The genus *Xanthogramma* Schiner, 1861 (Diptera: Syrphidae) in southeastern Europe, with descriptions of two new species

Zorica Nedeljković,[2] Antonio Ricarte,[1] Ljiljana Šašić Zorić, Mihajla Đan, Dragana Obreht Vidaković, Ante Vujić

Abstract—Examination of 122 specimens of *Xanthogramma* Schiner, 1861 (Diptera: Syrphidae) from varied localities in Europe (+Turkey) resulted in the description of two new species (*X. aeginae* Ricarte, Nedeljković, and Vujić **new species** and *X. pilosum* Nedeljković, Ricarte, and Vujić **new species**), as well as new data on six other species. Most of the examined material originated from the Balkan Peninsula and Greek islands. New species concepts were supported by morphological and molecular evidence. Relationships among the eight studied species were analysed and discussed based on the data of nuclear (ITS2) and mitochondrial (COI) genes sequences. An identification key to the European species of *Xanthogramma* is provided. Lectotypes are designated for *Doros decoratum* Zetterstedt, 1843, *Lasiophthicus novus* Rondani, 1857, *Syrphus laetus* Fabricius, 1794, *Syrphus ornatus* Meigen, 1822, and *Xanthogramma nobilitatum* Frey, 1946.

Introduction

Hoverflies (Diptera: Syrphidae), with over 6000 described species, are found in almost all geographic regions and habitats, where they fulfil important ecological roles such as pollination and predation of pest insects (Rotheray and Gilbert 2011). Within Syrphidae, the genus *Xanthogramma* Schiner, 1861 comprises large flies (Van Veen 2004) preferring grasslands and woodlands (Speight 2017). Larvae are Aphididae (Hemiptera) predators in ant (Hymenoptera: Formicidae) nests (Hölldobler 1929; Rotheray 1994; Speight 2017); nonetheless early stages are unknown for most *Xanthogramma* species. This genus belongs to the tribe Syrphini *sensu stricto* and is related phylogenetically to *Chrysotoxum* Meigen, 1803, *Epistrophe* Walker, 1852, and *Epistrophella* Dušek and Láska, 1967 (Mengual *et al.* 2008). *Xanthogramma* is present in the Palaearctic, Nearctic, and Oriental regions (Pape and Thompson 2013a), with 19 species recorded from the Palaearctic (Peck 1988). Violovitsh (1975) provided a diagnosis of the genus. Taxonomy within *Xanthogramma* remains in flux with the validity of several species still uncertain (Speight 2017). Speight and Sommaggio (2010) provided the first key to all known European species of *Xanthogramma*, which was reedited by Speight and Sarthou (2017) with modifications to better separate females of *X. dives* (Rondani, 1857), *X. pedissequum* (Harris, 1776), and *X. stackelbergi* Violovitsh, 1975.

Classical taxonomy is not always conclusive for species delimitation. Additional data sources, such as DNA, can help with this purpose. Mitochondrial DNA (mtDNA) cytochrome *c* oxidase I (COI) is frequently used as a molecular marker in taxonomic studies and has proven highly

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Z. Nedeljković,[2] A. Ricarte, L. Šašić Zorić, BioSense Institute-Research Institute for Information Technologies in Biosystems, Dr Zorana Đinđića 1, 21000 Novi Sad, Serbia
M. Đan, D. Obreht Vidaković, A. Vujić, Department of Biology and Ecology, University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovića 2, 21000 Novi Sad, Serbia

[1]Present address: Centro Iberoamericano de la Biodiversidad (CIBIO), Universidad de Alicante, carretera de San Vicente del Raspeig s/n, 03690 San Vicente del Raspeig, Alicante, Spain

[2]Corresponding author (e-mail: zoricaned14@gmail.com)
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informative in elucidating relationships at the species level in Syrphidae (*e.g.*, Ståhls *et al.* 2009; Marcos-García *et al.* 2011; Radenković *et al.* 2011; Vujić *et al.* 2013; Grković *et al.* 2015; Nedeljković *et al.* 2015; Popović *et al.* 2015; Ačanski *et al.* 2016; Šašić *et al.* 2016; Chroni *et al.* 2017). In addition, registered COI bar codes are useful for molecular identification of species (*e.g.*, Andrić *et al.* 2014). In Syrphinae taxonomy, the nuclear internal transcribed spacer 2 region (ITS2) is also useful for delimiting species borders, for example in the *Chrysotoxum festivum* Linnaeus, 1758 species group (Nedeljković *et al.* 2013) and in the genus *Melanostoma* Schiner, 1860 (Haarto and Ståhls 2014).

The main aim of the present study is to provide new insights into the systematics of *Xanthogramma* by integrating species morphology and DNA. Two new species from Greece are described and new distributional data – mainly from southeastern Europe – are provided for six other species.

Material and methods

Taxonomic study. A total of 122 specimens from Croatia, Czech Republic, Greece, Italy, Macedonia, Montenegro, Serbia, Spain, The Netherlands, and Turkey were studied. To describe and diagnose species, characters were studied with both Ceti (Medline Scientific, Oxfordshire, United Kingdom) and Nikon SMZ 745T (Nikon Corporation, Tokyo, Japan) binocular microscopes. Colour characters always refer to dry specimens. Body size was measured as the length from the tip of the frontal prominence (excluding antenna) to the tip of the abdomen. Wing length was measured from the insertion point on the thorax to the tip of the wing. Antennal size was measured as a relation between the distance from the apex of the basoflagellomere and the most prominent point of the pedicel and the width of the basoflagellomere at the level of the arista base. Measurements were made using an eye-piece micrometer. Morphological terminology follows Thompson (1999), except for the term "proepimeron", which follows Speight and Sarthou (2017). Examined material was identified with Speight and Sommaggio (2010) and Bartsch *et al.* (2009). A distribution map was created using the software GenGIS (version 2.1.1) (Parks *et al.* 2013). For type specimens, the symbol "/" separates data from different labels on the same pin. The numbers in the Examined material sections are part of unique identification labels of the specimens, while numbers with the abbreviation MS refer to the unique identification labels of the specimens used for the molecular analyses.

Examined material belongs to the following collections:

AVE – André Van Eck private collection, Tilburg, The Netherlands

FSUNS – Department of Biology and Ecology, Faculty of Sciences, University of Novi Sad, Serbia

HNHM – Hungarian Natural History Museum, Budapest, Hungary (Dr. Soltész Zoltán)

LSF – Museo Zoologico La Specola, Firenze, Italy (Dr. Luca Bartolozzi)

MAUA – The Melissotheque of the Aegean, University of the Aegean, Mytilene, Greece (Dr. Theodora Petanidou)

MB – Miroslav Barták private collection, Prague, Czech Republic

MCDS – Michael de Courcy Williams private collection, Alexandroupoli, Greece

MNHN – Muséum national d'Histoire naturelle, Paris, France (Dr. Simon Chagnoux)

MZH – Zoological Museum, Finnish Museum of Natural History, Helsinki, Finland (Dr. Gunilla Ståhls)

MZLU – Museum of Zoology, Lund, Sweden (Dr. Rune Bygebjerg)

NHM – Natural History Museum, London, United Kingdom (Dr. Nigel Wyatt)

NHMW – Naturhistorishes Museum Wien, Wien, Austria (Dr. Sehnal Peter)

NMBA – Naturhistorisches Museum der Benediktiner-Abtei, Admont, Austria (Dr. Petr Heřman)

WSB – Wouter Van Steenis, Breukelen, The Netherlands

ZISP – Zoological Museum, Academy of Sciences, Russian Academy of Sciences, St. Petersburg, Russia (Dr. Olga Ovtshinnikova)

ZMHB – Zoologishes Museum of Humbolt University, Berlin, Germany (Dr. Sven Marotzke)

ZMUC – Zoologisk Museum, Copenhagen, Denmark (Dr. Thomas Pape)

Molecular study. DNA was extracted from two to three legs of 50 *Xanthogramma* specimens of the eight studied species (see Supplementary Material Table 1) using the SDS extraction protocol (Chen *et al.* 2010). Sequences of two gene regions (3' ends of COI and ITS2) were used to confirm species boundaries. Polymerase chain reaction amplifications were done using the COI primer pair C1-J-2183 (alias Jerry) and TL2-N-3014 (alias Pat) (Simon *et al*. 1994), while the ITS2 were amplified using primer pair ITS2A and ITS2B (Beebe and Saul 1995).

Polymerase chain reactions were carried out in 25 μL reaction volumes. The reaction mixture contained 1× Taq Buffer without $MgCl_2$ (ThermoScientific, Vilnius, Lithuania), 2 mM $MgCl_2$, 0.1 mM of each nucleotide, 1.25 U Taq polymerase (ThermoScientific), 5 pmol of each primer, and ~ 50 ng template DNA. Amplifications were performed under the following polymerase chain reaction conditions: initial denaturation at 95 °C for two minutes; 29 cycles of denaturation at 94 °C for 30 seconds each; 30 seconds annealing at 49 °C; two minute extension at 72 °C; followed by a final extension of eight minutes at 72 °C. Polymerase chain reaction products were enzymatically purified using Exonuclease I and Shrimp Alkaline Phosphatase enzymes (ThermoScientific) according to the instructions of the manufacturer. Sequencing was performed in both directions using the BigDye Terminator v.3.1 cycle sequencing kit (Applied Biosystems, Waltham, Massachusetts, United States of America) at the Sequencing Service Laboratory of the Finnish Institute for Molecular Medicine, Helsinki, Finland.

The resulting DNA sequences were edited for base-calling errors using BioEdit version 7.2.5. (Hall 1999). The alignment of COI sequences was performed manually, while the alignment of the ITS2 fragment was carried out using the L-INS-I strategy as implemented in MAFFT (Katoh and Standley 2013) available on European Bioinformatics Institute bioinformatics framework (McWilliam *et al.* 2013). Sequences were deposited in GenBank (www.ncbi.nlm.nih.gov/genbank) and their accession numbers are listed in Supplementary Material Table 1. All analyses were rooted on *Melanostoma mellinum* (Linnaeus, 1758) (accession numbers: KJ848101 for COI, KJ848059 for ITS2), which was used as the outgroup. Variable positions were estimated using DnaSP version 5 (Librado and Rozas 2009). Maximum parsimony analyses were performed using the parsimony ratchet analysis (Nixon 1999) as implemented in TNT (Goloboff *et al.* 2008; generated from Winclada ASADO (Nixon 2008)), with 2000 iterations per replication and the rest parametres set by default. The bootstrap nodal support values were calculated using non-parametric bootstrapping with 1000 replicates in NONA (Goloboff 1999) spawned with the aid of Winclada ASADO (Nixon 2008).

