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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)

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Abstract.— Dehesas are typical Mediterranean habitats for extensive livestock raising. Hoverflies (Diptera: Syrphidae) may act as bioindicators in dehesas, but they are still poorly known in this habitat type. With the purpose of the present study, hoverfly diversity was surveyed in Campanarios de Azaba, a typical oak dehesa in Salamanca province, Spain. A total of 41 species were recorded, including *Eumerus azabense* **sp. nov.** This new species was found to belong to the *Eumerus tricolor* group, both in morphological and genetic terms, and clearly separated (DNA characters) from the similar *Eumerus niveitibia*, which is redescribed here. Genetic monophyly of the *E. tricolor* group is confirmed in the present paper. An updated hoverfly checklist of Salamanca province is provided (152 sp.) with indication of the 56 species recorded in Campanarios de Azaba. Obtained results address the importance of dehesa biodiversity, which includes species new to science.

Key words.— Iberian Peninsula, Salamanca, *Quercus*, *Eumerus azabense* sp. nov., *Eumerus niveitibia*, neotype, COI barcodes, bioindication.

INTRODUCTION

With a long history of human use, the Mediterranean Basin is one of 35 biodiversity hotspots on Earth (Myers *et al*. 2000, Mittermeier *et al*. 2011, Williams *et al*. 2011). The entire Iberian Peninsula except for some northern and north-western parts is included in this hotspot (Marchese 2015). This southern region of Europe has typical Mediterranean habitats such as the dehesa, which covers an extension of 3.5–4.0 million ha, mainly in the south-west of Spain (Olea and San Miguel-Ayaz 2006). Dehesa is an agrosilvopastoral system for extensive livestock raising (Olea and San Miguel-Ayaz, 2006) and originates from clearance and brushwood removal of the native Mediterranean forest (Ramírez-Hernández *et al*. 2014). The dehesa landscape has a characteristic savannah-like appearance with oaks of different species, *Quercus*

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spp, according to the region (Campos *et al*. 2013, Ramírez-Hernández *et al*. 2014, 2015a). Dehesas are considered to be important both in ecological and socio-economic terms (e.g. Bugalho *et al*. 2011, Marañón, 1991, Galante *et al*. 1991, Ramírez-Hernández *et al*. 2014), they are included in the 92/43/EEC Habitat Directive and the Nature 2000 Network (Olea and San Miguel-Ayaz 2006).

Some insect groups such as the hoverflies (Diptera: Syrphidae) might be used as bioindicators in productive systems (e.g. Sommaggio 1999, Sommaggio and Burgio 2014). However, knowledge of the dehesa hoverflies is insufficient for them to be used as bioindicators. Apart from the data on a few – mainly saproxylic – species from the Spanish provinces of Salamanca and Huelva (Marcos-García 1985, Ramírez-Hernández *et al*. 2014, Ricarte *et al*. 2016, Ricarte and Marcos-García 2017), hoverfly communities of dehesas are virtually unknown. Although hoverflies are well studied at the European level (Rotheray and Gilbert 2011, Speight 2015), regional faunas are still poorly understood, mainly those of southern Europe (Petanidou *et al*. 2011, Ricarte *et al*. 2014). New species of frequently-recorded Mediterranean genera still await discovery, as the recent description of new *Eumerus* species from Greece suggests (Ricarte *et al*. 2012, Grković *et al*. 2015).

Taxonomy provides the basic tools to understand alpha biodiversity of ecosystems. However, traditional taxonomy, based on morphological characters, is experiencing a substantial change by incorporation of new kinds of characters for species separation; for example, molecular, geometric morphometric and ecological characters (e.g. Haarto and Ståhls 2014, Nedeljković *et al*. 2015). DNA barcoding of taxa is becoming a routine practice in taxonomic studies, with the purpose of building reference DNA-sequence libraries for subsequent species identification (Kress *et al*. 2015).

The main aim of the present study is to better understand the hoverfly community of a typical dehesa from the Iberian Peninsula, as well as to contribute to knowledge of the taxonomy of the *Eumerus tricolor* group, which is represented in this habitat by a species new to science.

Material and methods

Study area. The hoverfly survey took place in the Biological Reserve of 'Campanarios de Azaba' (Fig. 1), a typical dehesa found in Salamanca, western Spain (40 29.769 N 6 47.551 W). This reserve has an extension of 522 ha. The altitude is 800 m. The climate is typical Continental. The average annual temperature is over 12°C. The average annual precipitation is less than 800 mm. Dominant tree species are *Q. rotundifolia* and *Q. pyrenaica*. Tree density is 39 trees/ ha. Campanarios de Azaba is managed by the 'Naturaleza

Figure 1. Campanarios de Azaba, Salamanca, Spain. A typical oak dehesa.

y Hombre' Foundation (http://fnyh.org/la-fundacion/) under sustainable practices of pasture grazing and tree pruning (Sánchez-Martínez *et al*. 2012). This area is included in the Natura 2000 Network and is catalogued as 'Reserva Entomológica' (Entomological Reserve) by the Asociación Española de Entomología (http://www.entomologica.es/).

Sampling protocol. Hoverflies were collected with Malaise traps, from May to November 2010 and from January to November 2011. Catcher pots contained ethanol 70° as preservative liquid and ethylene-glycol as anti-freezing. Samples were collected every 30 days; from June to September samples were collected every 15 days due to temperature provoking higher alcohol evaporation. Dehesa was divided into different vegetation units according to the % of scrub cover: unit 'P1', with 5–25% of scrub cover (low cover); units 'P19' and 'P20', with 30–90% of scrub cover (moderate to high cover). Four Malaise traps were used to collect insects, two (MT1, MT2) in the unit P1, one (MT19) in the unit P19 and other (MT20) in the unit P20 (Table 1). A small part of the examined material was collected with Emergence Traps ('ET'), Window Traps ('WT') and Beer Traps ('T-Cerveza') used by Ramírez-Hernández *et al*. (2014).

Morphological study. Hoverflies were identified using keys and descriptions in Bartsch *et al*. (2009a, 2009b), Claussen (1989), Gil-Collado (1930), Van Veen (2004), Violovitsh (1974), Vujić and Simić (1999), Ricarte *et al*. (2010), Marcos-García *et al*. (2007) and Goeldlin (1976). For species identification, male genitalia were dissected and prepared for study following Ricarte *et al*. (2012). Examined material was identified by Anita Nencioni, Antonio Ricarte and M. Ángeles Marcos-García, unless otherwise stated. Examined material is deposited at the Research Institute CIBIO, in the 'Colección Entomológica de la Universidad de Alicante' (CEUA). For examined material of *Eumerus niveitibia* Becker, 1921, repository collections are:

MAegean – The Melissotheque of the Aegean, University of the Aegean, Mytilene, Greece;
TAU – Zoölogisch Museum Amsterdam, Netherlands (ZMA); Tel Aviv University, Israel;
RMNH – Nationaal Natuurhistorisch Museum, Leiden, Netherlands.

For species descriptions, morphological terms follow Thompson (1999). Body length ('L') was measured from the tip of the frontal prominence (excluding antenna) to the tip of the abdomen. Wing length ('WL') was measured from the insertion point on the thorax to the tip of the wing. Measurements were made using an eyepiece micrometer. Species were illustrated either with photos or drawings. Photos were produced as stalks of individual images made with a camera (Leica DFC 450) attached to a binocular stereomicroscope (Leica M205 C). Stalks were made in Adobe Photoshop® v. 2015. Drawings were elaborated from photos made with a camera Leica DFC 320 attached to a binocular stereomicroscope Leica MZ16; hand-made drawings were processed in GNU Image Manipulation Program (GIMP) software. For the new species genitalia, the presented drawing was hand-made from a printed stalk of photos made with a camera (Leica DFC 450) attached to a binocular stereomicroscope (Leica M205 C). For each species, trophic habits of larvae and other relevant data are provided under 'Notes' following Speight (2015), unless otherwise stated.

Molecular study. COI barcodes were analysed from 18 *Eumerus* specimens, of which 10 represented the following species of the *E. tricolor* group *sensu* Chroni *et al*. (2017): *Eumerus tricolor* (1), *Eumerus grandis* (1), *Eumerus armatus* (1), *Eumerus sinuatus* (1), *Eumerus aurofinis* (1), *Eumerus ovatus* (1), *Eumerus niveitibia* (2) and *Eumerus azabense* sp. nov. (2) (Appendix 2). DNA voucher specimens were deposited in the following collections: CEUA, 'Colección Entomológica de la Universidad de Alicante', Spain; FSUNS, Faculty of Sciences, University of Novi

Table 1. Vegetation units in 'Campanarios de Azaba' dehesa, Salamanca, Spain. For each unit, the vegetation cover (%) and dominant plant species/community are detailed.

Malaise trap code	Woodland cover	Scrubland cover	Grassland cover	Vegetation unit code
MT1, MT2	40%, *Q. rotundifolia*	10%, *Lavandulo sampaianae*, *Cytisetum multifloris*	95%, *Stellarietea mediae*; 5%, pasture	P1
MT19	40%, dehesa-like *Q. rotundifolia* forest; 10%, marcescent oaks	90%, *Cytisus multiflorus*	40%, *Tubenarion guttatae*	P19
MT20	30%, *Q. rotundifolia* with deciduous trees (20%)	40%, *Lavandulo sampaianae* *Cytisetum multifloris*	60%, *Tubenarion guttatae*	P20

Sad, Serbia; MAegean, The Melissotheque of the Aegean, University of the Aegean, Mytilene, Greece.

DNA was extracted from two to three legs of dry pinned specimens. Extractions were carried out using the slightly modified SDS Extraction Protocol (Chen *et al*., 2010); samples were re-suspended in 30 μl of 0.1xTE buffer for further analyses. The COI barcodes (5' region of the mitochondrial cytochrome *c* oxidase subunit I gene) were amplified with forward primer LCO-1490 (5'-GGTCAACAAATCATAAAGATATTGG-3') and reverse primer HCO-2198 (5'-TAAACTTCAGGGTGACCAAAAAATCA-3') (Folmer *et al*. 1994). PCR reactions were carried out in 25 μl reaction volumes and the reaction mix consisted of 1xTaq buffer (ThermoScientific, Lithuania), 2 mM $MgCl_2$, 0.1 mM of each nucleotide, 1.25 U Taq polymerase, 5 pmol of each primer, and approximately 50 ng DNA. Amplification was performed in an Applied Biosystems Verity thermal cycler under the following conditions: initial denaturation for 3 min at 94°C; 30 s denaturation at 94°, 45 s annealing at 50°C, 1 min extension at 72°C (29 cycles); and the final extension for 8 min at 72°C. The PCR products were enzymatically treated with the Exonuclease I and Shrimp Alkaline Phosphatase enzymes (ThermoScientific, Lithuania) and then sequenced using the forward primer and ABI3730x1 Genetic Analyzer (Applied Biosystems) at the Finnish Institute for Molecular Medicine (FIMM), Helsinki, Finland (http://www.fimm.fi). The obtained sequences were submitted to GenBank (for accession numbers see Appendix 2).

For molecular data analysis, the COI barcode sequences were aligned using Clustal W (Thompson *et al*. 1994) as implemented in BioEdit version 7.2.5 (Hall 1999). A species of *Archimicrodon* Hull, 1945 (GenBank accession no. KU365483) and *Xanthogramma citrofasciatum* De Geer, 1776 (GenBank accession no. KU365484) were used as outgroups. The sequences were clustered using Maximum Likelihood (ML) analysis implemented in MEGA version 7.0.21 (Kumar *et al.*, 2016) under the General Time Reversible model-GTR (Nei and Kumar 2000) and invariant rate among sites (+I). Nodal support for the tree was assessed using non-parametric bootstrapping with 1000 replicates.

