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First records of *Chrysotoxum volaticum* Séguy, 1961 from Europe and *Platycheirus marokkanus* Kassebeer, 1998 from Spain (Diptera: Syrphidae) together with additional records of Spanish *Chrysotoxum* Meigen, 1803

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Abstract. The first European records of *Chrysotoxum volaticum* Séguy, 1961 from Spain and France, and *Platycheirus marokkanus* Kassebeer, 1998 from Spain are provided. These are further examples of North African species also present in the Iberian Peninsula. Diagnostic characters are given to separate *C. volaticum* and the similar *Chrysotoxum bicinctum* (Linnaeus, 1758), and additional records of other *Chrysotoxum* Meigen, 1803 hoverflies from Spain are also reported. We also provide DNA barcodes for *C. volaticum* and discuss the utility of DNA barcoding to identify species in the genus *Chrysotoxum*.

Key words. Ibero-Maghreb fauna, new species records, France, Spain, diagnosis, DNA barcoding.

INTRODUCTION

Syrphidae is a species rich family of Diptera which has received much attention during the last decades. Adults of this family are often wasp and bee mimic flower visitors, while larvae have very different feeding modes (Rotheray & Gilbert 1999, 2011). Adults of many species are important pollinators (Ssymank & Kearns 2009; Inouye et al. 2015), predatory larvae are important for pest control (Bugg et al. 2008, Pineda & Marcos-García, 2008; Amorós-Jiménez et al. 2012) and saprophagous larvae in the decomposition of organic material (Lardé 1989; Rotheray et al. 2009; Martínez-Falcón et al. 2012). The large amount of knowledge we now have about this family in Europe and the interest syrphids provoke in many academic and applied fields has led the international organisation IUCN to develop a European red list for Syrphidae (IUCN 2018). The data here reported will help the preparation of a red list from Spain.

MATERIAL AND METHODS

Morphological terminology follows Thompson (1999). The examined material originates from different collecting events in Spain and France in the last decades. The species were identified using original descriptions (Séguy 1961; Kassebeer 1998) and other literature (Nielsen 1999; de Courcy Williams et al. 2011; Nedeljković et al. 2013; Speight et al. 2013; Young et al. 2016). Many Spanish specimens were collected in the 'Sierra de Alcaraz', in the province of Albacete, a low mountainous area with open Pine forests with Mediterranean maquis (Van Steenis et al. 2017). The information provided under

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'Examined material' is given in the order of region or province, area and locality with an indication of the altitude, collecting date, in which a range is indicated with "–", the collector, without adding "leg." in the material studied section, and in some cases a specimen identifying number, rather than the precise label information.

The figures were made by the first author by stacking multiple photos in Zerene Stacker ver. 1.04 and then further edited with GNU Image Manipulation Program ver. 2.8.22. Each individual photo was taken with Cognisys StackShot at fixed intervals with a Canon EOS D6 SLR camera, a Canon MP-E 5× macro-zoom with a Yongnuo YN14EX ring flash attached. The colour plates were made with the aid of a Zeiss camera lucida on a Zeiss-stereomicroscope SV11 by Axel Ssymank.

Abbreviations for depositories / collections

AET = private collection of André van Eck, Tilburg, the Netherlands
ASW = private collection of Axel Ssymank
CEUA = Colección Entomológica de la Universidad de Alicante, CIBIO Institute, Alicante, Spain
CPP = private collection of Chris Palmer, Portsmouth, United Kingdom
DDG = private collection of Dieter Doczkal, Gaggenau, Germany
JSA = private collection of Jeroen van Steenis
MNCN = Museo Nacional de Ciencias Naturales, Madrid, Spain
MNHN = Muséum National d'Histoire Naturelle, Paris, France
MRL = private collection of Menno Reemer, Leiden, the Netherlands
MZW = private collection of Menno van Zuijen
NBC = Naturalis Biodiversity Center, Leiden, the Netherlands
NHM = The Natural History Museum, London, UK
SBH = private collection of Sander Bot, Haren, the Netherlands

The 5' region of the cytochrome *c* oxidase subunit I (COI) gene, the so called DNA barcode (Hebert et al. 2003a, 2003b) was obtained from three specimens of *Chrysotoxum volaticum* Séguy, 1961. Meso- and metalegs from dry, pinned specimens were used for DNA extraction. The extraction protocol follows Mengual et al. (2018) and the specimens were preserved and labelled as DNA voucher specimens for the purpose of morphological studies and deposited at the CEUA. DNA primers and PCR amplification protocols follow Rozo-Lopez & Mengual (2015).

RESULTS

Both *Chrysotoxum volaticum* and *Platycheirus marokkanus* have been mentioned to occur in Europe (Ssymank & Doczkal 2007; Van Steenis & Van Steenis 2014), but only records of *P. marokkanus* have been documented so far (Van Eck 2016).

Since Séguy's original description, *Chrysotoxum volaticum* has been reported only from Morocco by Claussen (1989) and Claussen & Hauser (1990). The original description of *C. volaticum* is not very informative and this species is missing from most identification keys. Thus, we provide here a table (Table 1) of diagnostic characters and a key to distinguish it from the similar *Chrysotoxum bicinctum* (Linnaeus, 1758).

Chrysotoxum bicinctum (Linnaeus, 1758)

Distribution. Widespread throughout Europe, possibly very rare in the Iberian Peninsula. In Spain, records of this species are confirmed just from the provinces of Asturias, Cantabria and Lérida.

Material examined. Many records in the authors' collections throughout Europe. **Spain**: 1♂ (CEUA), Asturias, Santillán, 6-VII-1986, M.A. Marcos García (26b), [det. as *C. bicinctum* form A by A. Ssymank in 2009]; 1♀ (CPP), Cantabria, Potes, Las Ilces, 43˚06'41" N, 4˚45'27" W, 754 m, 26-VI-2017, C.J. Palmer; 1♀ (CPP), Girona, Setcases, 26-VIII-1996, C.J. Palmer; 1♀ "yellow" (SBH), Lleida, Bordes de Graus, camping, 42˚40'07" N 1˚14'14" E, 1321 m, 4-VII-2019, S. Bot; 1♀ (SBH), Lleida, near Tavascan, 42˚40'59" N, 1˚13'59" W, 1400 m, 29-VII-2013, S. Bot; 1♂ (NBC), Lleida, Vall d'Aran, VIII-[19]45; 1♂ (CEUA), Santander, Vada, 22-VI-1987, M.A. Marcos García (34).

The two CEUA males were already published as *C. bicinctum* in Marcos-García (1990) and are here confirmed to belong to this species.

Remarks. This species is similar to *Chrysotoxum volaticum* and was, until recently, confused with this species in Europe (Ssymank & Doczkal 2007). Note that there is a form of *C. bicinctum* resembling *C. volaticum* in the more extensively dark coloured wing (Fig. 3F). These specimens are common in the UK and Scandinavia and are generally darker (Figs 2C, 2D), with dark legs, dark abdomen and dark-brown to entirely black (as in Figs 4A, 4C) mouth edge and hypostomal bridge. In the Pyrenees, intermediate forms are also found with a combination of characters in-between *C. bicinctum* and *C. volaticum* indicating possible hybridization.

There is one female (Spain, Pyrenees, coll. SBH) with black mouth edge and hypostomal bridge as in *C. volaticum* and a short wing macula, a black frons with small

pollinose maculae and narrow fascia on tergum IV as in *C. bicinctum*. Two other females (coll. SBH, Spain Lérida and France, Pyrenees) have a yellow hypostomal bridge, a black frons and a short wing macula as in *C. bicinctum*, but large pollinose maculae on the frons and a wide yellow fascia on tergum IV as in *C. volaticum*. These all could be females of *C. bicinctum* in which the last two are "yellow" forms in which the pollinose maculae on the frons are larger. There are three males (France, Pyrenees, coll. SBH), sympatric with one of the "yellow" females, which seem to be more straightforward identified as *Chrysotoxum volaticum*, although the frontal pollinosity, the frontal colour and the colouration of the scutellum seem to be more like in *C. bicinctum*.

Chrysotoxum volaticum Séguy, 1961

Distribution. Originally described from Algeria and Morocco (Séguy, 1961). Recently recorded from Morocco (Claussen, 1989; Claussen & Hauser, 1990). Dirickx (1994) also reported this species in the Mediterranean region of Morocco.

New to Europe and found in France, Portugal and Spain.

Material examined. Type series: 2 ♂, 3 ♀, "Moyen Atlas, Ifrane (Morocco), VI-[1]949", "Museum Paris 1949 L. Chopard"; 1 ♂ "Setif, Algérie, coll. Théry", "Museum Paris, Algérie, Setif A. Théry 1902" (MNHN). **France**: 2 ♀ (MRL), Cevennes, Causse Blandas, 10 km SW Le Vigan, 43°54'56" N, 3°28'51" E, 800 m, 20-VIII-2014, M. Reemer; 1 ♀ (JSA), Languedoc-Roussillon, Prades,

Table 1. Differentiating characters between *Chrysotoxum volaticum* and *C. bicinctum*.