Results

Two new species of the genus *Xanthogramma* are described. New distributional data, mainly from southeastern Europe, are provided for the other six studied species. An identification key to all the known European species of *Xanthogramma* is presented. Relationships among the studied taxa are analysed based on molecular characters of COI and ITS2 sequences.

Xanthogramma Schiner, 1861

Xanthogramma Schiner, 1861: 318. Type species *Xanthogramma ornatum* (Meigen, 1822), now regarded as a synonym of *Xanthogramma pedissequum* (Harris, 1776–1780). Gender: neuter.

Olbiosyrphus Mik, 1897: 66. Type species *Syrphus laetus* Fabricius, 1794, now *Xanthogramma laetum* (Fabricius, 1794).

Philhelius Coquillett, 1910: 378. Type species *Musca citrofasciata* De Geer, 1776, now of *Xanthogramma citrofasciatum* (De Geer, 1776).

Taxonomic notes. The name *Xanthogramma* was erected without included nominal species and instead representing just a group of flies differing from *Doros profuges* (Harris, 1780) (originally as *Doros conopseus* (Fabricius, 1775)) in the shape of the ventral part of face and abdomen (Schiner 1860). According to Article 12 of the International Commission on Zoological Nomenclature (1999), the name *Xanthogramma* was unavailable until a description of this taxon was provided by Schiner (1861). Thus, the genus dates from 1861 and not 1860, as erroneously assigned by authors such as Pape and Thompson (2013b). Schiner (1861) also included, for the first time, three species in the genus: *X. citrofasciatum*, *X. ornatum*, and *X. marginale* (Loew, 1854). According to Article 67.2.2 of the International Commission on Zoological Nomenclature (1999), these three became the only originally included nominal species in the genus *Xanthogramma* and were therefore elegible for type fixation. According to Article 69.1 of the International Commission on Zoological Nomenclature (1999), Williston (1887) was the first author who subsequently and validly designated one of the originally included nominal species (*X. ornatum*) as the type species of *Xanthogramma*, by stating "Type of genus *X. ornata* Meigen".

Olbiosyrphus Mik, 1897, was previously considered an independent but related genus (Dušek and Láska 1967), but is now considered a synonym of *Xanthogramma* (Vockeroth 1969).

Diagnosis. *Xanthogramma* adults are relatively large flies with the following charaters. Head: short antenna and oval basoflagellomere; thorax: with sharply defined, bright yellow markings on the scutum laterally and katepisternum; postpronotum bare, anterior anepisternum bare, metapleuron bare ventral to spiracle, scutellum black basally (yellow apically), extensively microtrichose wing, with vein R_{4+5} straight or nearly so, calypter bare; abdomen: never distinctly petiolate, nearly flat, black and with yellow markings, emarginate at least on tergum 4 and tergum 5 (Thompson and Rotheray 1998).

Xanthogramma flies resemble those of the genera *Sphaerophoria* LePeletier and Serville, 1828; *Doros* Meigen, 1803; *Epistrophe* Walker, 1852; and *Chrysotoxum* Meigen, 1803. From *Sphaerophoria*, *Xanthogramma* can be distinguished by a strongly emarginate abdomen (at least on tergum 4 and tergum 5) (Thompson and Rotheray 1998); from *Doros*, by the absence of an abdominal waist (Van Veen 2004) and vein A_1 dipped into the anal cell before tip (this vein is almost straight before apex in *Doros*) (Láska *et al.* 2013); from *Epistrophe*, by the presence of yellow maculae on the thoracic pleuron, which are absent in *Epistrophe*; and finally, from *Chrysotoxum*, by the length of the antennae, which are much shorter in *Xanthogramma* (Van Veen 2004).

Morphologically, the most similar genus to *Xanthogramma* is *Citrogramma* Vockeroth, 1969, but in *Xanthogramma* the subscutellar fringe is absent, the metasternum is bare, the antennal base is more promanent than the oral apex and the lateral yellow vitta of the scutum does not reach the scutellum (Mengual 2012).

European *Xanthogramma* species

Xanthogramma aeginae Ricarte, Nedeljković, and Vujić, new species

Figs. 1–2, 7, 12, 27, 31.

Type material. Holotype: ♂, "**Greece,** Chios, Palios Katarraktis, 8–10.iv.2012, leg. M. Taylor, 38.254°N, 26.086°E, UOTA-MEL, 028881, (MS104)" (deposited in FSUNS).

Paratypes: **Greece**, 1♂, Lesvos, 2.2 km SE Mystegna, 10 m, 39.204°N, 26.485°E, Phrygana Simple (Aegean University 0037398) (MS83) (MAUA); 1♂, 2♀, Chios, Ermioni-Thymiana, 5–7.iv.2012, Taylor, 38.309°N, 26.141°E, 2525 (1♂), UOTA-MEL 028941 (MS105), 2521 (1♀), 7.iv.2012, Taylor, 3971, UOTA-MEL 038479 (1♀) (MS108) (MAUA); 1♂, Chios, Palinaeon II, 30.iv–2.v.2012, Taylor, 38.575°N, 26.004°E, 2673, UOTA-MEL 027833 (MS106) (MAUA); 1♂, 3♀, Chios, Managros, 29–30.v.2012 (1♂), Poutziakas, 38.4638°N, 25.937°E, 2928, UOTA-MEL 026609, 29.iii.2012 (1♀), Toutziarakis, 29–30.iii.2012, Toutziarakis, UOTA-MEL 026610 (1♀), UOTA-MEL 026621 (1♀) (MAUA); 1♂, 1♀, Chios, Gridia, 8–10.iv.2012, Taylor, 38.216°N, 26.102°E, 2413, UOTA-MEL 027050 (1♂), UOTA-MEL 027051 (MS110) (1♀) (MAUA); 1♀, Chios, Armolia, 3–5.iv.2012, Taylor, 38.272°N, 26.044°E, UOTA-MEL 026894 (MS107) (MAUA); 1♂, 3♀, Chios, Palios Katarraktis, 8–10.iv.2012, Taylor, 38.254°N, 26.086°E, 2517, UOTA-MEL 028890 (1♂), 2514, UOTA-MEL 028906 (1♀), 2510, UOTA-MEL 029138 (1♀), 2511, UOTA-MEL 028916 (1♀) (MAUA); 1♀, Chios, Kampia Castle, 29–30.iii.2012, Toutziarakis, 38.581°N, 25.981°E, 2948, UOTA-MEL 026830, (MS109) (MAUA).

Diagnosis. Length = 12.2–12.3 mm; eyes with very short, sparse, yellow pile; frontal triangle with black pile; scutellum with long, yellow pile; notopleuron yellow, at most narrowly black near the anterior anepistenum; posterior anepisternum with a yellow macula in the posterior part; katepisternum, katatergum, proepimeron with a small, yellow macula each; posterior anepisternum with yellow macula in the posterior part; scutellum yellow, only black at the posterior corners and transparent yellow at the anterior part, mainly with long, black pile anteriorly and yellow pile posteriorly; wing cell R_1 brown pigmented; terga 2–4 each with a pair of yellow fasciae reaching the lateral margins; tergum 2 fasciae triangular with a low rounded median projection.

Xanthogramma aeginae can be distinguished from the similar *X. citrofasciatum* by the presence of a yellow macula on the proepimeron, which is completely black in *X. citrofasciatum* (Table 1). The pile of the posterior anepisternum are all

Figs. 1–4. *Xanthogramma* species, overall appearance, dorsal view. **1**, *Xanthogramma aeginae*, male holotype; **2**, *Xanthogramma aeginae*, female paratype; **3**, *Xanthogramma pilosum*, male holotype; **4**, *Xanthogramma pilosum*, female paratype.

black in *X. aeginae*, but mainly yellow in *X. citrofasciatum*.

Description. Male (Figs. 1, 7, 12). Length = 12.2–12.3 mm, Wing length = 8.2 mm. **Head**. Eyes with very short, sparse, yellow pile; frontal triangle yellow with black pile; vertical triangle black with black pollinosity and black pile; ocellar triangle nearly equilateral; occiput black pollinose along eye margin, with long black pile in dorsal part and yellow pile in ventral part; lunule dark yellow and transparent; antenna yellow to dark orange, scape and pedicel yellow with short, black pile; basoflagellomere oval, dark orange, black in dorsal part; arista yellow with short pile (length of cross-section of apical part of arista); face yellow with black pile in dorsal and ventral parts and with yellow pile in medial part; ventral part of gena yellow (only black at lateral corners) with black pile; occiput white pollinose, with long, black pile in dorsal part and yellow pile in medial and ventral parts. **Thorax** (Figs. 7, 27). Scutum black with two faint silverish-pollinose vittae extending for anterior two-thirds of scutum length; scutum with long, yellow pile in anterior half and intermixed yellow and black pile in posterior half; notopleuron yellow, at most narrowly black near

Table 1. Diagnostic morphological differences between *Xanthogramma citrofasciatum* and *Xanthogramma aeginae*.

Character	*X. citrofasciatum*	*X. aeginae*
Males and females		
Mesonotum	With short, yellow pile (Fig. 28)	With long, yellow pile anteriorly and long, black pile posteriorly (Fig. 27)
Notopleuron	Yellow dorsally and black ventrally (Fig. 8)	Yellow (Fig. 7)
Katepisternum	Black or with small yellow macula (Fig. 8)	Always with yellow macula (Fig. 7)
Proepimeron	Black (Fig. 8)	With yellow macula (Fig. 7)
Colour of pile on femora	Yellow	Black
Shape of maculae on tergum 2	Rectangular with more rounded medial apex (Fig. 9)	Triangular with pointed medial apex (Figs. 1, 12)
Males		
Maculae on tergum 3 and tergum 4	Reaching lateral margins of terga (Fig. 9)	Not reaching lateral margins of terga (Figs. 1, 12)

anterior anepistenum, lateral margin of scutum black posteriorly to transverse suture; notopleuron with intermixed long black and yellow pile; anterior anepisternum with small, yellow macula ventrally; posterior anepisternum with yellow macula in posterior part, anterior anepisternum with long, black pile in dorsal part and yellow pile in ventral part; proepimeron, katepisternum, katatergum with small, yellow macula (Fig. 7); legs completely yellow; femora with black pile; tibiae and tarsi with yellow pile; scutellum yellow, only black at posterior corners and transparent yellow in anterior part, scutellum mainly with long, black pile anteriorly and yellow pile posteriorly; wing membrane extensively microtrichose, wing cell R_1 brown pigmented.

