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Diversity of the genus *Eumerus* Meigen (Diptera, Syrphidae) on the eastern Mediterranean islands with description of three new species

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Summary. A list of 25 species of the genus *Eumerus* Meigen (Diptera: Syrphidae) from the eastern Mediterranean islands is presented. Descriptions are given for three new species: *Eumerus aurofinis* Grković, Vujić & Radenković **n. sp**. from Lesvos, Samos, Rhodes islands (Greece) and Bozdağ mountain (Turkey), *E. torsicus* Grković & Vujić **n. sp**. from Chios Island (Greece) and Cyprus; *E. crassus* Grković, Vujić & Radenković **n. sp**. from Lesvos Island (Greece). In addition to classical morphological characters, mitochondrial COI barcode sequences were generated for several specimens of two available taxa. The status of *Eumerus alpinus* Rondani, 1857 is revised, and the taxon is resurrected from synonymy of *E. olivaceus* Loew, 1848. The zoogeographical significance of the described endemic taxa to the biodiversity of the Aegean islands is discussed.

Résumé. Une liste de 25 espèces du genre *Eumerus* Meigen (Diptera: Syrphidae) de l'est des îles de la Méditerranée est présentée et trois nouvelles espèces sont décrites : *Eumerus aurofinis* Grković, Vujić & Radenković **n. sp**. des îles de Lesvos, Samos et Rhodes (Grèce) et des montagnes Bozdağ (Turquie), *E. torsicus* Grković & Vujić **n. sp**. d'île de Chios (Grèce) et de Chypre; *E. crassus* Grković, Vujić & Radenković **n. sp**. de l'île de Lesvos Island (Grèce). En plus des caractères de la morphologie classique, des séquences COI de barcoding ont été générées pour plusieurs spécimens disponibles de deux taxa. Le statut de *Eumerus alpinus* Rondani, 1857 a été révisé. La signification zoo-géographique des taxa endémiques décrits ont été discuté dans le contexte de la biodiversité des îles Egée.

http://zoobank.org/urn:lsid:zoobank.org:pub:AFB5F064-65A1-4ED2-A292-B9FE484EA0BB

Keywords: hoverflies; *Eumerus aurofinis*; *Eumerus torsicus*; *Eumerus crassus*; DNA barcoding; COI

Genus *Eumerus* is one of the most species-rich hoverfly genera, originating from the Old World with 256 registered species worldwide (Pape & Thompson 2015). It is widely distributed in Palaearctic, Afrotropical, Oriental and Australian regions (Stackelberg 1961). Recently, it has been introduced into the Nearctic and Neotropical regions due to commercialized import of plant bulbs (Marinoni & Morales 2007).

This is one of the largest hoverfly genera in the Palaearctic region, with 140 species listed by Peck (1988). In Europe, there are more than 50 species recorded (Speight 2014), with the highest species richness in the Mediterranean region (Ricarte et al. 2008). Species diagnosis and identification within *Eumerus* is not always feasible and face impediments such as (a) the existing key is not sufficient (Stackelberg 1961); (b) a large number of species are of obscure taxonomic status; and (c) the nomenclature of others is blurred (Peck 1988; Speight 2014). During recent decades, to overcome these shortcomings the traditional morphology-based taxonomy has become more integrative, and includes the use of molecular and biochemical data, morphological features (including morphometric data), ecological indices and biogeographical parameters (Dayrat 2005). One very popular tool in species identification and diagnosis is the generation of DNA barcodes of the mitochondrial gene cytochrome c oxidase I (COI); therefore it was implemented here.

Despite its wide geographical distribution and rich biodiversity, the genus lacks recent and comprehensive studies in systematics, biodiversity, ecology and biogeography. This is not the case for the related genus *Merodon* in the eastern Mediterranean region, for which many studies have been carried out during the last decade revealing its importance in e.g. pollination services, or resulting in descriptions of multiple new taxa (Vujić et al. 2007, 2011, 2013; Popov 2010; Radenković et al. 2011).

Eumerus are either blackish or reddish small to medium-sized hoverflies, usually with white or black markings on tergites. They have a flattened face without prominence. The femur is swollen and simple, without projections. The apical part of the ventral surface of the hind femur has two rows of stout spines, usually one row

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anterolateral, the other row posterolateral. The M1 wing vein is recurved.

Early stages of *Eumerus* can be found in underground storage organs of plants, as is also the case in the genus *Merodon* (Ricarte et al. 2008). Based on the morphological characters established for the mouthparts of the larval stages, Rotheray (1993) indicated that *Eumerus* larvae are fed on semi-liquid food and partially decaying plant bulbs and that their survival rate increases when fungal decay is present. Rotheray and Gilbert (1999) inferred the phylogeny of the Palaearctic Syrphidae by applying 187 larval morphological characters and considered that the genus *Eumerus* is the basal hoverfly taxon. There is a lack of more detailed information about the larval stages of the genus *Eumerus*, with only a few descriptions and observations available, primarily regarding economically important species (Pérez-Bañon & Marcos-García 1998).

Eumerus adults usually prefer warm and sunny places for resting, while they visit a range of different flowers, from families Apiaceae, Euphorbiaceae, Asteraceae and Ranunculaceae (Speight 2014). *Eumerus* species are usually fast flying and easily overlooked insects, and can be found near to the ground in association with their preferred flowers. Their ecological role is crucial, e.g. in pollination and nutrient cycles (Rotheray & Gilbert 2011).

In the present study, we aimed to: (a) document the diversity and distribution of *Eumerus* species in the eastern Mediterranean region (i.e. islands and adjacent regions); (b) describe three new species recorded in the eastern Mediterranean islands, both morphologically and genetically by generating DNA barcodes for the available taxa.

Material and methods

The present study is based on examination of newly collected specimens deposited in the collections of the Faculty of Sciences in the Department of Biology and Ecology at the University of Novi Sad (Serbia (FSUNS)) and in the Melissotheque of the Aegean at the University of the Aegean (Mytilene, Greece (MAegean)). The sampling method employed was hand netting pan-trapping, and Malaise trap. Sampling was carried out from spring 2010 to autumn 2014 and covered 28 islands in the eastern Mediterranean (Figure 1) and several sites adjacent to the surveyed islands on the Greek and Anatolian mainland. Islands and mainland localities were sampled for a minimum of three times during *Eumerus* adult flight season and for a minimum of two collecting days per visit. The total number of specimens was 2192.

Additionally, we studied collections deposited in the following European museums: MZUF – Museum of Zoology and Natural History of Firenze (Museo Zoologico "La Specola"), Italy; RMNH – Nationaal Natuurhistorisch Museum, Leiden, the Netherlands; ZHMB – Museum für Naturkunde, Von Humboldt Universität of Berlin, Germany; and ZMUC – Zoological Museum, Copenhagen University, Denmark. All available types of western Palaearctic species were checked and material from the collections of ZMHB and MZUF were considered here (types of *Eumerus alpinus* Rondani 1857 and *E. olivaceus* Loew, 1848). Identity of particular species was confirmed by A. Ricarte, D. Doczkal, and J. Smith as mentioned in Table 1.