Results

Taxonomy

Eumerus azabense Ricarte & Marcos-García sp. nov.
Figs 2–5, 6B

Examined material [CEUA]. *Holotype*: 1 m, Campanarios de Azaba, Salamanca, Spain, Malaise 19, 6.v.2011, leg. Quinto, García and Ramírez (DNA analysis; genitalia without hypandrium apex and part of the sub-triangular structure of surstylus, stored in a plastic microvial).

Paratypes: 3 m and 2 f, Campanarios de Azaba, Salamanca, Spain, Malaise 2, 7.vi.2011 (3 m and 1 f; 1 m without the right metaleg and part of right mesoleg detached; 1 m with right metaleg detached), 9.vii.2011 (1 f, DNA analysis), leg. Quinto, García and Ramírez; 4 f, Campanarios de Azaba, Salamanca, Spain, Malaise 10 (2 f), Malaise 19 (1 f), Malaise 20 (1 f), 26.vi.2010, leg. Hernández and Briones.

Etymology. The epithet 'azabense' means 'from Azaba' and refers to the type locality of this species, Campanarios de Azaba.

Diagnosis. Large species (L, 8.9–12.5 mm; WL, 7–9.5 mm; n=10), black (Fig. 2) except for the female terga, which are red, at least laterally (Fig. 3); dorsal part of body with inconspicuous dark blue reflections, which might be more obvious under microscope light (Figs 2A, 3A); eye with dense and long pilosity (Fig. 4); eyes approximated along a very short line (Fig. 4A); basoflagellomere trapezoid, with striae and a concave ellipsoidal area apically (Fig. 5); scutum, scutellum, pleuron and legs black; scutum and scutellum with both light brown and black pile; metafemur moderately swollen, with a row of 7 spinae on the ventral surface apically; dorsal part of all tibiae covered in silvery white pile obscuring partly the background colour of the tibia (Fig. 2B, see protibia); cells C, R, BM and CuP dark brown pigmented; vein R4+5 moderately curved; terga II–IV with two white-pollinose maculae not reaching the lateral margins (Fig. 2A); terga with white to light brown pile, except for the black pile on the posterior margin of tergum II and central parts of terga III and IV (Fig. 2A); white pile of sterna I and II wavy at the apex; male genitalia similar to those in *Eumerus niveitibia* (Fig. 6).

Description – Male (holotype). L = 10.9 mm, WL = 9 mm. *Head* (Fig. 4). Eye densely pilose, except for the bare posterior margin; eye pile light brown, long, slightly shorter on the lower and upper part of eye; eye facets near the eye contiguity 2× larger than those in the lower part of eye; vertical triangle and occiput black; ocellar triangle isosceles; vertical triangle with long erect black pile and, on the area posterior to the ocellar triangle, light brown pile intermixed; eyes approximated along a very short line, which is as wide as one of the closest eye facets; frontal triangle and face shiny, just sparsely pollinose, and with light brown pile; scape and pedicel black; pedicel with light brown pile, except for some black pile dorsally; basoflagellomere trapezoid, black (reddish black in a male paratype), grey pollinose, with striae; outer surface of the basoflagellomere apex with a concave ellipsoidal area; antennal arista black, basally thickened. *Thorax* (Fig. 2). Scutum, scutellum, pleuron and legs black, except for some reddish areas of the pleuron posteriorly and

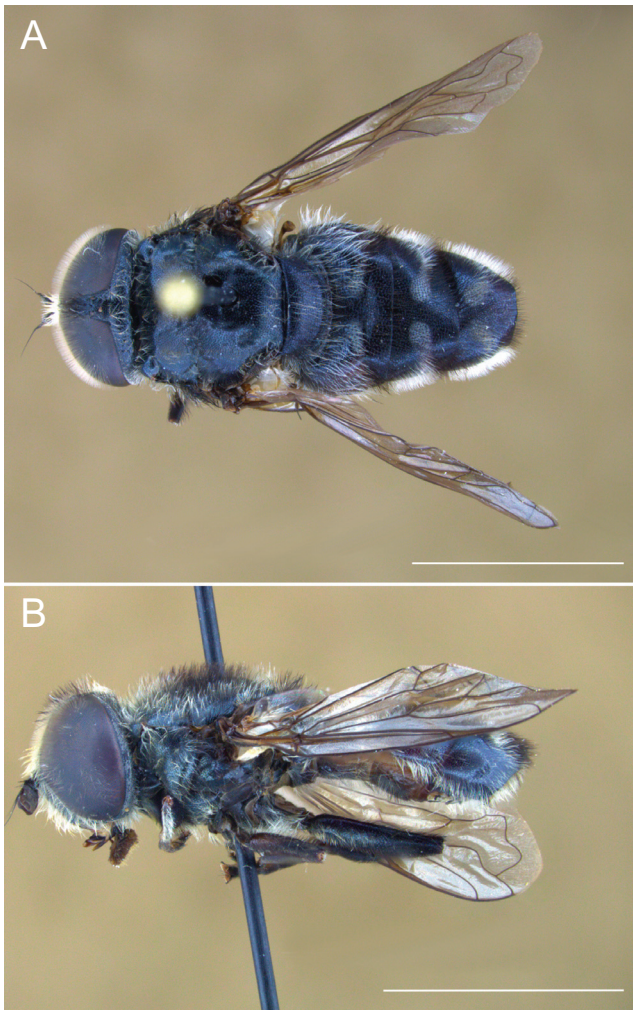

Figure 2. *Eumerus azabense* sp. nov., male holotype, overall appearance: (A) dorsal view; (B) lateral view. Scale bars = 5 mm.

a reddish macula on the mesofemur (all these parts completely black in the male paratypes); scutum and scutellum with long light brown pile and, on the notopleuron, posterior part of scutum, area above wing base, postalar callus and all over the scutellum, black pile intermixed; scutum and scutellum shiny black, sparsely punctate, with large punctures; pleuron pollinose, except for the shiny dorsal part of anepimeron, postero-dorsal part of anterior anepisternum and posterior part of posterior anepisternum; all femora with both black and white to light brown pile; metafemur moderately swollen, in its apical part with a row of 7 spinae on the anterior ridge of the ventral surface and a row of 5 spinae on the posterior ridge (most spinae of the posterior ridge are smaller and more closely arranged than those on the anterior ridge); dorsal part of all tibiae covered in semi-adpressed silvery-white pile in such a way that the background colour of the tibia is almost obscured by these white pile, if tibia seen in baso-dorsal view; wing microtrichose except for some bare areas in cells R, BM, CuP and alula; cells C, R, BM and CuP slightly pigmented (pigmentation is darker in the male paratypes); veins extensively black; vein R4+5 moderately curved; calypter light yellow; halter with whitish pedicel and blackish capitulum basally. *Abdomen* (Fig. 2). Terga II–IV with two white-pollinose maculae not reaching the lateral margins of terga; pollinose maculae of tergum II nearly parallel to the posterior margin of the tergum; pollinose maculae of terga III and IV expanded at their inner end, arranged in a more diagonal position than those in tergum II; terga II–IV extensively black; tergum II with a triangular red macula on the lateral margin; tergum III reddish laterally, including the outer half of the pollinose macula; lateral margin of tergum IV faintly reddish (in some paratypes, entire tergum IV virtually black); terga with white to light brown pile, except for the black

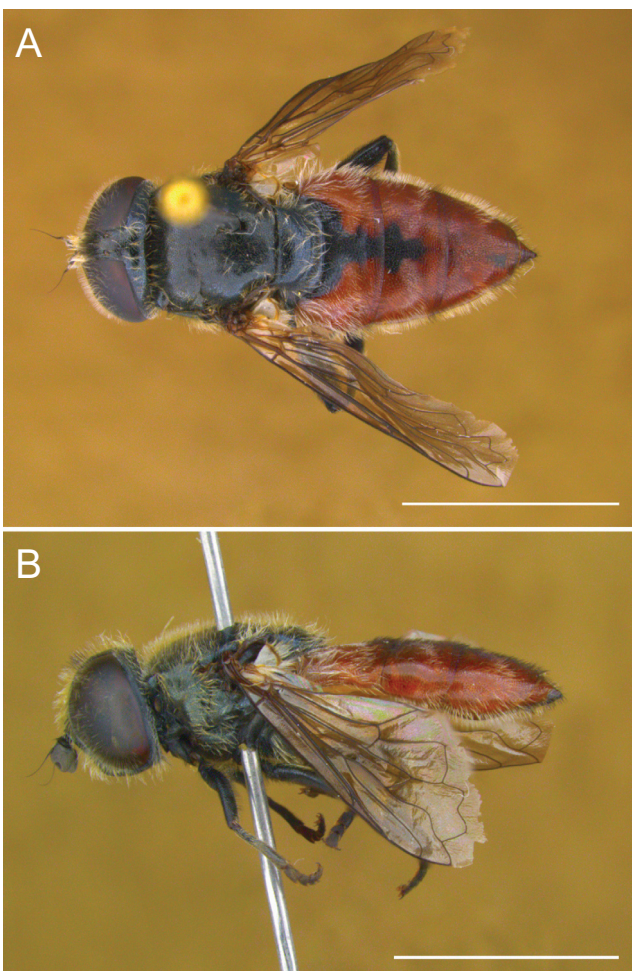

Figure 3. *Eumerus azabense* sp. nov., female paratype, overall appearance: (A) dorsal view; (B) lateral view. Scale bars = 5 mm.