	Chrysotoxum bicinctum	***Chrysotoxum volaticum***
Colouration of wing	Dark macula on wing margin shorter never reaching wing apex and **usually ending as a broad blunt spot above the bow of vein R4+5,** usually apical border of dark wing macula clearly demarcated. In dark specimens radial cell R1 also darkened and outer apical border diffuse	Dark brown to black on anterior margin, reaching the wing apex, **Radial cell R1 completely darkened and dark patch extending distinctly beyond the tip of this cell, dark spot in cell R2+3 reaching costa for up to about ½ of its length within this cell,** wing patch apically and on posterior margin clearly demarcated, sometimes reaching backwards to join R4+5 apically
Scutellum in dorsal view	**Almost completely black, with a narrow yellow posterior margin.** In bright specimen two narrow yellow or obscured small maculae may be present basally, in males sometimes fused to a narrow basal yellow line	**Scutellum largely yellow** with scarcely visible narrow black fascia basally and a black median fascia of varying extent: Females usually with broad median black fascia of ca. 0.5–0.7 × of length of scutellum
Frons, colour around the lunulae on frontal prominence	**Complete frons dark brown to black**; lunulae itself mostly dark brown to black, rarely obscurely yellow or in some specimen yellow	**Frons laterally and posteriorly of lunulae yellow.** However, the yellow part may be largely obscured with only laterally some dark-yellow colour
Pollinosity on frons	Males: narrow pollinose fascia white Females: **pollinose maculae smaller**, leaving about 1/5–¼ of the frons free in the middle	Males: narrow pollinose fascia yellowish Females: **pollinose maculae large, almost touching**, narrow non-pollinose line in between usually less than 1/5 of width of frons
Ratio: length of eye contiguity/ ocellar triangle (males only)	Eye contiguity often distinctly longer than ocellar triangle, Ratio ca. 1.1–1.3	Almost the same length, Ratio 0.9–1.1
Tergum III	Black usually with very narrow yellow fascia or well developed yellow pair of maculae, however dark specimen have a completely dark terum III	Black with a very narrow yellow posterior margin, rarely also with small yellow maculae
Tergum IV	**Yellow fascia narrow**, usually 0.2–0.4 of length of tergum IV, in light specimens wider	**Yellow fascia broad**, usually 0.4–0.75 of length of tergum IV,
Genae and hypostomal bridge	Genae below eyes with a black vitta, but **hypostomal bridge clearly yellow,** in dark specimens genae black and hypostomal bridge dark-brown to black	Genae below eyes and hypostomal bridge **usually completely black or with dark brownish patches on the sides;** a few individuals may have an almost yellow mouth edge

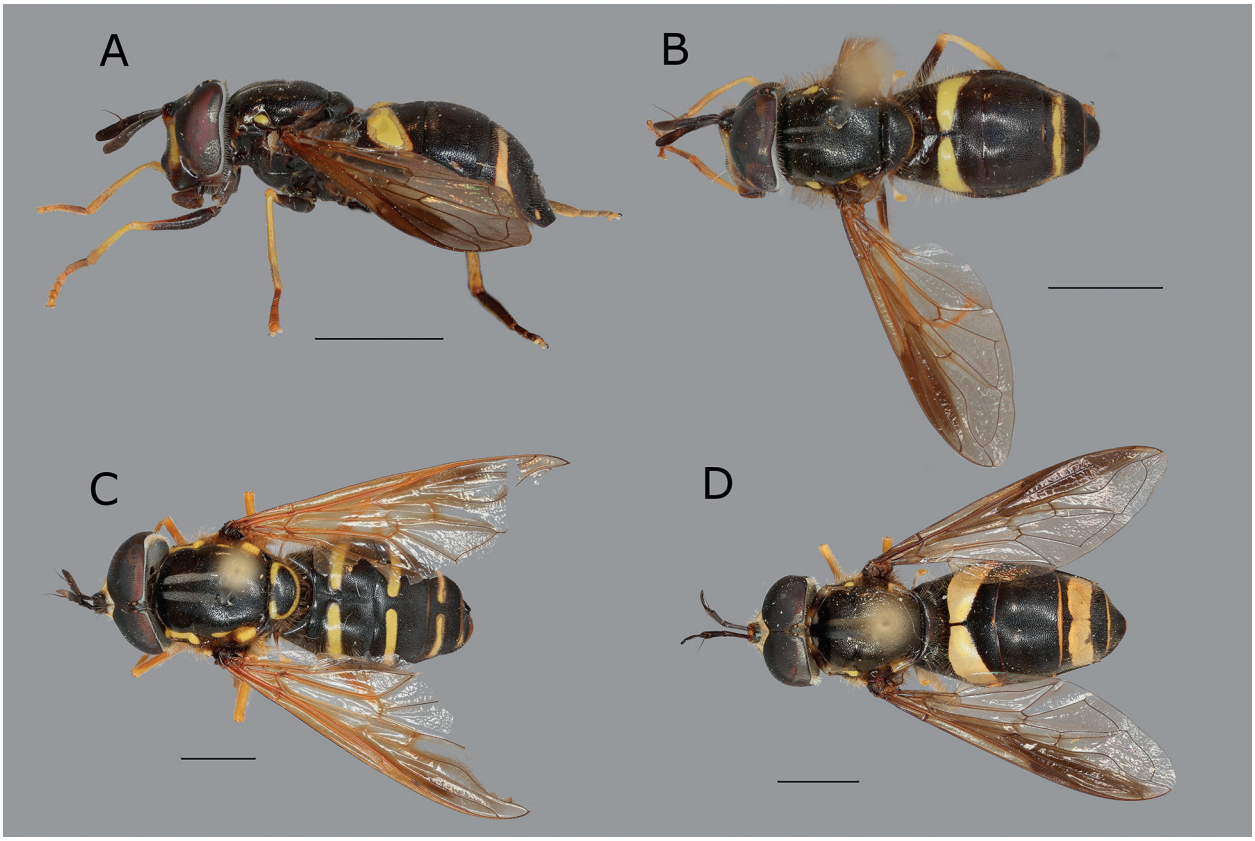

Fig. 1. Adult habitus. **A**. Lateral view. **B–D**. Dorsal view. **A**. *Chrysotoxum bicinctum*, ♀, Sweden. **B**. *C. bicinctum*, ♂, Sweden. **C**. *C. festivum*, ♂, Spain. **D**. *C. volaticum*, ♂, Sierra de Alcaraz. Scale bars: 2.5 mm.

Les Sauterelles, 42°34'15" N 2°24'49" E, 785 m, 12-VIII-2014, J. van Steenis; 1♀ (JSA), Vernet les Bains, Col de Mantet, 42°28'50" N 2°18'53" E, 1765 m, 17-VIII-2014, J. van Steenis; 3 ♂ (SBH), Pyrenees, Vallée d'Eyne, 42˚28'05" N, 2˚05'17" E, 1650 m, 23-VII-2013, S. Bot; 1 ♂ (NBC), Pyrenees Orientales, Font Rocheu, 11-VII-1965, J. v.d Vecht; 1 ♀ (NBC), Pyrenees Orientales, Fillols, 10-VII-1965, J. v.d. Vecht; 1 ♀ (NBC), Vaucluse, Carpentras VI-1953, P.M.F. Verhoeff; 12 ♀ (NBC), Vaucluse, Carpentras, 1–3-VIII-1953, P.M.F. Verhoeff; **Morocco**: 2 ♀ (NBC), Toubkal Massif, Oukaïmeden, 2500-2800 m, 2–8-VII-1977, v. Oorschot, Houkes & Oosterbroek; 1 ♀ (NBC), Arhbalou, 43 km S. Marrakech, route S513, 1000 m, 3–14-VII-1977, v. Oorschot, Houkes & Oosterbroek; **Portugal**: 1 ♀ (NBC), Doure, Resende, 16–19-VII-1953, P.M.F. Verhoeff; 1 ♀ (AET), Braga, Gilmonde, Barcelos, 41°29'02" N 8°46'00" W, 22-V-2012, R. Andrade; **Spain**: 1 ♂ (JSA), Albacete, Sierra de Alcaraz, Batán del Puerto, 38°34' N 2°21' W, 1200 m, 21-VI-2003, J. van Steenis; 2 ♂, 1 ♀ (JSA), 3 ♀ (MZW), Sierra de Alcaraz, Puerto de las Crucetillas, 38°31' N 2°26' W, 1400 m, 21-VI-2003, J. van Steenis & M.P. van Zuijen; 1 ♂, 1 ♀ (MZW), Sierra de Alcaraz, Puerto de las Crucetillas, 38°32' N, 2°24' W, 1100 m, 21-VI-2003, M.P. van Zuijen; 1 ♂, 1 ♀ (JSA), 1♀ (MZW), Sierra de Alcaraz, Puerto de las Crucetillas, 38°32' N, 2°23' W, 1000–1200 m, 22-VI-2003, J. van Steenis & M.P. van Zuijen; 1 ♀ (JSA), Sierra de Alcaraz, Cañada del Provencio, 38°31' N 2°20' W, 1000 m, 22-VI-2003, J. van Steenis; 1 ♂ (NBC), Andalucía, Prado Llano, 23-VII-1980; 1 ♀ (NBC), Andalucía, Prado Llano, 24-VII-1980; 1♀ (NBC), Vadillo Castril, Sierra de Cazorla, 3-VIII-1980; 5 ♂ (MRL), Andalucía, Sierra Nevada, 2 km N of Trevelez, 25-VI-2003, M. Reemer; 1 ♂ (MRL), Andalucía, Sierra Nevada, Trevélez, 37˚00'47" N, 3˚15'47" W, 1600 m, 10-VI-2019, M. Reemer; 1 ♀ (CEUA), Ávila, Becedas, 6-VII-1977, M.A. Marcos-García; 2 ♂ (ASW), 3 ♂, 1 ♀ (DDG), Castilla la Mancha, Sierra de Alcaraz, Riópar, 38°30'17" N, 2°27'36" W, ca. 775 m, 14-VI-2003, A. Ssymank & D. Doczkal; 4 ♂, 1 ♀ (ASW), 5♂, 1♀ (DDG), Sierra de Alcaraz, Espinares de León, 38°32'15" N, 2°24'18" W, ca. 1380 m, 14-VI-2003, A. Ssymank & D. Doczkal; 3 ♀ (CEUA), Ciudad Real, P.N. Cabañeros, respectively 20-V-2005, 5-VII-2005, 24-VIII-2005, A. Ricarte; 3 ♂ (NBC), Gerona, Ribas de Freser, 900 m, 25-VII-1970, V.S. v.d. Goot; 1 ♂ (NBC), Gerona, Ribas de Freser, 900 m, 26-VII-1970, V.S. v.d. Goot; 2 ♂ (NBC), Gerona, Mollo, 1300 m, 17-VII-1970,