The morphological characters used in descriptions and drawings were based on the terminology established by Thompson (1999), and those relating to male genitalia by

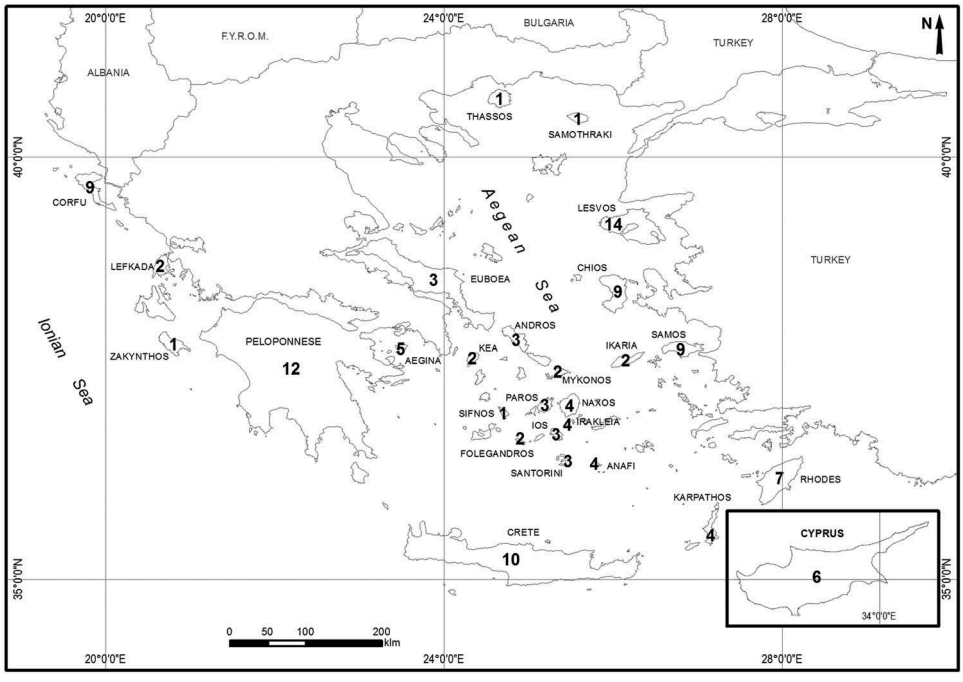

Figure 1. Map of Eastern Mediterranean with investigated islands and number of *Eumerus* species per island.

Table 1. *Eumerus* species on eastern Mediterranean islands (species described here are not included).

	Species	Type(s)	Distribution	Endemics
1	*Eumerus alpinus* Rondani 1857	Studied (MZUF)	Corfu, Lesvos	No
2	*Eumerus amoenus* Loew, 1848	Studied (ZMHB)	Aegina, Anafi, Crete, Chios, Corfu, Euboea, Iraklia, Karpathos, Lesvos, Peloponnese, Rhodes, Samos, Thassos	No
3	*Eumerus argyropus* Loew, 1848	Studied (ZMHB)	Chios, Corfu, Crete, Peloponnese	No
4	*Eumerus armatus* Ricarte et Rotheray, 2012	Not studied, identity confirmed by A. Ricarte	Lesvos, Peloponnese, Rhodes, Samos	Yes (limited to mentioned islands)
5	*Eumerus basalis* Loew, 1848	Studied (ZMHB)	Aegina, Anafi, Chios, Crete, Folegandros, Ikaria, Ios, Iraklia, Karpathos, Lesvos, Naxos, Peloponnese, Rhodes, Samos	No
6	*Eumerus claripennis* Coe, 1957	Not studied, identity confirmed by A. Ricarte	Lesvos	Yes (Balkan endemic)
7	*Eumerus clavatus* Becker, 1921	Studied (ZMHB)	Corfu	No
8	*Eumerus consimilis* Šimić et Vujić, 1996	Studied (FSUNS)	Peloponnese	No
9	*Eumerus emarginatus* Loew, 1848	Not studied, identity confirmed by D. Doczkal	Corfu, Crete, Lesvos, Peloponnese, Rhodes, Samos	No
10	*Eumerus lucidus* Loew, 1848	Studied (ZMHB)	Aegina, Chios, Lesvos	No
11	*Eumerus minotaurus* Claussen et Lucas, 1988	Studied (RMNH)	Corfu, Crete, Peloponnese	Yes (Balkan endemic)
12	*Eumerus niehuisi* Doczkal 1996	Studied (ZMHB)	Chios, Lesvos, Samos	No
13	*Eumerus niveitibia* Becker, 1921	Studied (ZMHB)	Crete, Lesvos, Peloponnese, Zakynthos	Yes (limited to mentioned islands)
14	*Eumerus obliquus* (Fabricius, 1805)	Studied (ZMUC)	Corfu	No
15	*Eumerus pulchellus* Loew, 1848	Studied (ZMHB)	Aegina, Anafi, Andros, Chios, Corfu, Crete, Folegandros, Ios, Iraklia, Karpathos, Kea, Lesvos, Mykonos, Naxos, Paros, Rhodes, Samos, Samothraki, Santorini	No
16	*Eumerus pusillus* Loew, 1848	Studied (ZMHB)	Aegina, Anafi, Andros, Chios, Crete, Euboea, Ios, Iraklia, Karpathos, Kea, Lesvos, Mykonos, Naxos, Paros, Rhodes, Samos, Santorini, Sifnos	No
17	*Eumerus sogdianus* Stackelberg, 1952	Not studied, identity confirmed by D. Doczkal	Peloponnese	No
18	*Eumerus strigatus* (Fallen, 1817)	Not studied, identity confirmed by D. Doczkal	Peloponnese	No
19	*Eumerus sulcitibius* Rondani, 1868	Studied (MZUF)	Andros, Chios, Crete, Ikaria, Lesvos, Paros, Peloponnese, Samos	No
20	*Eumerus tricolor* (Fabricius, 1798)	Types destroyed (ZMUC), identity confirmed by D. Doczkal	Corfu, Euboea, Lefkada, Peloponnese	No
21	*Eumerus truncatus* Rondani 1868	Studied (MZUF)	Crete, Lesvos, Naxos	No
22	*Eumerus vestitus* Bezzi, 1912	Not studied, identity confirmed by J. Smith	Santorini	No

Hurkmans (1993) and Doczkal (1996). Colour characters are described from dry mounted specimens. To study male genitalia, specimens were relaxed in a closed pot with a high level of humidity and the genitalia were extracted using an entomological pin with a hooked tip. Genitalia were stored in microvials containing glycerol after clearing in warm 10% potassium hydroxide (KOH) for a few minutes and washing in distilled water. Drawings were created by using photographs of characters taken with a Leica DFC 320 (Wetzlar, Germany) camera attached to a Leica MZ16 binocular stereomicroscope and then processed in Adobe Photoshop CS3 V 10.0 software (Adobe Systems, San Jose, CA, USA), using drawing tablet EasyPen i405 (Genius, KYE Systems America Corporation, Miami, FL, USA).

Each specimen subjected to molecular analysis was labelled as a DNA voucher specimen and deposited in the insect collections of the FSUNS, the MZH (Insect collection of the Zoology unit, Finnish Museum of Natural History, Helsinki, Finland) or

the MAegean. Table S1 (online supplementary information) provides the list of the specimens used for the species description, their collection data and the GenBank accession numbers of the generated DNA barcodes for *E. aurofinis* **n. sp**. and *E. torsicus* **n. sp**.

DNA analyses

Total genomic DNA was extracted using two or three legs from each specimen, performing the Chen et al. (2010) protocol for SDS extraction, slightly modified: (a) RNase A solution not added; (b) 40 mg ml^{-1} concentration of proteinase K solution; and (c) two additional steps of chloroform/isoamyl alcohol (24:1). DNA samples were re-suspended in 30 µl of TAE buffer.

