

New data on the genus *Chrysotoxum* Meigen (Diptera: Syrphidae) from North-East Turkey, Armenia, Azerbaijan and Iran including descriptions of three new species

Ante Vujić, Zorica Nedeljković, Rüstem Hayat, Ozan Demirözer, Ximo Mengual & Farzaneh Kazerani

To cite this article: Ante Vujić, Zorica Nedeljković, Rüstem Hayat, Ozan Demirözer, Ximo Mengual & Farzaneh Kazerani (2017) New data on the genus *Chrysotoxum* Meigen (Diptera: Syrphidae) from North-East Turkey, Armenia, Azerbaijan and Iran including descriptions of three new species, *Zoology in the Middle East*, 63:3, 250-268, DOI: [10.1080/09397140.2017.1349241](https://doi.org/10.1080/09397140.2017.1349241)

To link to this article: <http://dx.doi.org/10.1080/09397140.2017.1349241>



Published online: 13 Jul 2017.



Submit your article to this journal [↗](#)



Article views: 12



View related articles [↗](#)



View Crossmark data [↗](#)

New data on the genus *Chrysotoxum* Meigen (Diptera: Syrphidae) from North-East Turkey, Armenia, Azerbaijan and Iran including descriptions of three new species

Ante Vujić^a, Zorica Nedeljković^{b*}, Rüstem Hayat^c, Ozan Demirözer^d,
Ximo Mengual^e and Farzaneh Kazerani^f

^aDepartment of Biology and Ecology, Faculty of Sciences, University of Novi Sad, Novi Sad, Serbia; ^bBioSense Institute-Research Institute for Information Technologies in Biosystems, Novi Sad, Serbia; ^cIsparta, Turkey; ^dDepartment of Plant Protection, Faculty of Agriculture, Süleyman Demirel University, Isparta, Turkey; ^eZoologisches Forschungsmuseum Alexander Koenig, Leibniz-Institut für Biodiversität der Tiere, Bonn, Germany; ^fResearch Institute of Forests and Rangelands, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran

(Received 8 May 2017; accepted 26 June 2017; first published online 13 July 2017)

New data and records of the genus *Chrysotoxum* Meigen, 1803 are reported, arising from taxonomic and faunistic examination of adult specimens collected from 1920 to 2011 from four northeastern provinces of Turkey (Erzurum, Bayburt, Kars, and Artvin), and from the neighboring countries of Armenia, Azerbaijan and Iran. Three new species are described: *Chrysotoxum antennalis* Vujić, Nedeljković & Hayat sp. n., *C. clauseni* Vujić, Nedeljković & Hayat sp. n. and *C. persicum* Vujić, Nedeljković & Hayat sp. n. The first two are known only from northeastern Turkey, and the third also occurs in Armenia, Azerbaijan and Iran. These new species have in common an antenna with the basoflagellomere being shorter than the scape and pedicel together.

<http://www.zoobank.org/urn:lsid:zoobank.org:pub:4C264678-8E47-4DE0-AC7D-91DABC597BCD>

Keywords: Hoverflies, *Chrysotoxum antennalis* sp. n., *Chrysotoxum clauseni* sp. n., *Chrysotoxum persicum* sp. n., Middle East, Eastern Anatolia

Introduction

Hoverflies (Diptera: Syrphidae) represent one of the most species-rich dipteran families, with over 6000 described valid species from 188 genera (Brown, 2009; Thompson, 2013). Adults of these flies have a significant ecological role as pollinators (Larson, Kevan, & Inouye, 2001; Inouye, Larson, Ssymank, & Kevan, 2015), and immature stages can be important biological control agents and recyclers of organic matter (e.g. Morales & Wolff, 2010; Rotheray & Gilbert, 2011; Gresham et al., 2013).

The genus *Chrysotoxum* (Syrphinae: Syrphini) consists of large, wasp-mimicking species with elongated antennae, an abdomen strongly convex dorsally, with yellow fasciae on the terga, and the thoracic pleurae with yellow maculae (Thompson & Rotheray, 1998). Adults of this genus are found in many habitat types (Speight, 2015), and their larvae are associated with ants and/or root aphids (Rotheray, 1994). Determining the taxonomy of these distinctive hoverflies has often proven difficult due to subtle morphological differences (Nedeljković et al., 2013, 2015), and the high level of intra-

*Corresponding author. Email: zoricaned14@gmail.com

specific variability (Sang-Wook & Ho-Yeon, 2013). Although several taxonomic studies on European (Loew, 1841; Giglio-Tos, 1890; Rondani, 1845; Shannon, 1926) and American (Shannon, 1926) species of this genus have been carried out, *Chrysotoxum* urgently needs a complete and exhaustive revision (Speight, 2015). A comprehensive study of this genus was recently conducted for the Balkan Peninsula, resulting in revisions of the *festivum* and *vernale* species groups (Nedeljković et al., 2013, 2015).

Chrysotoxum species are distributed in all biogeographical regions except Australasia and Antarctica (Vockeroth, 1969; Thompson, Rotheray, & Zumbado, 2010). In the Palaearctic, 71 species have been recorded, 26 of which are present in Europe (Vockeroth, 1969; Violovitsh, 1974; Peck, 1988; Nedeljković et al., 2013, 2015). In the Middle East, Iran is the most species-rich country with 15 recorded *Chrysotoxum* species (Kazerani, Talebi, & Gilasian, 2013), followed by Turkey with 11 species (Tóth, 2013; Sarıbiyık, 2014), Armenia (11 species) and Azerbaijan with five species (<http://insectoid.info/checklist/syrphidae/azerbaijan>).

Turkey represents a geographic link between Europe, Asia and Africa. The Mediterranean Basin is one of the 25 world biodiversity hotspots (Myers, Mittermeier, Mittermeier, Fonseca, & Kent, 2000), and as part of it, Turkey is one of the most biodiverse countries in Europe and the Middle East. Studies on the syrphid fauna of Turkey began more than a century ago (Bischof, 1902). Since then, 303 species of Syrphidae from 73 genera have been recorded (Sarıbiyık, pers. comm.). Several hoverfly species have been described from Turkey in the last two decades. Iran is located in a crucial geographic position, acting as a connection between the Palaearctic and Oriental regions. The varied and unique habitats in Iran have contributed to a rich Syrphidae fauna, with 124 species recorded so far (Dousti & Hayat, 2006), of which 68 belong to the subfamily Syrphinae and 15 to the genus *Chrysotoxum* (Kazerani et al., 2013). In contrast with Turkey and Iran, Azerbaijan and Armenia lack recent faunistic studies or biological surveys, and the low numbers of recorded syrphid species from both countries (16 and 44 species, respectively) may reflect a lack of sampling and poor knowledge of their faunas.

In the present survey, the *Chrysotoxum* fauna of northeastern Anatolia – a highly mountainous region with few valleys and plains – and the neighboring countries of Armenia, Azerbaijan and Iran was studied. The main aim of this study was to provide new insights into the taxonomy of the genus *Chrysotoxum* from the Middle East and resulted in the description of three new species.

Material and Methods

The following references were used for identification: Violovitsh (1974), Claussen & Vujić (unpublished key), and Nedeljković et al. (2015). A total of 102 specimens from different localities in north-east Turkey (Artvin, Bayburt, Erzurum and Kars provinces), Azerbaijan, Armenia and Iran were examined. They were collected between 1920 and 2011 by various collectors.

To describe and diagnose the species, morphological characters were checked using a Nikon SMZ 745T binocular microscope. Body size was measured as the length ('L') from the tip of the frontal prominence (excluding antennae) to the tip of the abdomen. Proportional length of the antennal segments is given as a ratio ('r') of x:y:z ('x', scape; 'y', pedicel; 'z', basoflagellomere). Measurements were made using an eye-piece micrometer. High-resolution images of different body parts were captured using a Leica DFC320 video camera attached to a Leica MZ16 stereomicroscope, which was connected to a PC.

Morphological terms follow Thompson (1999). Colour characters were described from dry-pinned specimens. The following abbreviations have been used: T1 - first tergum, T2 - second tergum, T3 - third tergum, etc.; S1 - first sternum, S2 - second sternum, S3 - third sternum; n - number of specimens used for the taxonomic analyses.