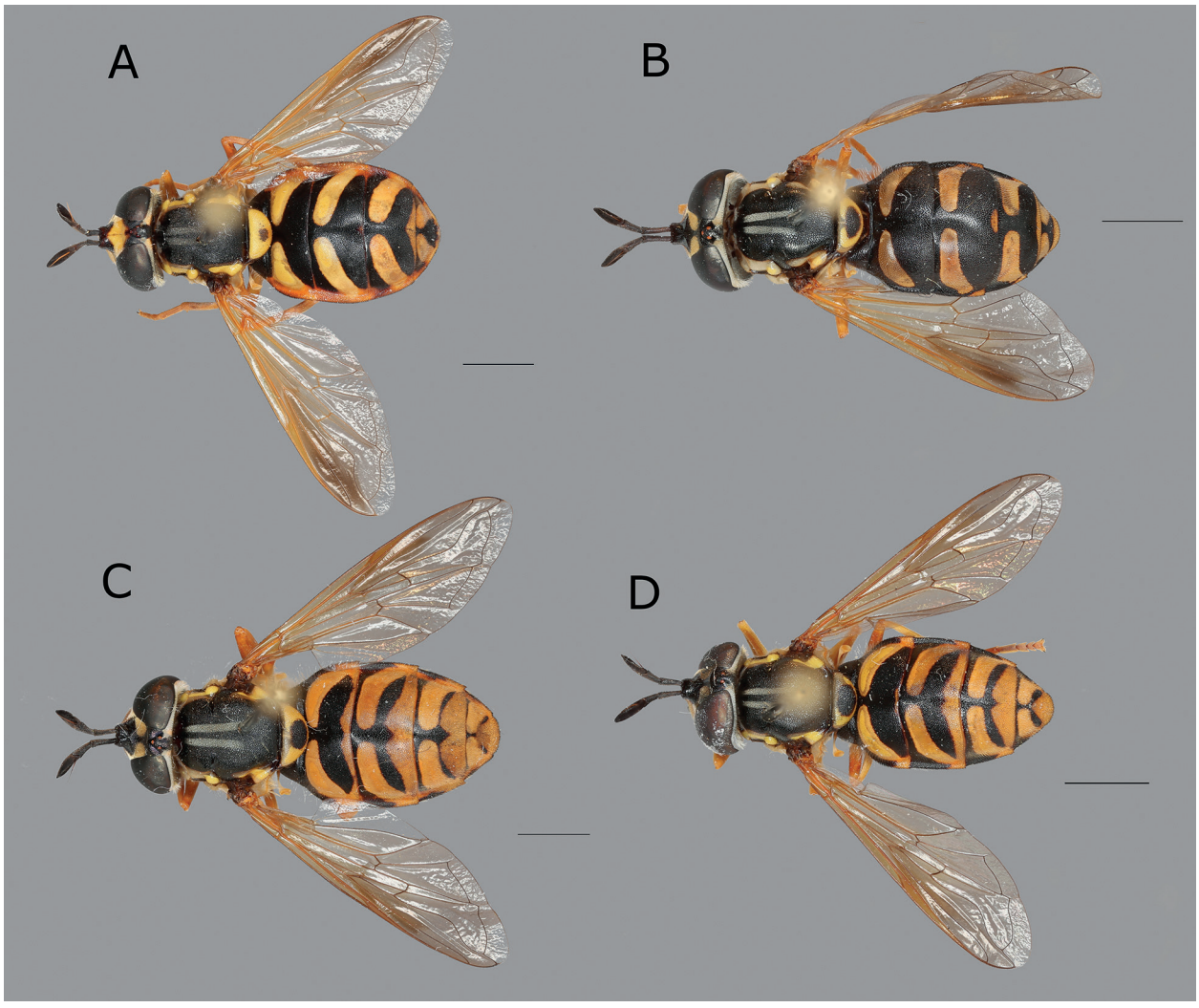

Fig. 2. Adult habitus, dorsal view, all from Sierra de Alcaraz. **A**. *Chrysotoxum cisalpinum*, ♀. **B**. *C. gracile*, ♀. **C**. *C. octomaculatum*, ♀. **D**. *C. octomaculatum*, ♀, dark form. Scale bars: 2.5 mm.

V.S. v.d. Goot; 2 ♂ (NBC), Gerona, Ribas, Zariquiey; 1 ♀ (NBC), La Rioja, dal v Najerilla, S. of Najera, ca 10 km S. of Anguiano, 22-VII–10-VIII-1988, P.J. v. Helsdingen; 2 ♀ (NBC), Gerona, Ribas de Freser, 900 m, 21-VII-1970, V.S. v.d. Goot; 1 ♀ (NBC), Gerona, Ribas de Freser, 900 m, 25-VII-1970, V.S. v.d. Goot; 1 ♀ (NBC), Gerona, Mollo, 1300 m, 19-VII-1970, V.S. v.d. Goot; 1 ♀ (NBC), Gerona, Sant Ilari de Sacala, VIII-1969, Serra; 1 ♂ (NBC), Granada, Capileira, 22-VII-1969, H. Overbeek; 1 ♀ (NBC), Montseny, St Pere de Vilamajor, Sagarra; 2 ♀ (NBC), Guadalajara, Tierzo bei Mo[illegible]na, 1100 m, 11-VII-1977, W. Schacht; 1 ♂ (NBC), Guadalajara, Tierzo bei M[illegible], 1100 m, 11-VII-1977, W. Schacht; 2 ♂ (NBC), Huesca, Torla, 1036 m, 8–26-VII-1974, J. Wolschrijn; 1 ♀ (MNCN), Huesca, San Juan de la Peña, 1220 m, Exp. Inst. de Entomología, 4-VIII-1943, *Chrysotoxum bicinctum* (L, 1758) Peris Torres det. 1945; 1 ♂ (MNCN) Jaén, Sierras de Segura, El Pardal, VI-1903, Escalera; 1 ♂ (CEUA), León, Valdetejas, 1200 m, 13-VII-1977, M.A. Marcos-García; 1 ♀ (NBC), Lerida, Alamacellas, Zariquiey; 1♂ (MNCN), Madrid, Escorial, Colección Lauffer, *Chrysotoxum bicinctum* L, det Strobl; Escorial, VIII-1905, Mercet, *Chrysotoxum bicinctum* L, Gil Collado det; 1 ♀ (CEUA), Salamanca, Béjar, 5-VII-1978, Carmen Calvo; 3 ♂ (CEUA), Fresnedoso, 3-VII-1978, Gonzalo Llorente; 1♂ (CEUA), Palomares-Béjar, 10-VII-1978, Gonzalo Llorente; 1 ♂ (CEUA), Porteros, 14-VI-1981, M. Portillo, *Th. villosa*; 1 ♂ (CEUA), Vallejosa de Riofrío, 15-VI-1979, Gonzalo Llorente; 1 ♀ (NBC), Nuria, 1800–2000 m, 22-VII-1970, V.S. v.d. Goot; 1 ♀ (MNCN), Segovia, San Ildefonso, VII-1906, Escalera; 1 ♀ (CEUA), Valencia, Chelva, 7–21-VI-1994, C. Pérez-Bañón; 1 ♀ (CEUA), Requena, 22-VI-1994, C. Pérez-Bañón; 1 ♂, Utiel, 7-VI-1994, C. Pérez-Bañón;

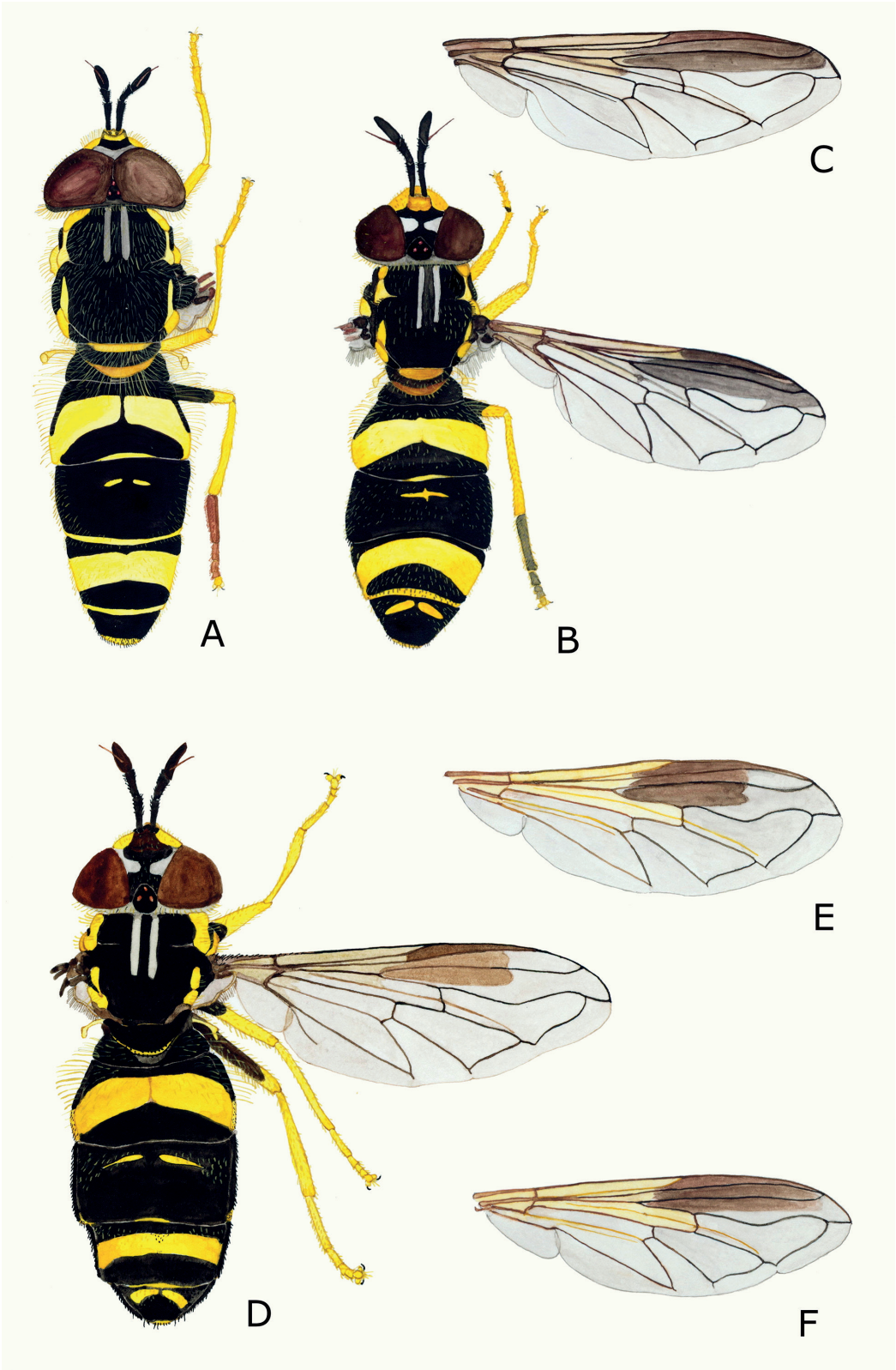

Fig. 3. Habitus and wing. **A.** *Chrysotoxum volaticum* ♂. **B**. *C. volaticum* ♀ with wing. **C**. Wing of *C. volaticum* ♂. **D**. *C. bicinctum*, typical form ♀ with wing. **E**. Wing of *C. bicinctum*, typical form ♂. **F**. Wing of *C. bicinctum* form 'A' from Brandenburg, Germany. All drawings ©A. Ssymank.

