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Research Article

Diversification of *Eumerus* Meigen, 1822 on Islands: Revision of the Most Speciose Syrphidae Genus (Diptera) on the Canaries, Spain

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With 300+ species, *Eumerus* Meigen, 1822, is one of the largest hoverfly genera worldwide. The Canaries are a volcanic archipelago consisting of seven major islands in the Macaronesian region, north-west of Africa. High biodiversity and endemicity levels are reported from these islands, especially for the invertebrates. Regarding the hoverflies, 20 genera are found on the Canaries. Although with the highest alpha diversity amongst hoverfly genera (10 species, of which seven are endemic to the archipelago), *Eumerus* has not been investigated in depth on the Canaries since 1982. Recent fieldwork and study of collection specimens under an integrative approach (morphology + mitochondrial DNA) have enhanced our knowledge of the *Eumerus* diversity in this archipelago, including a new species (*Eumerus macarius* Ricarte and Aguado-Aranda sp. n.), to science endemic to La Palma island. The new species is similar to *Eumerus purpureus* Macquart in Webb and Berthelot, 1839, for which a neotype is designated. *Eumerus aquilius* Walker, 1849, is proposed as a junior synonym of *E. purpureus*. A new *Eumerus* group endemic to the Macaronesia is defined morphologically and supported with DNA evidence: *E. purpureus* species group. Relationships and possible diversification of *Eumerus* from the Canaries are also discussed. After the present work, 11 species of *Eumerus* are present on the Canaries.

Keywords: La Palma; Macaronesia; Merodontini; neotype; new species

1. Introduction

Islands have always aroused interest among researchers as they act as natural laboratories for studying the distribution and diversification of biodiversity [1]. The colonization of island ecosystems occurs from the continental land masses through three main drivers [2]: (1) anemochory, winds that transport seed propagules and small terrestrial invertebrates over long distances; (2) hydrochory, marine currents that favor passive transport by flotation (e.g., seeds and animals on rafts) or the active transport of other animals that are poor swimmers (e.g., some mammals and reptiles), and (3) ornithocoria, birds that transport fruits, seeds and small invertebrates in their plumage, legs and digestive tract. After arriving at an island, biota can follow different paths of diversification, such as the "stepping-stone" pattern found in lizards of the genus *Gallotia* Boulenger, 1916 (Squamata: Lacertidae) [3] or the fly genus *Drosophila* Fallén, 1823 (Diptera: Drosophilidae) [4]. Nevertheless, the pattern of diversification is not always straightforward (i.e., from older to younger islands), and it can be affected by several

Table 1: Distribution of the genus *Eumerus* on the Canary Islands.

Species name	H	G	P	T	C	F	L	IUCN category	Total
E. amoenus	—	—	●	●	●	—	—	LC	3
E. canariensis	—	—	—	—	—	●	●	EN	2
E. dubius	—	—	—	—	●	—	—	EN	1
E. latitarsis	●	●	●	●	●	—	—	VU	5
***E. macarius* sp. n.**	—	—	●	—	—	—	—	NE	1
E. nivariae	—	—	—	●	—	—	—	CR	1
E. obliquus	—	—	●	—	●	—	—	LC	2
E. pulchellus	●	—	●	●	—	—	—	LC	3
E. purpurariae	—	—	—	—	—	●	●	EN	2
E. purpureus	●	●	●	●	●	—	—	VU	5
E. santosabreui	●	●	●	—	●	—	—	EN	4
Total	4	3	7	5	6	2	2	—	—

Note: Species endemic to the archipelago are highlighted in bold. Legend for the islands: El Hierro (H), La Gomera (G), La Palma (P), Tenerife (T), Gran Canaria (C), Fuerteventura (F), Lanzarote (L). Legend for the IUCN categories: not evaluated (NE), least concern (LC), vulnerable (VU), endangered (EN), critically endangered (CR).

factors such as hybridization, introgression, or multiple colonization events (e.g., [5]). As a result of the ecological features of the insular ecosystems, these are considered biodiversity hotspots with high levels of rare and unique biota found in these areas (e.g., [6]), especially in the Macaronesia region [7]. On the Canaries, over 50% of terrestrial invertebrate species are endemic to this archipelago [8], with many diversification examples found in taxa such as *Tarphius* Erichson, 1848 beetles [9], *Dolichoiulus* Verhoeff, 1900 millipedes [10], or *Dysdera* Latreille, 1804 spiders [11].