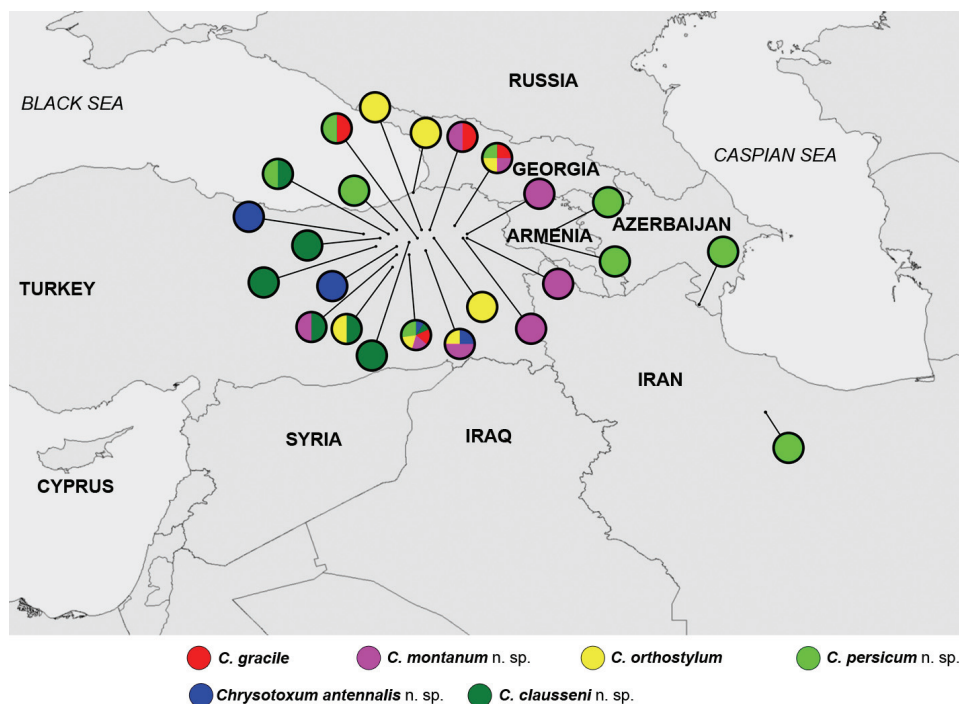


Figure 1. Map of population sampling locations of the species examined.

To study male genitalia, specimens were relaxed using a humidity chamber and the genitalia were extracted using an insect pin with a hooked tip. The genitalia were then cleaned in warm 10% KOH for 3 to 5 min and then washed in acetic acid, followed by ethanol, to neutralize the KOH. Finally, male genitalia were stored in microvials containing glycerol. For preparing the distribution map, GenGIS 2 software (Parks et al., 2013) was used.

Acronyms. EMIT, Entomological Museum of Isparta, Turkey; MfN, Museum für Naturkunde, Berlin, Germany; TMUI, Department of Entomology, Tarbiat Modares University, Tehran, Iran; ZISP, Zoological Museum, Academy of Sciences, Russian Academy of Sciences, St. Petersburg, Russia; ZFMK, Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany; ZMHB, Zoologisches Museum of Humboldt University, Berlin, Germany; NHMW, Naturhistorisches Museums Wien, Austria; NMVM, Museums Victoria, Melbourne, Australia; LSF, Museo Zoologico La Specola, Firenze, Italy; CSCA, California State Collection of Arthropods, USA, California, Sacramento.

Results

Revision of the studied material of the genus *Chrysotoxum* resulted in eight species being identified from North-East Turkey. Three of them are new records for Turkey and three are species new to science. Two of the new species – *C. antennalis* sp. n. and *C. clauseni* sp. n. – are exclusively known from North-East Turkey, and the third one, *C. persicum* sp. n., is known also from Armenia, Azerbaijan and Iran. These three species have in common an antenna with the basoflagellomere shorter than the scape and pedicel together.

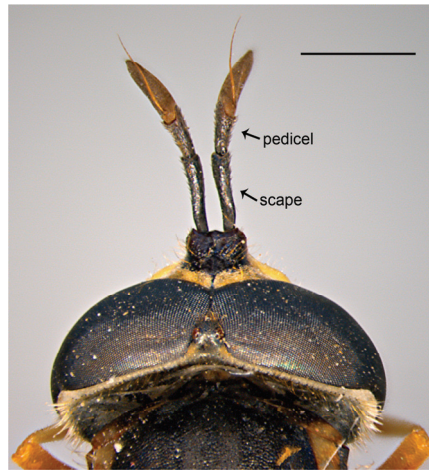


Figure 2. *Chrysotoxum antennalis* n. sp., antennae, dorsal view. – Scale bar = 1 mm.

***Chrysotoxum antennalis* Vujić, Nedeljković & Hayat sp. n.**

(Figures 2, 3B, 3D, 4B, 5A, 7A, 8E, 9A, 9B)

Type material. Holotype: ♂, TURKEY: Erzurum, Aziziye-Sorkunlu (40.07°N, 40.96°E), 30.vii.1998, 1800 m, leg. R. Hayat [08192, EMIT]. – Paratypes: 1♂, TURKEY, Erzurum, Pasinler-Pelitli (39.98°N, 41.66°E), 14.vii.1998, 1450 m, leg. Ö. Çalmaşur [08191, EMIT]; 1♂, 2♀, Erzurum, Palandöken Mountain (39.91°N, 41.27°E), 6.vii.1996, leg. R. Hayat [08193, 08194, 08195, EMIT]; 1♀, Erzurum, Umudum Plateau (40.01°N, 41.27°E), 8.viii.1991, leg. R. Hayat [08197, EMIT]; 1♀, Bayburt, Aydıntepe-İncili (40.39°N, 40.20°E), 9.ix.1994, leg. N. Aktürk [08198, EMIT].

Comparative material of other species. Holotype of *Chrysotoxum gracile* Becker, 1921: 1♂, Spain, 39386; *gracile* Becker, det. Becker; holotype (Claus) [ZMHB]. The holotype was examined by A. Vujić. It is in very bad condition and lacks both head and abdomen. – Lectotype of *Chrysotoxum vernale* Loew (1 male labelled as 'vernale, Schlerin' / 'Alte Sammlung' / S11470 [NHMW] and paralectotypes 1f labelled as 16/547 / vernale f Loew Alte Sammlung/*Chrysotoxum vernale* f Loew* (NHMW), 20 specimens labelled as "Coll H. Loew" and seven specimens not labelled but supposed to be part of Loew's collection and collected in Poznań (J. Ziegler, in. lit.); 10 of the 20 "Coll H. Loew" specimens are labelled as "Wien Schiner" (4 specimens), "Florenz Mann" (3 specimens), "Syrakus Zeller" (1 specimen), "Spanien" (1 specimen), "Paris" (1 specimen) [ZHMB] designated in Nedeljković et al., 2015. – Holotype of *Chrysotoxum verae* Violovitsh, 1973 and *Chrysotoxum rubzovi* Violovitsh, 1973 [ZISP]. This species was examined using high resolution photos of the dorsal and lateral overall views of the specimen.

Diagnosis. Medium-sized species (10–12 mm; n=5); scape long, longer than pedicel (x:y=1.4) (Figure 2); scutum with intermixed long yellow and short black pile; wing cells R₁ and R₂₊₃ with dark-brown macula; abdomen elongated and parallel-sided; abdominal fasciae yellow, not reaching the lateral margins (Figure 4B); pro- and mesofemora black in the basal third and metafemora black in the basal 2/3. This species resembles *Chrysotoxum gracile* and *C. vernale*. It shares a very long first antennal segment (scape) with *C. gracile*, and it shares with *C. vernale* the basal thirds of the pro- and mesofemora being black, and the basal 2/3 of the metafemur being black.

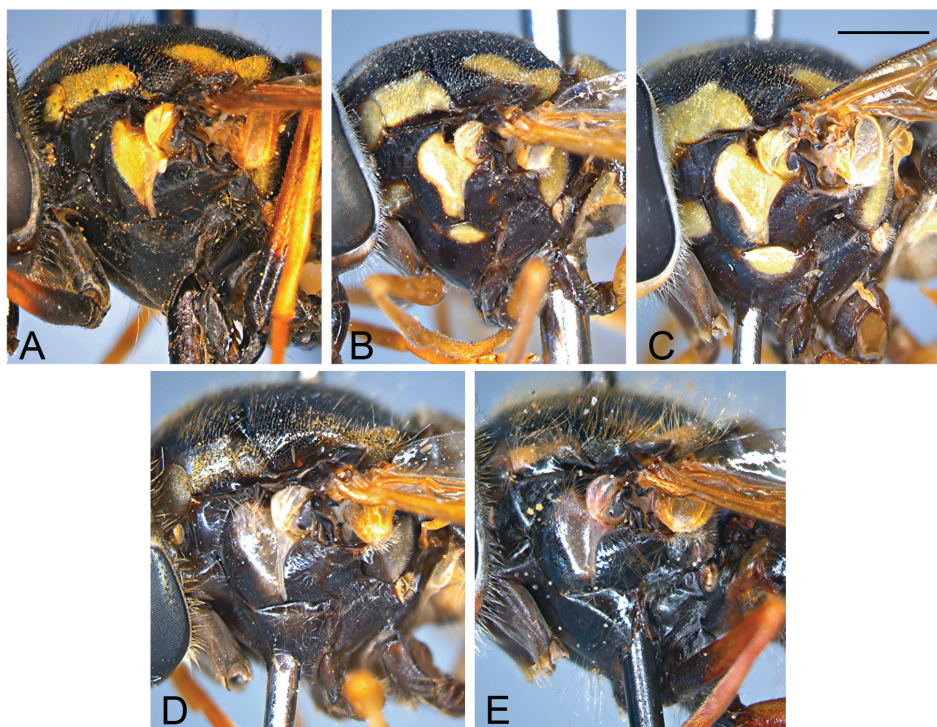


Figure 3. Pleuron, lateral view: A- *Chrysotoxum claussemi* sp. n. (male). B- *Chrysotoxum antennalis* sp. n. (female). C- *Chrysotoxum persicum* sp. n. (female). D- *Chrysotoxum antennalis* sp. n. (male). E- *Chrysotoxum vernale* (male). – Scale bar =1 mm.