Abdomen (Figs. 1, 12). Black with short, black pile, except tergum 1, anterior part of tergum 2 and yellow fasciae of all terga yellow pilose; sternum 1 black with narrow yellow fascia in posterior part; sternum 1 with long, yellow pile; sternum 2 black; anterior part of sternum 2 with two yellow, triangular maculae covered with yellow pile; posterior part of sternum 2 with narrow, yellow maculae covered with black pile; medial part of sternum 2 with yellow pile; sternum 3 with two yellow, rectangular fasciae connected in the middle with yellow pile and yellow fasciae in the posterior part with black pile, medial part of sternum 3 covered with black pile; sternum 4 black with two yellow maculae in the anterior part, connected in the middle, covered with black pile; medial and posterior parts of sternum 4 black pilose; sternum 5 black, with yellow fasciae in the anterior and posterior parts, sternum 5 with black pile; sterna completely surrounded by membrane. **Male genitalia** (Fig. 31). Surstylus square shaped, with "V" notch in upper part. Hypandrium 2 times longer than wide.

Female (Fig. 2). Length = 12.3 mm. Similar to male except for the following characters: black vitta extending from ocellar triangle to lunule; face yellow with long, black pile medially and yellow pile laterally; frons with long, black pile; ocellar triangle black with long, black pile.

Etymology. The name "*aeginae*" refers to Aegina (Αγινα, in Greek), wife of Zeus (Ζεύς, in Greek) in Greek mythology, because the type locality is in Greece.

Distribution and habitat (Fig. 38). Greece (the Aegean islands of Lesvos and Chios). This species inhabits Mediterranean forest and shrub areas.

Natural history. Adults fly from the end of March to the beginning of May. Larvae are unknown.

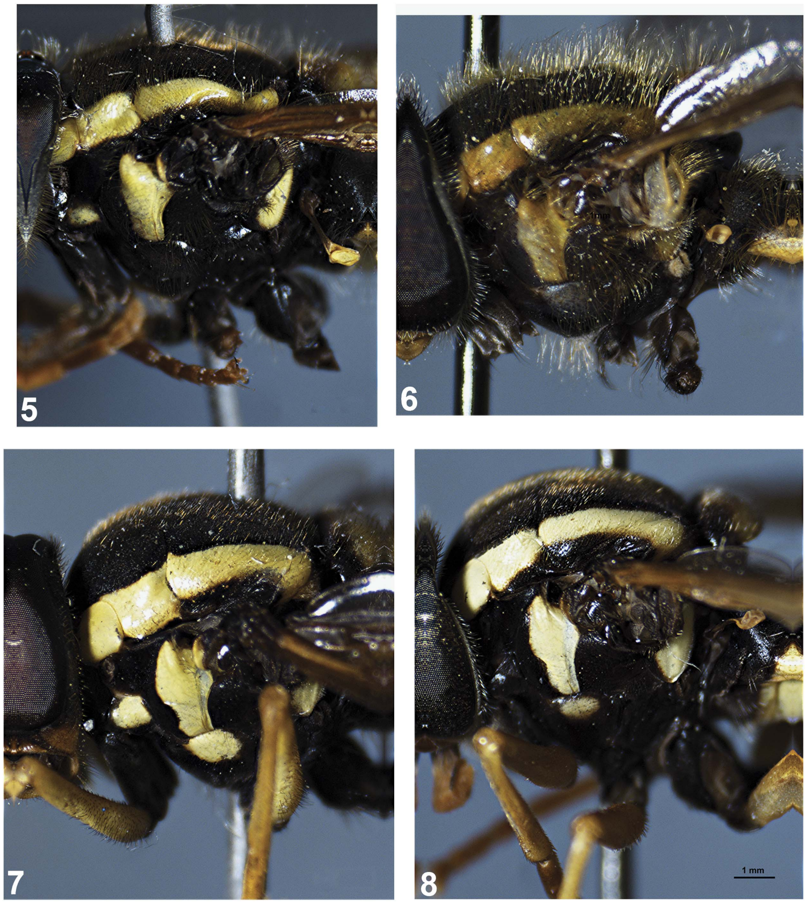
Xanthogramma citrofasciatum (De Geer, 1776)

Figs. 8–9, 28.

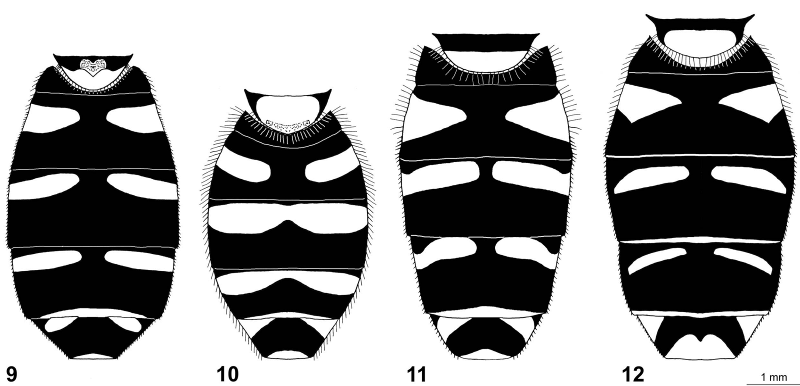
Musca citrofasciata De Geer, 1776: 118.

Musca anteambulo Harris, 1776: 60. Junior synonym.

Figs. 5–8. *Xanthogramma* species, thorax, lateral view. **5**, *Xanthogramma pilosum*, male holotype; **6**, *Xanthogramma laetum*, male; **7**, *Xanthogramma aeginae*, male holotype; **8**, *Xanthogramma citrofasciatum*, male.



Figs. 9–12. *Xanthogramma* species, abdomen, dorsal view. **9**, *Xanthogramma citrofasciatum*; **10**, *Xanthogramma laetum*; **11**, *Xanthogramma pilosum*, male holotype; **12**, *Xanthogramma aeginae*, male holotype.



Syrphus philanthinum Illiger in Rossi, 1807: 450. Junior synonym.

Material examined. The invalid lectotype of *Musca festiva* Linnaeus, 1758 (this lectotype was invalidated by International Commission on Zoological Nomenclature (2001)): 1 male labelled as "*festiva* 33" [red label], "LECTOTYPE/*Musca festiva* Linné/Design. Thompson 1981" [yellow label] (The Linnaean Collections, London, United Kingdom). **Croatia:** 1♂, Primorje, Trogir, 7. iv.1978, 43.517°N, 16.249°E (FSUNS); **Greece:** 1♂, Trigono, 11.v.1990, 40.738°N, 21.204°E (FSUNS); 1♂, Pieria, Mount Olympus, Stragos, 7–14.vi.2014, M. Minachilis, 40.105°N, 22.412°E (MAUA); 1♀, Pindos, Katara Pass, 15.v.2011, 39.796°N 21.229°E, Vujić (MS80) (FSUNS); 1♀, Mount Olympus, Litochotas-Prionia, 18.v.2011, 40.11°N 22.46°E, Vujić (MS79) (FSUNS); 1♀, Drama, Sidironero, 18.v.2011, 41.312°N 24.220°E, Vujić (MS78) (FSUNS); 1♂, Aegean islands, Lesvos, Ag. Marina, 1.iv.2015, J. Devalez, 39.063°N, 26.576°E (MAUA); 1♂, Chios, Palios Katarraktis, 12–14.iv.2013, G. Nakas, 38.255°N, 26.086° E (MAUA); **Macedonia:** 2♂, Baba Mountain, 20. iv.1990, 41.0032°N, 21.185°E (FSUNS); **Montenegro:** 1♀, Durmitor, Komarnica-Nevidio, 3.v.2009, Vujić, 42.98°N 19.068°E (MS77) (FSUNS); 1♀, Durmitor, Sušičko jezero, 31. v.2011, Vujić, 43.14°N 18.99°E (MS40) (FSUNS); **Serbia:** 1♂, Fruška gora, Glavica, 25. iv.1989, 45.153°N, 19.834°E (FSUNS) (published in Vujić and Glumac 1994); 1♂, Fruška gora, Stražilovo, 25.iv.2009, 45.17°N 19.97°E, Nedeljković (MS103) (FSUNS); 2♂, Stara planina, Dojkinačka reka, 6.v.1988 (1♂), 29–30. v.1988 (1♂), 43.220°N, 22.809°E (FSUNS); 2♂, Topli Do-Pilj, 28.v.1987, 43.352°N, 22.681°E (FSUNS); 1♂, Dubašnica, Mikuljska reka, 4. vi.1993, Radišić, 44.018°N, 21.906°E (FSUNS); 4♂, Lunga, 15.v.1994, Radenković, 44.014°N, 21.894°E (FSUNS); 9♂, 4♀, Demizlok, 30. iv.1995 (1♂, 2♀), 4.vi.1995 (1♂), 14.v.1994 (4♂, 1♀), 20.v.1996 (3♂, 1♀), 44.018448°N, 21.889°E (FSUNS); 1♂, 1♀, Dubašnica, Klisura Lazareve reke, 5.v.2012, Vujić (MS33, MS37) (FSUNS); 2♂, 2♀, Malinik, prema Vidikovcu, 3.v.2012, Vujić, 44.001°N 21.902°E (MS34, MS35, MS36, MS38) (FSUNS); 1♂, Beljavina, 6.vi.1993, 44.085104°N, 21.939197° E (FSUNS); 1♂, 1♀, Manastirište, 29.iv.1995 (1♂), 3.v.2012 (1♀) (MS39), 44.018°N, 21.961°E, leg. Vujić (FSUNS); 4♂, Malinik, 13.v.1994 (1♂), 1.v.1995 (2♂), 3.v.1996 (1♂), 44.001057° N, 21.902°E (FSUNS); 2♂, Malinik, ka Vidikovcu, 3.v.1996, 44.001°N, 21.902°E (FSUNS); 2♂, 1♀, Seličevica, 16.iv.1989, 43.238°N, 21.927°E (FSUNS); 2♂, Šar planina, Brezovica, 14.v.1997, Vujić and Radenković, 42.183165°N, 21.050°E (FSUNS); 1♂, Deliblatska peščara, Tilva, 25. iv.1998, Radišić, 44.947°N, 20.965°E (FSUNS); 1♂, Alibunar-slatina, 22.iv.1988, 45.055°N, 20.969°E (FSUNS); 1♂, 1♀, Kopaonik, Vujkovci, 1.v.1992, 43.338°N, 20.947°E (FSUNS); 1♂, Samokovska reka, 24.v.1992, 43.331°N, 20.739° E (FSUNS); 1♂, Kokorovac, 26.v.1987; 1♀, Radošice, 30.iv.1992, 43.274°N, 20.797°E (FSUNS); 1♂, Suva planina, Bojanine vode, 2. v.1988, 43.225°N, 22.117°E (FSUNS); **Turkey:** 1♀, Manisa, Kula, 18.iii.2014, J. Devalez, 38.607° N, 28.801°E (MAUA); 4♂, 1♀, 11 km E of Mugla, 1310 m, 1.v.2013, Barták and Kubik (MB).