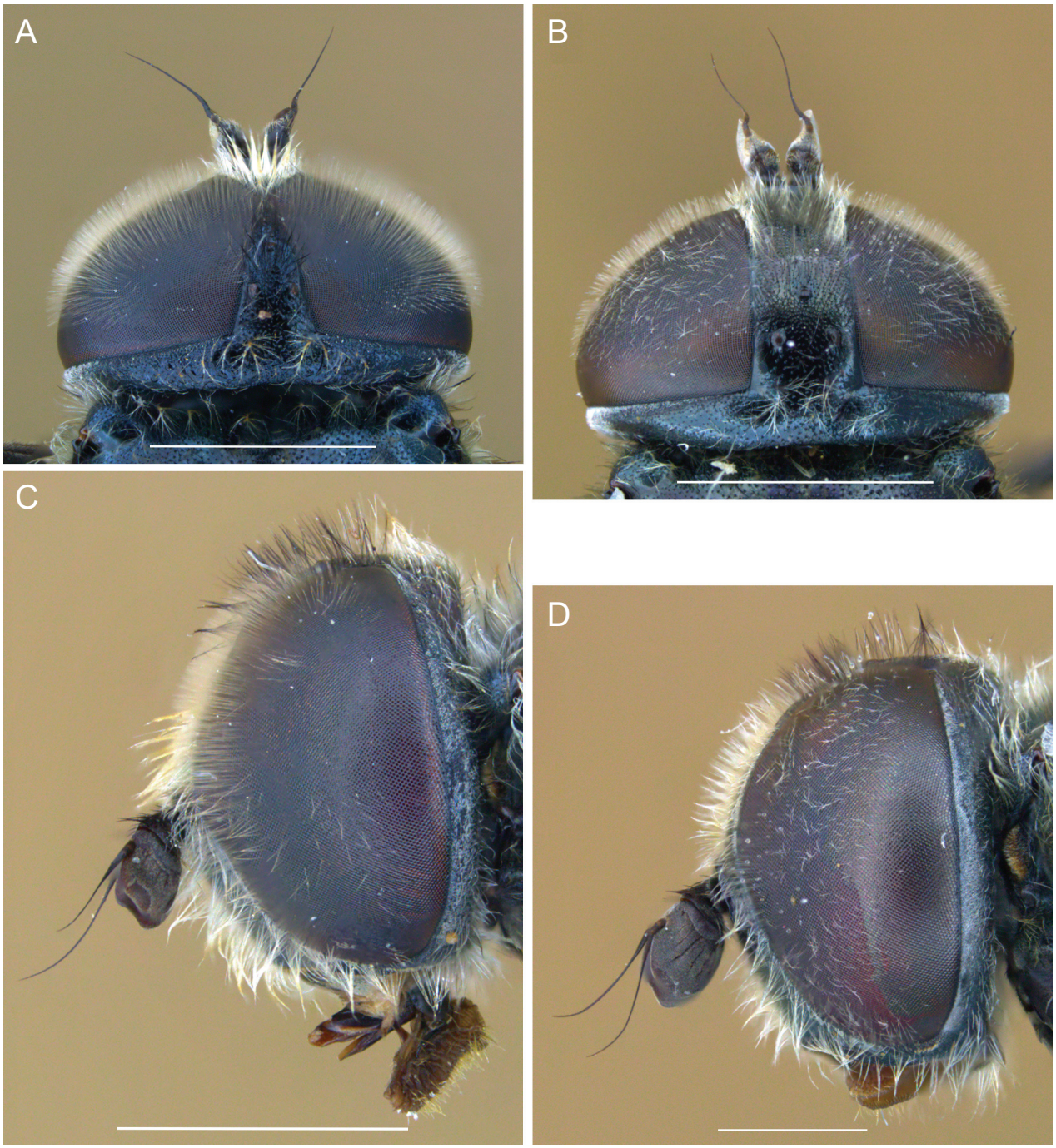

Figure 4. *Eumerus azabense* sp. nov., head: (A) male holotype, dorsal view; (B) female paratype, dorsal view; (C) male holotype, lateral view; (D) female paratype, lateral view. Scale bars = 2 mm (A, B, C), 1 mm (D).

pile on the posterior margin of tergum II and central parts of terga III and IV; lateral margins of terga II–IV with longer white pile, intermixed with black pile at the posterior corner of terga II and III and at the anterior corner of terga III and IV (black pile are variable in number according to the examined specimen); sterna I–IV reddish black, but sterna I and IV darker; sterna I–III with long white pile and, on the posterior margin, from just a few to some black pile intermixed; white pile of sterna I and II wavy at the apex. *Genitalia* (Fig. 6). Base of hypandrium with an elongate flat transversally-striated lingula extending for about a third of the hypandrium length; in lateral view, posterior lobe of the surstylus consisting of a sub-triangular piece

bearing setulae (near the cercus) and a globular piece sinuous and densely setulose in the inner surface (setulae very short and not sclerotised) and with a notch in the outer surface.

Female. L, 8.9–12.5 mm; WL, 7–9.5 mm (n=6). Same as male except for the following characters: frons shiny black, with light brown pile only (Fig. 4B); frons nearly as wide as metafemur; basoflagellomere black to dark brown (Fig. 5); black pile of scutum and scutellum sparser than in male; terga II–IV red (Fig. 3); between the pollinose maculae, terga II and III with a medial black vitta from the anterior to posterior margin, in tergum III sometimes not reaching the posterior margin (Fig. 3A); tergum IV from extensively red to having a black medial vitta never reaching the posterior margin of tergum; white pilosity of terga more extensive than that in male; sternum I black, sometimes with red to reddish black posterior margin; sterna II and III red to reddish black (when sternum III red, then its posterior margin reddish black) and sternum IV reddish black.

Taxonomic notes. This species belongs to the *E. tricolor* group due to the following characters: large body size (8–12 mm); body extensively black (Figs 2, 7), usually with red markings on tergites (Fig. 3); square-shaped basoflagellomere, with striae (Fig. 5, 8C, D); male genitalia with poorly developed anterior surstylar lobe (Fig. 6AC); posterior surstylar lobe with a densely-setulose interior accessory lobe (Fig. 6B). Accepting that the 'terga II and III have large red areas laterally' (step 11 of key), the studied males of *E. azabense* sp. nov. would key out as *Eumerus ovatus* Loew using Stackelberg (1961). However, male of *E. ovatus* can be readily separated from that of *E. azabense* sp. nov. by the pilosity of the central plate of terga III and IV, which is black and sparse in *E. azabense* sp. nov. (Fig. 2A), but silvery white and dense in *E. ovatus* [see Dussaix (2010)]. *E. azabense* sp. nov. is similar to *Eumerus niveitibia* Becker (see under Redescritpion of *E. niveitibia*), but they can be separated by the following characters: in *E. azabense* sp. nov., dorsal part of body has very inconspicuous dark-blue reflections (Fig. 2A); terga red, at least laterally (Figs 2A, 3); central plate of tergum IV (including pollinose maculae) extensively black pilose (Fig. 2A); in *E. niveitibia*, dorsal part of body has conspicuous blue reflections (Fig. 7); terga extensively black (Fig. 7); central plate of tergum IV (including pollinose maculae) extensively white pilose, especially in male (Fig. 7A). Differences found in the male genitalia of *E. azabense* sp. nov. and *E. niveitibia* were regarded as not diagnostic based on the available material (Fig. 6).

Range. Spain (Salamanca province).

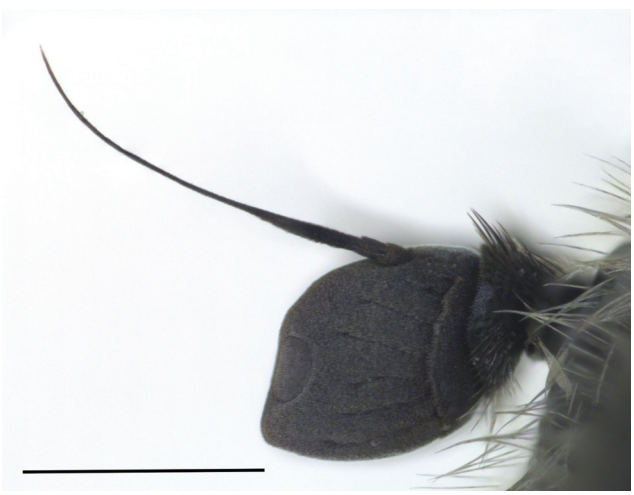

Figure 5. *Eumerus azabense* sp. nov., antenna, female paratype. Scale bar = 0.5 mm.

Eumerus niveitibia Becker, 1921
Figs. 6A, C, D, 7–9

Note. This species was described from a single male collected in mainland Greece, apparently in the mountain Parnassus ('Parnafs'). According to Pape & Thompson (2013), the holotype is deposited in the Museum für Naturkunde, Berlin, Germany. However, this holotype was lost in Becker's time (Joachim Ziegler in lit.) and here we designate a neotype. The taxonomic identities accepted in the present publication were established based on the descriptions of Becker (1921), Sack (1932) and Stackelberg (1961). Unique characters on the metatibia, the characteristic coloration of the body pile, as well as pile on the eyes and face undoubtly indicate species affiliations. To firmly associate the name *E. niveitibia* with a species concept, we designate here a male neotype. Due to high level of endemism in the hoverflies on the Greek islands (Ricarte *et al*. 2012, Grković *et al*. 2015, 2017, Chroni *et al*. in prep.), we designate as neotype a male from Bulgaria, which we consider to be conspecific with the missing holotype collected in mainland Greece.

Examined material. *Neotype* (designated here): 1 m, Nessebar, Bulgaria, 21.vii.2009, leg. A. Barendregt [RMNH]; *Other records*: 1 m, Eressos, Lesvos, Greece, 20.v.2004, leg. Messinger [MAegean]; 1 f, Parori, Peloponnese, Greece, 30.v.1995, leg. G. den Hollander [ZMA]; 1 m, Gebel Katharina, Sinai, Egypt, 25.vi.1998, leg. A. Freidberg & F. Kaplan [TAU].

Diagnosis. Large species (L, 10–12 mm; WL, 7–9 mm) with blue reflections (Fig. 7). Eye with long, pale and dense pilosity (Fig. 8); eye contiguity about 10 facets long; antenna with basoflagellomere striated and, apically, with a flattened ellipsoidal area, which in the female is remarkably enlarged (Figs 8C, D); unlike

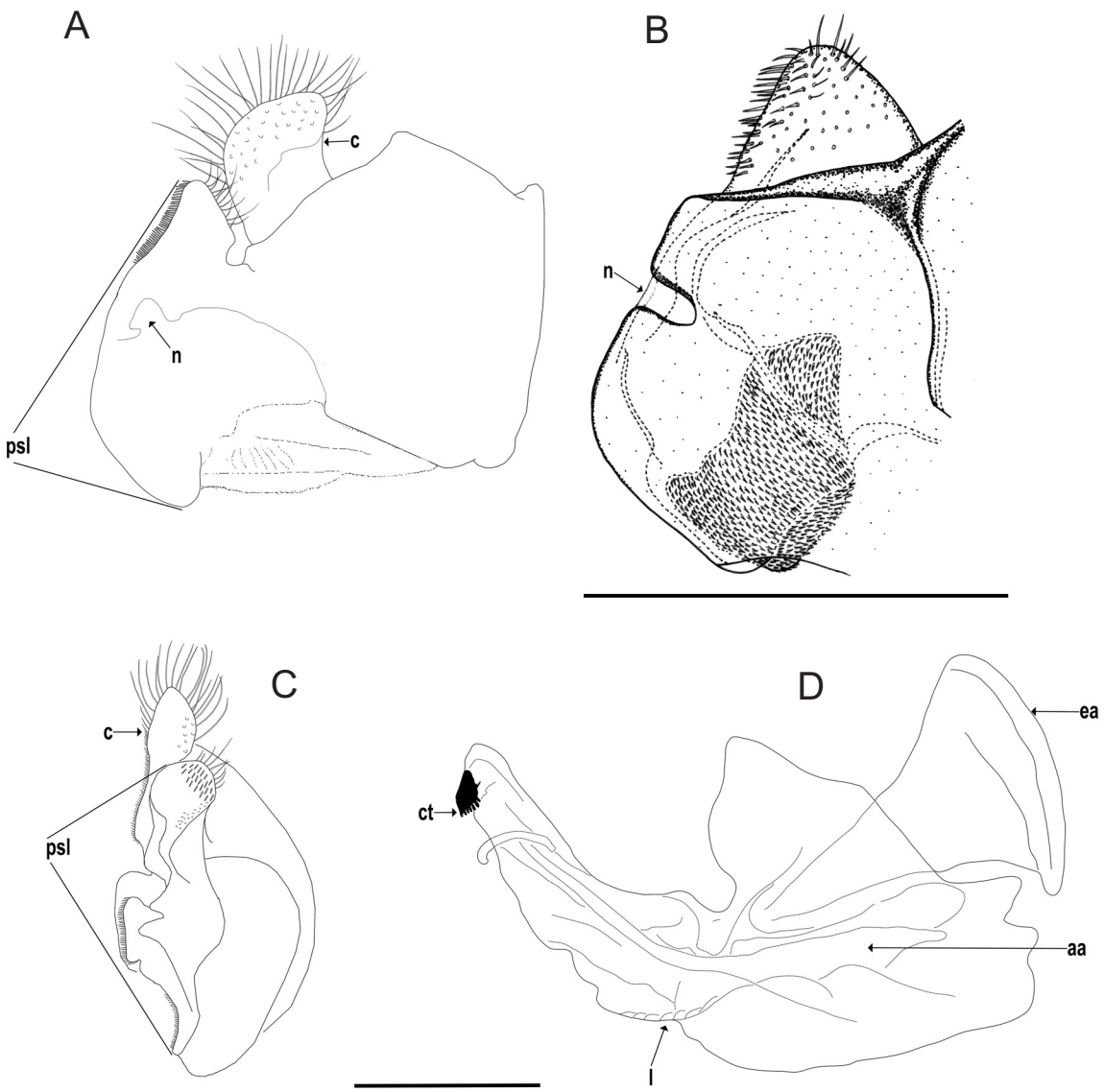

Figure 6. *Eumerus niveitibia* Becker, 1921 (specimen from Lesvos island) and *Eumerus azabense* sp. nov. (paratype), male genitalia: (A) epandrium of *E. niveitibia*, lateral view; (B) surstylus of *E. azabense* sp. nov. showing detail of the outer-side and inner-side structures, lateral view; (C) epandrium of *E. niveitibia*, anterior view; (D) hypandrium of *E. niveitibia*, lateral view. The anterior surstylar lobe is very poorly developed and then not indicated in the figure A–C. Legend: aa, aedeagal apodeme; c, cercus; ct, ctenidia; ea, ejaculatory apodeme; l, lingula; n, notch; psl, posterior surstylar lobe. Scale bars = 0.5 mm (upper bar applies to B; lower bar applies to A, C and D).

most species of the *E. tricolor* group, in male, terga are black (Fig. 7), just occasionally with faintly visible red maculae on lateral margins of terga II–IV and translucent distal margin of tergum IV; in male, body pilosity predominantly black on head and thorax, but white on abdominal terga (Fig. 7); in female and sometimes in male, pilosity predominantly white all over the body, except for the black-pilose terga. Legs black, ventrally with black pile and conspicuous silvery-white pile dorsally (Fig. 7B).