A standard primer pair was used to amplify the DNA barcodes of the mitochondrial cytochrome c oxidase subunit I gene fragment (COI, cox1); LCO-1490 (5′-GGTCAACAAATCATAAAGATATTGG-3′) and HCO-2198 (5′-TAAACTTCAGGGTGACCAAAAAATCA-3′) (Folmer et al. 1994). PCR amplifications were performed in a total volume of 25 µl, containing 25 ng μl^{-1} template of DNA, 5 pmol μl^{-1} of each primer, 0.08 mM of dNTPs, 1× reaction buffer (Fermentas, Thermo Fisher Scientific, Kent, UK) and 1.25 units of Polymerase (Dream Taq poly, Fermentas). We performed touchdown PCRs in an authorized PCR thermal cycler (Mastercycler® personal, Eppendorf, Hamburg, Germany), comprised of four steps: (a) initial denaturation at 94°C for 5 min; (b) denaturation at 94°C for 30 s, annealing at 60°C for 30 s with 0.5°C decrease per cycle and extension at 72°C for 1 min (total repetition of 18 cycles); (c) denaturation at 94°C for 30 s, annealing at 51°C for 30 s, extension at 72°C for 1 min (total repetition of 14 cycles); and (d) a final extension at 72°C for 10 min. Amplified products were visually inspected on 1.5% agarose gels. The ExoSap-IT kit (USB, Cleveland, OH, USA) was used for the PCR products purification and clean products were thereafter Sanger sequenced in both directions on an ABI 3730 DNA analyser (Applied Biosystems™, Thermo Fisher Scientific, Waltham, MA, USA) at the Sequencing Service laboratory of the Finnish Institute for Molecular Medicine (http://www.fimm.fi).

The obtained sequences were edited by eye, where required, using BioEdit 7.2.5 software (Hall 1999). The dataset included 12 DNA barcode sequences (eight sequences of *E. aurofinis* n. sp. and four sequences of *E. torsicus* n. sp.) with final length 601 nt. Pairwise distances between the species *E. aurofinis* **n. sp**. and *E. torsicus* **n. sp**. were conducted in MEGA version 6 (Tamura et al. 2013) and the computations were run by default using the p-distances model with 1000 bootstrap replicates. Basic parameters of intra and interspecific genetic diversity were calculated in DNASP v5 (Librado and Rosas, 2009).

Results

Diversity of the genus Eumerus *on the eastern Mediterranean islands*

We recorded 25 species in the 28 islands of the eastern Mediterranean. Of these, 22 species are previously known taxa (Table 1), whereas the three additional species are new and are described here. Moreover, regarding the two new species *E. aurofinis* **n. sp**. and *E. torsicus* **n. sp**., the pairwise distance computations showed a clear differentiation between them (0.115). Seven species are recorded for the first time for Greece: *Eumerus alpinus* Rondani, 1857, *Eumerus clavatus* Becker, 1921, *Eumerus consimilis* Šimić et Vujić, 1996, *Eumerus obliquus* (Fabricius, 1805), *Eumerus sogdianus* Stackelberg, 1952, *Eumerus truncatus* Rondani, 1868 and *Eumerus vestitus* Bezzi, 1912.

Islands with the highest diversity of *Eumerus* species are (Table 1): Lesvos (14 species), Peloponnese (12), Crete (10), Chios, Corfu, Samos (all with nine), Rhodes (seven) and Cyprus (six). Endemics are recorded on nine islands: Lesvos (four), Peloponnese (three), Crete, Rhodes and Samos (all with two) and Cyprus, Chios, Corfu, and Zakynthos (all with one endemic taxon).

Taxonomy

Eumerus alpinus Rondani, 1857 n. stat.

Based on our study of type specimens of West Palaearctic species of the genus *Eumerus* a new valid species is proposed from the list of synonyms of *Eumerus olivaceus* Loew, 1848.

Peck (1988) has cited *E. alpinus* Rondani, 1857 as a synonym of *E. olivaceus*. It was described from Piedmont in Italy as *E. alpinus* Bellardi (in litt.) in the paper of Rondani (1857). In the Rondani collection (MZUF) there is one male specimen with the original name label and corresponding data (as mentioned in the original description, this specimen was received from Professor Bellardi). We accept this specimen as the holotype. We also studied types of *E. olivaceus* in the Loew collection from ZMHB described from an unspecified number of males and female from Sicily in Italy. The morphological characters of examined types of these two taxa are clearly different, and we accepted *E. alpinus* as a name for populations on other parts of Apennine and Balkan peninsulas (*E. olivaceus* of authors). *E. olivaceus* remains as the name of the endemic species of Sicily.

Description of new species

Eumerus aurofinis* Grković, Vujić et Radenković n. sp.** ***Material examined. **Holotype. Greece** (Samos Island): 1 male, Koumaradhei, coll. 06.VI.2012, Vujić & Likov. Holotype is deposited in University of Novi Sad (FSUNS). **Paratypes. Greece**: Samos, Kosmadei, 1 male, 1 female, coll. 10.VI.2010, Rojo, Vujić & Ståhls; 1 male, coll. 12.VI.2010, Rojo, Vujić & Ståhls, 1 male, 1 female, coll. 07.VI.2012, Vujić; Koumaradhei, 1 male, 3 females, coll. 06.VI.2012, Vujić & Likov; Chora, 1 female, coll. 06.VI.2012, Vujić; Manolates, 1 female, coll. 15.V.2010, Ståhls; near Manolates, 1 male, coll. 08. VI.2010, Rojo, Vujić & Ståhls; Marathokambos, 1 female, coll. 06.VI.2012, Vujić & Likov; near Kastanea, 1 male, 1 female, coll. 12.VI.2010, Rojo, Vujić & Ståhls; near Kondeika, 2 males, coll. 09.VI.2010, Rojo, Vujić & Ståhls; near Leka, 1 male, 2 females, coll. 10.VI.2010, Rojo, Vujić & Ståhls; near Neochori, 2 males, coll. 17.

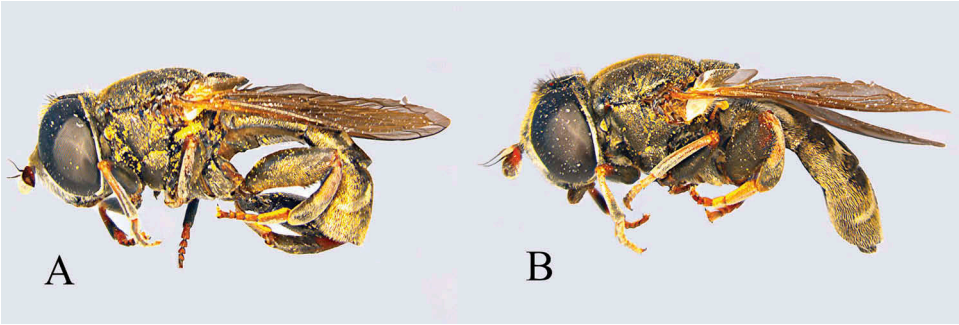

Figure 2. *Eumerus aurofinis* **n. sp**. (A) male; (B) female.

V.2010, Ståhls & Rättel; 1 male, 1 female, coll. 07. VI.2012, Ståhls & Rättel; near Platanos, 3 males, 1 female, coll. 09.VI.2010, Rojo, Vujić & Ståhls; near Stavrinides, 2 males, 3 females, coll. 08.VI.2010, Rojo, Vujić & Ståhls; Pyrgos, 1 male, 1 female, coll. 06. VI.2012, Vujić; 3 males, 2 females, coll. 08.VI.2012, Vujić & Likov; Rhodos, Kalathos, 1 male, 1 female, coll. 29.V.2014, Vujić; Lesvos, Skala Kallonis, 1 female, coll. 10.V.2006, Hull; **Turkey**: Mountain Bozdağ, near Çamurhamamı Köyü, 6 females, coll. 07.VI.2014, Vujić & Ačanski; Muğla, 1 male, 1 female, coll. 06.III.2014, Vujić & Ačanski (FSUNS).