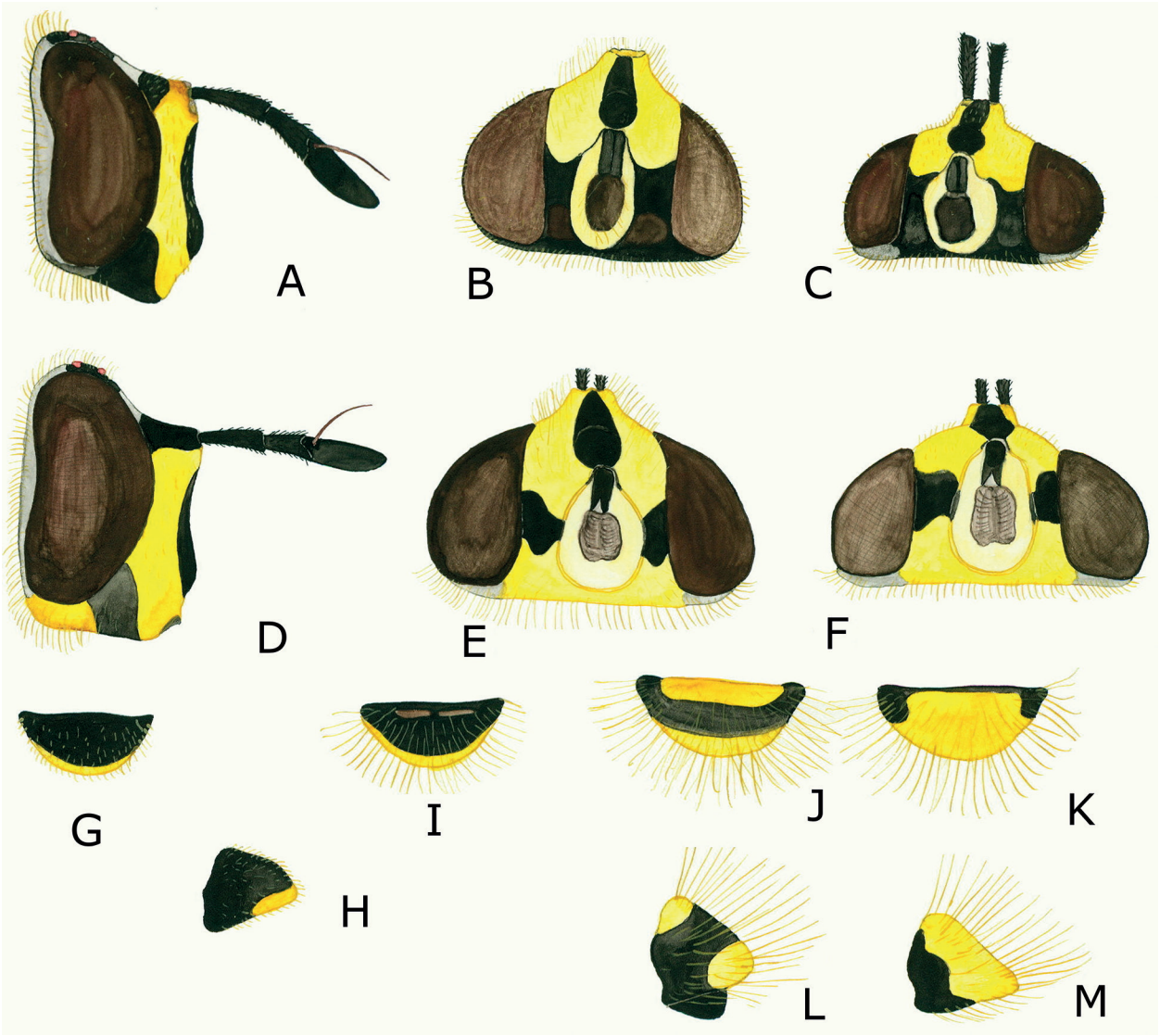

Fig. 4. Details of head and scutellum. **A**. *Chrysotoxum volaticum* ♀, head in lateral view. **B**. *C. volaticum* ♂, head ventral view. **C**. *C. volaticum* ♀ head ventral view. **D**. *C. bicinctum*, typical form ♀, head in lateral view. **E**. *C. bicinctum* ♂ head ventral view. **F**. *C. bicinctum* ♀ head ventral view. **G–H**. *C. bicinctum*, typical form ♀ scutellum, dorsal and lateral view. **I**. *C. bicinctum* form 'A' ♂ scutellum, dorsal view. **J, L, N**. *C. volaticum* ♂ scutellum in dorsal and lateral view, normal colouration. **K, M**. *C. volaticum* ♂ scutellum in dorsal and lateral view, bright colouration. All drawings ©A. Ssymank.

1 ♂ (NBC), Sierra Alta, 1600–1800 m, 26-VII-1965, V.S. v.d. Goot; 1 ♀ (CEUA), Santander, Vada, 22-VI-1987, M.A. Marcos García (34); 1 ♂ (NBC), Tarragona, Prades, 900 m, 1–10-VII-1967, H. & T. v. Oorschot, J. & M. Lourens; 1 ♂ (NBC), Teruel, Sra de Albarracín, Noguera, 1600 m, 12-VII-1977, W. Schacht; 1 ♂ (NBC), Teruel, Sierra de Albarracín, Noguera, 1600 m, 3–6-VIII-1980, W. Schacht; 1 ♀ (NBC), Teruel, Bronemales; 1 ♀ (NBC), Teruel, Aguas Amarguas, 1620 m, 21-VII-1965, V.S. v.d. Goot; 3 ♀ (NBC), 24-VII-1965; 2 ♀ (NBC), 29-VII-1965; 1 ♀ (NBC), Teruel, Sierra Alta, 1600–1800 m, 26-VII-1965, V.S. v.d. Goot; 3 ♀ (NBC), Teruel, Pajares, 1000 m, 20-VII-1972, V.S. v.d. Goot; 1 ♀ (NBC), Teruel, Puerto de Pajares, 1350–1700 m, 21-VII-1972, V.S. v.d. Goot; 3 ♀ (NBC), 22-VII-1972; 1 ♀ (NBC), Teruel, Santa Croche, 1150 m, 5-VIII-1965, V.S. v.d. Goot; 1 ♀ (NBC), Teruel, Santa Croche, 1150 m, 5-VIII-1965, V.S. v.d. Goot; 1 ♀ (NBC), Teruel, Sierra de Albarracín, Nogueta, 1600 m, 3–6-VIII-1980, W. Schacht; 2 ♀ (CEUA), Jaén, P.N. Cazorla, Coto Ríos, Llanos de Arance, 38º03'12.1" N, 02º50'10.6" E, 641 m, 13-VI-2019, A. Ricarte (ZFMK-DIP-00067297, ZFMK-DIP-00067298); 1 ♂ (CEUA), Jaén, Coto Ríos, meadow in riverbank opposite Fuente de la Pascuala camping site, 38º03'13" N, 2º50'09" E, 641 m, 29-V-2018, E. Galante (ZFMK-DIP-00067299).