Redescription of male. *Head* (Figs 7, 8). Eye contiguity about 10 facets long; eye densely pilose with bare posterior margin; eye with long pale pile, which are about a third shorter in the lower and posterior parts of eye; vertical triangle and occiput black with blue reflections; ocellar triangle isosceles; the distance between the anterior ocellus and a posterior ocellus is twice longer than the distance between posterior ocelli; distance between a posterior ocellus and eye margin small, same as half the diameter of an individual

ocellus; face and vertical triangle with long, black, dense pilosity; pile on mouth margin lighter; scape and pedicel brown; dorsal pile of pedicel long (as long as the pedicel depth) and black; ventral pile of pedicel pale, as long as the dorsal pile, with a few longer black pile intermixed; basoflagellomere dark brown, slightly axe-shaped, grey to golden pollinose; outer side of basoflagellomere with up to five radially-arranged striae and a concave ellipsoidal area on distal margin; arista dark brown, thickened basally. *Thorax* (Fig. 7). Scutum, scutellum and pleuron black, shiny, gently punctured, with more or less conspicuous blue reflection; scutum and pleuron with long, dense pile; pleural pile slightly wavy apically; pile on scutellum pale brown to white; katatergum with short, brown pile; mesofemur postero-laterally with a fringe of long, grey to white pile; metacoxa with very long white pile anteroventrally; metatrochanter with short black pile; metafemur slightly swollen, with pile of about the same length all over, pale brown to white dorsally and laterally, but black ventrally; apical part of metafemur with a row of 9–10 thorn-like spinae on the anterior ridge of the ventral surface (Fig. 9A) and a row of 8–9 thorn-like spinae on the posterior ridge; dorsal part of all tibiae covered in a conspicuous, long, silvery-white pilosity; wing transparent, entirely sparsely microtrichose; vein R4+5 moderately curved; halter light brown; calypter white. *Abdomen* (Fig. 7, 9C). Terga black with blue reflections; lateral margins of terga II–IV sometimes with faintly visible red maculae and the distal third of tergum IV translucent; tergum I covered in short black pile; terga II–IV covered in long white dense pilosity, which provides a velvet appearance to the abdomen; terga II and III posteriorly with shorter black pile; tergum IV with a few black pile only on anterior margin; each of terga II–IV with a pair of white pollinose maculae, which reach lateral margins only on tergum III; maculae on tergite II narrower, parallel to posterior margin of tergum; maculae on terga III and IV curved, wider at their inner ends; sternum I black; sterna II–IV yellowish to reddish black; sternum IV with blue reflections; sternum I with long yellowish to white pile and brown pile intermixed; sternum II with yellowish to white pile, slightly longer than those on sterna I and III–IV; sterna III and IV with long brown pile. *Genitalia* (Fig. 6). Base of hypandrium with an elongate transversally-striated lingula, rope-shaped in appearance in its outer side in lateral view; aedeagal apodeme with a dorsal process and, laterally, curved down; ejaculatory apodeme with very strong and expanded edge; subapical ctenidia; posterior surstylar lobe as in *E. azabense* sp. nov.

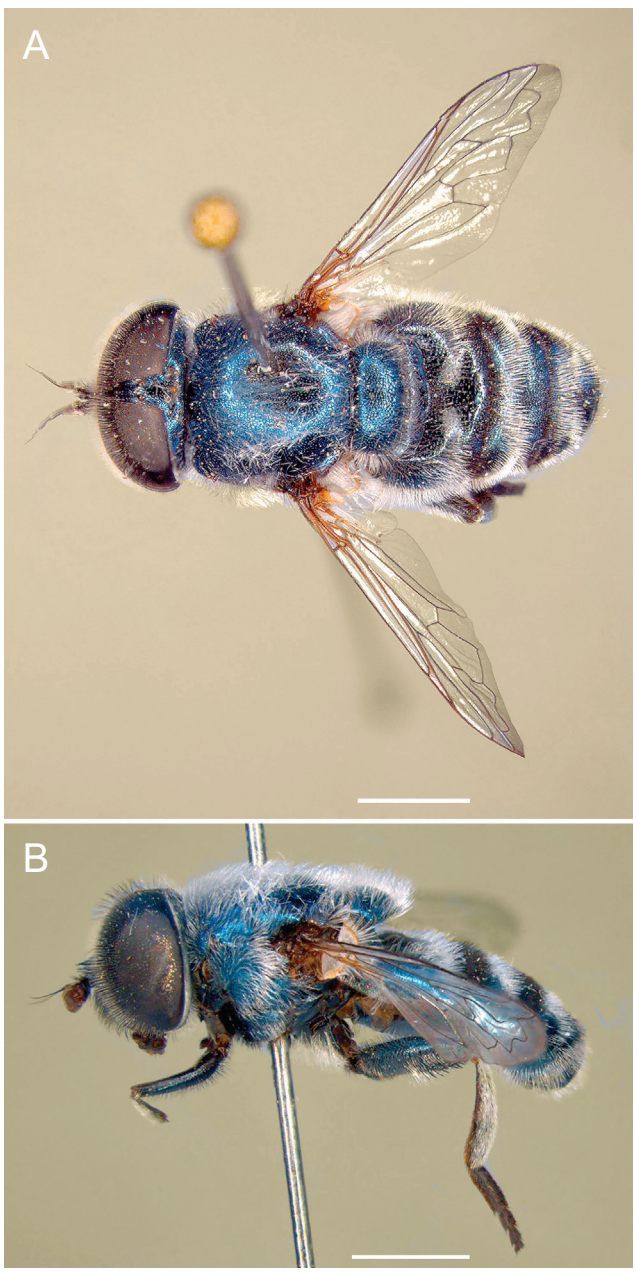

Figure 7. *Eumerus niveitibia* Becker, 1921, male neotype, overall appearance: (A) dorsal view; (B) lateral view. Scale bars = 2 mm.

Description of female. Same as male except for the following characters: ocellar triangle slightly longer than wide (Fig. 8B); face, frons and occiput with long white pile, except for the black pile on the ocellar triangle; frons narrower than metafemur; white pollinosity along dorsal eye corner (Fig. 8D); basoflagellomere large, wrinkled, reddish brown (Fig. 8D); scutum, anepisternum and katepisternum white pilose with a few black pile intermixed; scutum with a row of black setae just above wing insertion; postalar callus with distinctive black and white pile intermixed; anepimeron covered in black pile; metatrochanter with white pile; all pile on metafemur of about the same length;

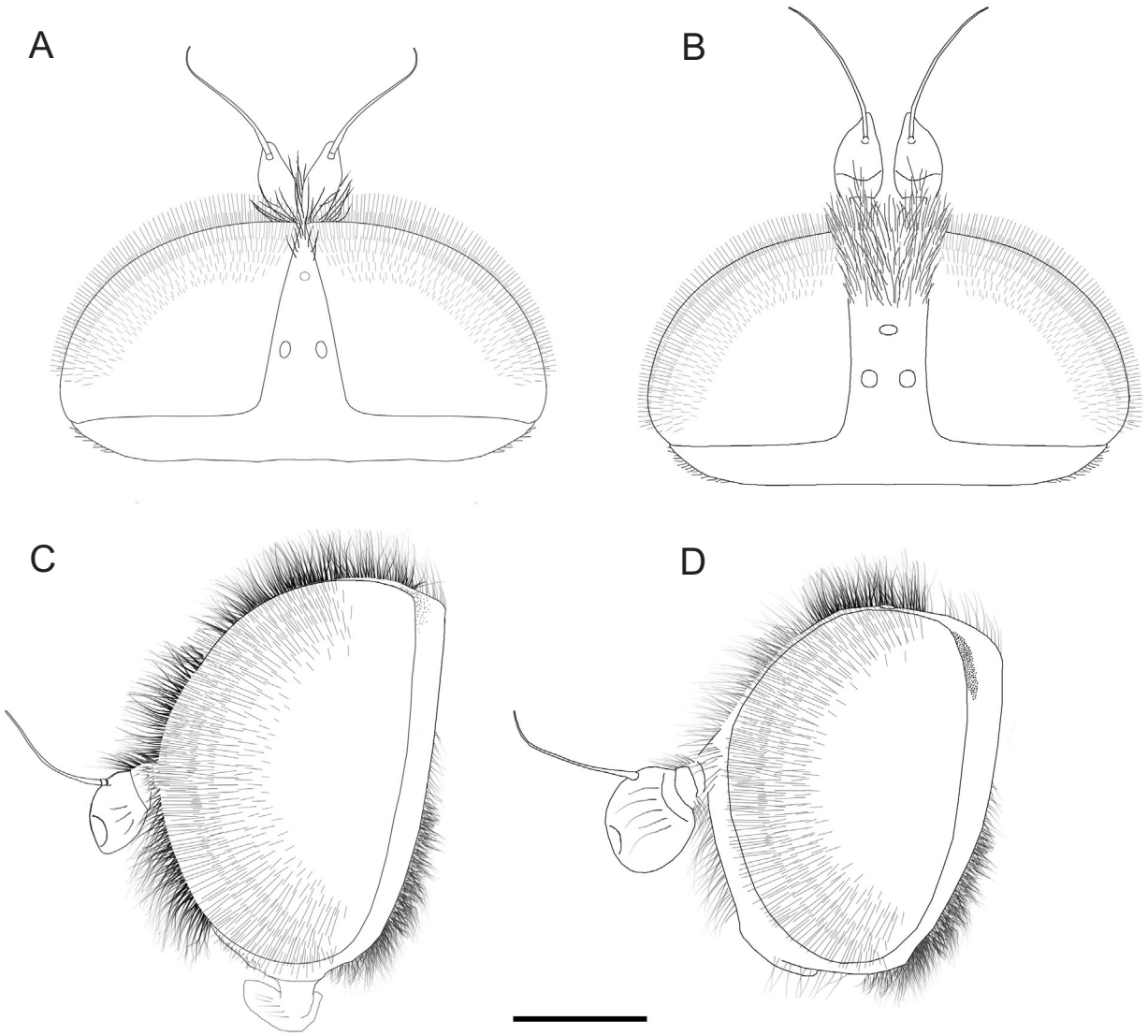

Figure 8. *Eumerus niveitibia* Becker, 1921, head: (A) male (specimen from Lesvos island), dorsal view; (B) female (specimen from mainland Greece), dorsal view; (C) male (specimen from Lesvos island), lateral view; (D) female (specimen from mainland Greece), lateral view. Scale bar = 1 mm.

metafemur with a row of 9 thorn-like spinae on the anterior ridge of the ventral surface and a row of 8–9 thorn-like spinae on the posterior ridge (Fig. 9B); tergum I covered in short black pile; terga II–IV covered in black pile, except for the white pile on the pollinose maculae and antero-lateral part of tergum II; body pilosity shorter and not as dense as in male; terga black, with three pairs of wide white maculae, similar to those in male; sterna I–IV black, with brown pile; sternum II with pale and dark brown pile intermixed; tergum V with intermixed white and black pile.