General description. Robust species (9–11 mm), with very short body hairs, dark appearance, and golden reflection on top of abdomen (Figure 2A, B).

Male. *Head*: Eyes (Figure 3A) dichoptic, three ommatidia spaced, eye contiguity bare, black colour. Eye with sparse hairs of medium length. Eye margin slightly broadening ventrally. Lower facial margin anteromedially not protruding in lateral view (Figure 3C). Anterior ocellus more distant from posterior ocelli than the later are from each other (Figure 3E). Distance from posterior ocellus to the upper eye corner is slightly longer than to anterior ocellus. Face and frons black with whitish and gold pollinosity, especially along the posterior eye margin. Posterolateral eye margin with white pollinosity. Vertex and postocular orbit black with gold socket at the hair bases. Dense white hairs on face and more yellow on the frons. Ommatidia closed to the eye contiguity enlarged. Hairs on vertex yellow except on ocellar triangle, where they are black. Hairs denser and shorter anterior of anterior ocellus. Posterior of anterior ocellus obscure groove which extends behind posterior ocelli. Antenna rounded, brown to reddish. Sensory pit rounded, located in the centre of outer side of distal part of antennal third segment. Long ventral hairs of pedicel length about half depth of pedicel, inner side with short pale hairs. First flagellomere little deeper than pedicel. Arista dark brown.

Thorax. Scutum and scutellum black with blue metallic lustre and dense punctuation, short pale hairs, little longer on anterior margin of presutural area. Prescutum with bronze pruinosity. Anterior part of presutural area with two white triangles of pruinescence and short white line in the middle, shorter than the length of triangle. Triangles sometimes extend behind the transverse suture. Posterior margin of scutellum broad with serration. Subscutellum small. In the middle of scutellum small depression. Presence of groove on scutellum parallel with its posterior margin. Pleurae black with gold pruinosity. Anepisternum with yellow hairs, posteriorly with longer yellow bristles directed backwards. Presutural cali with few yellow bristles. Katepisternum with pale hairs, slightly longer in posterior part. Halter yellow. Wing with brownish tinge with gradual shadows in the area posterior of intersection of Rs1 + 2 and Rs3 + 4. Wing entirely microtrichose. Calypter white in contrast to the dark appearance of the body. Legs dark, basal half and apical part of tibia, ventral side of tarsus red. Two rows of black spines on ventral preapical part of femora. Hind trochanter simple, hind femora thick (Figure 4E).

Abdomen. Twice as long as wide. Tergites black with metallic blue reflection medially and metallic green laterally. Punctuated, interspaces bigger than the puncture diameters, on tergite 3–4 denser punctuation. Tergites 2–4 with pairs of white pruinose lunules, separated in the middle. Abdomen pale haired, laterally with longer erect hairs. Sternites 2 and 3 with white hairs. Abdomen with gold pollinosity laterally. Tergite 4 with gold hairs laterally and on posterior part.

Male genitalia. (Figure 4A–D). Cercus small, rounded, recurved (Figure 4A). Interior accessory lobe of posterior surstyle lobe covered with dense microtrichia. Posterior surstyle lobe elongated, simple, on ventral apical ridge with short bristles, on dorsal side with longer sparse microtrichia. Hypandrium broad, curved, on dorsal side with sparse microtrichia (Figure 4B). Ctenidion situated apically. Aedeagus (Figure 4C, D: ae) and associated structures shown in Figure 4C, D: lateral sclerite of

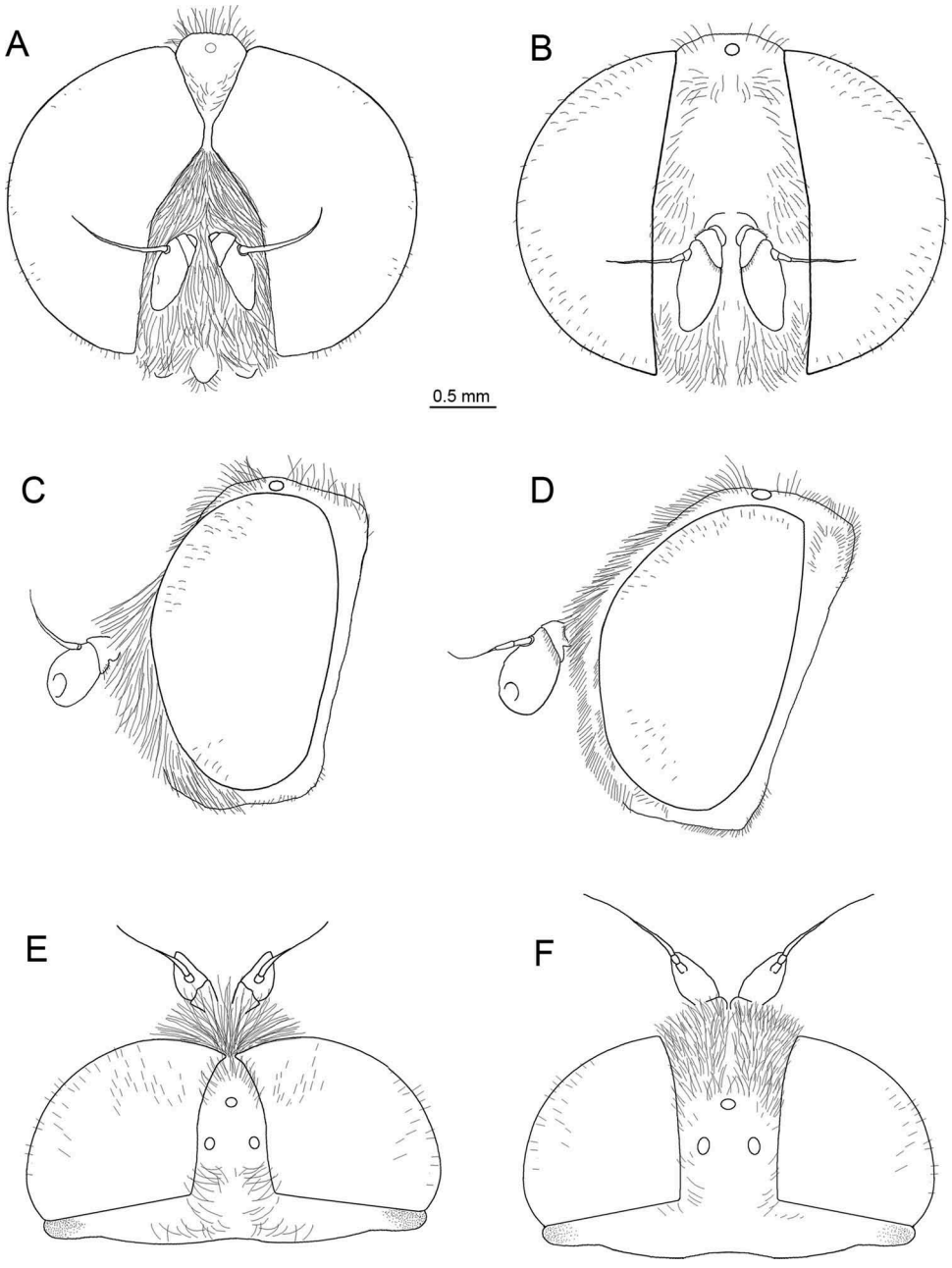

Figure 3. *Eumerus aurofinis* **n. sp**., head. Frontal view: (A) male; (B) female. Lateral view: (C) male, (D) female. Dorsal view: (E) male, (F) female.

aedeagus (Figure 4C, D: ls); ejaculator apodeme (Figure 4C, D: ea) narrow and elongated; aedeagal apodeme very expanded, kite shaped in ventral view (Figure 4C, D: ap).