Remarks. The holotype of *Xanthogramma anteambulo* (Harris, 1776) has not been checked because the Harris collection is probably lost (N. Wyatt, The Natural History Museum, London, United Kingdom, personal communication). The original description of *Xanthogramma anteambulo* matches *X. citrofasciatum* based on examination of the original publication (Harris 1776–1780: 60, fig. 17). The original type material of *Xanthogramma citrofasciatum* described by De Geer (1776) has presumably been lost or destroyed (N. Wyatt, personal communication). *Xanthogramma philanthinum* (Illiger in Rossi, 1807) was described under the genus *Syrphus*, later transferred to *Xanthogramma* by Bezzi and Stein (1907). We have searched for this type specimen in many collections (ZMHB, ZFMK = Zoologishes Forschungsmuseum Alexander Koenig, Germany, SNMB = Staatlishes Naturhistorisches Museum Braunschweig, Germany, LSF, MNM = Museo Civico di Storia Naturale di Milano, Italy) and we could not find it. According to Article 75.3 of the International Commission on Zoological Nomenclature (1999), a neotype is validly designated when there is an exceptional need. At the moment, *X. citrofasciatum* is not involved in any complex zoological problem and there is no doubt about its identity. *Xanthogramma aeginae* is similar to *X. citrofasciatum* but they can be easily separated by traditional morphology (see under diagnosis of *X. aeginae*), since they are not cryptic or sibling species. Comparisons, figures and keys provided in the present paper serve to fix the concept of *X. citrofasciatum* without need of a neotype designation.

Distribution. From southern Norway south to the Iberian Peninsula; from Ireland eastwards through central and southern Europe into European Russia and the former Yugoslavia; the Caucasus; western Siberia (Speight 2017).

Natural history. Adults fly from March to June. Larva undescribed but known to prey on aphids (Hemiptera: Aphididae) living in *Lasius* Fabricius, 1804 (Hymenoptera: Formicidae) nests (Speight 2017).

Xanthogramma dives (Rondani, 1857)

Syrphus dives Rondani, 1857: 136.

Material examined. Greece: 2♂, Lesvos, Agiassos, Sanatorio, 13.iv.2013, 39.07°N, 26.386°E (MS70, MS74), (FSUNS); 1♂, Samos, Neochori, 16.iv.2011, Vujić and Radenković, 37.70°N 26.76°E (MS67), (FSUNS); **Italy:** 1♀, Toscana, Caniparola, 15.v.2012, 44.112°N, 10.011°E, Vujić and Likov (MS54); **Montenegro:** 1♀, Orjen, 1.vi.2011, Vujić (MS48) (FSUNS); 1♂, Boka Kotorska, Morinj, 8–10.v.2010, 42.49°N, 18.64°E, Vujić (MS52) (FSUNS); **Serbia:** 1♂, Mokrin, Pašnjaci velike droplje, 7.vi.2016, 45.925°N, 20.298°E, Nedeljković and Tot (MS144) (FSUNS); 1♂, Fruška gora, Šakotinac, vii.2010, Vujić (MS62) (FSUNS); 1♂, Kovilj, Blizu manastira, 4.vii.2011, 45.213°N, 20.0370°E, Vujić (MS56) (FSUNS); 1♂, Pčinja, Vogance, 18.vi.2012, 42.351°N, 21.913°E, Vujić (MS61) (FSUNS).

Distribution. Uncertain due to confusion between *X. pedissequum* and *X. stackelbergi*. This species has been confirmed from Spain, France, The Netherlands, Germany, Switzerland, Italy, and Norway (Speight 2017).

Natural history. Adults fly from May to mid-June and from July to the beginning of September. The larva is not described (Speight 2017).

Remarks. The lectotype of *X. dives*, confirmed and designated by Speight and Sommaggio (2010), was examined from high-resolution photographs of the head, thorax, and abdomen (dorsal and lateral views). Label data: "Lectotypus/*Syrphus dives* Rondani/design. C. Kassebeer 1992" (LSF).

Xanthogramma laetum (Fabricius, 1794)

Figs. 6, 10, 23, 29.

Syrphus laetus Fabricius, 1794: 301.

Lasiophthicus novus Rondani, 1857: 140. Junior synonym.

Material examined. Published material: **Serbia**: 1♀, Fruška Gora, Stari Ledinci, 10.v.1957, 45.196°N, 19.787°E (FSUNS); 1♀, Fruška Gora, Stražilovo, 16.v.1982, 45.176°N, 19.971°E (FSUNS) (published in Vujić and Glumac 1994); 1♂, Serbia, Obedska bara, Kupinovo, 23.iv.1986, 44.714°N, 20.048°E (FSUNS) (published in Vujić *et al*. 1998). **Montenegro**: 1♂, Durmitor, Sušičko jezero, 16–17.v.2001, Vujić, 43.140°N, 18.999°E (FSUNS). New material: **Czech Republic:** 2♂, Vráž near Pisek, 400 m, near brook, Malaise trap, 10.v–4.vi.2011, M. Barták, 49.399°N, 14.133°E (MB); 2♀, Vráž near Pisek, 400 m, Pyramidal trapwood, 11.iii–11.iv.2014 (1♀), 6.vi–25.viii.2012. (1♀), 49.399°N, 14.133°E, M. Barták (MB); **The Netherlands:** 1♂, Li Savelsbos, 19.v.2012, Van Eck (AVE); 1♀, Valkenburg, Schaelsberg, 26.iv.2007, 50.861°N, 5.831°E, W. Van Steenis (MS149) (WSB); **Spain:** 1♂, Alava, Delika, 29.iv.2016, 42.967°N, 2.988°W, Van Eck (MS148) (AVE).

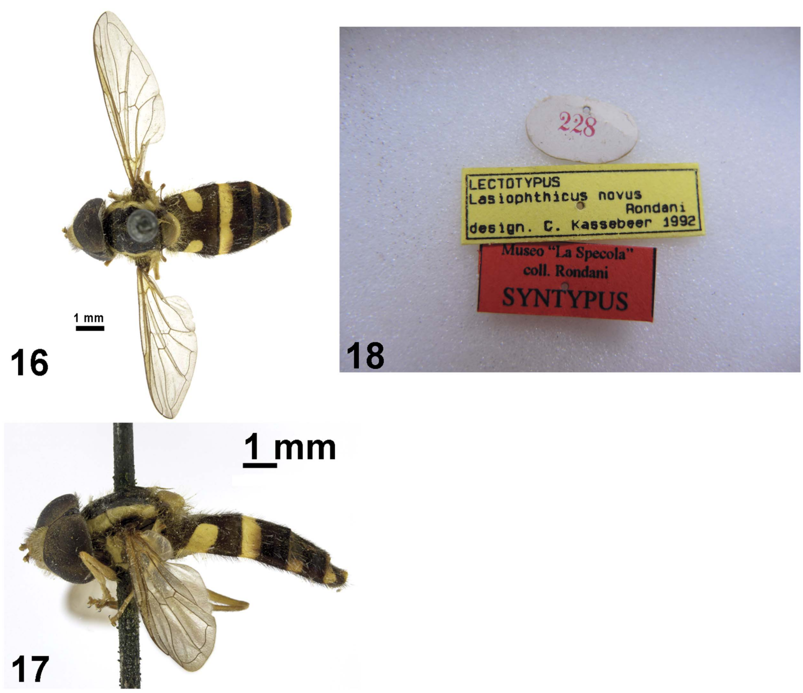
Type material examined. Lectotype (**here designated** in order to fix identity of the species) of *Xanthogramma laetum* (Fabricius, 1794) – "p. 243 47" [yellow label]/"*laetus*" (handwritten)/"LECTOTYPUS *Syrphus laetus* Fabricius design. C. Kassebeer 1992" [yellow label] (ZMUC) (Figs. 13–15).

Lectotype (**here designated** in order to fix identity of the species) of *Xanthogramma novum* (Rondani, 1857) – "Museo "La Specola""/"Coll. Rondani"/"SYNTYPUS" [red label], "LECTOTYPUS/*Lasiopthicus novus* Rondani/design C. Kassebeer 1992" [yellow label], "228" [white label] (LSF) (Figs. 16–18).

Remarks. The lectotype of *X. laetum* was examined from high-resolution photographs of the head and thorax (dorsal and lateral views). The lectotype is in very poor condition, lacking legs and abdomen. Although the lectotype of *X. laetum* was labelled as such by Kassebeer, this

Figs. 13–15. *Syrphus laetus* (=*Xanthogramma laetum*), lectotype. **13**, dorsal view; **14**, lateral view; **15**, labels.

Figs. 16–18. *Lasiophthicus novus* (=*Xanthogramma novum*), lectotype. **16**, dorsal view; **17**, lateral view; **18**, labels.



designation was never published. We confirm Kassebeer's identification and herein formally designate this specimen as lectotype in order to fix identity of the species. This specimen belongs to the type series of *X. laetum* designated by Fabricius (1794).

Photographs (dorsal and lateral views) were also examined of the lectotype of *X. novum*. The lectotype of *X. novum* labelled by Kassebeer in LSF was never published. We confirm Kassebeer's identification and herein formally designate this specimen as lectotype in order to fix identity of the species. This specimen belongs to the type series of *X. novum* designated by Rondani (1857).

Distribution. From northern Germany south to southwestern France (Pyrenées-Atlantiques); from Belgium eastwards through central and southern Europe (Italy, former Yugoslavia) to Romania and European parts of Russia (Speight 2017).

Natural history. Adult fly from March to September. The larvae are undescribed (Speight 2017).

Xanthogramma marginale (Loew, 1854)

Doros marginale Loew, 1854: 18.

Xanthogramma morenae Strobl, 1899: 144. Junior synonym.

Material examined. Spain: 3♀, Grazalema, Cadiz, 14.vi.2014, 36.757°N, 5.365°W, Vujić (FSUNS).