Taxonomy notes. This species belongs to the *E. tricolor* group (see Taxonomic notes under *E. azabense* sp. nov.). To separate this species from *E. azabense* sp. nov., see taxonomic notes of *E. azabense* sp. nov. In males of *E. niveitibia*, the colouration of body pile ranges from almost completely white (Fig. 7) to predominantly blackish brown. Males of *E. azabense* sp. nov. show a variable number of black pile in the lateral margins of terga II–IV. In *Eumerus sinuatus* Loew, 1855, another *E. tricolor* group species, colour of mesoscutum pile also varies, from golden yellow (specimens from unknown locality, deposited in the Museum für Naturkunde, Berlin) to predominantly black (specimens from Fruška Gora, Serbia). Thus, colouration of body pile appears to be a variable character in species of the *E. tricolor* group.

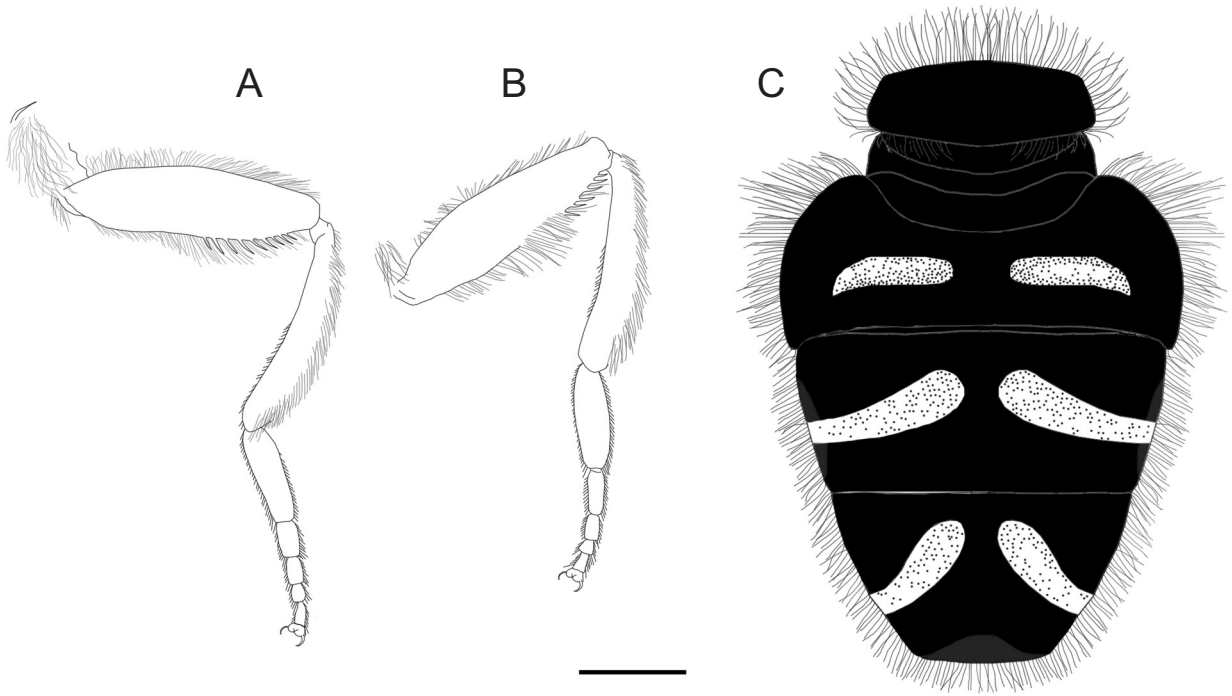

Figure 9. *Eumerus niveitibia* Becker, 1921: (A) leg, male (specimen from Lesvos island); (B) leg, female (specimen from mainland Greece); (C) abdomen, male (specimen from Lesvos island), dorsal view. Scale bar = 1 mm.

Molecular study

The COI barcodes comprised 570 nucleotides for the total analysed dataset. The analysis supported the studied morphological species of *Eumerus*. The two analysed specimens of *E. azabense* sp. nov. shared the same COI haplotype and were separated clearly from the similar *E. niveitibia* (bootstrap value = 100). In addition, the analysis clearly distinguished *E. azabense* sp. nov. and *E. ovatus* which formed the same clade with *E. sinuatus*. Furthermore, monophyly of *E. tricolor* group was confirmed, since it separated from species of other groups (bootstrap value = 100). The obtained ML tree shows that the new species, *E. azabense* sp. nov., clearly belongs to the *E. tricolor* group (Fig. 10).

Hoverfly survey in Campanarios de Azaba, Salamanca, Spain

We studied 645 hoverfly specimens representing 41 species of 19 genera. Examined material is listed below under each species. Species are presented in alphabetical order.

Cheilosia brunnipennis Becker, 1894

New to the Iberian Peninsula.

Examined material. 12.IV.2011: 2♀♀ (Malaise 19), leg. Quinto, García and Quirce, det. Clauss Claussen.

Notes. Prior to the present study, this species was known from southern France and Morocco, apart from other regions of Europe. Thus, the presence of *C. brunnipennis* was expected in the Iberian Peninsula. Larva undescribed, presumably phytophagous.

Chrysotoxum cisalpinum Rondani, 1845

Examined material. 9.VII.2011: 1♂ (Malaise 2), 2♀♀ (Malaise 20), leg. García, Ramírez and Cortés; 9.VII.2011: 1♀ (Malaise 20), leg. García, Ramírez and Moreno; 29/30.VII.2010: 1♀ (Malaise 20), leg. Olmo Hernández; 29.IX.2011: 1♂ (Malaise 19), 1♀ (Malaise 20), leg. Quinto, García and Ramírez.

Notes. This species is relatively widespread in Europe (see Speight 2015), but it has been rarely recorded in the Iberian Peninsula. Gil Collado (1930) states that *C. cisalpinum* is present in the localities of Villaverde, El Pardo (Madrid province) and Seseña (Toledo province), central Spain. However, he erroneously affiliated Seseña to Madrid province and this led Marcos-García *et al*. (1998) – and Ricarte and Marcos-García (2017) – to state that *C. cisalpinum* was recorded only from Madrid. This species was also recorded from Madrid by Leclercq (1963). Thus, the material examined in the present study adds Salamanca to the list of

Spanish provinces where this species has been recorded. Larva undescribed, presumably predatory.

Chrysotoxum intermedium Meigen, 1822

Examined material. 12.IV.2011: 2♂♂ (Malaise 20), 1♀ (Malaise 1), leg. Quinto, García and Quirce; 7.VI.2011: 2♂♂ 1♀ (Malaise 1), 1♂ 2♀♀ (Malaise 20), leg. Quinto, García and Ramírez.

Notes. Larva undescribed, presumably predatory (Rojo *et al*. 2003).

Chrysotoxum octomaculatum Curtis, 1837

Examined material. 9.VII.2011: 1♂ 1♀ (Malaise 1), 1♂ (Malaise 2), leg. García, Ramírez and Cortés; 29/30.VII.2010: 1♀ (Malaise 2), leg. Olmo Hernández; 7.VI.2011: 3♀♀ 1♂ (Malaise 1); 1♂ (Malaise 2), 1♀ (Malaise 19), leg. Quinto, García and Ramírez.

Notes. Larva undescribed, presumably predatory.

Chrysotoxum vernale Loew, 1841

Examined material. 6.V.2011: 1♀ (Malaise 19); 7.VI.2011: 1♀ (Malaise 19), leg. Quinto, García and Ramírez.

Notes. Larva undescribed, presumably predatory.

Didea fasciata Macquart, 1834

Examined material. 7.VI.2011: 1♀ (Malaise 1), 1♀ (Malaise 19) leg. Quinto, García and Ramírez.

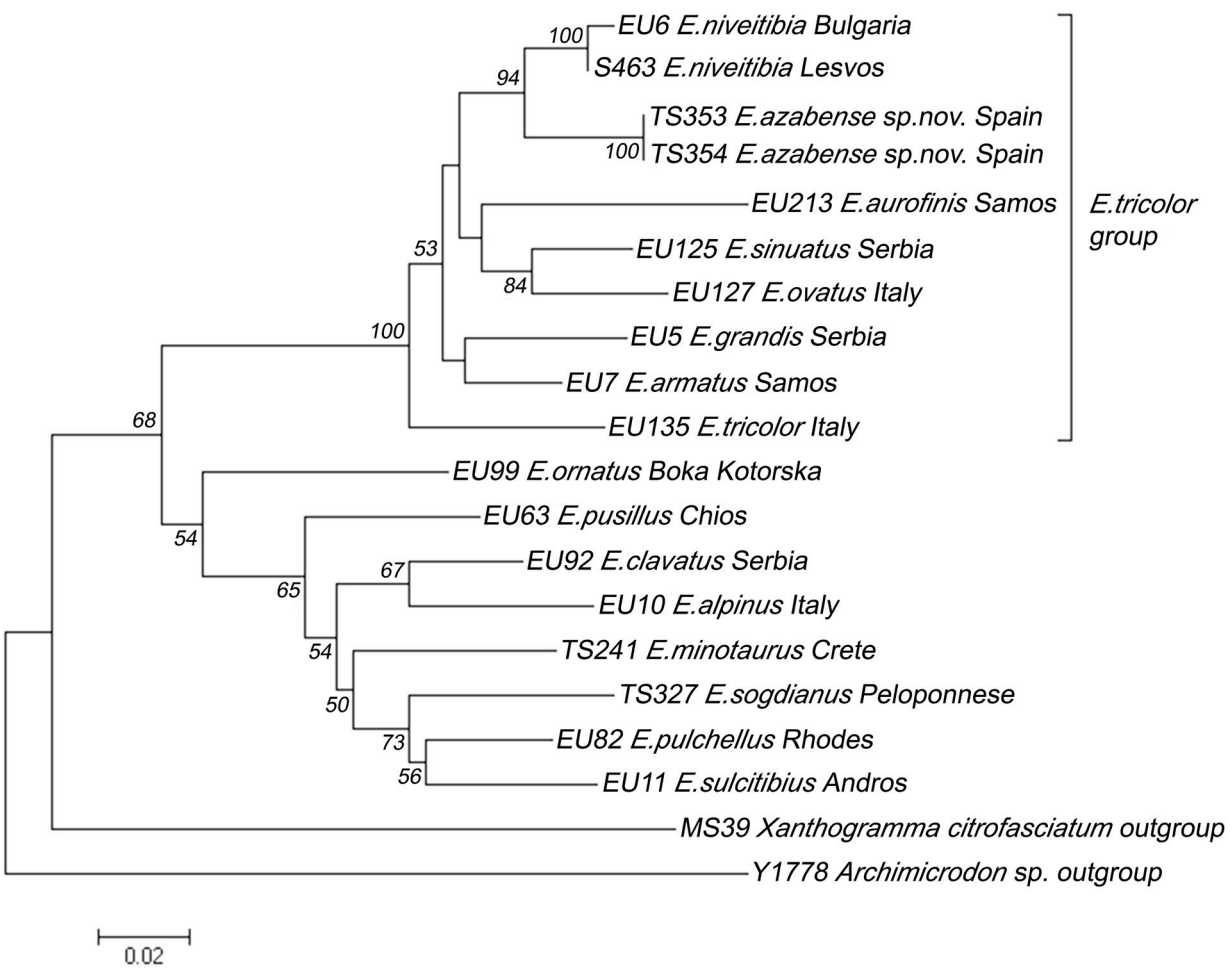

Figure 10. ML tree based on COI barcode sequences for species of the *Eumerus tricolor* and other *Eumerus* groups analysed in the present study. Values of bootstrap support are depicted near the nodes (>50).