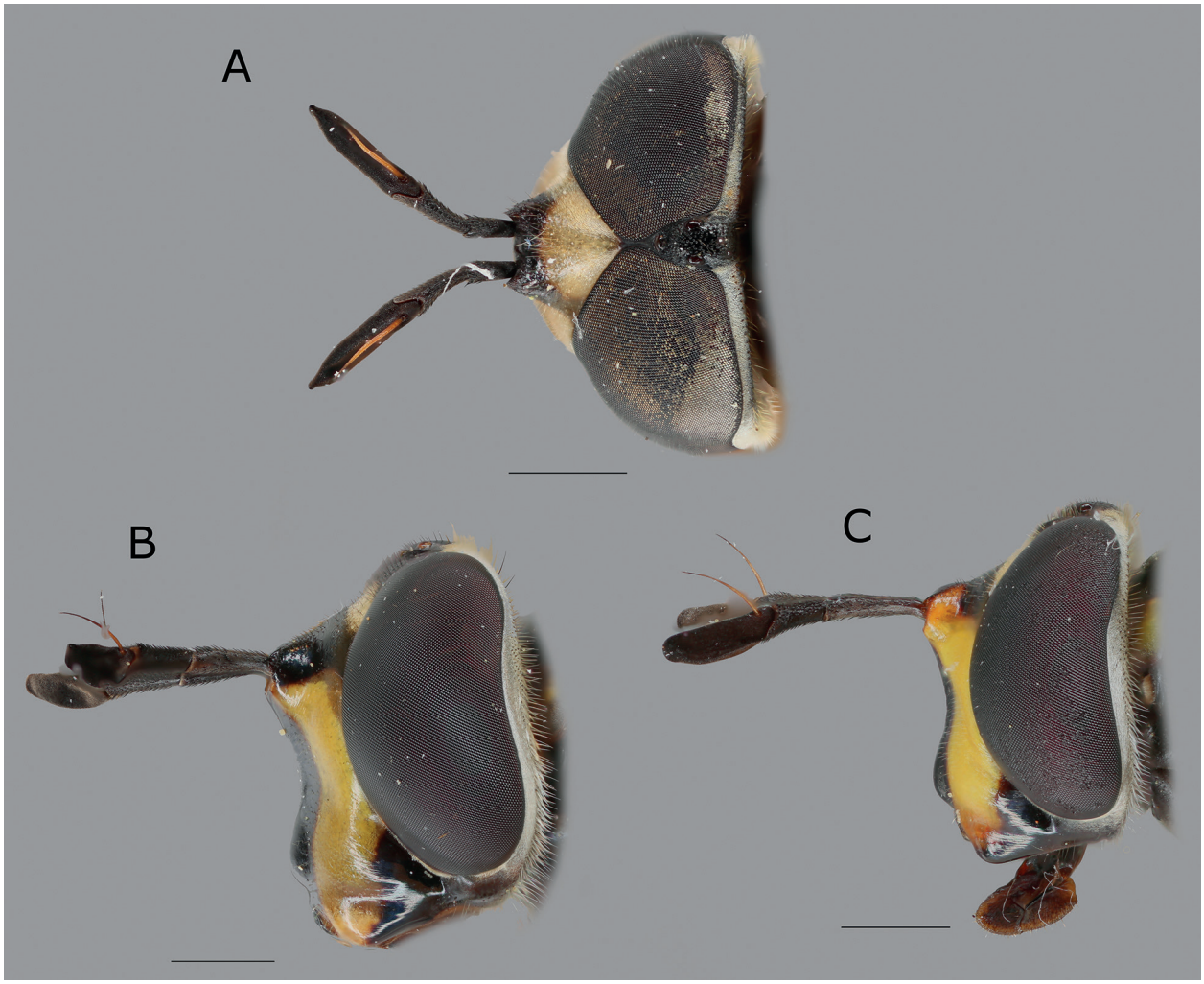

Fig. 5. Head; **A**. Dorsal view. **B–D**. Lateral view. **A**. *Chrysotoxum cisalpinum*, ♂, Sierra de Alcaraz. **B**. *C. festivum*, ♀, Spain. **C.** *C. volaticum*, ♀, Sierra de Alcaraz. Scale bars: 1.0 mm.

Remarks. This species is similar to *Chrysotoxum bicinctum*, differing by the characters mentioned in Table 1. See also Figs 3A–C, 4A–C, 4J–M.

Many Spanish specimens were collected while visiting flowers of *Thapsia villosa* L.

The Spanish examined material represents the first record from Spain, including specimens previously identified as *C. bicinctum* from the provinces of Jaén, Madrid, Segovia (Gil Collado, 1930), Ávila, Cáceres, Salamanca (Marcos-García 1986), Valencia (Pérez-Bañón, 1995), Ciudad Real (Ricarte 2008) and Huesca (MNCN specimen identified as *C. bicinctum* by Peris Torres), all of them now confirmed to belong to the species *C. volaticum*. All other records of *C. bicinctum* in Ricarte & Marcos-García (2017), which were not accessible to the authors of the present paper, must be regarded as doubtful until they are re-examined.

Genetics. Three specimens were successfully sequenced and the 5′–COI sequences were submitted to GenBank (accession numbers MT517826, MT517825, MT517824 for specimens ZFMK-DIP-00067297, ...00067298, and ...00067299 respectively). The obtained three DNA barcodes are identical. We compared our molecular data with two other DNA barcodes from specimens identified as *C. volaticum* from Morocco (Jeff H. Skevington, unpub. data), and the two Moroccan specimens have an uncorrected pairwise-distance of 0.017–0.0185 (similarity of 98.3% and 98.15% respectively) with our specimens, and the uncorrected pairwise-distance between them is 0.00155 (99.845% similarity). The Barcode Index Number (BIN) (Ratnasingham & Hebert 2013) helps to assign individuals to presumptive species, called operational taxonomic units (OTUs) and they are good estimators of valid species, but there are cases of discordance between BINs and accepted species boundaries. For *C. vol-*

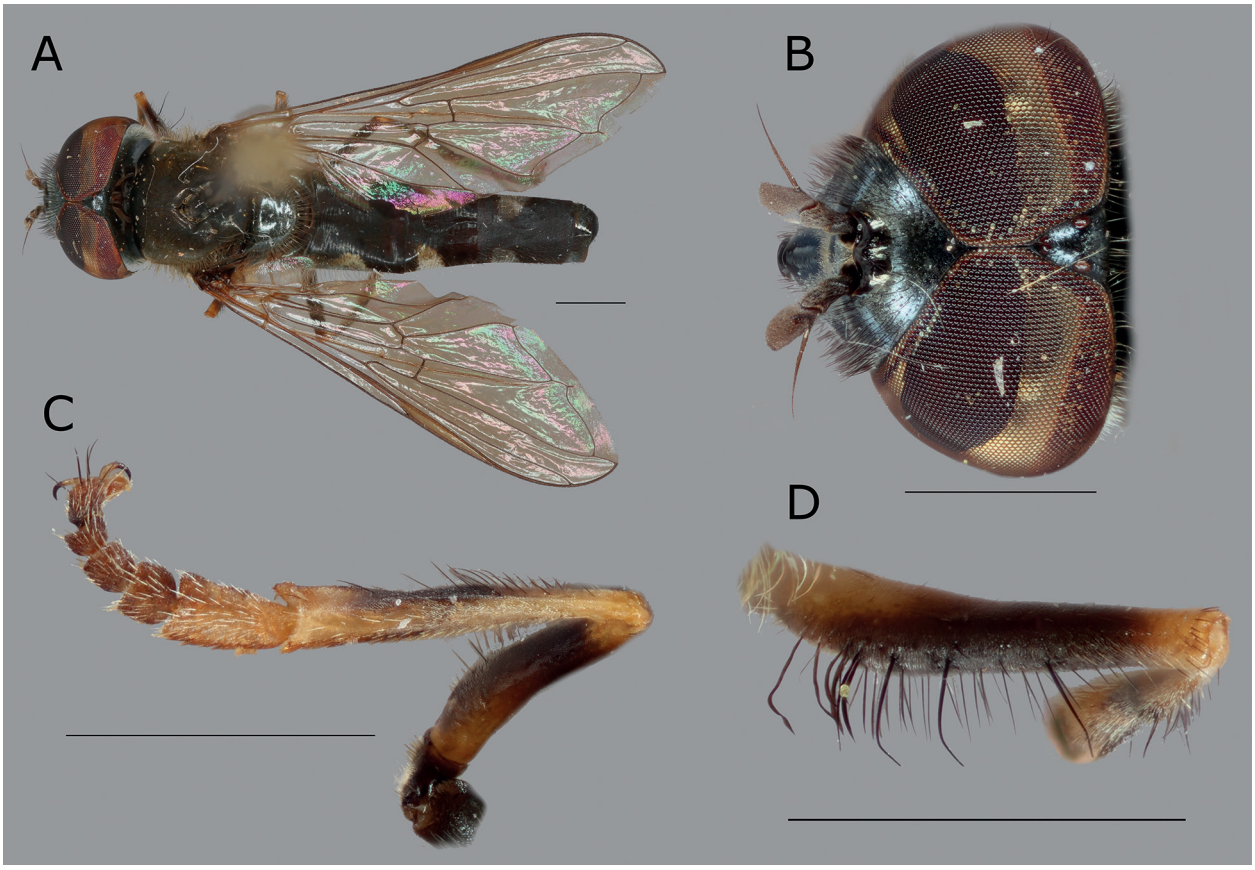

Fig. 6. *Platycheirus marokkanus*, ♂, from Sierra de Alcaraz. **A**. Adult habitus, dorsal view. **B**. Head, dorsal view. **C**. Protibia and tarsus dorsal view. **D**. Profemur, dorsal view. Scale bars: 1.0 mm.

aticum there is the BIN BOLD:AAJ0967 (https://doi.org/10.5883/BOLD:AAJ0967), but individuals assigned to this BIN were identified to belong to 12 different morphological species, e.g., *Chrysotoxum arcuatum* (Linnaeus, 1758), *C. bicinctum*, *C. biguttatum* Matsumura, 1911, *C. elegans* Loew, 1841, *C. festivum* (Linnaeus, 1758), *C. graciosum* Violovitsh, 1975, *C. montanum* Nedeljković & Vujić, 2015, *C. octomaculatum* Curtis, 1837, *C. sapporense* Matsumura, 1916, *C. vernale* Loew, 1841, *C. verralli* Collin, 1940, and *C. volaticum*. This means that the algorithm that automatically assigns individuals to OTUs based on sequence variation in the COI DNA barcode region is not able to find enough differences among the COI sequences of these species; in other words, the intraspecific variation of this gene region overlaps with the interspecific variation among these 12 species.

The nearest-neighbour in BOLD systems (http://www.boldsystems.org) is *C. orthostylum* Nedeljković & Vujić, 2015 (with BIN BOLD:ADJ6446), but the p-distance within BOLD:AAJ0967 overlaps with the distance between the two BINs: in other words, there is no barcoding gap between the members of BOLD:AAJ0967 and *C. orthostylum*.

Modification to existing keys

In the current identification keys (e.g., Speight et al. 2016; Bot & Van de Meutter, 2019) the following text should be added to separate *Chrysotoxum bicinctum* from *C. volaticum*:

5. Yellow fascia on tergum III as deep as those on tergum IV 6
– Yellow fascia on tergum III strongly reduced, absent to at most half the width of the fascia on tergum IV 5A

5A. Wing with large dark macula; radial cell R_1 completely darkened (usually blackish) and dark macula extending distinctly beyond the apex of this cell, almost reaching the apex of the wing and reaching costal border on about ½ of its length within cell R_{2+3}, dark wing macula usually apically clearly demarcated; scutellum almost completely yellow or with a dark-brown to black median fascia,

at least basally in dorsal view broadly yellow; frontal prominence immediately above insertion of antennae yellow to brown-yellow, in some specimens blackish; genae below eyes and hypostomal bridge usually completely black or with dark brownish maculae on the sides, rarely partly yellow ..... ***Chrysotoxum volaticum*** Séguy, 1961

– Dark macula on wing margin shorter, never reaching wing apex and usually leaving the apical area of the radial cell R_1 clear, if extending beyond the apex of R_1 not reaching the costal border of cell R_{2+3}; scutellum black with at most apex narrowly yellow, sometimes with small yellow macula or narrow yellow fascia, anterior part black (in extensively yellow coloured specimens sometimes also a yellow fascia along the anterior margin); frons immediately above lunule black to blackish-brown; genae below eyes with a black fascia and hypostomal bridge yellow, in dark specimens genae entirely black and hypostomal bridge brownish-black ..... ***Chrysotoxum bicinctum*** (Linnaeus, 1758)

Additional records of species of *Chrysotoxum* from Spain

***Chrysotoxum cautum* (Harris, 1776)**

Distribution. Widespread throughout Europe. Recorded from several Spanish provinces, from Alicante to Lugo (Ricarte & Marcos-García, 2017).