Chrysotoxum antennalis sp. n. can be distinguished from *C. gracile* by the following combination of characters: wing cells R_1 and R_{2+3} with dark-brown macula (absent in *C. gracile*), katepisternum black in males (Figure 3D) (yellow in *C. gracile*); mesonotum with intermixed black and yellow pile (mesonotum only with yellow pile in *C. gracile*); pro- and mesofemora black in the basal third and metafemur black in the basal 2/3 (completely yellow in *C. gracile*); frons of females with rectangular connected microtrichose maculae (Figure 5A) (in *C. gracile* these maculae are separated (Figure 5G)). *Chrysotoxum antennalis* sp. n. differs from *C. vernale* by having a pale posterior margin of at least T4 (all black in *C. vernale*); katepisternum with a yellow spot in females (Figure 3B) (all black in *C. vernale*) and frons with rectangular connected microtrichose maculae (Figure 5A) (in *C. vernale* these maculae are separated and triangular (Figure 5D)).

Chrysotoxum antennalis sp. n. shares a very long first antennal segment (scape) with *C. verae* Violovitsh, 1973 described from the Russian Caucasus Mountains and Armenia. *Chrysotoxum antennalis* sp. n. can be distinguished from *C. verae* by the very elongated abdomen (which is more oval in *C. verae*) and the black katepisternum (in *C. verae* it has yellow maculae). *Chrysotoxum antennalis* sp. n. shares an elongated abdomen with *Chrysotoxum rubzovi* Violovitsh, 1973, but can be distinguished from this species by the black katepisternum.

Description. Male (Figure 9A). L=14 mm. **Head:** Eye pile straight and yellow, denser and longer in the dorsal half; vertical triangle black with black pollinosity in the anterior

part and silver pollinosity in the posterior part with yellow pile; frontal triangle black with long yellow pile and the silver pollinosity in the posterior part; face yellow with yellow pile and black vitta extending from antennal bases to the mouth edge, occupying 1/3 of the facial width; mouth edge black with yellow pile; antennae black, scape longer than pedicel ($x:y=1.4$) (Figure 2), arista bare, dark-brown; occiput white pollinose with long yellow pile. – *Thorax*: Mesonotum black with two longitudinal, silver pollinose vittae extending for 2/3 of its length, covered with long yellow and short black pile; vittae narrower than ocellar triangle; katapisternum completely black (Figure 3D); scutellum yellow except for the central part, covered with long yellow and short black pile, blackish at the lateral corners; legs yellow except basal third of pro- and mesofemora and basal 2/3 of metafemora which are black, covered with yellow pile; wing membrane extensively microtrichose; wing cells R_1 and R_{2+3} brown-pigmented. – *Abdomen*: Elongated, parallel-sided; shiny black with short black pile, except T1 and anterior part of T2 which have yellow pile; fasciae not reaching the lateral margins of terga, covered with yellow pile (figure 4B); all sterna shiny black with black pile, except for yellow maculae and fasciae that are covered with yellow pile; S1 and anterior part of S2 with long and erect yellow pile; anterior margin of S3 with two interconnected yellow fasciae, not reaching the lateral margins; anterior margin of S4 with two yellow maculae not reaching the lateral margins. – *Male genitalia*: Hypandrium and epandrium almost the same length (Figure 7A). Surstylus almost the same length as the rest of epandrium (Figure 8E).

Female (Figure 9B). Frons with broad rectangular microtrichose maculae connected in the center (Figure 5A); mesonotum with short black pile; T3, T4 and T5 with broad yellow fasciae in the posterior part and reaching the lateral margin, covered with short black pile. Katapisternum with yellow maculae (Figure 3B).

Etymology. *Chrysotoxum antennalis* sp. n. refers to the long antennal scape of the species. Name in apposition.

Taxonomic notes. Width of yellow fasciae on T3 and T4 can vary, occupying 1/4 to 1/3 of body width.

Distribution (Figure 1). Northeast Turkey (Erzurum and Bayburt provinces).

Flight period. From April to September.

***Chrysotoxum claussemi* Vujić, Nedeljković & Hayat sp. n.**

(Figures 3A, 4D, 5C, 6A, 7B, 8G, 9C, 9D)

Type material. Holotype: 1♂, TURKEY: Erzurum, Güngörmez, (40.16°N, 41.34°E), 4.viii.1990, leg. R. Hayat, *Chrysotoxum* sp. cf. *vernale* Lw. det. Claussen, 1994, f3 partly dark [08205, EMIT]. – Paratypes: 1♂, TURKEY: Erzurum, Karagöbek Mountain (39.60°N, 40.85°E), 5.vii.1989, leg. R. Hayat [08201, EMIT]; 1♂, Erzurum, Şenkaya Plateau (40.29°N, 40.62°E), 5.vii.1992, leg. R. Hayat [08204, EMIT]; 3♂, 4♀, Erzurum, Palandöken Mountain, 39.91°N, 41.27°E, 28.vi.1996 (2♂, 4♀), 2200m, leg. R. Hayat [08199, 08206, 08203, 08207, 08209, 08210, EMIT], 19.vii.1996 (1♂), leg. S. Fırat [08202, EMIT]; 1♂, 1♀, Erzurum, Pazaryolu-Akbulut (40.42°N, 40.77°E), 18.vi.1994, leg. R. Hayat [08200, 08211, EMIT]; 1♀, Erzurum, Aziziye-Atlıkonak (39.89°N, 40.96°E), 18.vii.1997, leg. Ö. Çalmaşur [08208, EMIT]; 1♀, Bayburt, Kop Mountain (40.05°N, 40.51°E), 28.vi.1990, leg. R. Hayat [08212, EMIT].

Comparative material of other species. Type material of *Chrysotoxum vernale* listed above.



Figure 4. Abdomen, dorsal view: A- *Chrysotoxum gracile*. B- *Chrysotoxum antennalis* sp. n.. C- *Chrysotoxum vernale*. D- *Chrysotoxum clausseni* sp. n.. E- *Chrysotoxum octomaculatum*. F- *Chrysotoxum persicum* sp. n. – Scale bar = 1 mm.

Diagnosis. Medium-sized species (11–14 mm; n=10); scape and pedicel almost the same length ($x:y=1$); mesonotum covered with intermixed short and long black pile; scutellum yellow with pale and transparent central macula; katepisternum completely black (Figure 3A); pro- and mesofemora black in the basal 1/3 and metafemur black in the basal 2/3; metafemur of female black in the basal 2/3.

This species is similar to *C. vernale* from which it can be distinguished by the yellow transparent macula on the scutellum (black in *C. vernale*) and the colour of the metafemora in females, which are black in the basal 2/3 (Figure 6A), in contrast to *C. vernale* in which they are completely yellow (Figure 6B).

Description. Male (Figure 9C). L=14 mm. – *Head*: Eye pile straight and yellow, denser and longer in the dorsal half; vertical triangle black with black pollinosity in the anterior corner and silver pollinosity in the posterior part; vertical triangle with black pile in the anterior part and intermixed black and yellow pile in the posterior part; frontal triangle black with black pile and with white pollinosity in the posterior part; face yellow with yellow pile and black vitta extending from antennal bases to mouth edge; mouth edge black; antennae black; scape and pedicel almost the same length ($x:y=1$) with short

black setae; arista light-brown, bare; occiput white pollinose with black pile (exceptionally some yellow pile can be present). – *Thorax*: Mesonotum black with short black setae and intermixed long yellow pile; mesonotum with two longitudinal, silvery pollinose vittae extending for 2/3 of its length; vittae narrower than ocellar triangle; katopisternum completely black (Figure 3A); scutellum yellow with transparent yellow central macula, blackish at the lateral corners, with short black and long yellow pile; legs yellow, basal 1/3 of pro- and mesofemora and basal 2/3 of metafemora black with yellow pile (some short black setae can be present in the apical parts of femora); wing membrane extensively microtrichose; wing cells R_1 and R_{2+3} brown-pigmented. – *Abdomen*: Shiny black with short black setae, except T1 and the anterior part of T2 which have yellow pile; abdominal fasciae yellow, not reaching lateral margins, covered with yellow pile (Figure 4D); all sterna shiny black with black pile, except yellow maculae and fasciae which are covered with yellow pile; S1 and anterior part of S2 with long erect yellow pile; anterior margin of S3 with two interconnected yellow fasciae, not reaching the lateral margins; anterior margin of S4 with two yellow maculae not reaching the lateral margins. – *Male genitalia* (Figure 7B): Similar to *C. vernale* (Figures 7G, 8C), but surstylus longer (Figure 8G).

Female (Figure 9D). Frons with triangular microtrichose maculae (Figure 5C); scutum with short black setae; metafemora black in the basal 2/3.