Notes. Prior to the present study, *D. fasciata* was known from Spain and Portugal but it wasn't recorded from Salamanca province. Larva described, predatory.

Epistrophe eligans (Harris, 1780)

Examined material. 6.V.2011: 1♀ (Malaise 1), 1♀ (Malaise 20); 7.VI.2011: 1♀ (Malaise 20), leg. Quinto, García and Ramírez.

Notes. Larva described, predatory.

Epistrophe nitidicollis (Meigen, 1822)

Examined material. 7.VI.2011: 1♂ (Malaise 20), leg. Quinto, García and Ramírez.

Notes. Larva described, predatory.

Episyrphus balteatus (De Geer, 1776)

Examined material. 27/28.IX.2010: 1♂ (WT 5.1), leg. Olmo Hernández.

Notes. Larva described, predatory.

Eristalis similis (Fallén, 1817)

Examined material. 6.V.2011: 1♂ (WT 20.2); 7.VI.2011: 1♀ (Malaise 1), 1♀ (Malaise 19), leg. Quinto, García and Ramírez; 12.IV.2011: 1♂ (WT 16.1), leg. Quinto, García and Quirce; 20/22.V.2010: 1♂ (ALCORNOQUE, 'cork oak, Quercus suber'), leg. Micó, Quinto and Briones.

Notes. Larva described, saprophagous.

Eumerus azabense Ricarte & Marcos-García sp. nov. (See new species description)

Eumerus pulchellus Loew, 1848

Examined material. 29/30.VII.2010: 1♀ (Malaise 19), leg. Olmo Hernández.

Notes. Larva described, phytophagous.

Eupeodes corollae (Fabricius, 1794)

Examined material. 26.VI.2010: 2♂♂ 1♀ (Malaise 10); 27.VI.2010: 1♂ 4♀♀ (Malaise 3); 29/30.VII.2010: 1♂ (WT 15.1), 1♀ (WT 18.1), leg. Hernández and Briones; 26.VI.2010: 1♀ (Malaise 20), leg. Micó, Quinto and Briones; 6.V.2011: 1♀ (Malaise 2), leg. Olmo Hernández; 12.IV.2011: 1♀ (Malaise 2); 6.V.2011: 2♂♂ 1♀ (Malaise 1); 7.VI.2011: 1♂ (Malaise 2), 1♀ (Malaise 1); 3.XI.2011: 1♂ 3♀♀ (Malaise 2), 1♂ (Malaise 20), leg. Quinto, García and Ramírez.

Notes. Larva described, predatory.

Eupeodes latifasciatus (Macquart, 1829)

Examined material. 12.IV.2011: 1♀ (Malaise 19), leg. Quinto, García and Quirce; 7.VI.2011: 1♀ (Malaise 1), 1♀ (Malaise 2), 1♀ (Malaise 3), leg. Quinto, García and Ramírez.

Notes. Larva described, predatory.

Eupeodes lucasi (Marcos-García & Láska, 1983)

Examined material. 27.VI.2010: 1♀ (Malaise 3), leg. Hernández and Briones; 6.V.2011: 1♀ (Malaise 2); 7.VI.2011: 1♂ (Malaise 2); 3.XI.2011: 1♂ (Malaise 20), leg. Quinto, García and Ramírez.

Notes. Larva undescribed, presumably predatory.

Ferdinandea aurea Rondani, 1844

Examined material. 3.I.2011: 2♂♂ (Malaise 20); 29.IX.2011: 2♂♂ 2♀♀ (Malaise 1), 4♂♂ (Malaise 20); 3.XI.2011: 1♂ (Malaise 19), 4♂♂ 1♀ (Malaise 20), 1♂ (ET 19), leg. Quinto, García and Ramírez.

Notes. Larva undescribed, saproxylic. Adults have been collected from tree rot holes in *Quercus faginea* and *Q. pyrenaica* (Ricarte *et al*. 2010).

Ferdinandea cuprea (Scopoli, 1763)

Examined material. 14.VII.2011: 1♀ (T-Cerveza C13-3), 1♀ (T-Cerveza C6.4), 1♂ 1♀ (T-Cerveza Clab2), leg. García, Ramírez and Cortés; 2.VIII.2011: 1♂ (T-Cerveza C13-4), leg. García, Ramírez and Moreno.

Notes. This species is widespread and unthreatened in Europe. However, there are no enough data about its abundance in the Iberian Peninsula where it is restricted to its northern area and where it appears to be rarer than *F. aurea* and *F. fumipennis*. Larva described, saproxylic.

Ferdinandea ruficornis (Fabricius, 1775)

Examined material. 14.VII.2011: 1♀ (T-Cerveza Clab2), leg. García, Ramírez and Cortés.

Notes. This species is considered to be threatened with extinction in Europe. Larva undescribed, presumably saproxylic and apparently associated to the burrows of *Cossus cossus* caterpillars.

Melanostoma mellinum (Linneaus, 1758)

Examined material. 9.VII.2011: 1♂ 1♀ (Malaise 2), leg. García, Quinto and Cortés; 7.VI.2011: 1♂ (Malaise 2); 9.VII.2011: 1♂ 3♀♀ (Malaise 1), 6♂♂ 7♀♀ (Malaise 2), 11♂♂ 15♀♀ (Malaise 19), 8♂♂ 9♀♀ (Malaise 20), leg. García, Ramírez and Cortés; 26.VI.2010: 4♂♂ 2♀♀ (Malaise 19); 27.VI.2010: 1♀ (WT 18.2), leg. Hernández and Briones; 26.VI.2010: 2♀♀ (Malaise 20), leg. Micó, Quinto and Briones; 29/30.VII.2010: 1♂ (Malaise 19), leg. Olmo Hernández; 6.V.2011: 2♀♀ (Malaise 1), 1♀ (Malaise 19), 1♀ (Malaise 20); 7.VI.2011: 4♂♂ 5♀♀ (Malaise 1), 3♂♂ 2♀♀ (Malaise 2), 1♂ 3♀♀ (Malaise 19), 2♀♀ (Malaise 20); 9.VII.2011: 2♂♂ (Malaise 20); 29.IX.2011: 1♀ (Malaise 19), leg. Quinto, García and Ramírez.

Notes. Larva described, predatory.

Melanostoma scalare (Fabricius, 1794)

Examined material. 9.VII.2011: 2♀♀ (Malaise 1), 1♂ (Malaise 2), leg. García, Ramírez and Cortés; 26.VI.2010: 2♂♂ 5♀♀ (Malaise 20), leg. Micó, Quinto and Briones; 12.IV.2011: 2♂♂ (Malaise 2), 1♂ (Malaise 19), 1♀ (WT 19.2), Quinto, García and Quirce; 12.IV. 2011: 1♂ (Malaise 19); 7.VI.2011: 1♀ (Malaise 1), 1♂ (WT 3.1), 1♂ (WT 19.2), Quinto, García and Ramírez.

Notes. Larva described, predatory.

Meliscaeva auricollis (Meigen, 1822)

Examined material. 27/28.XI.2010: 1♀ (WT 15.1), leg. Hernández and Briones; 7.VI.2011: 1♂ 1♀ (Malaise 20), leg. Quinto, García and Ramírez.

Notes. Larva described, predatory.

Merodon chalybeus Wiedemann in Meigen, 1822

Examined material. 27/28. IX.2010: 2♀♀ (Malaise 20), leg. Olmo Hernández; 7.VI.2011: 1♀ (Malaise 2), leg. Quinto, García and Ramírez, det. A. Vujić.

Notes. Larva undescribed, presumably phytophagous.

Merodon clavipes (Fabricius, 1781)

Examined material. 7.VI.2011: 1♀ (Malaise 2), leg. Quinto, García and Ramírez.

Notes. Larva undescribed, presumably phytophagous.

Merodon geniculatus Strobl in Czerny & Strobl, 1909

Examined material. 7.VII.2011: 2♀♀ (Malaise 2), leg. Quinto, García and Ramírez, det. A. Vujić.

Notes. Larva undescribed, presumably phytophagous.

Merodon ibericus Vujić in Popović *et al*., 2015

Examined material. 9.VII.2011: 1♀ (Malaise 2), leg. García, Quinto and Cortés. 7.VI.2011: 1♀ (Malaise 1), leg. Quinto, García and Ramírez

Notes. Larva undescribed, presumably phytophagous.

Merodon italicus Rondani, 1845

Examined material. 9.VII.2011: 1♀ (Malaise 19), García, Quinto and Cortés; 2.VIII.2011: 1♂ (Malaise 19), leg. García, Ramírez and Moreno.

Notes. Larva undescribed, presumably phytophagous.

Merodon obscuritarsis Strobl in Czerny, 1909

Examined material. 6.V.2011: 1♀ (Malaise 19); 7.VI.2011: 1♀ (Malaise 2), leg. Quinto, García and Ramírez.

Notes. Larva undescribed, presumably phytophagous.

Paragus bicolor (Fabricius, 1794)

Examined material. 9.VII.2011: 2♀♀ (Malaise 2), 3♀♀ (Malaise 19), leg. García, Ramírez and Cortés; 2.VIII.2011: 1♂ (Malaise 19), leg. García, Ramírez and Moreno; 27.VI.2010: 1♀ (Malaise 3), leg. Hernández and Briones; 26.VI.2011: 2♀♀ (Malaise 20), leg. Micó, Quinto and Briones; 7.VI.2011: 1♀ (Malaise 19), leg. Quinto, García and Ramírez.

Notes. Larva undescribed, but apparently predatory on aphids found in *Rumex* (Gomes, 1981).

Paragus haemorrhous Meigen, 1822

Examined material. 9.VII.2011: 1♀ (Malaise 2), leg. García, Ramírez and Cortés; 26.VI.2010: 1♀ (Malaise 20); 26.VI.2011: 1♀ (Malaise 20), leg. Micó, Quinto and Briones; 7.VI.2011: 1♀ (Malaise 19), leg. Quinto, García and Ramírez.

Notes. Larva described, predatory.

Paragus pecchiolii Rondani, 1857

Examined material. 7.VI.2011: 1♀ (Malaise 2), leg. Quinto, García and Ramírez.

Notes. Larva described, predatory.

Paragus quadrifasciatus Meigen, 1822

Examined material. 9.VII.2011: 1♀ (Malaise 2), leg. García, Ramírez and Cortés; 2.VIII.2011: 1♂ (Malaise 2), leg. García, Ramírez and Moreno; 29/30.VII. 2010: 1♀ (Malaise 19), 1♀ (Malaise 20), leg. Olmo Hernández.

Notes. Larva described, predatory.