Remarks. A female specimen of *X. marginale* labelled as "neotype" was examined from high-resolution photographs of the head, thorax, and abdomen (dorsal and lateral views). Label data: "Andalusia" (handwritten)/"3773"/"*marginalis* Loew" (handwritten)/"Zool.Mus.Berlin"/"NEOTYPUS Doros marginalis Loew, design. C. Kassebeer 1992" [yellow label] (ZMHB). The designation of this specimen as neotype was never published. According to the International Commission on Zoological Nomenclature (1999) a neotype is validly designated when there is an exceptional need to fix a species concept in the framework of a complex taxonomic problem. The concept of *X. marginale* is not in question, as it is clearly different to all other European species (see diagnostic characters in the key provided in the present paper). Thus, a neotype designation is unnecesary at this moment and the specimen labelled by C. Kassebeer is confirmed to not have any neotype status. The holotype of *Xanthogramma morenae* (which was originally described as a variety of *X. marginale*) was examined by A. Vujić in NMBA. Label data: "Xanth. marginale Lw. var. Morenae m. Span: Cardenas Strobl ♂".

Distribution. Portugal, central and southern Spain, southern France, Italy and North Africa (Morocco, Algeria) (Speight 2017).

Natural history. Adults fly from April to mid of June. The larvae are undescribed (Speight 2017).

Xanthogramma pedissequum (Harris, 1776)

Musca pedissequus Harris, 1776: 61.

Syrphus ornatus Meigen, 1822: 298. Junior synonym.

Syrphus pulchrum Meigen, 1835: 69. Junior synonym.

Doros decoratum Zetterstedt, 1843: 694. Junior synonym.

Xanthogramma bilobatum Szilády, 1940: 64. Junior synonym.

Xanthogramma flavifrons Szilády, 1940: 64. Junior synonym.

Xanthogramma nigripes Szilády, 1940: 64. Junior synonym.

Xanthogramma nobilitatum Frey, 1946: 162. Junior synonym.

Xanthogramma flavipleura Coe, 1957: 62. Junior synonym.

Material examined. Serbia: 2♂, Pašnjaci velike droplje, 7.vi.2016, 45.925°N 20.298°E, Tot, Nedeljković, and Markov (MS125, MS126) (FSUNS); 1♂, Slano Kopovo, 6.vii.2013, 45.631°N, 20.196°E, Stepanov (MS63) (FSUNS).

Remarks. The holotype of *Xanthogramma pedissequum* is lost (Pape and Thompson 2013a). We examined one male and one female from Bristol, United Kingdom – near the type locality – collected by E.A. Fonseca (NHM). The lectotype of *X. ornatum* was examined with high-resolution photographs of the dorsal and lateral habitus of the specimen. The lectotype (**here designated** in order to fix identity of the species) is labelled as follows: "LECTOTYPE" / "*S. ornatus* ♂" (hand written) / "14S1 40" (handwritten) /

"MNHN Paris ED4027". We have searched for the type specimen of *X. pulchum* (Meigen, 1835) in the MNHN and NHMW collection, but we could not find it.

The lectotype of *Xanthogramma decoratum* (Zetterstedt, 1843) was examined with high-resolution photographs of the dorsal and lateral habitus of the specimen (MZLU). The lectotype (**here designated** in order to fix identity of the species) is labelled as follows: "*D. decoratum.* ♀. Scan." (handwritten) / "Lectotypus *Doros decoratum* Zetterstedt design. C. Kassebeer 1992 / 1992 **509**" (blue label) / "MZLU Type no. 5714:1" (MZLU) (Figs. 19–21). The lectotype of *X. decoratum* labelled by Kassebeer was never published. We confirm Kassebeer's identification and herein formally designate this specimen as lectotype in order to fix identity of the species. This specimen belongs to the type series of *X. decoratum* designated by Zetterstedt (1843).

The type series of *Xanthogramma bilobatum* Szilády, 1940, *Xanthogramma flavifrons* Szilády, 1940, and *Xanthogramma nigripes* Szilády, 1940 were destroyed in a fire (Soltész Zoltán, HNHM, personal communication). The lectotype and paralectotype (one male and one female, respectively) of *Xanthogramma nobilitatum* (described originally as a variety of *X. ornatum*) were examined with high-resolution photographs of the dorsal and lateral habitus of the specimen (MZH) (Figs. 33–34). We designate the male as lectotype (**here designated**) in order to fix identity of the species. This specimen belongs to the type series of *X. nobilitatum* designated by Frey (1946).

The type of *Xanthogramma flavipleura* Coe, 1957 is lost (N. Wyatt, personal communication). After the examination of the type specimens of all taxa considered as synonyms of *X. pedissequum,* we confirm their status as synonyms.

Distribution. Uncertain, due to confusion with both *X. dives* and *X. stackelbergi*. Known from United Kingdom and European Atlantic seaboard countries south to southern France and into central Europe to the Alps (France, Switzerland) (Speight 2017).

Natural history. Adults fly from May to September, with a peak in July. The larvae are predators of root aphids tended by *Lasius* Fabricius, 1804 (Hymenoptera: Formicidae) (Speight 2017).

Xanthogramma pilosum Nedeljković, Ricarte, and Vujić, new species

Figs. 3–5, 11, 22, 24, 32.

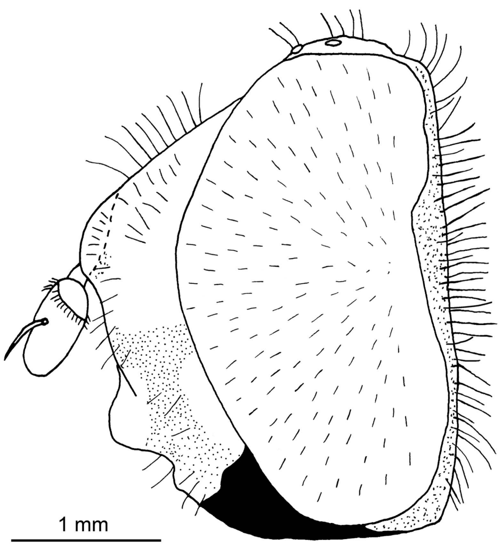
Type material. HOLOTYPE: ♂, **Greece:** Lesvos, Plomari, Agios Issidoros, 13.iv.2011, Vujić and Radenković, 38.971°N, 26.387°E,

Figs. 19–21. *Doros decoratus* (=*Xanthogramma decoratum*), lectotype. **19**, dorsal view; **20**, lateral view; **21**, labels.

(MS81) (FSUNS). PARATYPES: **Greece:** 1♂, Lesvos, Plomari, Agios Issidoros, 13.iv.2011, Vujić and Radenković, 38.971°N, 26.387°E (MS82) (FSUNS); 1♀, Rhodope, Maroneia, 21. iv.2014, de Courcy Williams M., 40.893°N, 25.515°E (MS115) (MCDS).

Diagnosis. Eyes long and densely pilose; frontal triangle with yellow pile; lateral parts of gena black, median part of face yellow with yellow pile; scutum with two pollinose vittae; scutellum with long, yellow pile; notopleuron yellow, at most narrowly black near the anterior anepisternum; proepimeron with small, yellow macula; posterior anepisternum with yellow macula in the posterior part; katepisternum with faint yellow macula; katatergum with yellow macula; wing cell R_1 with brown pigment; anterior and apical part of cell R_{2+3} with brown pigment.

Fig. 22. *Xanthogramma pilosum* male holotype, head, lateral view.



Xanthogramma pilosum can be separated from *Xanthogramma laetum* (Fabricius, 1794) by the colour of the gena laterally, which is black in *X. pilosum* (Fig. 22) and mainly yellow in *X. laetum* (in some specimens partly black) (Table 2). Other differences separating these two species are the colour of the proepimeron in males, which is yellow in *X. pilosum* (Fig. 5) and black in *X. laetum* (Fig. 6). Pile on the frontal triangle and face are mainly black in *X. laetum*, but yellow in *X. pilosum*. Wing cells R_1, C, and R_{2+3} have brown pigment in *X. pilosum* (Fig. 24), while yellow in *X. laetum* (Fig. 23).

Description. Male (Figs. 3, 5, 11, 22, 32). Length = 9.2 mm; Wing length = 8.5 mm. **Head** (Fig. 22). Eye conspicuously pilose (longest pile about 1.1 × longer than diameter of posterior ocelli), with bare areas near eye contiguity and near posterior eye margin; eye pile straight and yellow, denser and longer dorsally; vertical triangle black with black pollinosity and yellow pile; ocellar triangle nearly isosceles; occiput grey pollinose along eye margin, with long, yellow pile; frontal triangle yellow with yellow pile dorsally and some short, black pile ventrally (near lunule); lunule transparent black; antenna yellow, scape and pedicel with short yellow pile; basoflagellomere oval, basoflagellomere at the level of the arista base = 1.25 mm; arista with short, sparse pile; face yellow with yellow pile; lateral parts of gena black, median part of gena yellow with yellow pile. **Thorax** (Fig. 5). Scutum black with two white pollinose vittae extending for anterior two-thirds of scutum length, scutum with long yellow pile; notopleuron yellow, at most narrowly black near anterior anepisternum; proepimeron with small yellow macula; posterior anepisternum with yellow macula on posterior part;

Figs. 23–24. *Xanthogramma* species, right wing, dorsal view. **23**, *Xanthogramma laetum*; **24**, *Xanthogramma. pilosum*, holotype.

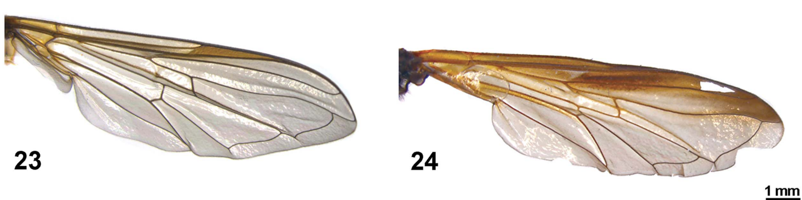
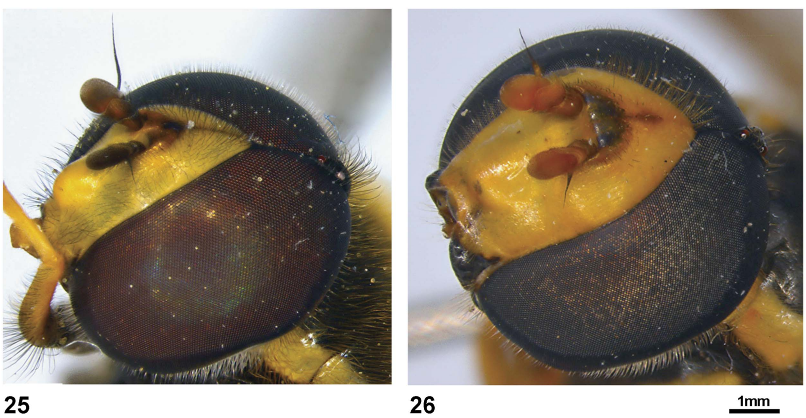


Table 2. Diagnostic morphological differences between *Xanthogramma laetum* and *Xanthogramma pilosum*.