Etymology. This new species is named in honour of our colleague and great syrphidologist Claus Claussen.

Taxonomic notes. Lateral corners of scutellum can vary from completely black to almost transparent light brown.

Distribution (Figure 1). North-East Turkey (Erzurum and Bayburt provinces).

Flight period. From April to September.

***Chrysotoxum gracile* Becker, 1921**

Material. TURKEY: 3♂, 1♀, Erzurum, Atatürk University Campus, (39.90°N, 41.24°E), 15.vi.1997 (1♂), (leg. R. Hayat) [08160, EMIT], 7.vii.1993 (1♂) leg. E. Kılıç [08161, EMIT]; 13.vi.1996 (1♂), 1850 m, leg. R. Hayat [08163, EMIT]; 1♀, 21.viii.1992, leg. R. Hayat [08165, EMIT]; 1♂, Erzurum, Tortum, (40.29°N, 41.54°E), 9.vi.1996, leg. G. Tozlu [08162, EMIT]; 1♀, Erzurum, Oltu- Başaklı, 40.48°N, 41.81°E, 1.vii.2000, 1800 m, leg. Ö. Çalmaşur [08164, EMIT]; 1♀, Erzurum, Şenkaya Plateau, 40.56°N, 42.35°E, 9.vii.1990, leg. R. Hayat [08167, EMIT]; 1♀, Erzurum, Palandöken Mountain (39.91°N, 41.26°E), 6.vii.1996, leg. R. Hayat [08166, EMIT].

Distribution in Turkey: Erzurum province (Figure 1). New for Turkey.

***Chrysotoxum montanum* Nedeljković & Vujić, 2015**

Material. TURKEY: Erzurum, 1♂, 1♀, Atatürk University Campus, (39.90°N, 41.24°E), 9.vi.2005, 1850 m, leg. R. Hayat [08213, 08224, EMIT]; 2♂, Erzurum, Dumluköy (40.56°N, 42.35°E), 20.vi.1996, leg. R. Hayat [08217, 08218, EMIT]; 1♀, Erzurum, Oltu, Başaklı (40.48°N, 41.81°E), 1.vii.2000, 1800 m, leg. Ö. Çalmaşur [08220, EMIT]; 1♀, Erzurum, Pasinler-Rabat (39.98°N, 41.66°E), 13.vi.1996, leg. G. Tozlu [08222, EMIT]; 1♂, Erzurum, Rabat (39.98°N, 41.66°E), 13.vi.1996, 2400 m, leg. E. Yıldırım [08216, EMIT]; 1♀, Erzurum, Palandöken Mountain (39.91°N, 41.27°E), 1.vii.1997, 2400 m, leg. R. Hayat [08223, EMIT]; 1♀, Erzurum, Aziziye-Atlıkonak (39.89°N, 40.96°E), 11.vi.2000, 2000 m, leg. Ö. Çalmaşur [08226, EMIT];

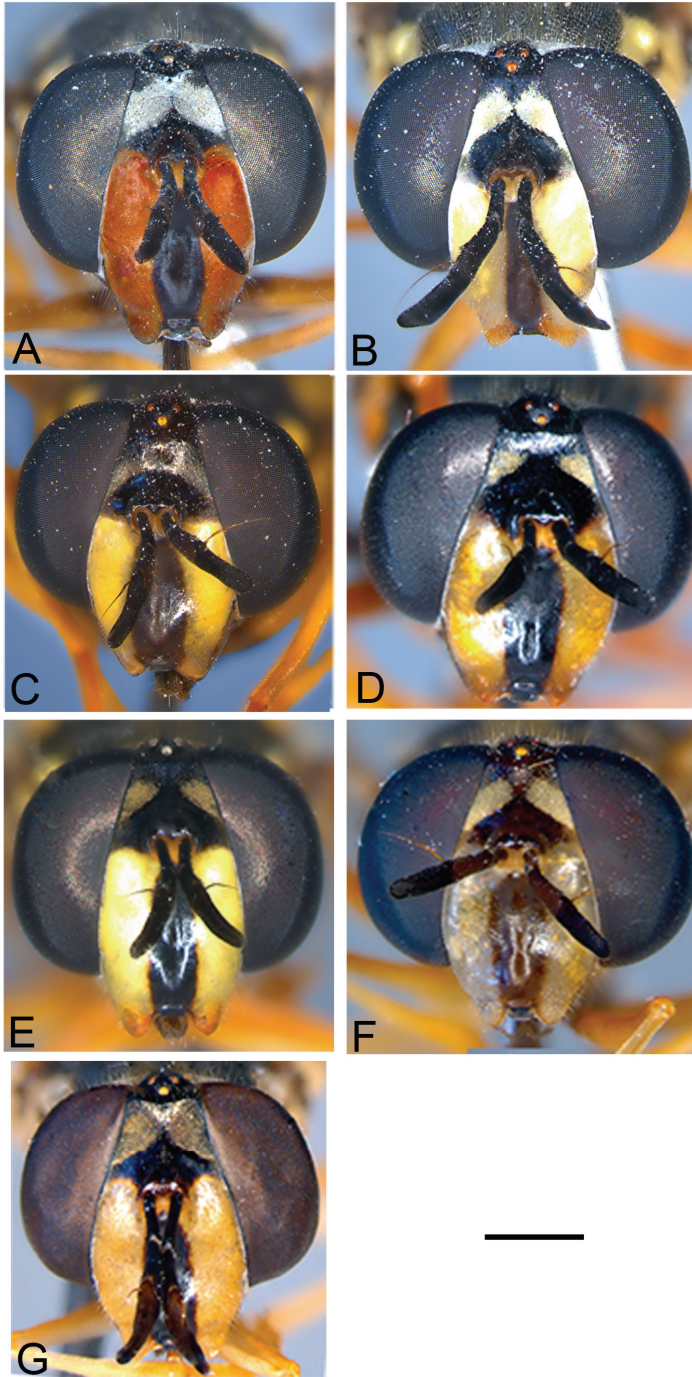


Figure 5. Frons of females, frontal view: A- *Chrysotoxum antennalis* sp. n.. B- *Chrysotoxum persicum* sp. n.; C- *Chrysotoxum clauseni* sp. n.; D- *Chrysotoxum vernale*. E- *Chrysotoxum octomaculatum*. F- *Chrysotoxum orthostylum*. G- *Chrysotoxum gracile*. – Scale bar = 1 mm.

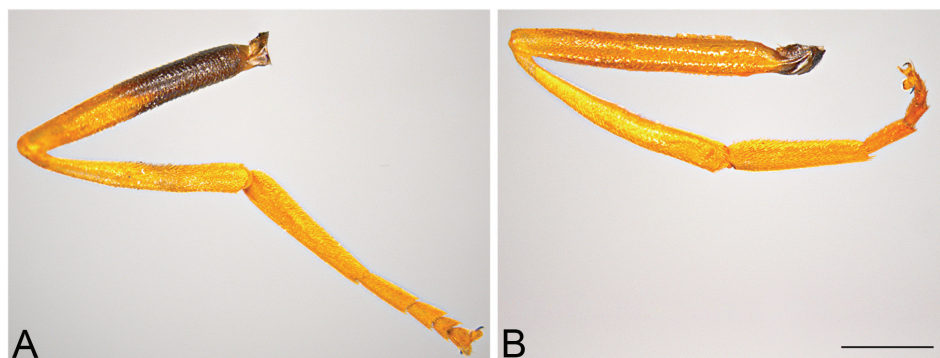


Figure 6. Metaleg, dorsal view; A- *Chrysotoxum clauseni* sp. n. (female); B- *Chrysotoxum vernale* (female). – Scale bar = 1 mm.

1♀, Erzurum, Pasinler-Pelitli (40.10°N, 41.63°E), 14.vii.1998, 1450 m, leg. Çalmaşur [08225, EMIT]; 1♂, Kars, Kağızman-Karakurt, EIE Spring (40.31°N, 42.65°E), 1391m, 23.v.2008, leg. R. Hayat [08215, EMIT]; 1♂, Kars, Sarıkamış-Karakurt, S. Geçmez (40.33°N, 42.59°E), 4.vi.2000, leg. G. Tozlu [08219, EMIT]; 1♂, Kars, Sarıkamış-Çatak (40.4°N, 42.67°E), 1927m, 14.vi.2008, leg. R. Hayat [08221, EMIT].

Distribution in Turkey: Erzurum and Kars provinces (Figure 1). New for Turkey.