Female. Similar to the male except normal sexual dimorphism and for the following characteristics: *Head*. Face and frons (Figure 3B) black, covered with white and gold pollinosity. Short yellow hairs from anterior ocellus to antennal socket and brighter hairs from antennae to mouth edge. From anterior ocellus obscure groove which extends to antennal socket. Ocelli in equilateral triangle (Figure 3F). Antenna oval, red (Figure 3D). Eye sparse haired. *Abdomen*. Wide as thorax. Tergites black, tergites 2–4 with a pair of grey pollinose lunules, tergite 4 entirely covered with short yellow hairs.

Diagnosis. It differs from the all the other species of the genus in having very short body hairs, golden reflections and short golden hairs on the top of the abdomen. Male genitalia with specific shape of surstyle lobe (Figure 4A) and aedeagal apodeme (Figure 4C, D: ap); sternum 4 in male simple without any additional structure.

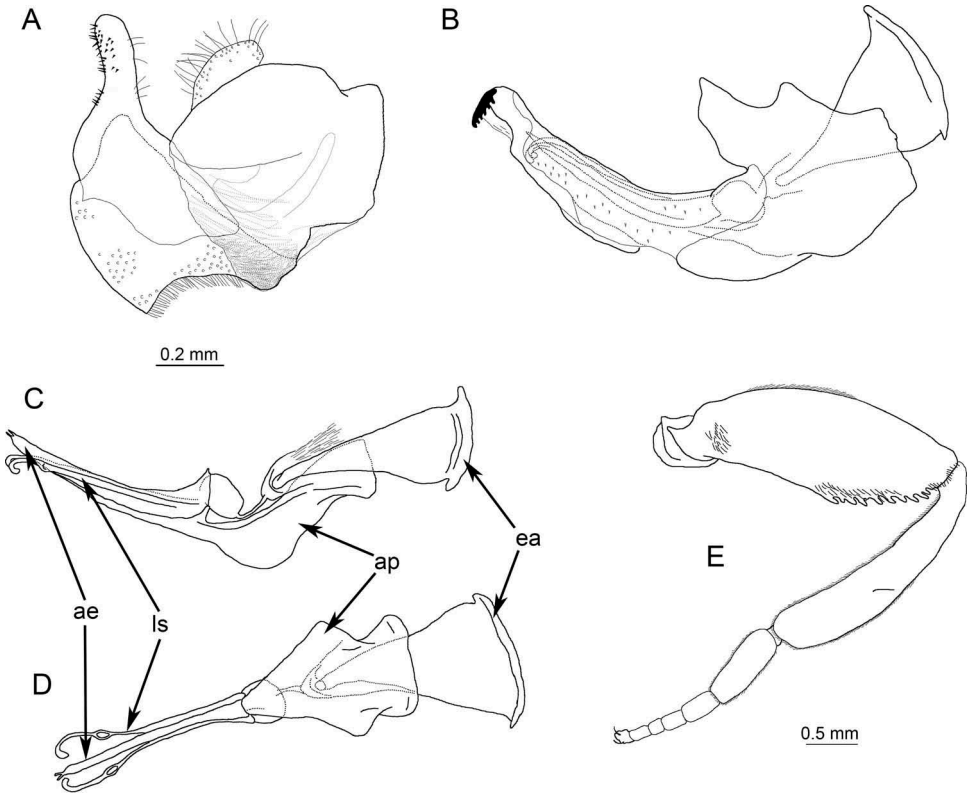

Figure 4. *Eumerus aurofinis* **n. sp**., (A–D) male genitalia: (A) epandrium, lateral view; (B) hypandrium, lateral view; (C) aedeagus and accessory structures, lateral view; (D) aedeagus and accessory structures, ventral view (ae – aedeagus, ls – lateral sclerite of aedeagus, ap – aedeagal apodeme, ea – ejaculator apodeme). (E) Hind leg, male.

Etymology. The epithet is derived from the Latin words *aurum* (gold) and *finis* (end) and refers to the golden reflection of the tip of abdomen.

DNA voucher specimen. All DNA voucher specimens are deposited in the DNA voucher specimen collection of FSUNS, and specimens voucher, GenBank accession numbers as well as locality information can be found in Table S1 (online supporting information).

In total three different haplotypes were recorded for *E. aurofinis* (Table 2). Basic indices of genetic diversity are given in Table 2. The most frequent haplotype was found in four specimens from Samos Island and one from Turkey (Mt Bozdag). One haplotype was also detected in Samos Island (1 specimen), while the third occurred exclusively on Rhodes Island.

Table 2. Basic genetic diversity indices for *Eumerus aurofinis* **n. sp**. and *E. torsicus* **n. sp**. based on DNA barcode sequences.

Parameter	*E. aurofinis*	*E. torsicus*	Total
N	8	4	12
h	3	2	5
Hd	0.607	0.667	0.803
π	0.0039	0.0022	0.059
k	2.036	1.333	35.227

N – number of specimens; h – number of haplotypes; Hd – haplotype diversity; π – nucleotide diversity; k – average number of nucleotide differences

Eumerus torsicus Grković & Vujić n. sp.

Material examined. **Holotype. Greece** (Chios Island): 1 male, Elinta, coll. 9–11.XI.2012, Nakas. Holotype is deposited in University of Novi Sad (FSUNS). **Paratypes. Greece**: Chios, Elinta, 2 males, coll. 9–11. XI.2012, Nakas. **Cyprus**: Troodos Mountains, Almirolivado, 4 females, coll. 18.IX.2011, Hionistra, Xióni, 6 males, 12 females, coll. 18.IX.2011, Kakopetria, 1 male, 17.IX.2011; Makria Kondarka, 1 male, 3 females, 18.IX.2011.

General description. Large species (9–11 mm), with long and narrow abdomen (Figure 5A, B).

Male. *Head*. Eyes bare, holoptic, 10–11 ommatidia long contiguity. Eye margin almost parallel. Lower facial margin flattened. Vertex and postocullar orbit black with white pollinosity anterior of anterior ocellus and posterior of posterior ocelli, to upper eye margin (Figure 6A). Ocelli

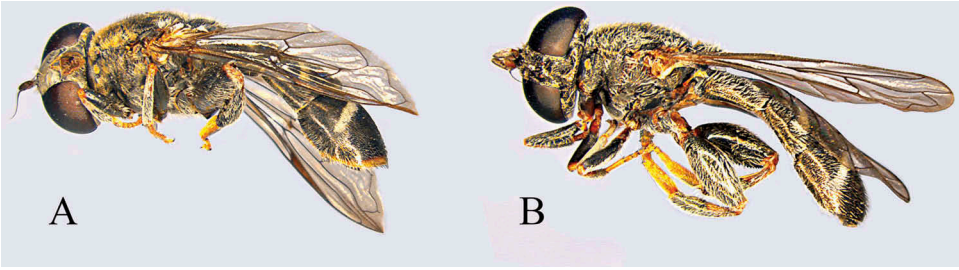

Figure 5. *Eumerus torsicus* **n. sp**. (A) male; (B) female.