Character	*X. laetum*	*X. pilosum*
Males and females		
Eye pile	Dense, long (length about 1 mm), same length in dorsal and ventral parts of eye (Fig. 25)	Sparse, shorter (length about 0.6 mm), denser and longer dorsally (Fig. 22, 26)
Face	Narrow (11–13 mm)	Broad (17–18 mm)
Antennae	Brown, arista dark brown to black	Dark yellow, arista brown
Wing cells C, R_1 and R_{2+3}	Yellow pigment (Fig. 23)	Dark brown pigment (Fig. 24)
Mesonotum	With dense, long, yellow pile (Fig. 29)	With sparse, long and short, yellow pile intermixed (Fig. 30)
Colour of pile on femora	Black	Yellow
Colour of femora	Black in the basal parts	Entirely dark yellow
Shape of maculae on tergum 2	Rectangular (Fig. 10)	Triangular (Figs. 3, 11)
Maculae on tergum 3 and tergum 4	Variable, connected in medial part of terga or completely separated (Fig. 10)	Interrupted in medial part of terga (Fig. 5)
Males		
Proepimeron	Black (Fig. 6)	With yellow macula (Fig. 5)

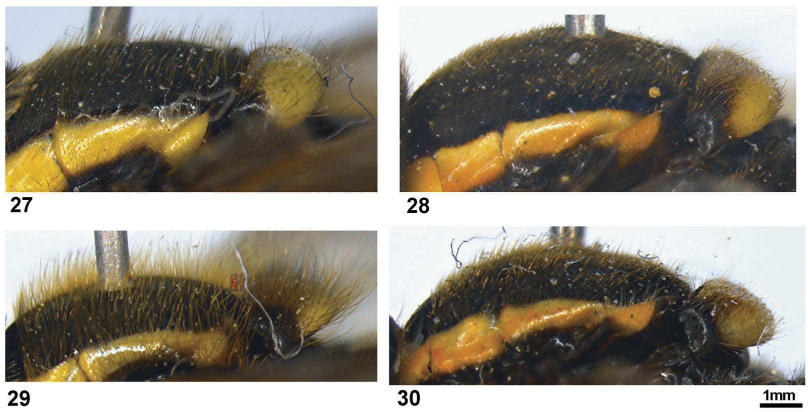
Figs. 25–26. *Xanthogramma* species, male, head, anterolateral view. **25**, *Xanthogramma laetum*; **26**, *Xanthogramma pilosum*, holotype.



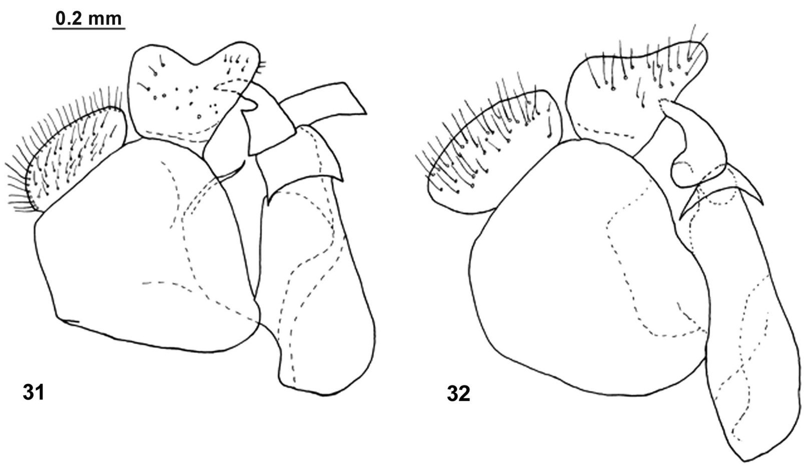
katepisternum with faint yellow macula; metaepisternum with yellow macula; scutellum transparent black in anterior part, clearly black at lateral corners and yellow in posterior part, with long, yellow pile; all legs yellow with yellow pile; wing membrane entirely microtrichose; wing cell R_1 and anterior part of cell R_{2+3} with brown pigment; stigma dark brown to black. **Abdomen** (Figs. 3, 11). Shiny black with short, black pile, except tergum 1, anterior part of tergum 2, and yellow fasciae on terga with yellow pile; yellow fasciae reaching lateral margins of terga; sternum 1 completely black, covered with long, yellow pile; sterna 2–4 black with yellow fascia on anterior margin, fasciae reaching lateral margins; sternum 2 with long, yellow pile; sterna 3 and 4 with yellow pile anteriorly (including fasciae) and black pile posteriorly. Sterna 2–4 completely surrounded by membrane. **Male genitalia** (Fig. 32). Surstylus triangular with rounded apex. Hypandrium 2.5 × longer than wide.

Female (Fig. 4). Length = 12 mm. Similar to male except for following characters: face yellow with yellow pile; black vitta extending from

Figs. 27–30. *Xanthogramma* species, male, mesonotum, lateral view. **27**, *Xanthogramma aeginae*, holotype; **28**, *Xanthogramma citrofasciatum*; **29**, *Xanthogramma laetum*; **30**, *Xanthogramma pilosum*, holotype.



Figs. 31–32. *Xanthogramma* species, male genitalia, lateral view. **31**, *Xanthogramma aeginae*, holotype; **32**, *Xanthogramma pilosum*, holotype.



ocellar triangle to lunule with yellow and black pile intermixed; ocellar triangle black with long, yellow pile.

Etymology. The specific epithet "*pilosum*" is derived from the Latin adjective *pilosum* meaning pilose, referring to the pilose eyes of this species.

Distribution and habitat (Fig. 38). Greece, both mainland (Rhodopes Mountains in the Thrace region) and insular (Lesvos Island). This species inhabits Mediterranean forest and shrub regions.

Natural history. Adults fly from mid to end of April. Larvae are unknown.

Xanthogramma stackelbergi Violovitsh, 1975

Xanthogramma stackelbergi Violovitsh, 1975: 99.

Material examined. Greece: 2♂, Peloponnese, Karyes, 25 km N from Sparta, 22.v.2016, 37.304°N 22.421°E, Vujić, Nedeljković, Ačanski, Likov, and Miličić (MS142, MS143) (FSUNS); **Serbia:** 1♀, Fruška gora, Papratski Do, 10.viii.2013, 45.137°N, 19.673°E, Nedeljković (MS147) (FSUNS); 1♂, Malinik, Manastirište, 22.vi.2012, 44.019°N 21.960°E, Vujić (MS58) (FSUNS); 1♀, Đerdap, Donji Milanovac, 7.v.2010, 44.460°N 22.155°E, Vujić (MS45) (FSUNS).

Remarks. The holotype of *X. stackelbergi* was examined with high-resolution photographs of the dorsal and lateral habitus of the specimen (ZISP).

Distribution. Uncertain, due to confusion between *X. dives* and *X. pedissequum*. Known from Norway, Sweden, Finland, parts of European Russia, United Kingdom, Denmark, The Netherlands, southern Germany, Switzerland, France, Italy (Speight 2017), and Spain (Ricarte and Marcos García 2017).

Natural history. Adults fly from mid-May to mid-August. Larvae are not described (Speight 2017).

Key to European species of *Xanthogramma*

Adapted from Speight and Sommaggio (2010)

1. Tergum 2 wider than long; alula entirely covered in microtrichia 2
- Tergum 2 longer than wide; alula with bare area . . . . . ***X. marginale*** (Loew, 1854)

2. Males; eyes holoptic (contiguous dorsally) 3
- Females; eyes dichoptic (eyes are separated dorsally) 9

3. Eye pile very sparse and, at most, as long as the diameter of the anterior ocellus; terga 2–4 each with a pair of pale (yellow) fasciae 5
- Eye pile dense, longer than the diameter of the anterior ocellus (two times longer or more; terga 2–4 each with a pair of pale (yellow) fasciae) 4

4. Eye pile dense, consistently long (about 1 mm) all over the eye; wing cells C, R_1 and R_{2+3} with yellow pigment; proepimeron entirely black; face narrow (11–13 mm); tergum 2 with rectangular maculae; tergum 3 with a pair of pale maculae in the medial part of tergum that appears as a yellow fascia (in some specimens, tergum 3 with a pair of yellow maculae not united medially) . . . . . ***X. laetum*** (Fabricius, 1794)
- Eye pile shorter (about 0.6 mm), denser and longer on the dorsal part of eye; wing cells C, R_1 and R_{2+3} with dark brown pigment; proepimeron with a yellow macula; face broad (17–18 mm); tergum 2 with triangular maculae; tergum 3 with a pair of yellow fasciae interrupted in the medial part of tergum . . . . . ***X. pilosum* Nedeljković, Ricarte, and Vujić, new species**

5. Pale maculae on tergum 2 1.5 times as wide as long, well separated from the base of the tergite; all legs entirely yellow 6
- Pale maculae on tergum 2 at most 1.25 times as wide as long, almost reaching the base of the tergite laterally; metafemora black in the apical fourth 7

6. Proepimeron black; katepisternum mainly black, especially with faint yellow macula; notopleuron black ventrally . . . . . ***X. citrofasciatum*** (De Geer, 1776)
- Proepimeron with a yellow macula ventrally; katepisternum with a yellow macula; notopleuron yellow, at most narrowly black near the anterior anepisternum . . . ***X. aeginae* Ricarte, Nedeljković, and Vujić, new species**

7. Lateral parts of thorax with 1–2 yellow maculae . . . . . ***X. pedissequum*** (Harris, 1776)
- Lateral parts of thorax with more than two yellow maculae 8

8. Wing cells R_1 and R_{2+3} with a black macula in the apical part; medial extremity of yellow maculae on tergum 2 usually pointed (fig. 1a–b: Speight and Sommaggio 2010); anterior margin of black vitta across sternite 2 straight or with a low, more-or-less rounded median projection (fig. 1e–f: Speight and Sommaggio 2010) . . . . . . ***X. dives*** (Rondani, 1857)
- Wing cells R_1 and R_{2+3} hyaline in the apical; inner extremity of yellow maculae on tergum 2 very rounded (Fig. 1c–d: Speight and Sommaggio 2010); anterior margin of the black vitta across sternum 2 with a pointed, median extension (fig. 1g–h: Speight and Sommaggio 2010) . . . . . ***X. stackelbergi*** Violovitsh, 1975

9. Eye pile very sparse, shorter than the diameter of the anterior ocellus 11
- Eye pile longer than the diameter of the anterior ocellus 10