Chrysotoxum orthostylum Vujić, 2015

Material. TURKEY: 1♀, Artvin, Hopa (41.39°N, 41.42°E), 3.ix.1994, leg. Y. Kansul [08186, EMIT]; 1♂, Erzurum, Dumlu-Köşkköyü (40.56°N, 42.35°E), 1.vii.1996, leg. R. Hayat [08183, EMIT]; 1♂, 1♀, Erzurum, Atatürk University Campus (39.90°N, 41.25°E), 13.vi.1996, 1♀, 1850 m, leg. R. Hayat [08184, EMIT], 1♂, 18.vi.2005 [08178, EMIT]; 1♂, 4♀, Erzurum, Palandöken Mountain (39.90°N, 41.26°E), 2200 m, 28.vi.1996 (1♂), leg. R. Hayat [08179, EMIT], 15.vii.1991 (2♀), 2400 m, leg. R. Hayat [08187, 08190, EMIT], 6.vii.1996 (1♀) [08188, EMIT], 7.vii.1996 (1♀), [08189, EMIT]; 1♂, Erzurum, Karagöbek Mountain (40.17°N, 41.44°E), 5.vii.1989, (leg. R. Hayat), *Chr. af. arcuatum* L. det. Claussen, 1994 [08151, EMIT]; 1♂, Erzurum, Uzungözü (40.53°N, 41.55°E), 23.vi.1996, leg. S. Fırat [08177, EMIT]; 2♂, Erzurum, Pasinler-Rabat (39.97°N, 41.66°E), 11.vii.1996, 2400 m, leg. İ. Aslan [08180, 08182, EMIT]; 1♀, Erzurum, Narman-Kireçli Mountain, (40.34°N, 41.87°E), 1.vii.2000, 2200 m, leg. Ö. Çalmaşur [08185, EMIT].

Distribution in Turkey: Erzurum and Artvin provinces (Figure 1). New for Turkey.

Chrysotoxum parmense Rondani, 1845

Material. TURKEY: 1♂, Erzurum, Aziziye-Yaylalı, 15.vii.1997, (39.94°N, 41.105°E) (leg. E. Kılıç) [08159, EMIT].

Chrysotoxum persicum Vujić, Nedeljković & Hayat sp. n.

(Figures 3C, 4F, 5B, 7F, 8A, 9E, 9F)

Type material. Holotype: ♂, TURKEY: Erzurum, Atatürk University Campus (39.90°N, 41.25°E), 15.vii.1993, leg. E. Kılıç [08152, EMIT]. – Paratypes: 1♀, TURKEY: Erzurum, İspir-Çayırözü (40.47°N, 40.98°E), 4.vii.1997, leg. E. Kılıç [08156, EMIT]; 1♀,

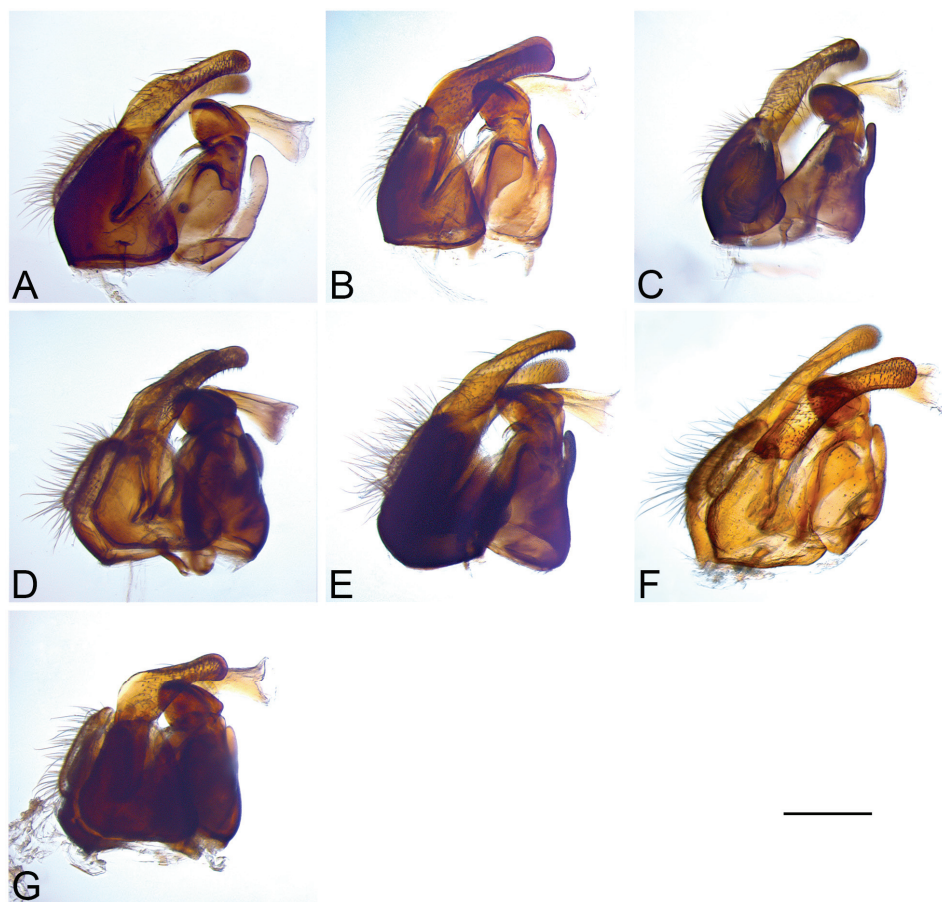


Figure 7. Male genitalia, lateral view; A- *Chrysotoxum antennalis* sp. n.. B- *C. claussemi* sp. n.. C- *C. elegans*. D- *C. octomaculatum*. E- *C. orthostylum*. F- *C. persicum* sp. n.. G- *C. vernale*. – Scale bar=0.5 mm.

Erzurum, Pazaryolu-Akbulut (40.41°N, 40.79°E), 3.vii.1997, leg. E. Kılıç [08154, EMIT]; 1♀, Erzurum, Tortum-Aksu (40.40°N, 41.49°E), 27.vii.1998, 1300 m, leg. R. Hayat [08157, EMIT]; 1♀, Erzurum, Dumlü-Köşkköyü (40.56°N, 42.35°E), 1.vii.1996, leg. R. Hayat [08155, EMIT]; 2♂, 2♀, Erzurum, Atatürk, University Campus, 1867 m (39.90°N, 41.25°E), 19.vii.2005 (1♂, 2♀), leg. J. H. Stuke [ZFMK, ZFMK-DIP-00017449, 017450, 017448], 25.vi.2008 (1♂), leg. R. Hayat [08153, EMIT]; 1♀, Erzurum, Palandöken Mountain (39.91°N, 41.27°E), 6.vii.1996, leg. R. Hayat [08158, EMIT]; 4♀, Erzurum, Tortum, 1860 m (40.25°N, 41.53°E), 26.vii.2005, leg. J.H. Stuke [ZFMK, ZFMK-DIP-00017451, 017452, 017447, 017448]; AZERBAIJAN: 1♀, Lerik, Zuvand Gosmalian, 1300 m (38.67°N, 48.33°E), 12.vi.1996, leg. M. Hauser AS-ZUV [ZFMK, ZFMK-DIP-00017446]; 1♀, Baku, Altyagach, 1200 m (40°50'N, 48°50'E), 23.vi.1996, leg. M. Hauser AS-ZUV [CSCA, ZFMK-DIP-00019864]; 2♂, Lerik, Zuvand Gosmalian, 1300 m (38.67°N, 48.33°E), 12.vi.1996, leg. M. Hauser AS-ZUV [1♂, CSCA, ZFMK-DIP-00019865; 1♂, ZFMK, ZFMK-DIP-00019867]; ARMENIA: 3♂, 1♀, prope Eilar, Kotaiko (40.54°N, 44.77°E), leg. A. Schelkovnikov [MfN, ZFMK-

DIP-00017462, 017455, 017458, 017461, ZFMK, ZFMK-DIP-00017465]; 2♂, Yerevan, Etchmiadzin, Piragan (40.17°N, 44.53°E), 4500 ft, 16.vii.1924 [MfN, ZFMK-DIP-00017456, 017459]; 1♀, Yerevan, Piragan, 6.x.1924 [MfN, ZFMK-DIP-00017453]; 1♂, 1♀, Yerevan, leg. A. Schelkovnikov [MfN, ZFMK-DIP-00017466, 017467]; 1♂, prope Yerevan, Parakar, 30.v.1927, leg. Paramonow [MfN, ZFMK-DIP-00017460]; 1♂ [unreadable locality data], 1.vii.1920 [MfN, ZFMK-DIP-00017463]; Iran: 1♀, Qazvin, Lushan (36.09°N, 49.85°E), 22.vi.2011, leg. A. Nadimi [TMUI, ZFMK-DIP-00017445].

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). – *Chrysotoxum elegans* (Villers, 1789) “is regarded as homonymous with *Musca eligans* Harris, 1780 (*elegans* in Index)” (Peck, 1988), so the authors believe that it is not necessary to review the type material. The depository of Villers’ type material is unknown and may have been destroyed or lost (Wyatt Niger, per. 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).

Diagnosis. Medium- to large-sized species (12–15 mm, n=7); x:y=1.35; frontal triangle with yellow pile; wing cells R_1 and R_{2+3} with dark brown maculae; katapisternum with yellow maculae (Figure 3C); T3–T5 with yellow maculae in the posterior part reaching the posterior margin (Figure 4F); male surstylus elongated, about four times longer than wide (Figure 7F); frons of females with broad rectangular microtrichose maculae (Figure 5B). – *Chrysotoxum persicum* sp. n. can be distinguished from the similar *C. octomaculatum* by the yellow pile on the frontal triangle (black in *C. octomaculatum*). In addition, wing cells R_1 and R_{2+3} have dark-brown spots that are absent in *C. octomaculatum*. Ratio of scape and pedicel (x:y) is 1.35 in *Chrysotoxum persicum* n. sp. and 1.25 in *C. octomaculatum*. Male surstylus is elongated (about 4× longer than wide) (Figure 7F) but, in *C. octomaculatum*, it is about 3× longer than wide (Figure 7D). Frons of females has broader rectangular microtrichose maculae (Figure 5B) than *C. octomaculatum* (Figure 5E).