Paragus strigatus Meigen, 1822

Examined material. 9.VII.2011: 1♀ (Malaise 1), 1♀ (Malaise 2), 1♀ (Malaise 20), leg. García, Ramírez and Cortés; 26.VI.2010: 4♂♂ 2♀♀ (Malaise 20); 26.VI.2011: 1♀ (Malaise 20), leg. Micó, Quinto and Briones; 29/30.VII.2011: 1♀ (Malaise 2), 1♂ 1♀ (Malaise 20), leg. Olmo Hernández; 7.VI.2010: 1♂ (Malaise 2); 7.VI.2011: 1♂ 1♀ (Malaise 2); 29.IX.2011: 1♂ (Malaise 1), leg. Quinto, García and Ramírez; 27.VI.2010: 1♀ (WT 18.2), leg. Hernández and Briones.

Notes. Larva undescribed, presumably predatory.

Paragus tibialis (Fallén, 1817)

Examined material. 9.VII.2011: 1♂ (Malaise 2), leg. García, Quinto and Cortés; 9.VII.2011: 1♂ 1♀ (Malaise 2), 1♂ (Malaise 20), leg. García, Ramírez and Cortés; 2.VIII.2011: 1♂ (Malaise 1), 1♀ (Malaise 19), leg. García, Ramírez and Moreno; 26.VI.2010: 3♀♀ (Malaise 19); 27.VI.2010: 4♂♂ 10♀♀ (Malaise 3), leg. Hernández and Briones; 26.VI.2010: 1♂ 2♀♀ (Malaise 20); 26.VI.2011: 2♂♂ 4♀♀ (Malaise 20), leg. Micó, Quinto and Briones; 29/30.VII.2010: 2♂♂ 1♀ (Malaise 20), Olmo Hernández.

Notes. Larva undescribed, predatory. Information on the biology of this aphid-feeding larva is provided by Marcos-García (1981).

Paragus vandergooti Marcos-García, 1986

Examined material. 9.VII.2011: 3♀♀ (Malaise 2) leg. García, Ramírez and Cortés; 2.VIII.2011: 1♀ (Malaise 19), leg. García, Ramírez and Moreno; 26.VI. 2010: 1♀ (Malaise 10), leg. Hernández and Briones; 29/30.VII.2010: 1♀ (Malaise 19), 2♀♀ (Malaise 20), Olmo Hernández.

Notes. Larva undescribed, presumably predatory.

Pelecocera lusitanica (Mik, 1898)

Examined material. 29.IX.2011: 1♂ (Malaise 1); 3.XI.2011: 1♀ (ET 19), leg. Quinto, García and Ramírez.

Notes. Larva undescribed, presumably phytophagous.

Scaeva pyrastri (Linnaeus, 1758)

Examined material. 27.VI.2010: 1♀ (Malaise 3), leg. Hernández and Briones.

Notes. Larva described, predatory.

Sphaerophoria scripta (Linnaeus, 1758)

Examined material. 29/30.VII.201: 1♂ 1♀ (Malaise 2), 4♂♂ 5♀♀ (Malaise 19), 5♂♂ 5♀♀ (Malaise 20), leg. Olmo Hernández; 26.VI.2010: 9♂♂ 6♀♀ (Malaise 10), 25♂♂ 44♀♀ (Malaise 19), 2♂♂ (WT 18.2); 27.VI.2010: 1♂ 2♀♀ (Malaise 1), 19♂♂ 12♀♀ (Malaise 3); 26.VI.2011: 1♂ (Malaise 10), leg. Hernández and Briones; 9.VII.2011: 4♀♀ (Malaise 2), leg. García, Quinto, Cortés; 9.VII.2011: 8♂♂ 5♀♀ (Malaise 1), 6♂♂ 8♀♀ (Malaise 2), 2♂♂ 5♀♀ (Malaise 20), leg. García, Ramírez and Cortés; 2.VIII.2011: 2♂♂ 2♀♀ (Malaise 19), 1♀ (Malaise 20), leg. García, Ramírez and Moreno; 26.VI. 2010: 30♂♂ 22♀♀ (Malaise 20); 7.VI.2011: 1♂ (Malaise 20); 26.VI.2011: 17♂♂ 3♀♀ (Malaise 20), leg. Micó, Quinto and Briones; 12.IV.2011: 1♂ 1♀ (Malaise 19), leg. Quinto, García and Quirce; 26.VI.2010: 1♂ (Malaise 20); 12.IV.2011: 1♀ (Malaise 19), 1♀ (Malaise 20); 6.V.2011: 1♂ 4♀♀ (Malaise 1), 1♀ (Malaise 2), 4♀♀ (Malaise 19), 2♀♀ (Malaise 20); 7.VI.2011: 7♂♂ 9♀♀ (Malaise 1), 2♂♂ 8♀♀ (Malaise 2), 3♂♂ 8♀♀ (Malaise 19), 3♂♂ 5♀♀ (Malaise 20); 6.IX.2011: 1♀ (Malaise 19); 29.IX.2011: 1♀ (Malaise 1), 3.XI.2011, 2♀♀ (Malaise 20), leg. Quinto, García and Ramírez.

Notes. Larva described, predatory.

Syrphus vitripennis Meigen, 1822

Examined material. 12.IV.2011: 1♂ (Malaise 19), leg. Quinto, García and Quirce.

Notes. Larva described, predatory.

Volucella elegans Loew, 1862

Examined material. 7.VI.2011: 1♂ (WT 3.1), leg. Quinto, García and Ramírez.

Notes. Larva undescribed.

Volucella inanis (Linneaus, 1758)

Examined material. 27/28.IX.2010: 1♀ (Malaise 19), Olmo Hernández.

Notes. Larva described, the 1st and 2nd instars are parasitic in wasps' nests, on larvae of *Vespula germanica* and *V. vulgaris*, while the 3rd instar is more a parasitoid.

Xanthogramma marginale (Loew, 1854)

Examined material. 7.VI.2011: 1♀ (Malaise 19), leg. Quinto, García and Ramírez.

Notes. Larva undescribed, presumably predatory.

Discussion

As a result of the survey carried out in the oak dehesa of Campanarios de Azaba, 41 hoverfly species were collected, including a species new to science, *Eumerus azabense* sp. nov., and a species new to the Iberian Peninsula, *Cheilosia brunnipennis*. In addition, and according to Ramírez-Hernández *et al*. (2015b) and Ricarte and Marcos-García (2017), two species were new to Salamanca province, *Chrysotoxum cisalpinum* and *Didea fasciata*. In total, 56 hoverfly species are recorded at present from the dehesa of Campanarios de Azaba (see Appendix 1). *Paragus* and *Merodon* had the highest number of species amongst the 19 genera recorded, with 7 and 6 species respectively. In fact, *Merodon* is the second Eristalinae genus with more species recorded in Spain and *Paragus* the first Syrphinae genus (Ricarte and Marcos-García 2017). Dehesa is a typical Mediterranean ecosystem in which species of *Paragus* and *Merodon* are abundant because of their mainly Mediterranean distribution. However, *Cheilosia*, which is the richest genus in Spain (Ricarte and Marcos-García 2017), is poorly represented in this oak dehesa due to the fact that it has its highest species diversity further north, in the Cantabrian mountain range and near areas (Marcos-García 1990, Ricarte *et al*. 2014).

The new species, *Eumerus azabense* sp. nov., was found to be morphologically similar to *E. niveitibia*; for example, they shared similar male genitalia (Fig. 6). However, molecular analyses confirmed that *E. azabense* sp. nov. and *E. niveitibia* were clearly separate species (Fig. 10). Thus, the present study is another example of how useful an integrative approach (morphological and molecular data) can be in delimiting species borders. In addition, obtaining the DNA barcode of *E. azabense* sp. nov. might be useful for future studies, when *Eumerus* larvae are encountered in the study area. To build a complete DNA barcode database of hoverflies may help in identification of early stages, when rearing is an impossible or unsuccessful process (Ståhls *et al*. 2009, Andrić *et al*. 2014). This application of DNA barcodes is even more important for genera such as *Eumerus* and *Merodon*, which are especially diverse in taxonomic terms, have poorly known larval biology and include a few species causing damage in commercial plants (Ricarte *et al*. 2008). To enhance the knowledge of early stages is actually one of the main challenges of current syrphidology; for example, the larvae of 20 of the 41 species recorded in Campanarios de Azaba are undescribed.

Most species found during the course of the present study have, or are meant to have, predatory larvae (27 spp.). The presence and abundance of hoverfly species that are natural predators of a wide range of homopterans (pest insects) is greatly important for pest control (Bugg *et al*. 2008). On the one hand, dehesas may play a key role as refuges and reproduction areas of natural enemies that assist in controlling the pests of neighbouring crops. Many predatory species recorded in Campanarios de Azaba are migratory (e.g. *S. scripta*, *E. balteatus*, *E. corollae*) and move easily among different areas (Speight 2015) within the Iberian Peninsula. On the other hand, dehesas may act as prey reservoirs for predatory hoverflies of crops during periods of low infestation (Bortolotto *et al*. 2016).

Only four saproxylic species were found in the present study. However, 18 saproxylic species were collected by Ramírez-Hernández *et al*. (2015b) in this area, with emergence traps and window traps. The underrepresentation of species with saproxylic habits in the present study is due to the sampling technique. In fact, Malaise traps have not proven useful to collect certain hoverfly species in other habitats and regions (e.g. Burgio and Sommaggio 2007, Marcos-García *et al*. 2012). Thus, the combination of different sampling methods is necessary to get a complete inventory of the hoverfly diversity of a Mediterranean habitat (Ricarte and Marcos-García, 2008).

Within the saproxylics, *F. ruficornis* was collected during the course of the present study. This is a species considered to be threatened with extinction in most of its European range (Speight 2015). Prior to this survey, *F. ruficornis* was collected only from a locality in Spain, the Cabañeros National Park, where it was found in *Q. pyrenaica* forests (Ricarte *et al*. 2010). Campanarios is also the habitat of many other saproxylic hoverflies of genera such as *Callicera*, *Mallota*, *Myolepta*, *Sphiximorpha* and *Spilomyia* (see Appendix 1). This saproxylic community of hoverflies is sustained thanks to the presence of suitable microhabitats for their larvae, i.e. rot holes and sap runs in trees (Ramírez-Hernández *et al*. 2015a).

Dehesas are productive systems that require a better use of natural resources and production

optimisation. Hoverflies can be used as management stools with Syrph the Net, the database of European Syrphidae (StN) (Speight *et al*. 2010 in combination with Monteil 2010). The present paper represents an important step towards the consolidation of hoverflies as management tools in this habitat, since provides data on association hoverfly-habitat for 41 species and updates the species list of Salamanca province (152 spp., see Appendix 1). A new habitat category for dehesa will eventually be coded in future versions of StN based on the data provided in the present study, as well as other data from other studies.

Dehesas are 'mosaic landscapes' generated after a long history of human use; grassland, scrubland and woodland components are combined in this landscape (Fig. 1), like in other similar landscapes such as 'raña', in Cabañeros National Park. In these mosaic landscapes, turnover among different components of the landscape (beta diversity) has a high specific weight in the total biodiversity (Ricarte *et al*. 2011). Other studies on the dehesa insects have shown the importance of this landscape as a biodiversity reservoir (e.g. Viejo *et al*. 1989; Ramírez-Hernández *et al*. 2014). Within this habitat biodiversity, there are individual species that can act as flagships for conservation, for example the threatened *F. ruficornis*, or the new *E. azabense* sp. nov., which might be endemic of this habitat type. In addition, the Vulnerable *M. dusmeti* Andréu, 1926 is also present in Campanarios (Ramírez-Hernández *et al*. 2015b). For these and other reasons stated in this paper, dehesas should be treated as key Mediterranean ecosystems in which biodiversity maintenance and stockbreeding production combine.

