial part; frons with broad rectangular microtrichose maculae (Figure 1D).

Etymology. The name ”*bozdagensis*” is derived from Bozdağ, the name of the Turkish Mountain where the type specimens were collected.

Distribution. Turkey (İzmir Province).

Addendum to the identification key of Vujić et al. (2017)

couplet 15.

15 Lateral margins of T3−T5 without yellow vitta 15a
– Lateral margins of T3−T5 with yellow vitta..... 16

15a T2 with triangular fasciae; T3−T5 with broad yellow vittae (occupying about 1/3 of the tergal length) (Figure 2A); robust species (L=19 mm)..... *C. bozdagensis* sp. n.

15b T2 with rounded triangular fasciae; T3−T5 with narrow yellow vittae (occupying about 1/5 of the tergal length) (Figure 2B); medium-sized species (L=14-15 mm)..... *C. elegans* Loew

Molecular analysis

The combined sequence dataset of the 3’ COI region and the ITS2 region comprises 23 sequences from morphologically similar *Chrysotoxum* species occurring in Turkey, with a total length of 1026 nucleotide characters. Parsimony analysis resulted in two equally parsimonious trees of 243 steps in length (Consistency Index = 90, Retention Index = 92). The strict consensus tree (length = 244) resolved *Ch. bozdagensis* sp. n. as a monophyletic clade with a high bootstrap support value (92) and as a sister clade to the clade *Ch. festivum* + *Ch. elegans*. *Chrysotoxum octomaculatum* is resolved as sister clade to *Ch. montanum* (Figure 4).

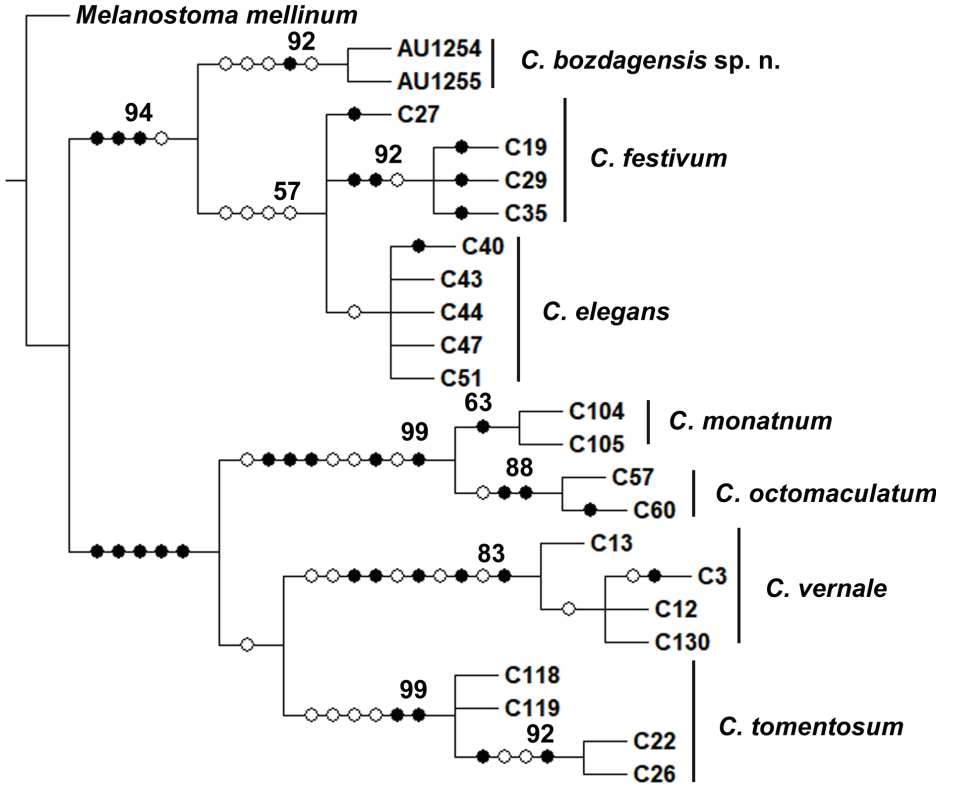

Figure 4. Strict consensus tree based on combined COI and ITS2 sequences. Filled circles, non-homoplasious changes; open circles, homoplasious changes.

Discussion

Sarıbıyık (2014) listed 11 *Chrysotoxum* species for Turkey and Vujić et al. (2017) expanded this list to 17 species. With the new species described here, the list now comprises 18 species, representing about 78% of the European *Chrysotoxum* species reported in Speight, Castella, and Sarthou (2015). Erzurum province in eastern Anatolia alone harbours 11 *Chrysotoxum* species, making it the richest area within Turkey for this genus. Kastamonu, Bolu, and Aksaray are other Turkish areas rich in *Chrysotoxum* species, with 6 and 5 species, respectively. Only two species have been recorded so far from İzmir Province, i.e. where the newly-described species in the present study was found. The paucity of described and recorded species from these latter regions may be due to the sporadic nature of studies conducted in these areas but also due to morphological similarity between species.

Supplementary Material

Table S1 is given as a Supplementary Annex.

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Disclosure Statement

No potential conflict of interest was reported by the authors.

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