Description. Male (Figure 9E). L=18 mm. – *Head.* Eye pile straight and yellow, denser and longer in the dorsal half; frontal triangle black with silver/white pollinosity and long yellow pile; vertical triangle black with silver pollinosity, posterior part of vertical triangle with yellow pile and anterior with black pile; antenna black; arista dark-brown, bare; x:y=1.35; face yellow with yellow pile and black vitta extending from antennal bases to mouth edge, occupying 1/6 of the facial width; mouth edge yellow with yellow pile; occiput white pollinose, with long yellow pile. – *Thorax.* Mesonotum black with two longitudinal, silvery pollinose vittae extending for two-thirds of its length, covered with long yellow pile; vittae broader than ocellar triangle; scutellum yellow, except central part which has light brown maculae, transparent yellow at the lateral corners; legs yellow except coxae and trochanters which are light brown, covered only with yellow pile; wing membrane extensively microtrichose; wing cells R_1 and R_{2+3} with black maculae in the apical parts; katapisternum with yellow macula. – *Abdomen.* Shiny black and mainly with yellow pile; T1 shiny black with long yellow pile; T2–T4 shiny black with broad yellow fasciae in the anterior part of the tergum and reaching the lateral margins, covered with long yellow pile (Figure 4F); yellow fascia in the posterior part covered with short black pile, reaching the posterior margin of the T2–T4

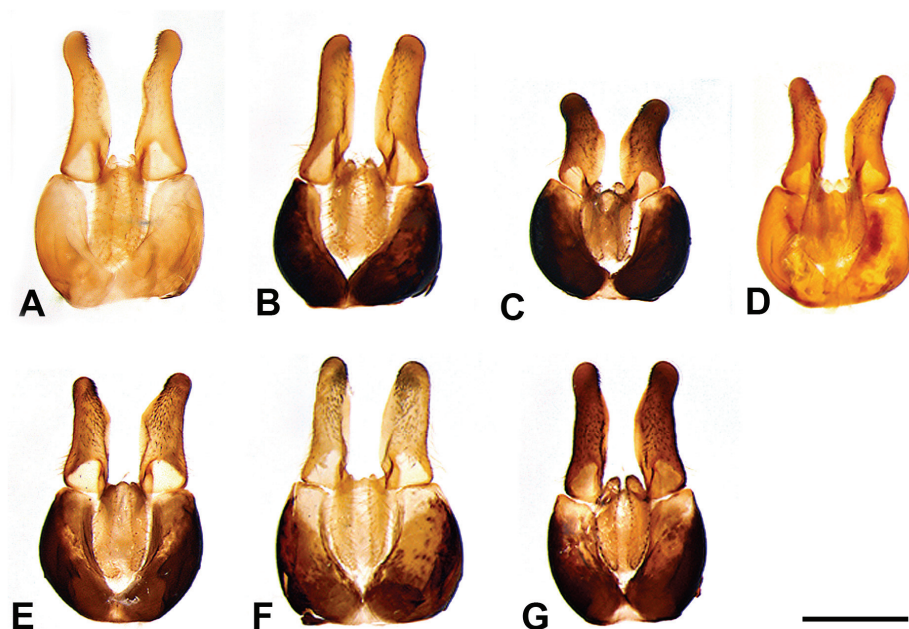


Figure 8. Male genitalia, dorsal view; A- *Chrysotoxum persicum* sp. n.. B- *C. orthostylum*. C- *C. vernale*. D- *C. octomaculatum*. E- *C. antennalis* sp. n. F- *C. elegans*. G- *C. clauseni* sp. n. – Scale bar=0.5 mm.

connected with the anterior fasciae in the lateral margin; lateral margin black in anterior and yellow in posterior part, covered with short black and long yellow pile; S1 yellow with small black central macula; entire S1 with long yellow pile; S2–S4 shiny black with yellow maculae and fasciae; anterior part of S2 with two yellow maculae connected in the medial part of sternum, covered with long yellow pile, posterior part of S2 with yellow fascia covered with short black pile; S3 and S4 with two yellow maculae in the anterior part and yellow fascia in the posterior part covered with short black pile. – *Male genitalia* (Figure 7F). Similar to *C. orthostylum* (Figures 7E, 8B); surstylus long and thin (about four times longer than wide) (Figure 8A); tip of hypandrium more straight in comparison to *C. orthostylum*.

Female (Figure 9F). Frons with broad rectangular microtrichose maculae (figure 5B); scutum with short yellow pile.

Etymology. The epithet *persicum* refers to the Persian Empire, which covered the area of distribution of this species during the first imperial dynasty under Cyrus the Great (founder of the Achaemenid Empire).

Taxonomic notes. Posterior yellow fasciae on T3 and T4 can vary in width (occupying from 1/3 to 1/2 of the tergum surface).

Distribution (Figure 1): North-East Turkey (Erzurum Province), Armenia, Azerbaijan and Iran (Qazvin Province).

Flight period. From the end of May to the end of July.

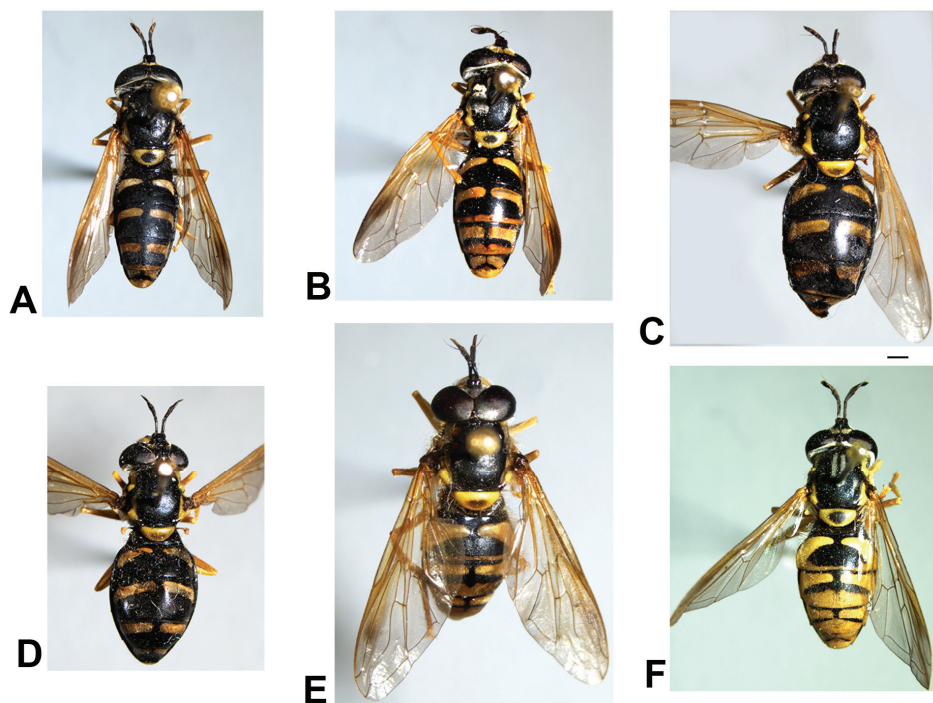


Figure 9. New *Chrysotoxum* species, dorsal view; A- C. *antennalis* sp. n., male; B- C. *antennalis* sp. n., female. C- C. *clausseini* sp. n., male. D- C. *clausseini* sp. n., female. E- C. *persicum* sp. n., male. F- C. *persicum* sp. n., female. – Scale bar = 1 mm.

Chrysotoxum vernale Loew, 1841

Material. TURKEY: 1♂, Erzurum, Oltu-Çamlıbel, (40.48°N, 41.76°E), 2.vi.1997 (leg. L. Gültekin) [08176, EMIT]; 1♀, Erzurum, Palandöken-Gölet, (39.85°N, 41.35°E), 20.vi.1996, (leg. Ö. Çalmaşur) [08175, EMIT]; 1♂, 2♀, Erzurum, Atatürk University Campus, (39.90°N, 41.24°E), 28.v.1994 (♂), 20.vi.1998 (1♀), 9.vi.2005 (1♀), 1850 m, leg. R. Hayat [08173, EMIT; 08172, EMIT; 08168, EMIT]; 1♂, Erzurum, Palandöken Mountain (39.85°N, 41.35°E), 7.vii.1996 (leg. R. Hayat) [08170, EMIT]; 1♂, Dumluköşkköyü, (40.56°N, 42.35°E), 1.vii.1996, (leg. R. Hayat) [08169, EMIT]; 1♂, 1♀, Şenkaya-Turnalı, (40.58°N, 42.21°E), 25.vii.1991 (1♂), 25.vii.1996 (1♀), 2000m, (leg. E. Yıldırım) [08174, EMIT; 08171, EMIT].