The syrphids, hoverflies or flower flies (Diptera: Syrphidae), are one of the best-known Diptera families, with over 300 genera and 6,700 described species worldwide [12]. Likewise, the genus *Eumerus* Meigen, 1822 (Eristalinae: Merodontini), is one of the most diverse genera, with 300+ known species [13]. It shows the widest distribution within the Merodontini, being present in the Afrotropical, Australasian, Oriental, and Palaearctic Regions [14, 15]. *Eumerus* has also been introduced in the Nearctic and Neotropical Regions due to the international trade of plants [16, 17]. The almost cosmopolitan distribution of *Eumerus* is conditioned by the trophic regimes of the immature stages. Depending on the species, larvae of *Eumerus* feed on living parts of plants, such as underground storage organs (phytophagous), or decaying plant materials (saprophagous) [17, 18]. The less restrictive a diet is (e.g., saprophagous), the easier it is for a species to expand. These species will show the widest distribution ranges since their larva are able to feed on multiple plant species. For example, the saprophagous larva of *Eumerus obliquus* (Fabricius, 1805) mainly develops on decaying tubers and fruits of up to 11 plant genera [17]. Comparatively, phytophagous species, such as the larva of *Eumerus larvatus* Aracil, Grković and Pérez-Bañón in Aracil et al. [19], which develops only on stems of *Cistanche phelypaea* (L.) Cout [19] will show the most restricted distributions, often conditioning endemism. Thus, the presence/absence of host plants plays an important role in the colonization capacity of *Eumerus* species.

Macquart [20] conducted the first study devoted to the Diptera from the Canaries. In this work, he described two new *Eumerus* endemic to the archipelago: *Eumerus latitarsis* Macquart in Webb and Berthelot, 1839, and *Eumerus purpureus* Macquart in Webb and Berthelot, 1839. Subsequent works on the Diptera fauna increased the levels of diversity found on the Canaries, but no new *Eumerus* were reported. Nevertheless, in the late 20th century, the number of *Eumerus* species from the Canaries was considerably increased as a result of the works elaborated by Santos Abreu [21] and Báez [22]. At present, 10 species are known to be present on the Canary Islands, of which seven are endemic (Table 1): *Eumerus amoenus* Loew, 1848, *Eumerus canariensis* Báez, 1982, *Eumerus dubius* Báez, 1982, *Eumerus latitarsis*, *Eumerus nivariae* Báez, 1982, *Eumerus obliquus* (Fabricius, 1805), *Eumerus pulchellus* Loew, 1848, *Eumerus purpurariae* Báez, 1982, *Eumerus purpureus*, and *Eumerus santosabreui* (Santos Abreu, 1924). The relatively recent discovery of many new species on the Canaries suggests that the true diversity of *Eumerus* might be underestimated. However, no further studies focused on reassessing the *Eumerus* diversity on the Canaries were conducted after 1982.

With the purpose of the present study, we collected fresh material of *Eumerus* as well as revised specimens from the Canaries preserved in different collections. The morphological variation observed was contrasted with the results of genomic analyses in order to correlate our morphological hypothesis under an integrative approach (i.e., morphology and DNA). Therefore, the main aim of the present work is to update and enhance the knowledge of the diversity of *Eumerus* from the Canary Islands, located in the Macaronesia. Our specific aims are (1) to assess the morphological variability found in *E. purpureus* (i.e., *Eumerus* aff. *purpureus* vs. typical *E. purpureus*) in comparison with DNA data; (2) to discuss the putative origin and diversification pattern of *Eumerus* on the Canaries.

2. Materials and Methods

2.1. Study Area. Macaronesia is a biogeographical region [23] that comprises the volcanic archipelagos of the Azores, Madeira, the Savage Islands, the Canary Islands, and Cape Verde, as well as part of the north-western coast of Africa [2].

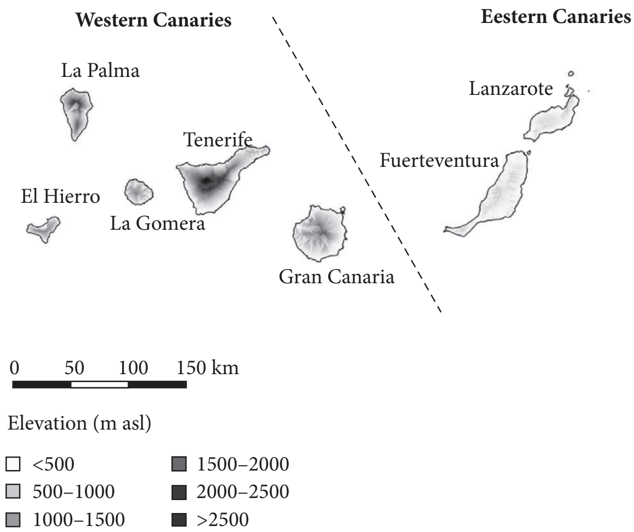

FIGURE 1: Map of the Canary Islands.