Examined material. **Spain**: 4♂, 5♀ (MZW), Zaragoza, Hoya de Huesca county, Murillo de Gállego, 1-V-2010, M.P. van Zuijen.

Remarks. This is an easily recognizable species based on the extensively yellow abdomen, the large male genitalia and the cleft in female tergum V. This is the first record for the province of Zaragoza.

***Chrysotoxum cisalpinum* Rondani, 1845**

Distribution. Widespread in the Mediterranean region. In Spain, recorded only from the provinces of Madrid and Salamanca (Ricarte & Marcos-García, 2017; Ricarte et al. 2018).

Examined material. **Spain**: 1♂ (JSA), Albacete, Sierra de Alcaraz, Batán del Puerto, 38°34' N 2°21' W, 1200 m, 21-VI-2003, J. van Steenis; 5♂, 4♀ (JSA), 4♀ (MZW), Sierra de Alcaraz, Puerto de las Crucetillas, 38°31' N 2°26' W, 1400 m, 21-VI-2003, J. van Steenis & M.P. van Zuijen; 2♂, 1♀ (JSA), Sierra de Alcaraz, Puerto de las Crucetillas, 38°32' N 2°24' W, 1200 m, 21-VI-2003, J. van Steenis; 2♂, 1♀ (JSA), 1♂ (MZW), Sierra de Alcaraz, Puerto de las Crucetillas, 38°32' N 2°23' W, 1000-1200 m, 22-VI-2003, J. van Steenis & M.P. van Zuijen; 1♂ (DDG), Riópar, Sierra de Alcaraz, 38°30'17"N, 2°27'36"W, 750 m, 14-VI-2003, D. Doczkal; 4♀ (ASW), Espineras de León, Sierra de Alcaraz, close to Río de los Endrinales, 38°32'15"N, 2°24'18"W, 1380 m, 14-VI-2003, A. Ssymank.

Remarks. This species is easy to recognize based on the predominantly yellow frons (Figs 1A, 5A). Most of the specimens were collected on flowers of *Thapsia villosa*. This is the first record for the province of Albacete.

***Chrysotoxum festivum* Linnaeus, 1758**

Distribution. A widespread species in the Palaearctic region. In Spain recorded from several provinces in the northern half (Ricarte & Marcos-García, 2017).

Examined material. **Spain**: 1♂, 4♀ (JSA), Lleida, Sort, Col del Canto, 38°22'17" N 1°14'10" E, 1725 m, 18-VIII-2014, J. van Steenis.

Remarks. These specimens (Fig. 1B) differ from central European specimens of *Chrysotoxum festivum* by the entirely black hypostomal bridge (Fig. 5B); sternum II entirely black, anteriorly with yellow macula in *C. festivum*; black facial vitta very broad, broader than in other specimens; wing extensively bare of microtrichia, at most along anterior margin of cell Cu narrowly bare in *C. festivum*. Further Iberian material and a study of relevant type species is needed to establish the true identity of these specimens. This is the first record for the province of Lleida.

***Chrysotoxum gracile* Becker, 1921**

Distribution. Spain and France (Becker, 1921; Speight et al., 2013). In Spain, recorded only from the provinces of Avila, Huesca and Madrid (Ricarte & Marcos-García, 2017).

Examined material. **Spain**: 3♂, 1♀ (MZW), Albacete, Sierra de Alcaraz, Puerto de las Crucetillas, 38°32' N 2°24' W, 1100 m, 21-VI-2003, M.P. van Zuijen; 1♀ (JSA), Albacete, Sierra de Alcaraz, Puerto de las Crucetillas, 38°31' N 2°26' W, 1400 m, 21-VI-2003, J. van Steenis; 3♂ (CPP), Cantabria, Potes, Las Ilces, 43°06'41"N, 4°45'27" W, 754 m, 26-VI-2017, CJ Palmer; 1♀ (CEUA), Madrid, Universidad Rey Don Juan Carlos, en *Sil. rupestris*, 21-VII-2011, *Chrysotoxum festivum*? det. MªA. Marcos, *Chrysotoxum gracile* det. Ricarte and Nedeljković X-2019 (103); 2♂ (CPP), Palencia, Alto de la Varga, 42°54'32"N, 4°38'33" W, 1404 m, 24-VI-2017, CJ Palmer.

Remarks. This species (Fig. 1C) can be identified using the key in Speight et al. (2016). The narrower abdomen and the bicoloured metafemur, although sometimes very vague, are good characters to separate this species from *Chrysotoxum festivum* in which the abdomen is wider and the metafemur is almost entirely darkish orange-yellow, strongly contrasting with the yellow metatibia. The specimens from Sierra de Alcaraz were found visiting flowers of *Thapsia villosa*, while that from Madrid was found in flowers of *Silene rupestris* L. This is the first record for the province of Albacete.

***Chrysotoxum octomaculatum* Curtis, 1837**

Distribution. Widespread in Central and Southern Europe. In Spain, scattered records from Alicante to Pontevedra (Ricarte & Marcos-García, 2017).

Examined material. **Spain**: 2♀ (JSA), Albacete, Sierra de Alcaraz, Batán del Puerto, 38°34' N 2°21' W, 1200 m, 21-VI-2003, J. van Steenis; 1♂ (MZW), Sierra de Alcaraz, Puerto de las Crucetillas, 38°32' N 2°24' W, 1100 m, 21-VI-2003, M.P. van Zuijen; 1♀ (JSA), 1♀ (MZW), Sierra de Alcaraz Puerto de las Crucetillas, 38°31' N 2°26' W, 1400 m, 21-VI-2003, J. van Steenis & M.P. van Zuijen; 2♂, 3♀ (JSA), 1♀ (MZW), Sierra de Alcaraz, Puerto de las Crucetillas, 38°32' N 2°23' W, 1000-1200 m, 22-VI-2003, J. van Steenis & M.P. van Zuijen; 1♂, 1♀ (ASW), 2 ♂ (DDG), Riópar, Sierra de Alcaraz, 38°30'17"N, 2°27'36"W, 775 m, 14-VI-2003, A. Ssymank & D. Doczkal; 2♂ (ASW), 3♂, 2♀ (DDG), Espineras del León, Sierra de Alcaraz, close to Río de los Endrinales, 38°32'15"N, 2°24'18"W, 1380 m, 14-VI-2003, A. Ssymank & D. Doczkal; 1♂ (CPP), Cantabria, Potes, Las Ilces, 43˚06'41"N 4˚45'27"W, 26-VI-2017, 754 m, C.J. Palmer; 6♂, 1♀ (ASW), 8 ♂ (DDG), Granada, Cortijo los Capotes, Almijara, 36°52'44"N, 3°43'54"W, 1240-1270 m,11-VI-2003, A. Ssymank & D. Doczkal; 2♂ (ASW), 1 ♂ (DDG), Bosque del Puerto Navazo, Alhama de Granada, *Quercus rotundifolia*-forest, 36°58'29"N, 4°00'59"W, 1180 m, 12-VI-2003, A. Ssymank & D. Doczkal; 1♀ (DDG), Jaén, Sierra Morena, Río Guarrizas, 36°24'27"N 3°23'00"W, 790 m, 13-VI-2003, D. Doczkal; 3♂ (CPP), Palencia, Cervera de Pisuerga, 42˚52'24"N 4˚31›17»W, 1144 m, 23-VI-2017, CJ Palmer.

Remarks. This is a large and extensively yellow coloured species, especially in southern populations (Fig. 2C), although two smaller and rather dark specimens were collected (Fig. 2D), somewhat resembling *Chrysotoxum verralli* Collin, 1940. Most of the specimens were collected while visiting flowers of *Thapsia villosa*. These are the first record for the province of Albacete, Cantabria, Granada and Jaén.

Records of species of *Platycheirus marokkanus* from Spain

***Platycheirus marokkanus* Kassebeer, 1998**

Distribution. Morocco and Portugal (Kassebeer, 1998; van Eck, 2016). New to Spain.

Examined material. Spain: ♂ (JSA), Albacete, Sierra de Alcaraz, Batán del Puerto, 38°34' N 2°21' W, 1200 m, 21-VI-2003, J. van Steenis; 1 ♂ (DDG), Granada, Almijara, Cortijo los Capotes, 36°52'44"N, 3°43'54"W, 1240-1270 m, 11-VI-2003, D. Doczkal.

Remarks. This species (Fig. 6) belongs to the *Platycheirus albimanus* sub-group and is most similar to *P. laskai* Nielsen, 1999. In *P. albimanus* (Fabricius, 1781), *P. ciliatus* Bigot, 1884 and *P. muelleri* Marcuzzi, 1941 the apex of the protibia and the first tarsomere of protarsus is much wider than in *P. marokkanus*, and in *P. nigrofemoratus* Kanervo, 1934 the first tarsomere of protarsus is clearly wider than the maximum width of the protibia. In *P. laskai*, *P. marokkanus* and *P. nigrofemoratus* the setae on the protibia are short, at most as long as medial width of protibia, while in the other species these setae are long, more than twice as long as medial width of protibia. The angle of approximation of the eyes in males is 90° in *P. albimanus*, *P. laskai* and *P. nigrofemoratus*; about 100° in *P. marokkanus*; and about 120° in *P. ciliatus* and *P. muelleri*. Two species each have one character not shared with any other species; *P. laskai* has only one long black seta on profemur, which is placed apically, all others have three setae placed baso-medially; *P. ciliatus* has the basal tuft of setae on profemur with slightly flattened apex, while in all others the apex of these setae is narrowly rounded. In *P. muelleri* the ventral surface of protarsus has characteristic black markings, while in *P. marokkanus* these markings are reduced and at most dark-brownish.

The male specimen from Albacete was collected on flowers of *Thapsia villosa*.