Key for Turkish species of the genus *Chrysotoxum* Meigen

Chrysotoxum impressum Becker, 1921 is not included in the key because of its uncertain taxonomic status.

- 1 T3 with narrow yellow fascia or completely black; T2 with broader yellow fascia than fasciae on T2–T5 *C. binctum* (Linnaeus)
- T2–T5 with yellow fasciae of more or less the same width 2
- 2 Male genitalia extremely large, asymmetric; female T6 with membranous central interruption; basoflagellomere almost the same length as the scape and pedicel together *C. cautum* (Harris)

- Male genitalia smaller, as long as S4, symmetric; female T6 without membrane central interruption 3
- 3 Basoflagellomere distinctly longer than scape and pedicel together 4
- Basoflagellomere shorter or the same length as scape and pedicel together 6
- 4 Robust species; scutum matt; abdominal fasciae on T3 and T4 not reaching the lateral margins; T3 and T4 with thorn-like processes; abdomen with long pile *C. fasciolatum* (De Geer)
- Smaller species; scutum shiny black; abdominal fasciae reaching the lateral margins; abdomen with short pile 5
- 5 Scutum with two dusted vittae broader than ocellar triangle; female with long pile on scutum and scutellum *C. lessonae* Giglio-Tos
- Scutum with two dusted vittae narrower than ocellar triangle; female with short pile on scutum and scutellum *C. intermedium* Meigen
- 6 Scutum with two broad silvery pollinose vittae (about 2× broader than ocellar triangle), connecting in the medial part of scutum, extending for 4/5 of its length *C. parmense* Rondani
- Scutum with two not so broad silvery pollinose vittae (broad as ocellar triangle), extending for 2/3 to 3/4 of its length 7
- 7 Scape longer than pedicel (x:y=1.4) 8
- Scape almost the same length as pedicel (x:y=1) 9
- 8 Legs completely yellow; scutum and scutellum only with yellow pile *C. gracile* Becker
- Pro- and mesofemora black in the basal third (male and female), metafemora of male black in basal 2/3 (yellow in female); scutum and scutellum with intermixed yellow and black pile *C. antennalis* sp. n. Vujić, Nedeljković & Hayat
- 9 Pro- and mesofemora black in the basal 1/3, metafemora black in basal 2/3; katepisternum completely black or with a small yellow macula 10
- All legs completely yellow; katepisternum with a yellow macula 13
- 10 Scutum only with yellow or with intermixed black and yellow pile 11
- Scutum only with black pile *C. montanum* Nedeljković & Vujić
- 11– Scutellum yellow with central transparent yellow macula *C. clauseni* sp. n. Vujić, Nedeljković & Hayat
- Scutellum yellow with central black macula 12
- 12 Posterior corners of T3 and T4 developed into thorn-like processes; male surstylus elongate, 3.7× longer than wide (Figure 7E); frons in female with lateral rectangular microtrichose maculae (Figure 5F) *C. orthostylum* Vujić
- Posterior corners of T3 and T4 not developed into thorn-like processes; male surstylus not so elongated; frons in female with lateral triangular microtrichose maculae (Figure 5D) *C. vernale* Loew
- 13 Wing cells R₁ and R₂₊₃ with dark maculae; yellow fasciae on terga not reaching the lateral margins 14
- Wing cells R₁ and R₂₊₃ without dark maculae; yellow fasciae on terga reaching the lateral margins 15

- 14 Abdomen slender, 2 times longer than wide; posterior corners of T3 and T4 developed into thorn-like processes; mesonotum with intermixed yellow and black pile; abdomen broader (S5 1.3–1.5× wider than long); face with black vitta extending from antennal bases to mouth edge, occupying 1/3 of the facial width *C. orthostylum* Vujić
- Abdomen more oval, 1.6–1.7 times longer than wide; posterior corners of T3 and T4 not developed into thorn-like processes; mesonotum only with long yellow pile; abdomen narrower (S5 1.1–1.3 times wider than long); face with black vitta extending from antennal bases to mouth edge, occupying 1/4–1/5 of the facial width *C. festivum* (Linnaeus)
- 15 Lateral margins of T3–T5 without yellow vitta *C. elegans* Loew
- Lateral margins of T3–T5 with yellow vitta 16
- 16 Frontal triangle with yellow pile; x:y=1.35; male: surstylus is elongated (about 4 times longer than wide) (figure 7F); frons in female with broad rectangular microtrichose maculae (figure 5B) *C. persicum* sp. n. Vujić, Nedeljković & Hayat
- Frontal triangle with black pile; x:y=1.25; male: surstylus not so elongated (about 3 times longer than wide) (figure 7D); frons in female with not so broad rectangular microtrichose maculae (Figure 5E). *C. octomaculatum* Curtis

Discussion

Arising from this study, eight *Chrysotoxum* species have been identified from northeast Turkey, including three species new to science as well as three species new to the Turkish fauna. Accordingly, the checklist of *Chrysotoxum* species for Turkey, including the newly-described species from this study, now comprises 17 species, representing about 74% of the European *Chrysotoxum* species recorded in Speight, Castella, and Sarthou, (2015).

The Mediterranean Basin is considered a biodiversity “hot-spot” (Myers et al., 2000). The Mediterranean region in a broad sense (i.e. including Anatolia, Armenia, and Hyrcania), together with the Far East, are the most species-rich areas in the Palaearctic, with a highly endemic insect fauna (Oosterbroek, 1994). The most species-rich areas of the Mediterranean are the Balkans and Anatolia (also known as Asia Minor or Asian Turkey) (Oosterbroek, 1994). The main reason for such high diversity in Anatolia is its topographic and climatic variability, as well as its geographic position as a “bridge” between Asia, Africa and Europe (Çıplak, 2003).

Anatolia was an important refugium during the Quaternary ice ages, receiving populations via the Balkan Peninsula and the Caucasus Mountains (Çıplak, 2003), explaining why elements of the Balkan hoverfly fauna occur in Anatolia. For example, *Paragus kopdagensis* Hayat & Claussen, 1997 (described from Erzurum Province) has thus far only been additionally recorded in Serbia and the Caucasus Mountains (Speight et al., 2015; Radenković, 1999; Nedeljković, 2011). Additionally, in this study, two species of the genus *Chrysotoxum* (*C. montanum* and *C. orthostylum*) described from the Balkan Peninsula (Nedeljković et al., 2015) have been reported for the first time in Turkey. Sixteen species of *Chrysotoxum* have been recorded from the Balkan Peninsula to date (Nedeljković et al., in prep.). The Anatolian and Balkan Peninsulas differ somewhat in their complement of *Chrysotoxum* species: *C. parmense*, *C. antennalis* sp. n., *C. claussenii* sp. n. and *C. persicum* sp. n. have only been recorded on the Anatolian Penin-

sula, whereas *C. lineare* (Zetterstedt) has only been recorded from the Balkan Peninsula. *C. lineare* has a western distribution, whereas *C. parmense* is distributed in Southern Europe, North Africa and the Middle East (Speight, 2015).

Our results confirm that as a high-mountain region (also known as Anti-Taurus), intersected by valleys and plains (Saribiyik, 2014), Eastern Anatolia is a centre of speciation in Turkey. With 67 hoverfly species, representing circa 21% of the total number of hoverfly species recorded in Turkey (Saribiyik, 2014), Erzurum Province is one of the most species-rich parts of Turkey. 22 hoverfly species, are only known from Erzurum, including: *Chrysotoxum vernale* and *Chrysotoxum gracile*. Low numbers of hoverfly species have been recorded from Azerbaijan and Armenia, but this is surely due to the fact that the hoverfly fauna in both these countries has been poorly studied. More faunistic and taxonomic work throughout the Middle East and European-Asian region is necessary in order to ascertain the taxonomy of the genus *Chrysotoxum*, which still needs a complete revision (Speight, 2015).

Acknowledgements

We kindly thank Dr Olga Ovtshinnikova (ZISP) for the pictures of the type specimens of *Chrysotoxum* described by Violovitsch, Dr Luca Bartolozzi (LSF) for the pictures of the type specimens of *Chrysotoxum chrysopolitum* Rondani, and Dr Antonio Ricarte (CIBIO) for the pictures of type specimens of *C. octomaculatum* Curtis. We thank our colleagues for collecting some of the specimens. Thanks to Dr Nigel Wiatt (BMNH) for information about the Curtis and Harris type specimens. We thank Dr Jelena Ačanski for preparing the map and for help in preparing the figures. We thank John O'Brien and Marija Miličić for English revision and Laura Likov MSc for taxonomic advice. Thanks to the members of the Palynology Laboratory, University of Novi Sad (Serbia) for enabling us to use their technological facilities.

Funding

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Research Project No: OI173002).

Disclosure Statement

No potential conflict of interest was reported by the authors.