Covering around 7500 km^2, the Canaries (Figure 1) are a volcanic archipelago of seven major islands in the Atlantic Ocean, between 27°37′ and 29°25′N, and 13°20′ and 18°10′ W [8]. The Canaries are located in the Mediterranean Basin, a biodiversity hotspot [24]. The archipelago shows a predominantly Mediterranean climate of mild temperatures (20–22°C) and low annual rainfall (especially in Fuerteventura and Lanzarote), except for the hyper-humid Laurel forest [2, 25]. In biogeographical terms, two groups of islands can be distinguished [26]: the Eastern (Fuerteventura and Lanzarote) and Western Canaries (El Hierro, La Palma, La Gomera, Tenerife, and Gran Canaria). The archipelago was formed in the Oligocene, with Fuerteventura as the oldest (20 million years) and El Hierro as the youngest island (1 million years) (e.g., [8]).

With regard to the distribution of plant species according to altitude, the following vegetation zones can be distinguished on the Canaries [27]: "Tabaibal-Cardonal" (0–200 m asl, e.g., scrublands of *Euphorbia* L.), thermophilus forests (200–400 m, for example landscapes of *Juniperus turbinata* subsp. *canariensis* (Guyot and Mathou) Rivas-Martínez et al.; *Pistacia lentiscus* L., *Pistacia atlantica* DC., and *Olea cerasiformis* Rivas Mart. and del Arco), Laurisilva-"Monteverde" (500–1500 m, e.g., forests of *Laurus novocanariensis* Rivas Mart., Lousã, Fern.Prieto, E.Días, J.C.Costa, and C.Aguiar), pine forest (1500–2000 m, formations of *Pinus canariensis* C.Sm.) and "Retamar" (>2000 m, shrub vegetation such as *Echium wildpretii* H.Pearson and *Nepeta teydea* Webb and Berthel.) (Figure 2).

2.2. Examined Material. A total of 110 adult specimens of 11 species of *Eumerus* were studied. New material was collected by hand net at different localities of El Hierro, La Palma, and Tenerife in 2022. Material deposited in the following entomological collections was also examined:

- NHM = Natural History Museum, London, UK.
- CEUA-CIBIO = "Colección Entomológica de la Universidad de Alicante," Alicante, Spain.
- CNC = Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Canada.
- MNCN = "Museo Nacional de Ciencias Naturales," Madrid, Spain.
- MUNA = "Museos de Tenerife Naturaleza and Arqueología," Tenerife, Spain.
- PSB = Personal collection of Sander Bot, Haren, The Netherlands.

All the specimens examined were databased in an Excel table. A unique barcode label was assigned to the new material added to the CEUA-CIBIO collection. In the examined material lists, data from different labels of the same specimen are separated by a double forward slash (//) while a single forward slash (/) separates the different sides of the same label. Collection acronyms are indicated in brackets. Additional information not specified in the labels is indicated in curly brackets ({}). The information on the specimens examined is detailed in a Supporting Information file (Supporting Information 1), except that for the type material of the new species and the neotype of *E. purpureus*, which are indicated in the main text. Conservation status of all species of *Eumerus* from the Canaries was obtained from the European Red List of Hoverflies [28].

2.3. Morphological Study. Material was identified using the keys in Báez [29] and Báez [22]. Additionally, each species of *Eumerus* endemic to the Canary Islands was run through the unpublished key elaborated by Leif Lyneborg for the Afrotropical *Eumerus*. This was done to test if these species could also be present in Africa, due to the geographical proximity of the Canary Islands to this continent. Additionally, a comprehensive review of the literature was performed to reveal any putative species similar to those endemic to the archipelago. Measurements of the body length, basoflagellomere ratio (length:width; see Aguado-Aranda et al. [30]: figure 4), and the eye contiguity were taken with the software Leica Application Suite X (LAS X) v3.0.4.16529. Photographs of specimens were taken using a Leica DFC 450 camera attached to a Leica M205 C binocular microscope. Male genitalia were dissected and prepared following Ricarte et al. [31] and stored in glycerin in plastic microvials (pinned with the specimen). Hand drawings of male genitalia were done by the first author from printed photographs. Morphological terminology followed Thompson [32] for adults, except for the term "hair/s" (replacement for "pilis/pile"), the terms "fore," "mid" and "hind" (replacement for "pro," "meso" and "meta"), and the term "notopleural sulcus," which follows Doczkal and Pape [33]. Terminology for male genitalia follows Doczkal [34]. For illustrations cited from the literature, "figure/s," in lower case, are used.