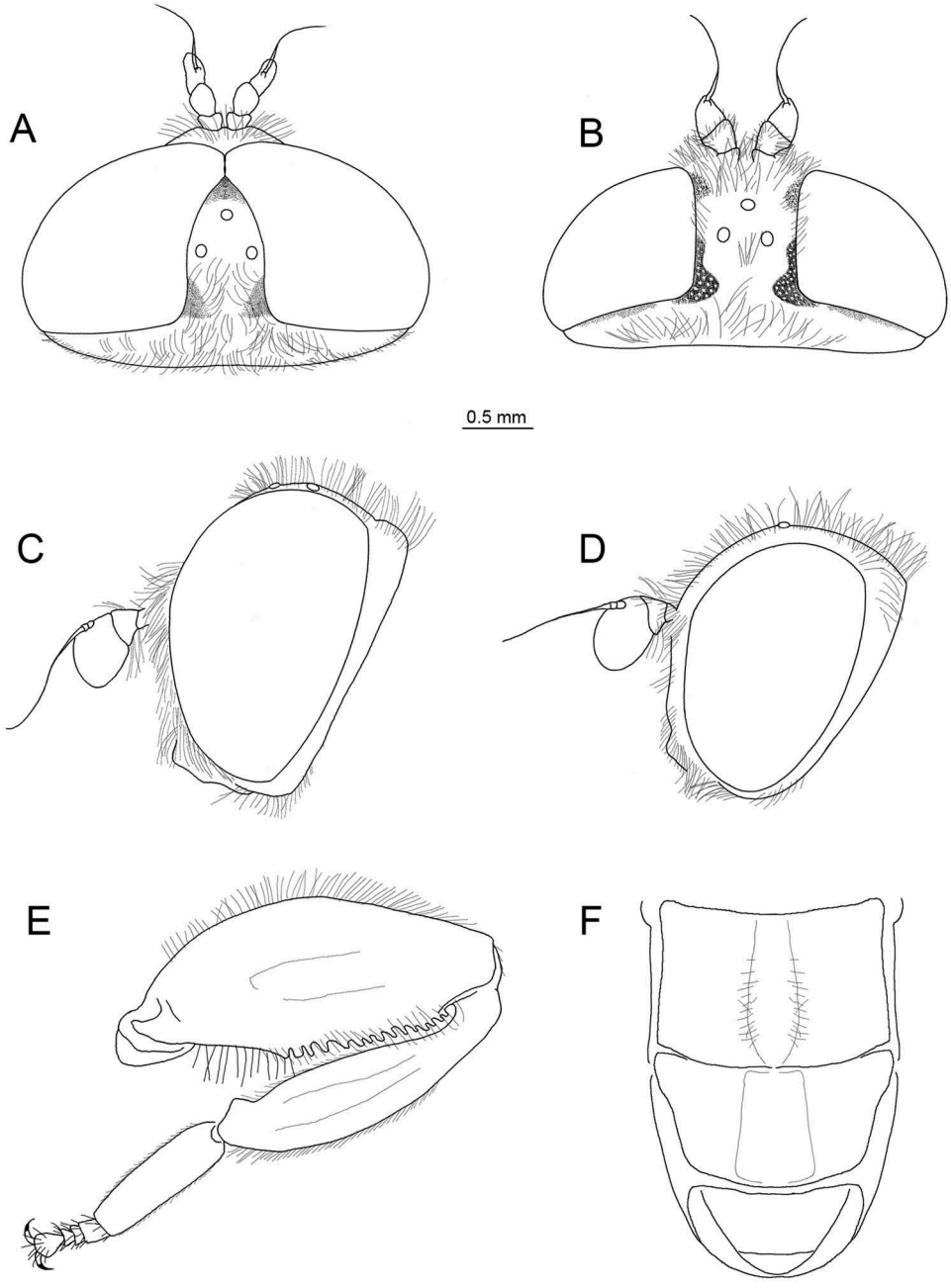

Figure 6. *Eumerus torsicus* **n. sp**., head, dorsal view: (A) male; (B) female. Head, lateral view: (C) male; (D) female. (E) Hind leg, male. (F) Sternites 2–4, female.

form an equilateral triangle. Anterior ocellus smaller than the posterior two. Vertex and postocullar orbit with long white hair, except on ocellar triangle, which are black. White pollinosity behind upper eyes margins. Face black with white pollinosity and long white hairs. Antenna fan-shaped, slightly elongated on ventral corner, reddish-brown (Figure 6C). Scape and pedicel dark, except distal margin of pedicel which is reddish. Sensory pit on brighter area, at the ventral base of third antennal segment. Long white ventral hairs of pedicel are longer than depth of pedicel, dorsal hairs black and white, as long as depth of pedicel. Arista dark brown.

Thorax. Scutum and scutellum black with gold-green lustre, with dense punctuation and short pale hairs which are a little longer on the scutellum. Scutum with two pairs of white stripes, the pair in the middle spreading toward the full-length of the scutum, the lateral pair of shorter stripes extending from the transverse suture to the posterior margin of the scutum. Posterior margin of scutellum with narrow edge. Pleurae black with gold pollinosity and long yellow pilose. Halter pale yellow. Wing entirely transparent; vena spuria well expressed, ending at rm crossvein. Legs dark, yellow haired. Ventral side of hind tarsus yellow-gold, apical part of femora and basal part of tibia reddish. Fore and middle tarsi entirely gold. Hind trochanter slightly tapered ventrally, femora thick. Hind tibia twisted in apical fifth (Figure 6E). Hind basitarsus long, as long as half of hind tibia; tarsal segments 2–5 extremely short (Figure 6E).

Abdomen. Three times as long as wide, with dense punctuation, white haired. Tergite 1 with white pollinosity laterally. Tergites 2–4 with pairs of white pruinose lunules separated in the middle. Posterior margin of tergite 4 colourless. Sternite 2–3 with pale hairs in the middle. Sternite 4 in specific form (Figure 7E).

Male genitalia. (Figure 7A–D). Cercus small, rounded. Interior accessory lobe of posterior surstyle lobe covered with dense microtrichia. Posterior surstyle lobe very elongated, narrowing toward the top, slightly recurved with short bristles laterally and few long bristles dorsally (Figure 7A). Hypandrium narrow, simple, ctenidion situated apically (Figure 7B). Aedeagus (Figure 7C, D: ae) and associated structures shown in Figure 7C, D: lateral sclerite of aedeagus (Figure 7C, D: ls), aedeagal apodeme three-pointed on the top, keel-shaped ventrally (Figures 7C, D: ap); ejaculator apodeme broad, with narrow edge (Figures 7C, D: ea).