References

- Bischof, J. (1902): Ergebnisse einer naturwissenschaftlichen Reise zum Erdschias Dagh (Kleinasien). *Annalen des k. k. naturhistorischen Hofmuseums*, 20: 1–9.
- Brown, B. V. (2009): Introduction. Pp. 1–7. In: Brown, B.V., Borkent, A., Cumming, J. M., Wood, D. M., Woodley, N. E., Zumbado, M. A. (Eds), *Manual of Central American Diptera*. Vol. 1. Ottawa (Canada): NRC-CNRC Research Press.
- Çıplak, B. (2003): Distribution of Tettigoniinae (Orthoptera, Tettigoniidae) bush-crickets in Turkey: the importance of the Anatolian Taurus Mountains in biodiversity and implications for conservation. *Biodiversity and Conservation*, 12, 47–64.
- Curtis, J. (1823–1840): British Entomology; being illustrations and descriptions of the genera of insects found in Great Britain and Ireland: containing coloured figures from nature, of the most rare and beautiful species, and in many instances of the plants upon which they are found. Vol. VIII, Diptera. London: Omalopectera.
- Dousti, A. B., & Hayat, R. (2006): A catalogue of the Syrphidae (Insecta: Diptera) of Iran. *Journal of the Entomological Research Society*, 8, 5–38.

- Giglio-Tos, E. (1890): Le specie Europee del genere *Chrysotoxum* Meig. *Atti della R. Accademia delle Scienze di Torino*, 26, 134–165.
- Gresham, S. D. M., Charles, J. G., Sandanayaka, M. W. R., & Bergh, J. C. (2013): Laboratory and field studies supporting the development of *Heringia calcarata* as a candidate biological control agent for *Eriosoma lanigerum* in New Zealand. *Biocontrol*, 58, 645–656.
- Hayat, R. (1997): *Sphegina* (*Sphegina*) *alaoglu*, a new hover-fly from north-eastern Turkey (Diptera: Syrphidae). *Zoology in the Middle East*, 14, 109–113.
- Hayat, R., & Claussen, C. (1997): A new species and new records of the genus *Paragus* Latreille, 1804 from Turkey (Diptera: Syrphidae). *Zoology in the Middle East*, 14, 99–108.
- Hurkmans, W., & Hayat, R. (1997): Ethology and ecology of *Merodon* (Diptera: Syrphidae) in Turkey II: descriptions of new species and notes on other syrphid flies. *Dipterists Digest*, 3, 62–79.
- Inouye, D., Larson, B. M. H., Ssymank, A., & Kevan, P. G. (2015): Flies and flowers III: Ecology of foraging and pollination. *Journal of Pollination Ecology*, 16, 115–133.
- Larson, B. M. H., Kevan, P. G., & Inouye, D. W. (2001): Flies and flowers: taxonomic diversity of anthophiles and pollinators. *The Canadian Entomologist*, 133: 439–465.
- Loew, H. (1841): Ueber die Gattung *Chrysotoxum*. *Stettiner Entomologische Zeitung*, 2, 136–141.
- Kazerani, F., Talebi, A., & Gilasian, E. (2013): An annotated checklist of the subfamily Syrphinae (Diptera: Syrphidae) of Iran. *Entomofauna*, 34, 517–556.
- Morales, G. E., & Wolff, M. (2010): Insects associated with the composting process of solid urban waste separated at the source. *Revista Brasileira de Entomologia*, 54, 645–653.
- Myers, N., Mittermeier, R. A., Mittermeier, C. G., Fonseca, G. A. B., & Kent, J. (2000): Biodiversity hotspots for conservation priorities. *Nature*, 403, 853–858.
- Nedeljković, Z. (2011): Taxonomic analyses of the species from the subfamily Syrphinae (Diptera: Syrphidae) in Serbia. Novi Sad (Serbia): University of Novi Sad (unpubl. Ph.D. thesis).
- Nedeljković, Z., Ačanski, J., Đan, M., Obreht-Vidaković, D., Ricarte, A., & Vujić, A. (2015): An integrated approach to delimiting species borders in the genus *Chrysotoxum* Meigen, 1803 (Diptera: Syrphidae), with description of two new species. *Contributions to Zoology*, 84, 285–304.
- Nedeljković, Z., Ačanski, J., Vujić, A., Obreht, D., Đan, M., Ståhls, G., & Radenković, S. (2013): Taxonomy of *Chrysotoxum festivum* Linnaeus, 1758 (Diptera: Syrphidae) – an integrative approach. *Zoological Journal of the Linnean Society*, 169, 84–102.
- Oosterbroek, P. (1994). Biodiversity of the Mediterranean region. Pp. 289–307. In: Forey, P. I., Humphries, C. J., Vane-Wright, R. I. (Eds), *Systematics and conservation evaluation*. Oxford (U.K.): Clarendon Press.
- Parks, D. H., Mankowski, T., Zangooei, S., Porter, M. S., Armanini, D. G., Baird, D. J., Langille, M. G. I., & Beiko, R. G. (2013): GenGIS 2: Geospatial analysis of traditional and genetic biodiversity, with new gradient algorithms and an extensible plugin framework. *PLoS One*, 8, 7, e69885.
- Peck, L. V. (1988): Syrphidae. Pp. 1–327. In: Soós, A., & Papp, L. (Eds), *Catalogue of Palaearctic Diptera*. Budapest: Akademia Kiado.
- Radenković, S. (1999): Taxonomy and the distribution of genus *Paragus* Latreille, 1804 (Diptera: Syrphidae). Novi Sad: University of Novi Sad (unpubl. M.Sc. thesis).
- Rondani, C. (1845): Species Italicae generis *Chrysotoxi insectis* Dipteris, observatae et distinctae. Fragmentum decimum ad inserviendum dipterologiae Italicae. *Annales de la Société Entomologique de France*, 3, 193–203.
- Rotheray, G. E. (1994): Colour guide to hoverfly larvae (Diptera, Syrphidae) in Britain and Europe. *Dipterists Digest*, 9, 1–156.
- Rotheray, G. E., & Gilbert, F. (2011): *The natural history of hoverflies*. Ceredigion (U.K.): Forrest tex.
- Sang-Wook, S., & Ho-Yeon, H. (2013): Clarification of previously confused *Chrysotoxum sapporensis* and *Chrysotoxum graciosum* (Insecta: Diptera: Syrphidae) in East Asia based on morphological and molecular data. *Animal Cells and Systems*, 17, 277–289.
- Sarıbiyik, S. (2014): Check list of Turkish flower flies (Diptera: Syrphidae). *Munis Entomology and Zoology*, 9, 570–585.

- Shannon, R. C. (1926): The Chrysotoxine Syrphid flies. *Proceedings of the United States National Museum*, 69, 1–20.
- Speight, M. C. D. (2015): Species accounts of European Syrphidae (Diptera), 2015. Syrph the Net, the database of European Syrphidae. Dublin: Syrph the Net publication.
- Speight, M. C. D., Castella, E., & Sarthou, J. P. (2015): Syrph the Net 2015. In: Speight, M. C. D., Castella, E., Sarthou, J. P., & Vanappelghem, C. (Eds), *Syrph The Net On Cd, Issue 10*. Dublin: Syrph the Net Publications.
- Thompson, F. C. (1999): A key to the genera of the flower flies of the Neotropical Region including the descriptions of genera and species and a glossary of taxonomic terms. *Contributions on Entomology, International*, 3, 319–378.
- Thompson, F. C. (2013): Family Syrphidae. In: Thompson, F. C., & Pape, T. (Eds), *Systema Dipterorum*. version 1.5. www.diptera.org (accessed 2 November 2016).
- Thompson, F. C., & Rotheray, G. (1998): Family Syrphidae. Pp. 81–139. In: Papp, L., & Darvas, B. (Eds), *Contributions to a Manual of Palaearctic Diptera* 3. Budapest: Science Herald.
- Thompson, F. C., Rotheray, G. E., & Zumbado, M. A. (2010): Syrphidae (flower flies). Pp. 763–792. In: Brown, B. V., Borkent, A., Cumming, J. M., Wood, D. M., Woodley Norman, E., & Zumbado, M. A. (Eds), *Manual of Central American Diptera*. Ottawa: NRC Research Press.
- Tóth, S. (2013): Additional data to the hoverfly fauna of Turkey (Diptera: Syrphidae). *Natura Somogyiensis*, 23, 239–254.
- Van Steenis, J., Ricarte, A., Vujić, A., Birtele, D., & Speight, M. C. D. (2016): Revision of the West-Palaearctic species of the tribe Cerioidini (Diptera: Syrphidae). *Zootaxa*, 4196, 151–209.
- Villers, C. J de (1789): Caroli Linnaei entomologia, faunae sueciae descriptionibus aucta. Lugduni [= Lyon].
- Violovitsh, N. A. (1974): A review of the Palaearctic species of the genus *Chrysotoxum* Mg. (Diptera, Syrphidae). *Энтомологическое обозрение (Entomological Review)*, 53, 196–217.
- Vockeroth, J. R. (1969): A revision of the genera of the Syrphini (Diptera: Syrphidae). *Memoirs of the Entomological Society of Canada*. 62, 1–176.