10. Tergum 2 with two rectangular yellow maculae; tergum 3 and tergum 4 each with a transverse yellow fascia across their entire width . . . . **_X. laetum_** (Fabricius, 1794)
- Tergum 2 with two triangular yellow maculae; tergum 3 and tergum 4 each with a pair of yellow fasciae not reaching the medial part of terga. . . . . **_X. pilosum_ Nedeljković, Ricarte, and Vujić, new species**

11. Legs entirely yellow; wings entirely covered in microtrichia. 12
- Metafemora black on the apical fourth 13

12. Proepimeron entirely black; notopleuron black ventrally. . . . . **_X. citrofasciatum_** (De Geer, 1776)
- Proepimeron with yellow macula; notopleuron yellow, at most narrowly black near the anterior anepisternum . . . . **_X. aeginae_ Ricarte, Nedeljković, and Vujić, new species**

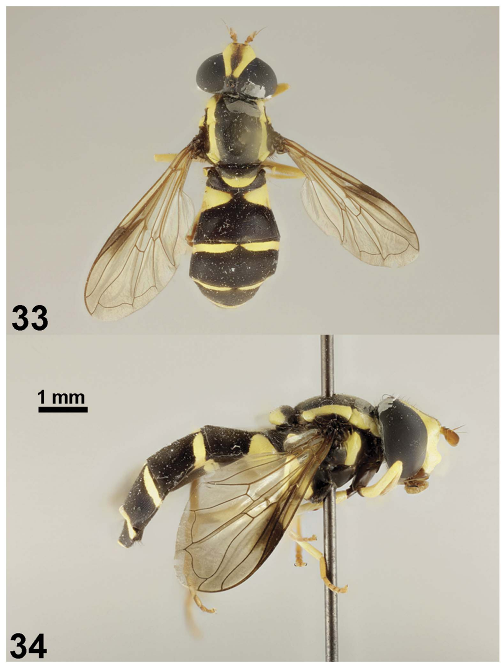
13. Thorax with 1–2 yellow maculae laterally . . . . **_X. pedissequum_** (Harris, 1776)
- Thorax with more than two yellow maculae laterally 14

14. Wing cells R_1 and R_{2+3} with a black macula in the apical part. . . . . **_X. dives_** (Rondani, 1857)
- Wing cells R_1 and R_{2+3} hyaline in the apical part . . . . **_X. stackelbergi_** Violovitsh, 1975

Molecular analyses of *Xanthogramma* species

A 700-base-pair fragment of the 3'-end of the COI gene was obtained for 41 specimens of *Xanthogramma*. ITS2 sequences varying in length from 351 base pairs to 372 base pairs were obtained for 49 specimens. The alignment of in-group ITS2 sequences resulted in a data set of 391 characters, while with the added outgroup sequence the alignment yielded 415 characters when insertion/deletion events were considered. The length of ITS2 sequence of the outgroup taxa (*Melanostoma mellinum*) used in alignment was 390 base pairs. The final COI data set of the in-group taxa had 66 variable positions, 61 of which were parsimony informative. The ITS2 data set had 59 variable positions and 56 were parsimony informative.

COI and ITS2 sequences were analysed separately but also as a combined data set under the maximum parsimony approach. The parsimony analysis of ITS2 sequences resulted in four equally parsimonious trees with 223 steps of length (consistency index = 90, retention index = 91). The strict consensus tree (length = 225) resolved the species *X. laetum* and *X. marginale*, as well as the two new species, *X. pilosum* and *X. aeginae* , as monophyletic clades. *Xanthogramma aeginae* clade and *X. citrofasciatum* were resolved in a polytomy with the sequences of *X. dives* and *X. stackelbergi*. *Xanthogramma citrofasciatum* clade has low bootstrap support value, with one sample outside the clade (MS103). *Xanthogramma pedissequum* was resolved as a paraphyletic, and the cluster *X. dives, X. stackelbergi, X. citrofasciatum*, and *X. aeginae* was nested within it. In addition, *Xanthogramma laetum* was resolved as the sister species to remaining *Xanthogramma* species (Fig. 39).



Figs. 33–34. *Xanthogramma nobilitatum*, lectotype. **33**, dorsal view; **34**, lateral view.

The parsimony tree of COI sequences (length = 130 steps, consistency index = 91, retention index = 96) resolved four clades, which corresponded to *X. marginale*, *X. pilosum*, *X. citrofasciatum*, and *X. aeginae*, as well as a clade that comprised sequences of three different species (*X. pedissequum*, *X. dives*, and *X. stackelbergi*). Within the last clade, *X. pedissequum* sequences form a nested clade with low bootstrap support. *Xanthogramma citrofasciatum* and *X. aeginae* were resolved as sister species. *Xanthogramma laetum* was not included in this analysis as we were not able to produce COI sequences for this species (Fig. 40).

Maximum parsimony analysis of the combined COI and ITS2 sequences resulted in two equally parsimonious trees (length = 354 steps, consistency index = 90, retention index = 94). The topology of the strict consensus tree (length = 363) was similar to that of COI tree (Fig. 41).

Discussion

This study integrates information from different sources, including both morphological and molecular data, to establish species limits within the European *Xanthogramma* species. Species boundaries, first established according to adult morphological characters, were treated as hypotheses and tested using a parsimony analysis of COI and ITS2 sequences. The results of this analysis clearly confirmed the presence of two *Xanthogramma* species new

Figs. 35-37. *Syrphus ornatus* (= *Xanthogramma ornatum*), lectotype. **35**, dorsal view; **36**, lateral view; **37**, labels.

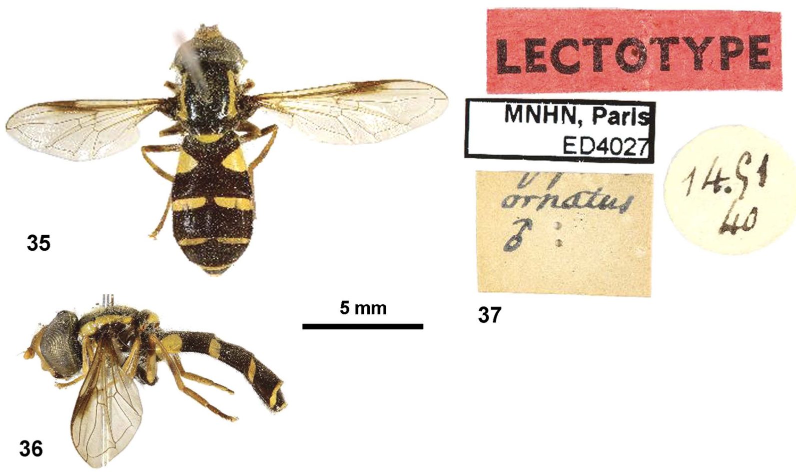


Fig. 38. Map of population sampling locations of the examined species.

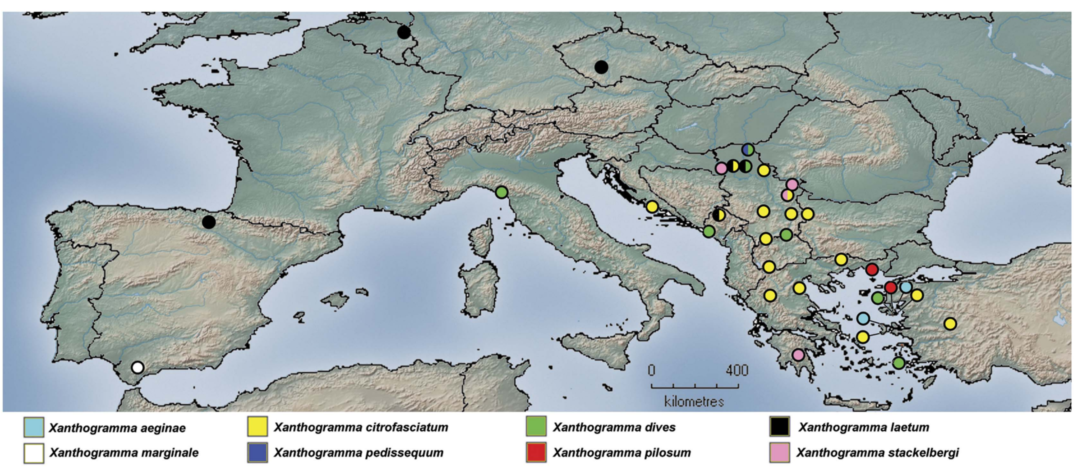
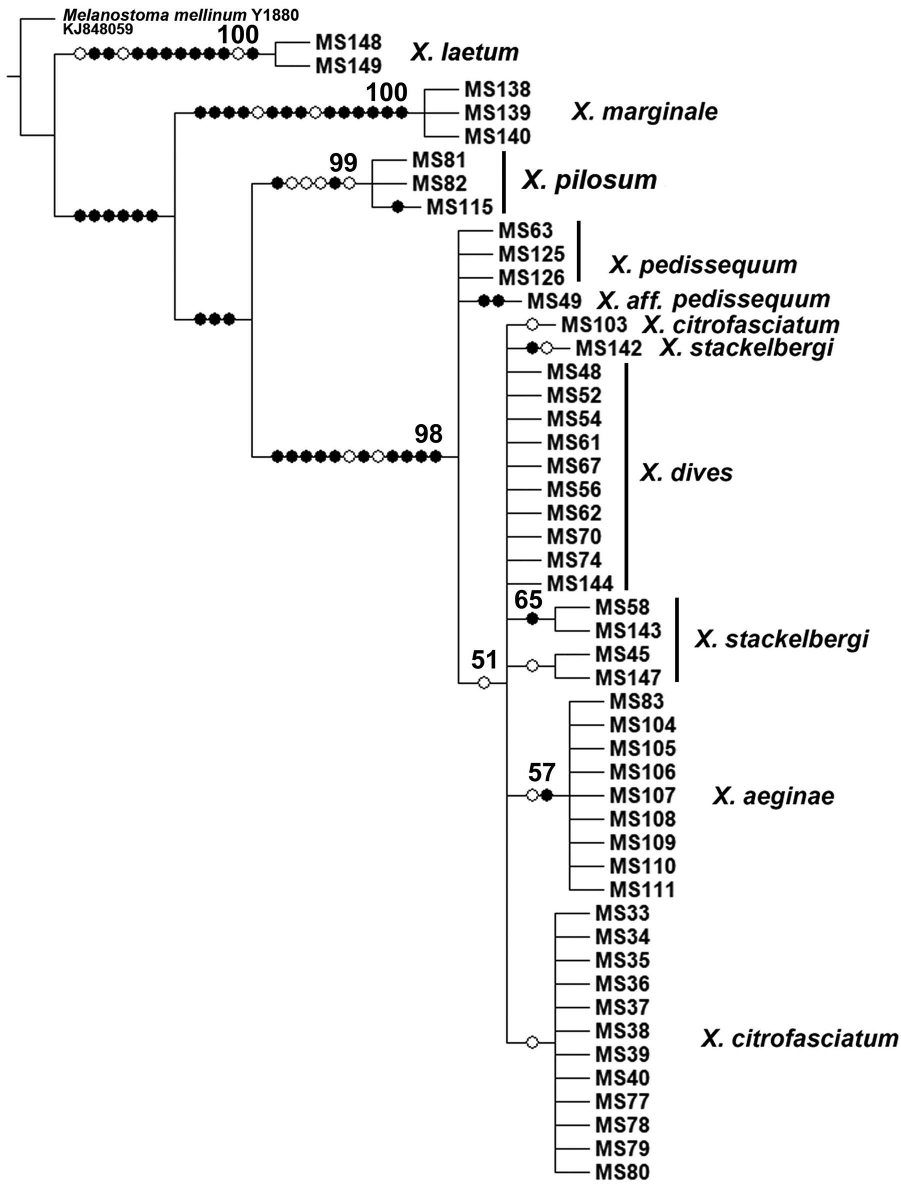