Female. Similar to the male except normal sexual dimorphism and for the following characteristics: *Head*. Face and frons black with white pollinosity toward eye margin and behind posterior ocelli, except in the area of vertex (Figure 6B). Gold pollinosity from vertex to antennal socket. Face from antennae to mouth densely covered

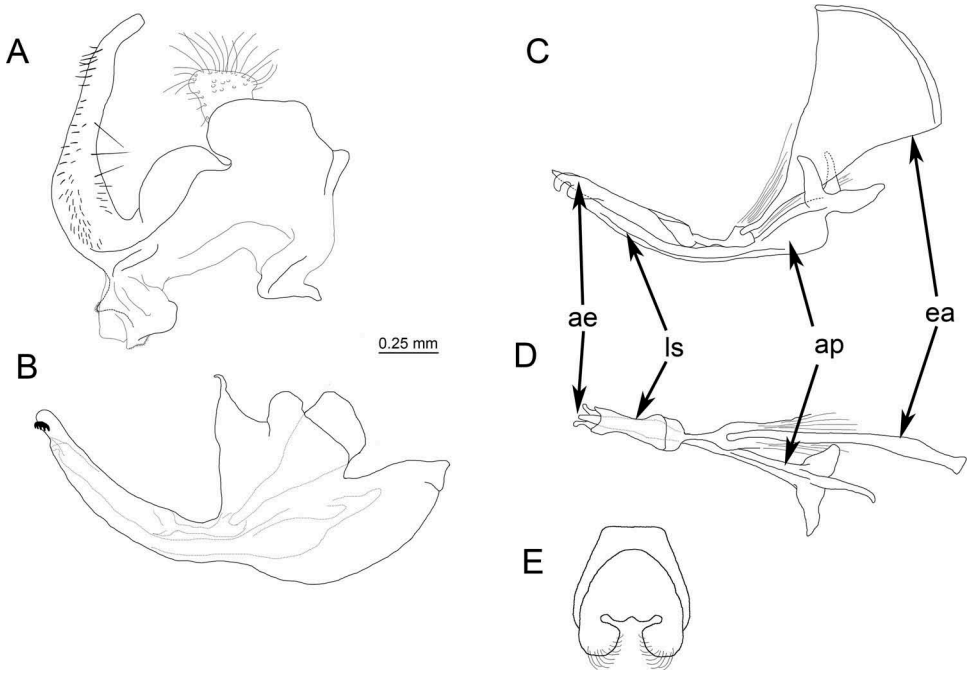

Figure 7. *Eumerus torsicus* **n. sp.**, (A–D) male genitalia: (A) epandrium, lateral view; (B) hypandrium, lateral view; (C) aedeagus and accessory structures, lateral view; (D) aedeagus and accessory structures, ventral view (ae – aedeagus, ls – lateral sclerite of aedeagus, ap – aedeagal apodeme, ea – ejaculator apodeme). (E) Male sternite 4.

with white pollinosity and white hairs. Antenna oval, almost round, reddish-brown (Figure 6D). *Abdomen*. Tergites black covered with white hairs and with pairs of white lunules on tergites 2–4.

Diagnosis. The male differs from all the other species of the genus in the twisted apical fifth of the hind tibia and extremely short tarsal segments 2–5 on hind leg (Figure 6E); male genitalia with very long and two times curved posterior surstyle lobe (Figure 7A); sternum 4 with two broad apical prolongations (Figure 7E). In female, pollinose areas on frons with black undusted dots (Figure 6B); sternites 2–3 very narrow, about 5 times longer than broad (Figure 6F).

Etymology. The epithet is derived from the Latin verb *torqueo* and relates to the twisted apical part of hind tibia in male.

DNA voucher specimen. All DNA voucher specimens are deposited in the DNA voucher specimen collection of FSUNS, and specimens voucher, GenBank accession numbers as well as locality information can be found in Table S1 (online supporting information).

Two haplotypes were found for *Eumerus torsicus* (Table 2). Basic indices of genetic diversity are given in Table 2. One haplotype is exclusive for Cyprus (2 specimens), and the other for Chios Island (2 specimens).

Eumerus crassus Grković, Vujić & Radenković n. sp.

Material examined. **Holotype. Greece** (Lesvos Island): Ag. Ermogenis Beach, 1 male, coll. 02.V.2008, Vujić (antennae lacking, only right scape and pedicel present). Holotype is deposited in University of Novi Sad (FSUNS).

General description.

Male. (*Figure 8A) Head*. Eyes holoptic, covered with dense hairs, with 3–4 ommatidia long contiguity. Eye margins almost parallel, slightly broadening ventrally. Face and frons black with sparse gold and white pollinosity except on ocellar triangle. Ocelli in almost equilateral triangle, anterior ocellus only slightly farther from posterior ocelli than the latter are from each other (Figure 9G). Face and frons with dense white hairs. Lower facial margin protruding (Figure 9F). Pedicel elongated, longer than deep. Ventral hairs of pedicel a little longer than dorsal hairs.

Thorax. Scutum and scutellum black with gold lustre, covered with dense pale hairs. Scutum with a pair of white pruinose triangles which are expanding in obscure lines extending almost to the end of scutum. White pinstripe with grey pollinosity in the middle of the scutum. Pleura black with very short yellow dense microtrichia and longer pale hairs on katepisternum, anepisternum and anepimeron. Wing transparent with dense brown to yellow microtrichia. *Leg*. Hind femur black with long yellow hairs and covered with gold pollinosity; hind tibia black and yellow at the base. Tarsus with silver pollinosity.

Abdomen. Abdomen oval, slightly tapering toward the top, wide as the width of the thorax, with white short hairs (Figure 8B). Tergites 2–3 with pairs of white pollinose lunules. Tergite 4 as long as wide, covered with white dense hairs, quite longer than those of the tergites 2 and 3.

Male genitalia. (Figure 9A, C). Most similar to genitalia of *Eumerus sogdianus*, Stackelberg, 1952 (Figure 9B). Cercus rounded, with the notch on posterodorsal margin. Posterior surstyle lobe elongated, with folded dorsal margin covered with hairs. Ventral margin inside with dense long hairs. Interior accessory lobe of posterior surstyle lobe covered with microtrichia. Hypandrium simple (Figure 9C). Aedeagal apodeme ray-shaped in ventral view.

Female. Unknown.

Diagnosis. Morphologically related to "*strigatus*" group of species (*sensu* Speight et al. 2013), differs from all related

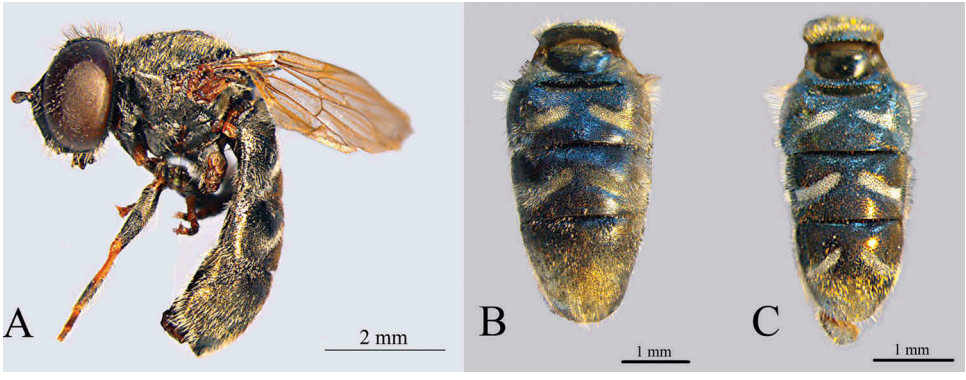

Figure 8. *Eumerus crassus* **n. sp**. (A) male; (B) tergites; (C) *Eumerus sogdianus*, tergites.