DISCUSSION

The genus *Chrysotoxum* has been studied intensively during the past decade and several cryptic species have been described (e.g., Nedeljković et al. 2013, 2015; Vujić et al. 2017), with focus on the Balkan Peninsula and the Middle East fauna. These studies revealed a reality that some taxonomists knew beforehand (e.g., Sommaggio 2001): there are species complexes within *Chrysotoxum*. The genus shows large inter- and intraspecific variability in adult characters and an almost lack of species specific characters in genital morphology (Sommaggio 2001; Nedeljković et al. 2013) and the use of molecular data

showed a similar degree of variability (Masetti et al. 2006; Nedeljković et al. 2015), a fact corroborated with our new DNA barcodes. The material of *Chrysotoxum volaticum* collected by the authors in Spain was compared to the type material of Séguy in the National History Museum in Paris (Muséum Nationale d'Histoire Naturelle) and can be clearly assigned to *Chrysotoxum volaticum* Séguy, 1961. The validity of the species *C. volaticum* appears to be confirmed not only by morphology but also by the simultaneous co-occurrence of this species and *C. bicinctum* in the Spanish and French Pyrenees, plus the presence of several intermediate specimens. The majority of specimens of *Chrysotoxum bicinctum* and *C. volaticum* can be identified without doubt. Only in a few cases yellow forms of *C. bicinctum* could be identified as *C. volaticum* and dark forms of *C. volaticum* could be identified as *C. bicinctum*.

Species identification using molecular characters has been argued as an application of DNA barcoding (Hebert et al. 2003a, 2003b). The use of DNA barcodes to distinguish species is based on the so-called "barcoding gap" (Meyer & Paulay 2005), in other words, that the intraspecific genetic distance of one species is much less than the interspecific distance between this species and its closest relative. The published literature is full of examples where there is no barcode gap between a group of species (e.g., Wiemers & Fiedler 2007; Robinson et al. 2009; van Velzen et al. 2012; Koroiva & Kvist 2017). It seems that the geographical scale is one of the reasons that explains the low or high intraspecific variation of the COI gene (Bergsten et al. 2012), which strongly depends on taxonomic groups and practices (Čandek & Kuntner 2015). In the family Syrphidae, some published datasets already point out that the use of COI as DNA barcode does not help in species identification as the barcoding gap does not exist in certain species groups or genera, e.g., Mengual et al. (2006) and Ståhls et al. (2009) for *Merodon* Meigen, 1803, Haarto and Ståhls (2014) for *Melanostoma* Schiner, 1860, Jordaens et al. (2015) for some Afrotropical species and genera, Nedeljković et al. (2018) for *Xanthogramma* Schiner, 1860, Morinière et al. (2019) for some species of the German hoverfly fauna, among others. Masetti et al. (2006) were the first to report very low interspecific molecular divergence among *Chrysotoxum* species. Skevington and Sommaggio (2009) pointed out this problem for the Nearctic species of *Chrysotoxum*. The lack of resolution when using DNA barding in *Chrysotoxum* was again stated for the Palaearctic species in Nedeljković et al. (2013) and from the results of large barcoding campaigns, such as "German Barcode of Life" (GBOL, www.bolgermany.de; Geiger et al. 2016) and "Barcoding Fauna Bavarica" (BFB, www.faunabavarica.de; Haszprunar 2009). Our new DNA barcodes of *C. volaticum* are identical to sequences of *C. festivum* and *C. bicinctum*, and are very similar (>99%) with other *Chrysotoxum* species of the BIN BOLD:AAJ0967. New molecular markers need to be studied to prove their suitability for species identification in the genus *Chrysotoxum*, but so far, the 5' region of the COI gene performs very poorly.

The habitat in the Sierra de Alcaraz where *Chrysotoxum volaticum* was collected, with grassy vegetation in the vicinity of a brook in a valley at high altitude in a mountain range, is comparable to the situation described by Claussen & Hauser (1990) for the localities from the Middle Atlas Mountains in Morocco. All other specimens from central and northern Spain were mostly collected in *Quercus pyrenaica* Willd. forests and, in the case of the specimens from Cabañeros N.P., the sampling locality had forest with a peat-bog and a temporal stream. In Spain, adults of *C. volaticum* were observed on flowers of *Thapsia villosa* L. (yellow-flowering tall Apiaceae) which were in full flower. *Thapsia villosa*, together with other plants, was also recorded as a visited flower by Marcos-García (1986). Many individuals were observed on the flowers, amongst other species of *Chrysotoxum*, wasps and other Diptera. These are the first data about flowers visited by *C. volaticum*.

Although some specimens have overlapping characters of *C. volaticum* and *C. bicinctum*, see under the remarks section of *C. bicinctum*, most studied specimen can be assigned clearly to either one. More specimens from other parts of their distributional range need to be studied, especially the intermediate forms from the Pyrenees, in order to corroborate the validity of the morphological characters used here to separate these two species and to define better the species within this species group. This is part of ongoing research to study the species of the genus *Chrysotoxum* (Ricarte et al. 2019). The Ibero-Maghreb *Chrysotoxum* fauna is in need of a thorough revision. Hopefully though, this paper will aid in the recognition of these species as faunistic elements of the Iberian Peninsula.

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REFERENCES

Amorós-Jiménez R, Pineda A, Fereres A, Marcos-García MA (2012) Prey availability and abiotic requirements of immature stages of the aphid predator *Sphaerophoria rueppellii*. Biological Control 63: 17–24. https://doi.org/10.1016/j.biocontrol.2012.06.001

Bergsten J, Bilton DT, Fujisawa T, Elliott M, Monaghan MT, Balke M, Hendrich L, Geijer J, Herrmann J, Foster GN, Ribera I, Nilsson AN, Barraclough TG, Vogler AP (2012) The effect of geographical scale of sampling on DNA barcoding. Systematic biology 61(5): 851–869. https://doi.org/10.1093/sysbio/sys037

Bot S, Van de Meutter F. 2019. *Veldgids Zweefvliegen*. KNNV Uitgeverij, Zeist.

Bugg RL, Colfer RG, Chaney WE, Smith HA, Cannon J (2008) Flower flies (Syrphidae) and other biological control agents for aphids in vegetable crops. UC ANR Publication 8285. Online at http://anrcatalog.ucanr.edu/pdf/8285.pdf [last accessed 23 May 2020]

Čandek K, Kuntner M (2015) DNA barcoding gap: reliable species identification over morphological and geographical scales. Molecular Ecology Resources 15: 268–277. https://doi.org/10.1111/1755-0998.12304

Claussen C (1989) Syrphiden aus Marokko (Diptera, Syrphidae). Entomofauna, Zeitschrift für Entomologie 10(24): 357–375

Claussen C, Hauser M (1990) Neue Syrphidenvorkommen aus Marokko und Tunesien (Diptera, Syrphidae). Entomofauna, Zeitschrift für Entomologie 11 (25): 433–438

De Courcy Williams M, Toussidou M, Speight MCD (2011) Hoverflies (Diptera, Syrphidae) new to Greece from the Rhodope Mountains of Thrace and eastern Macedonia, including *Simosyrphus scutellaris* new to Europe. Dipterists Digest 18: 181–198

Dirickx, H.G. (1994): Atlas des Diptères syrphides de la région méditerranéenne. Studiedocumenten van het K.B.I.N. 75. RBINS, Brussels

Geiger M, Moriniere J, Hausmann A, Haszprunar G, Wägele W, Hebert P, Rulik B (2016) Testing the Global Malaise Trap Program – How well does the current barcode reference library identify flying insects in Germany? Biodiversity Data Journal 4: e10671. https://doi.org/10.3897/BDJ.4.e10671

Gil-Collado, J. (1930) Monografia de los Sírfidos de España. Trabajos del Museo Nacional de Ciencias Naturales (Serie Zoológica) 54: 1–376

Haarto A, Ståhls G (2014) When mtDNA COI is misleading: congruent signal of ITS2 molecular marker and morphology for North European *Melanostoma* Schiner, 1860 (Diptera, Syrphidae). ZooKeys 431: 93–134. https://doi.org/10.3897/zookeys.431.7207

Haszprunar G (2009) Barcoding Fauna Bavarica – eine Chance für die Entomologie. Nachrichtenblatt bayerischer Entomologen 58 (1/2): 45–47. Online at https://www.zobodat.at/pdf/NachBlBayEnt_058_0045-0047.pdf [last accessed 23 May 2020]

Hebert PDN, Cywinska A, Ball SL, deWaard JR (2003a) Biological identifications through DNA barcodes. Proceedings of the Royal Society of London B 270: 313–321. https://doi.org/10.1098/rspb.2002.2218

Hebert PDN, Ratnasingham S, DeWaard JR (2003b) Barcoding animal life: Cytochrome C oxidase subunit 1 divergences among closely related species. Proceedings of the Royal Society of London B 270: S96–S99. https://doi.org/10.1098/rsbl.2003.0025

Inouye D, Larson BMH, Ssymank A, Kevan PG (2015) Flies and flowers III: Ecology of foraging and pollination. Journal of Pollination Ecology 16 (16): 115–133. IUCN (2018) Hoverfly. https://www.iucn.org/commissions/ssc-groups/invertebrates/hoverfly

Jordaens K, Goergen G, Virgilio M, Backeljau T, Vokaer A, De Meyer M (2015) DNA barcoding to improve the taxonomy of the Afrotropical hoverflies (Insecta: Diptera: Syrphidae). PLoS ONE 10 (10): e0140264. https://doi.org/10.1371/journal.pone.0140264

Kassebeer CF (1998) Die marokkanischen Arten der Gattung *Platycheirus* Le Peletier & Serville, 1828 (Diptera, Syrphidae). Dipteron 1 (2): 25–36

Koroiva R, Kvist S (2017) Estimating the barcoding gap in a global dataset of cox1 sequences for Odonata: close, but no cigar. Mitochondrial DNA Part A 29 (5): 765–771. https://doi.org/10.1080/24701394.2017.1357709

Lardé G (1989) Investigation on some factors affecting larval growth in a coffee-pulp bed. Biological Wastes 30: 11–19. https://doi.org/10.1016/0269-7483(89)90139-0

Marcos-García, M.A. (1986): Los Syrphidae (Diptera) de las sierras occidentales del Sistema Central español: Subfamilias: Chrysotoxinae, Spheginae, Chilosiinae, Pelecocerinae, Volucellinae y Cinxiinae. Boletín de la Asociación española de Entomología 10: 159–180