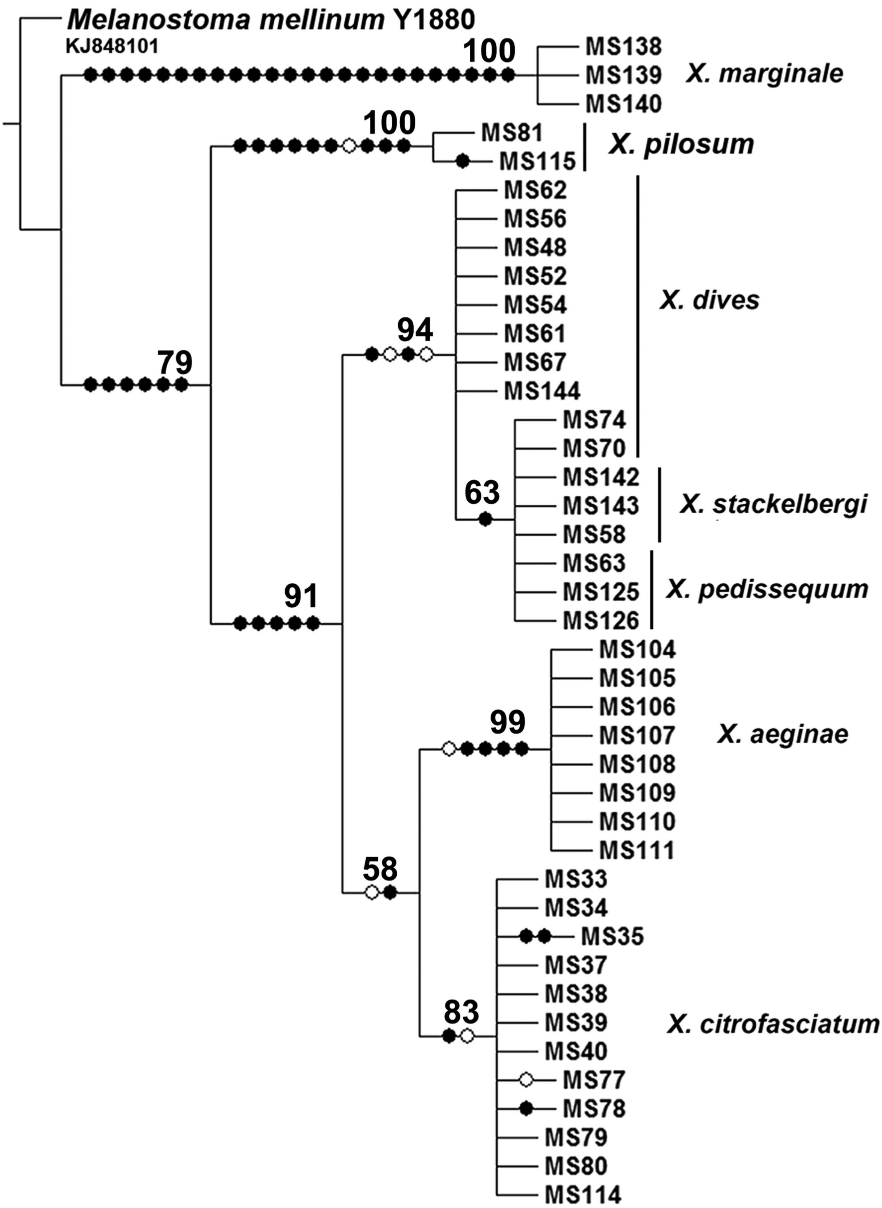
Fig. 39. ITS2 strict consensus tree of four equally parsimonious trees. Length = 225 steps; consistency index (ci) = 89; retention index (RI) = 90. Bootstrap values higher than 50 are indicated near nodes. Filled circles indicate non-homoplasious changes and open circles homoplasious changes. *aff.*, species affinis.



to science: *X. aeginae* and *X. pilosum*. In addition, the new data on the other six European species of *Xanthogramma* contribute to a greater understanding of the distribution and phenology of these species.

Xanthogramma aeginae can be distinguished from the similar *X. citrofasciatum* by the presence of a yellow macula on the proepimeron (Fig. 7), which is completely black in *X. citrofasciatum* (Fig. 8). The pile of the posterior anepisternum are all black in *X. aeginae*, but mainly yellow in *X. citrofasciatum*. *Xanthogramma pilosum* can be separated from the similar *Xanthogramma laetum* by the colour of the gena laterally, which is black in *X. pilosum* (Fig. 22) and mainly yellow in *X. laetum*. Other differences separating these two

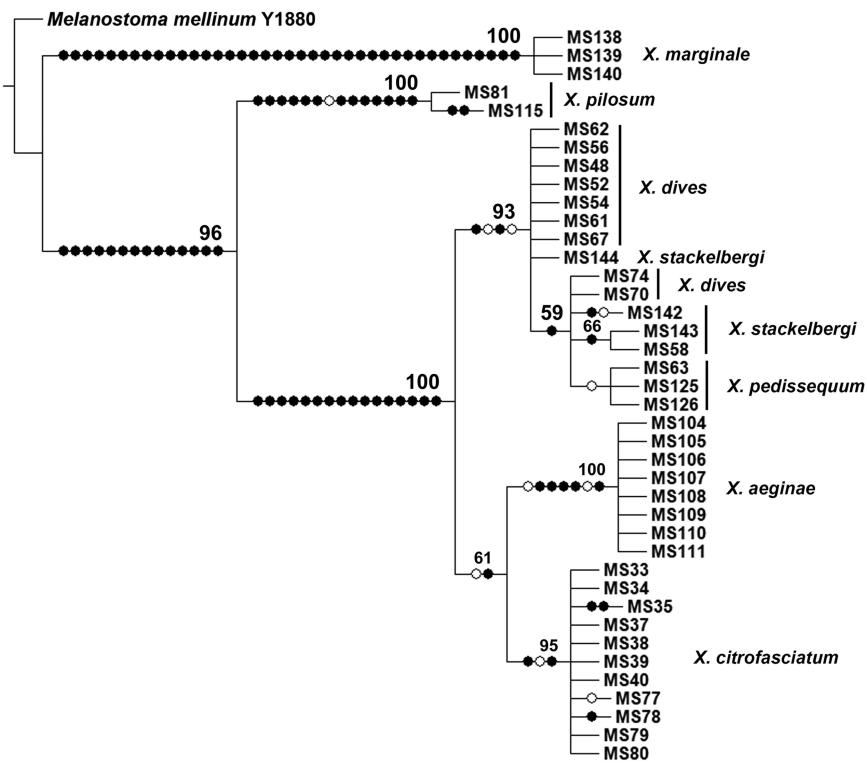
Fig. 40. COI tree based on maximum parsimony approach. Length = 130 steps; consistency index (ci) = 91; retention index (RI) = 96. Bootstrap values higher than 50 are indicated near nodes. Filled circles represent non-homoplasious changes and open circles homoplasious changes.



species are the colour of the proepimeron in males, which is yellow in *X. pilosum* (Fig. 5) and black in *X. laetum* (Fig. 6).

Xanthogramma pilosum and *X. aeginae* were confirmed as new species based on molecular data analyses. Both species form monophyletic clades on maximum-parsimony trees of COI, ITS2 (Figs. 36–37), and combined 3'COI and ITS2 (Fig. 41). *Xanthogramma aeginae* is morphologically similar and closely related to *X. citrofasciatum. Xanthogramma pilosum* is morphologically similar to *X. laetum* from which differs based on ITS2 sequences. These two species form clearly separated monophyletic clades on ITS2 tree (Fig. 39).

Fig 41. Combined analysis of COI and ITS2 sequences. Strict consensus of two equally parsimonious trees. Length = 363 steps; consistency index = 88; retention index = 92. Bootstrap values higher than 50 are indicated near nodes. Filled circles denote non-homoplasious changes and open circles homoplasious changes.



Regarding other *Xanthogramma* species, molecular markers failed to separate *X. dives* and *X. stackelbergi*, in accordance with the fact that many of the morphological characters used to identify them are variable (Speight and Sommaggio 2010). However, *Xanthogramma pedissequum*, which has the closest morphology to *X. dives* and *X. stackelbergi*, is resolved as separate species based on ITS2 sequences, even though these three species are indistinguishable based on COI sequences. In addition, a specimen of *X. pedissequum* (MS49) from Montenegro (Durmitor Mountain) differs from the other three specimens of the same species (MS63 – Serbia, Novi Bečej; MS125, MS126 – Serbia, Mokrin) by two non-homoplasious characters on ITS2 tree (Fig. 39). In addition, subtle morphological differences of this outlier (MS49) were detected in comparison with the other analysed *X. pedissequum* specimens. Thus, further studies are required to resolve the taxonomy of the *X. pedissequum* species group.

Southeastern Europe, which includes the Balkan Peninsula and Aegean Islands, is one of the most important regions of biodiversity within Europe. This diversity results from the fact that this peninsula serves as a crossroads for European, Mediterranean, and Asian faunas (Crnobrnja-Isailović 2007; Savić 2008; Poulakakis *et al.* 2015). For hoverflies, species diversity in the Balkan Peninsula is among the highest in Europe, with many endemic and relict species (Vujić *et al.* 2001), as well as cryptic taxa (Nedeljković *et al.* 2013, 2015; Popović *et al.* 2015; Vujić *et al.* 2013, 2015; Ačanski *et al.* 2016; Šašić *et al.* 2016). Our research confirms that the Balkan Peninsula and Aegean Islands are important reservoirs of hoverfly diversity in Europe.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.4039/tce.2018.21

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