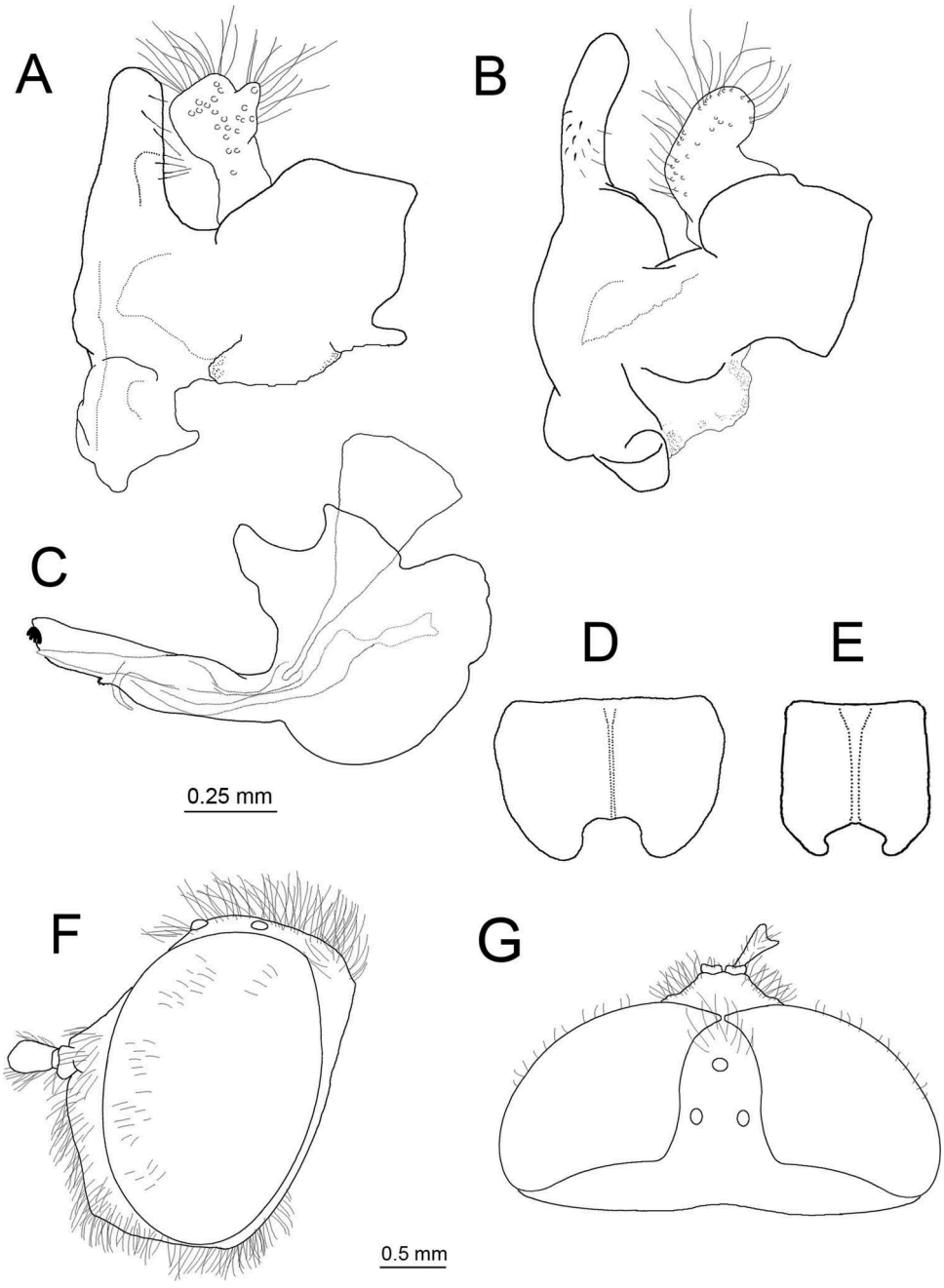

Figure 9. Epandrium: (A) *E. crassus* **n. sp**.; (B) *E. sogdianus*. (C) *E. crassus* **n. sp**. hypandrium. (D, F) Sternite 4: (D) *Eumerus crassus* **n. sp**.; (E) *E. sogdianus*. (F, G) *E. crassus* **n. sp**., head, male: (F) lateral view; (G) dorsal view.

species of the genus in more robust body (Figure 8B, C), clear differences in structure of male genitalia and shape of sternite 4. Male genitalia similar to *Eumerus sogdianus* from which it differs in cerci with the notch on posterodorsal margin, broad posterior surstyle lobe with straight margins, narrower and bent in *E. sogdianus* (Figure 9A, B); and broad sternite 4, with two apical prolongations, narrower in *E. sogdianus* (Figure 9D, E).

Etymology. The epithet is derived from the Latin word *crassus* (solid) demonstrating the body habitus more robust comparing to the related taxon.

Discussion

We present a survey of the diversity and distribution of *Eumerus* species in the eastern Mediterranean region,

where a high number of species, i.e. 25, was recorded (see Table 1). This is almost three quarters (71%) of all *Eumerus* species known for south-eastern Europe accounting for 35 species in total (Vujić et al. 2015). The latter highlights the significance of the eastern Mediterranean region as a hotspot for the genus. Indeed, our findings support the expectation of Petanidou et al. (2013) to encounter a considerable number of species new to science in the Aegean Islands. Among the 25 species in the eastern Mediterranean, seven are endemic as their geographical distribution is limited to the Balkan Peninsula and/or only to the eastern Mediterranean islands. Four species out of the 25 were previously known (*Eumerus armatus* Ricarte and Rotheray, 2012, *E. claripennis* Coe,1957, *E. minotaurus* Claussen & Lucas, 1988, *E. niveitibia* Becker, 1921) and three species are new to science and are described here (*E. aurofinis* **n. sp**., *E. torsicus* **n. sp**. and *E. crassus* **n. sp**.). Islands with the highest number of recorded species belonged to the group of large islands (area >420 km^2, based on Vujić et al. Forthcoming 2016). Islands with the highest diversity of *Eumerus* species usually harbour endemics as well (Crete, Cyprus, Lesvos, Peloponnese, Rhodes and Samos), although two islands with high diversity (Chios and Corfu) lack endemic species. Among the small islands (area <420 km^2), it was only on Zakynthos where we registered one endemic taxon (*E. niveitibia*).

Only three species are restricted to particular island(s) (and thus can be considered as island endemics): *E. niveitibia* (Crete, Lesvos, Peloponnese and Zakynthos), *E. torsicus* **n. sp**. (Chios and Cyprus) and *E. crassus* **n. sp**. (Lesvos). Comparing the percentage of the island endemic species (12%) with recent results for the hoverfly genus *Merodon* (12.3%) in eastern Mediterranean islands (Vujić et al. submitted), the level of endemicity is essentially the same, and twice the percentage of the endemic butterfly fauna reported by Dennis et al. (2000).

Considering the species richness of the genus and its great significance to ecosystems, many studies should have been published, but this is not the case for *Eumerus*; few taxonomical studies exist, and DNA barcodes are deficient or absent; very few *Eumerus* sequences can be found in GenBank. The latter is an issue as the species delimitation within *Eumerus* has proven a challenge, and there is no appropriate key for identification of the European *Eumerus* species, so DNA barcodes would be useful in species identification in addition to diagnostic features and figures of the important morphological characters. This could be even more useful when it comes to newly described species, as in the present study for *E. aurofinis* **n. sp**. and *E. torsicus* **n. sp**.. For these two species an integrative approach, i.e. a blend of morphological characters and DNA sequences, was applied to achieve and confirm species delimitation. The determined pairwise distance (0.115) and average number of nucleotide differences between these two species (70.625) significantly contribute to species delimitation and also reveal slight intraspecific divergence. For an island endemic species *E. torsicus* **n. sp**., recorded haplotypes also showed exclusive occurrence for each island (Chios and Cyprus).

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Supplemental data

Supplemental data for this article can be accessed here.

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