Marcos-García, M.A. (1990): Catálogo preliminar de los Syrphidae (Diptera) de la Cordillera Cantábrica (España). EOS 66 (2): 83–100

Martínez-Falcón AP, Marcos-García MA, Moreno CE, Rotheray GE (2012) A critical role for *Copestylum* larvae (Diptera, Syrphidae) in the decomposition of cactus forests. Journal of Arid Environments 78: 41–48. https://doi.org/10.1016/j.jaridenv.2011.10.010

Masetti A, Lucetti A, Sommaggio D, Burgio D, Mantovani B (2006) Phylogeny of *Chrysotoxum* species (Diptera: Syrphidae) inferred from morphological and molecular characters. European Journal of Entomology 103: 439–467. https://doi.org/10.14411/eje.2006.059

Mengual X, Ståhls G, Láska P, Mazánek L, Rojo S (2018) Molecular phylogenetics of the predatory lineage of flower flies *Eupeodes-Scaeva* (Diptera: Syrphidae), with the description of the Neotropical genus *Austroscaeva* gen. nov. Journal of Zoological Systematics and Evolutionary Research 56: 148–169. https://doi.org/10.1111/jzs.12212 Corrigendum: https://doi.org/10.1111/jzs.12282

Mengual X, Ståhls G, Vujić A, Marcos-García MA (2006) Integrative taxonomy of Iberian *Merodon* species (Diptera, Syrphidae). Zootaxa 1377: 1–26. https://doi.org/10.11646/zootaxa.1377.1.1

Meyer CP, Paulay G (2005) DNA barcoding: Error rates based on comprehensive sampling. PLoS Biol. 3:2229–2238. https://doi.org/10.1371/journal.pbio.0030422

Morinière J, Balke M, Doczkal D, et al. (2019) A DNA barcode library for 5,200 German flies and midges (Insecta: Diptera) and its implications for metabarcoding-based biomonitoring Molecular Ecology Resources 19(4): 900–928. https://doi.org/10.1111/1755-0998.13022

Nedeljković Z, Ačanski J, Dan 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, Dan 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

Nedeljković Z, Ricarte A, Šašić Zorić L, Đan M, Obreht Vidaković D, Vujić A (2018) The genus *Xanthogramma* Schiner, 1861 (Diptera: Syrphidae) in southeastern Europe, with descriptions of two new species. Canadian Entomologist 150 (4): 440–464. https://doi.org/10.4039/tce.2018.21

Nielsen TR (1999) Check-list and distribution maps of Norwegian Hoverflies, with description of *Platycheirus laskai* nov. sp. (Diptera, Syrphidae). NINA Fagrapport 35: 1–99

Pérez-Bañón, C. (1995) Tesis de Licenciatura: Estudio de la comunidad de sírfidos de las sierras valencianas del Negrete y Utiel (Diptera, Syrphidae). Facultad de Ciencias, Universidad de Alicante, Spain

Pineda A, Marcos-García MA (2008) Evaluation of several strategies to increase the residence time of *Episyrphus balteatus* (Diptera, Syrphidae) releases in sweet pepper greenhouses. Annals of applied biology 152 (3): 271–276. https://doi.org/10.1111/j.1744-7348.2008.00215.x

Ratnasingham S, Hebert PDN (2013) A DNA-based registry for all animal species: the Barcode Index Number (BIN) system. PLOS ONE 8 (7): e66213. https://doi.org/10.1371/journal.pone.0066213

Ricarte A, Marcos-García MA (2017) A checklist of the Syrphidae (Diptera) of Spain, Andorra and Gibraltar. Zootaxa 4216 (5): 401–440. https://doi.org/10.11646/zootaxa.4216.5.1

Ricarte A, Nencioni A, Tubić NK, Grković A, Vujić A, Marcos-García MA. (2018) The hoverflies of an oak Dehesa from Spain, with a new species and other insights into the taxonomy of the *Eumerus tricolor* group (Diptera: Syrphidae). Annales Zoologici 68: 259–280. https://doi.org/10.3161/000345 41ANZ2018.68.2.005

Ricarte A. (2008) Tesis Doctoral: Biodiversidad de sírfidos (Diptera: Syrphidae) y conservación de los hábitats en el Parque Nacional de Cabañeros, España. Universidad de Alicante, 244 + 27 pp. Available from: http://rua.ua.es/dspace/handle/10045/9663 [last accessed 9 Jan. 2018]

Ricarte A, Nedeljković Z, Marcos-García MA. (2019) A preliminary revision of the Spanish *Chrysotoxum* Meigen and *Xanthogramma* Schiner hoverflies (Diptera: Syrphidae). Book of abstracts of the 10th International Symposium on Syrphidae (ISS10): 53.

Robinson E, Blagoev GA, Hebert PDN, Adamowicz SJ (2009) Prospects for using DNA barcoding to identify spiders in species-rich genera. ZooKeys 16: 27–46. https://doi.org/10.3897/zookeys.16.239

Rotheray GE, Gilbert F (1999) Phylogeny of Palaearctic Syrphidae (Diptera): evidence from larval stages. Zoological Journal of the Linnean Society 127: 1–112. https://doi.org/10.1111/j.1096-3642.1999.tb01305.x

Rotheray GE, Gilbert F (2011) The natural history of hoverflies. Forrest Text, Ceredigion, Wales

Rotheray GE, Marcos-García MA, Hancock G, Pérez-Bañón C, Maier CT (2009) Neotropical *Copestylum* (Diptera, Syrphidae) breeding in Agavaceae and Cactaceae including seven new species. Zoological Journal of the Linnean Society 156 (4): 697–749. https://doi.org/10.1111/j.1096-3642.2008.00503.x

Rozo-Lopez P, Mengual X (2015) Mosquito species (Diptera, Culicidae) in three ecosystems from the Colombian Andes: identification through DNA barcoding and adult morphology. ZooKeys 513: 39–64. https://doi.org/10.3897/zookeys.513.9561

Séguy E (1961) Diptères Syrphidés de l'Europe occidentale. Mémoires du Muséum national d'histoire naturelle, Nouv. Ser., A, Zoologie 23. Paris, France

Skevington JH, Sommaggio D (2009) An intractable problem? Revision of Nearctic *Chrysotoxum*. Pp. 49–51 in: Radenković S (ed.) The book of abstract, 5th International Symposium on Syrphidae, Novi Sad, Serbia

Sommaggio D (2001) The species of the genus *Chrysotoxum* Meigen, 1822 (Diptera: Syrphidae) described by Giglio Tos. Bolletino Museo Regionale die Scienze Naturali Torino 18: 115–126

Speight MCD, Nedeljković Z, Lebard T (2016) *Chrysotoxum tomentosum* Giglio-Tos,1890 et *Epistrophe cryptica* Doczkal & Schmid, 1994 en France, avec une clef pour les espèces françaises de *Chrysotoxum* (Diptera: Syrphidae). Bulletin de la Société Linnéenne de Bordeaux 151: 225–235

Speight MCD, Sarthou V, Garrigue J (2013) *Brachyopa silviae*, *Chrysotoxum gracile* and *Eumerus pusillus* (Diptera: Syrphidae) new to France. Dipterists Digest 20: 33–40

Ssymank A, Doczkal D (2007) Contributions to the hoverfly-fauna (Diptera: Syrphidae) of southern Spain. Poster presentation 4th international Symposium on Syrphidae, Siikaranta, Finland

Ssymank A, Kearns C (2009) Flies-pollinators on two wings. Pp. 39–52 in: Ssymank A, Hamm A, Vischer-Leopold M (Eds) Caring for pollinators – safeguarding agro-biodiversity and wild plant diversity. Bundesamt für Naturschutz, Bonn, Germany. Online at https://www.besnet.world/caring-pollinators-safeguarding-agro-biodiversity-and-wild-plant-diversity-current-progress-and-need [last accessed 23 May 2020]

Ståhls G, Vujić A, Pérez-Bañon C, Radenković S, Rojo S, Petanidou T (2009) COI barcodes for identification of *Merodon* hoverflies (Diptera, Syrphidae) of Lesvos Island, Greece. Molecular Ecology Resources 9: 1431–1438. https://doi.org/10.1111/j.1755-0998.2009.02592.x

Thompson FC (1999) A key to the genera of the flower flies (Diptera: Syrphidae) of the Neotropical Region including descriptions of new genera and species and a glossary of taxonomic terms used. Contributions to Entomology, International 3: 321–378

van Eck A (2016) Hoverflies (Diptera, Syrphidae) new to the fauna of mainland Portugal, with an updated hoverfly checklist. Boletín de la Sociedad Entomológica Aragonesa 59: 187–203

van Steenis J, Hauser M, van Zuijen MP (2017) Review of the *Eumerus barbarus* species group (Diptera: Syrphidae) from the western Mediterranean Basin. Bonn Zoological Bulletin 66 (2): 145–165. Online at https://www.zoologicalbulletin.de/BzB_Volumes/Volume_66_2/145_165_BzB66_2_Steenis_et_al.pdf [last accessed 23 May 2020]

van Steenis J, van Steenis W (2014) Two new West-Palaearctic species of *Brachyopa* Meigen, 1822 (Diptera, Syrphidae) with description and records of additional European species. Norwegian Journal of Entomology 61: 42–52. Online at http://www.entomologi.no/journals/nje/2014-1/pdf/nje-vol61-no1-steenis.pdf [last accessed 23 May 2020]

van Velzen R, Weitschek E, Felici G, Bakker FT (2012). DNA barcoding of recently diverged species: relative performance

of matching methods. PLoS One 7 (1): e30490. https://doi.org/10.1371/journal.pone.0030490

Vujić A, Nedeljković Z, Hayat R, Demirözer O, Mengual X, Kazerani F (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: 250–268. https://doi.org/10.1080/09397140.2017.1349241

Wiemers M, Fiedler, K (2007) Does the DNA barcoding gap exist? – a case study in blue butterflies (Lepidoptera: Lycaenidae). Frontiers in Zoology 4: 8. https://doi.org/10.1186/1742-9994-4-8

Young AD, Marshall SA, Skevington SH (2016) Revision of *Platycheirus* Lepeletier and Serville (Diptera: Syrphidae) in the Nearctic north of Mexico. Zootaxa 4082: 1–317. https://doi.org/10.11646/zootaxa.4082.1.1