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Appendix 1. A checklist of the Syrphidae of Salamanca province, Spain (152 spp.). Species recorded in Campanarios de Azaba (56 spp.) are indicated with 'CA' after the species name. Species written in bold are new to Salamanca. This species list is based on Ramírez-Hernández *et al*. (2015b), Ricarte and Marcos-García (2017) and results of the present study.

Brachypalpus valgus (Panzer, 1798)
Callicera aenea (Fabricius, 1777)
Callicera fagesii Guerin-Meneville, 1844 CA
Callicera macquarti Rondani, 1844 CA
Callicera spinolae Rondani, 1844 CA
Ceriana conopsoides (Linnaeus, 1758)
Ceriana vespiformis (Latreille, 1804) CA
Cheilosia aerea Dufour, 1848
Cheilosia albitarsis (Meigen, 1822)
Cheilosia andalusiaca Torp Pedersen, 1971
Cheilosia brunnipennis Becker, 1894 CA
Cheilosia gigantea (Zetterstedt, 1838)
Cheilosia latifrons (Zetterstedt, 1843)
Cheilosia mutabilis (Fallén, 1817)
Cheilosia paralobi Malski, 1962
Cheilosia scutellata (Fallén, 1817)
Cheilosia variabilis (Panzer, 1798)
Cheilosia vernalis (Fallén, 1817)
Chrysogaster basalis Loew, 1857
Chrysogaster solstitialis (Fallén, 1817)
Chrysotoxum bicinctum (Linnaeus, 1758)
Chrysotoxum cautum (Harris, 1776)
Chrysotoxum cisalpinum Rondani, 1845 CA
Chrysotoxum festivum (Linnaeus, 1758)
Chrysotoxum intermedium Meigen, 1822 CA
Chrysotoxum latifasciatum Becker, 1921
Chrysotoxum octomaculatum Curtis, 1837 CA
Chrysotoxum vernale Loew, 1841 CA
Dasysyrphus albostriatus (Fallén, 1817)
Dasysyrphus pinastri (De Geer, 1776)
Didea fasciata Macquart, 1834 CA
Epistrophe eligans (Harris, 1780) CA
Epistrophe flava Doczkal & Schmid, 1994
Epistrophe nitidicollis (Meigen, 1822) CA
Episyrphus balteatus (De Geer, 1776) CA
Eristalinus aeneus (Scopoli, 1763)
Eristalinus megacephalus (Rossi, 1794)
Eristalinus sepulchralis (Linnaeus, 1758)
Eristalinus taeniops (Wiedemann, 1818)
Eristalis arbustorum (Linnaeus, 1758)
Eristalis horticola (De Geer, 1776)
Eristalis pertinax (Scopoli, 1763)
Eristalis similis (Fallén, 1817) CA
Eristalis tenax (Linnaeus, 1758)
Eumerus amoenus Loew, 1848
Eumerus azabense Ricarte & Marcos-García sp. nov. CA
Eumerus barbarus (Coquebert, 1804)
Eumerus funeralis Meigen, 1822
Eumerus pulchellus Loew, 1848 CA
Eumerus pusillus Loew, 1848
Eumerus sabulonum (Fallén, 1817)
Eumerus strigatus (Fallén, 1817)
Eumerus sulcitibius Rondani, 1868
Eupeodes corollae (Fabricius, 1794) CA
Eupeodes flaviceps (Rondani, 1857)
Eupeodes latifasciatus (Macquart, 1829) CA
Eupeodes lucasi (Marcos-García & Láska, 1983) CA
Eupeodes luniger (Meigen, 1822)
Ferdinandea aurea Rondani, 1844 CA
Ferdinandea cuprea (Scopoli, 1763) CA
Ferdinandea fumipennis Kassebeer, 1999 CA
Ferdinandea ruficornis (Fabricius, 1775) CA
Helophilus pendulus (Linnaeus, 1758)
Helophilus trivittatus (Fabricius, 1805)
Heringia heringi (Zetterstedt, 1843)
Lejogaster metallina (Fabricius, 1776)
Mallota cimbiciformis (Fallén, 1817) CA
Mallota dusmeti Andréu, 1926 CA
Mallota fuciformis (Fabricius, 1794) CA
Melanogaster aerosa (Loew, 1843)
Melanogaster hirtella Loew, 1843
Melanostoma mellinum (Linnaeus, 1758) CA
Melanostoma scalare (Fabricius, 1794) CA
Meliscaeva auricollis (Meigen, 1822) CA
Merodon aeneus Megerle in Meigen, 1822
Merodon avidus Meigen, 1822
Merodon chalybeus Wiedemann in Meigen, 1822 CA
Merodon clavipes (Fabricius, 1781) CA
Merodon elegans Hurkmans, 1993
Merodon escorialensis Strobl, 1909
Merodon flavus Sack, 1913
Merodon funestus (Fabricius, 1794)
Merodon geniculatus Strobl in Czerny & Strobl, 1909 CA
Merodon ibericus Vujić in Popović *et al*. 2015 CA
Merodon italicus Rondani, 1845 CA
Merodon obscuritarsis Strobl, 1909 CA
Merodon parietum Wiedemann in Meigen, 1822
Merodon quercetorum Marcos-García, Vujić & Mengual, 2007
Merodon teruelensis (Van der Goot, 1966)
Merodon trochantericus Costa, 1884
Merodon unicolor Strobl in Czerny & Strobl, 1909
Microdon devius (Linnaeus, 1761)
Microdon mutabilis (Linnaeus, 1758)
Milesia crabroniformis (Fabricius, 1775)
Milesia semiluctifera (Villers, 1789)
Myathropa florea (Linnaeus, 1758) CA
Myolepta difformis Strobl, 1909 CA
Myolepta dubia (Fabricius, 1805) CA
Myolepta obscura (Becher, 1882) CA
Myolepta vara (Panzer, 1798) CA
Neoascia podagrica (Fabricius, 1775)
Orthonevra frontalis (Loew, 1843)
Orthonevra nobilis (Fallén, 1817)
Paragus albifrons (Fallén, 1817)
Paragus bicolor (Fabricius, 1794) CA
Paragus cinctus Schiner & Egger, 1853
Paragus flammeus Goeldlin, 1971
Paragus haemorrhous Meigen, 1822 CA
Paragus pecchiolii Rondani, 1857 CA
Paragus punctulatus (Zetterstedt, 1838)
Paragus quadrifasciatus Meigen, 1822 CA
Paragus strigatus Meigen, 1822 CA
Paragus tibialis (Fallén, 1817) CA

Appendix 1. Continued.

Paragus vandergooti Marcos-García, 1986 CA
Parhelophilus versicolor (Fabricius, 1794)
Pelecocera lusitanica (Mik, 1898) CA
Pelecocera tricincta Meigen, 1822
Pipiza festiva Meigen, 1822
Pipizella annulata (Macquart, 1829)
Pipizella viduata (Linnaeus, 1758)
Pipizella virens (Fabricius, 1805)
Platycheirus albimanus (Fabricius, 1781)
Platycheirus angustatus (Zetterstedt, 1843)
Platycheirus fulviventris (Macquart, 1829)
Platycheirus rosarum (Fabricius, 1787)
Platycheirus scutatus (Meigen, 1822)
Platynochaetus setosus (Fabricius, 1794)
Riponnensia splendens (Meigen, 1822)
Scaeva albomaculata (Macquart, 1842)
Scaeva mecogramma (Bigot, 1860)
Scaeva pyrastri (Linnaeus, 1758) CA
Scaeva selenitica (Meigen, 1822)
Sericomyia hispanica Peris, 1962
Sphaerophoria rueppellii Wiedemann, 1830
Sphaerophoria scripta (Linnaeus, 1758) CA
Sphegina limbipennis Strobl, 1909
Sphiximorpha subsessilis (Illiger in Rossi, 1807) CA
Spilomyia digitata (Rondani, 1865) CA
Syritta flaviventris Macquart, 1842
Syritta pipiens (Linnaeus, 1758)
Syrphus ribesii (Linnaeus, 1758)
Syrphus vitripennis Meigen, 1822 CA
Volucella bombylans (Linnaeus, 1758)
Volucella elegans Loew, 1862 CA
Volucella inanis (Linnaeus, 1758) CA
Volucella pellucens (Linnaeus, 1758)
Volucella zonaria (Poda, 1761)
Xanthandrus comtus (Harris, 1776)
Xanthogramma marginale (Loew, 1854) CA
Xanthogramma pedissequum (Harris, 1780)
Xylota segnis (Linnaeus, 1758)
Xylota sylvarum (Linnaeus, 1758)

Appendix 2. *Eumerus* specimens of the *E. tricolor* and other species groups molecularly analysed in the present study. The GenBank accession number (5' fragment of COI) is provided for each specimen (in bold, numbers of sequences newly-generated in this study; in normal, previously-generated sequences).

Specimen ID	Specimen vaucher	Species	Species group	Sex	Collecting locality	GenBank accession number
EU5	FSUNS: G0293	*Eumerus grandis* Meigen, 1822	*tricolor*	male	Serbia, Đerdap	**MG604930**
EU6	FSUNS: G0955	*Eumerus niveitibia* Becker, 1921	*tricolor*	male	Bulgaria, Nessebar	**MG604931**
EU7	FSUNS: G1014	*Eumerus armatus* Ricarte & Rotheray, 2012	*tricolor*	male	Greece, Samos	MG559898
EU10	FSUNS: G1147	*Eumerus alpinus* Rondani, 1857	*alpinus*	female	Italy, Toscana	KX083349
EU11	FSUNS: G3002	*Eumerus sulcitibius* Rondani, 1868	*sulcitibius*	male	Greece, Andros	MG560025
EU63	FSUNS: 0863	*Eumerus pusillus* Loew, 1848	*basalis*	male	Greece, Chios	MG559994
EU82	FSUNS: G3005	*Eumerus pulchellus* Loew, 1848	*pulchellus*	male	Greece, Rhodes	MG559958
EU92	FSUNS: G3014	*Eumerus clavatus* Becker, 1923	*clavatus*	male	Serbia, Pčinja	KX083350
EU99	FSUNS: G2219	*Eumerus ornatus* Meigen, 1822	*ornatus*	male	Montenegro, Boka Kotorska	KY865449
EU125	M-UAegean: G2735	*Eumerus sinuatus* Loew, 1855	*tricolor*	male	Serbia, Fruška Gora	**MG604932**
EU127	FSUNS: G3015	*Eumerus ovatus* Loew, 1848	*tricolor*	male	Italy, near Cunetone	**MG604933**
EU135	FSUNS: G3018	*Eumerus tricolor* (Fabricius, 1798)	*tricolor*	female	Italy, Baragazza	KY865450
EU213	FSUNS: G1785	*Eumerus aurofinis* Grković, Vujić & Radenković, 2015	*tricolor*	female	Greece, Samos	KT221009
S463	FSUNS: E0613	*Eumerus niveitibia* Becker, 1921	*tricolor*	male	Greece, Lesvos	**MG604934**
TS241	FSUNS: 06724	*Eumerus minotaurus* Claussen & Lucas, 1988	*minotaurus*	female	Greece, Crete	KY865467
TS327	FSUNS: 11593	*Eumerus sogdianus* Stackelberg, 1952	*strigatus*	male	Greece, Peloponnese	**MG604935**
TS353	CEUA00106286	*Eumerus azabense* Ricarte & Marcos-García **sp. nov.**	*tricolor*	male	Spain, Salamanca	**MG604936**
TS354	CEUA00106285	*Eumerus azabense* Ricarte & Marcos-García **sp. nov.**	*tricolor*	female	Spain, Salamanca	**MG604937**