2.4. Nomenclatural Acts. The new names contained in this article are available under the International Code of Zoological Nomenclature. This work and the nomenclatural acts it contains have been registered in ZooBank. Zoobank Life Science Identifier (LSID) for this publication is urn:lsid:zoobank.org:pub:8C5801E3-162D-4A5B-B6CD-4E174BF057EF. The LSID registration and any associated information can be viewed in a

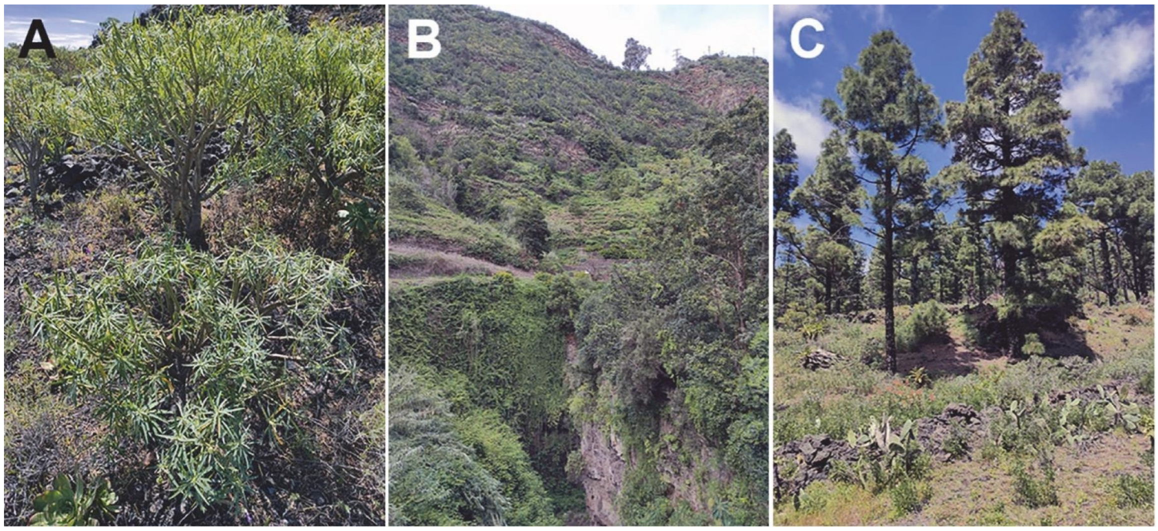

Figure 2: Vegetation zones where *Eumerus* hoverflies were reported: (A) Tabaibal-Cardonal; (B) Laurisilva forest; (C) Pine forest. Photos by D. Miró-Espí.

web browser by adding the LSID to the prefix http://zoobank.org/.

2.5. Molecular Study. DNA was extracted from 1 to 2 legs of two specimens (1♂ and 1♀) of *E. canariensis*, four specimens (2♂♂ and 2♀♀) of *Eumerus hispidus* Smit, Aguiar and Wakeham-Dawson, 2004, two specimens (1♂ and 1♀) of *E. latitarsis*, two specimens (1♂ and 1♀) of *E. pulchellus*, one specimen (male) of *E. purpurariae*, two specimens (1♂ and 1♀) of *E. purpureus* and one specimen (male) of the new species, all of them originating from Macaronesia. The NZY Tissue gDNA Isolation kit was used for all specimens, except for *E. canariensis*, *E. purpurariae*, and *E. nivariae*. DNA of specimens of these three species was extracted using the QIAGEN DNeasy Blood and Tissue kit in the research laboratory of Jeffrey H. Skevington (by the first author). PCR amplification protocols and thermocycler conditions of the 5′ end region of the Cytochrome *c* oxidase subunit I gene (hereafter, COI-5′), and the COI-5′ fragments "A," "B" and "C" for the female of *E. canariensis* and the male of *E. nivariae*, followed Aguado-Aranda et al. [35]. PCR products were visualized with an electrophoresis process in a 1%–2% agarose gel. Purifications and sequencing reactions of COI-5′ fragments followed Aguado-Aranda et al. [35]. The rest of the PCR products were purified and sequenced at Macrogen (Macrogen, Inc.).

The editing of the sequences was conducted with the program Sequencher v5.4.6. Then, COI-5′ sequences for each species of *Eumerus* available at the public repositories GenBank and BOLD were downloaded (Supporting Information 2). Alignments were performed manually and checked with the program AliView v1.25 [36]. The final COI-5′ matrix had a length of 658 bp. Molecular analyses with 1000 replications were conducted using the maximum likelihood (ML) composite model for neighbor-joining (NJ), and the general time reversible (GTR) model with gamma distribution (+G) and invariant sites (+I) model for ML proposed by the corrected Akaike information criterion (AICc) in MEGA7 [37]. *Eristalis tenax* (Linnaeus, 1758) was included in the matrix as an outgroup.

3. Results

3.1. Integrative Approach and Systematic Placement of the New Species. As a result of the present study, a total of 19 new specimens were collected of the following species (for further details, see Supporting Information 1): seven specimens (4♂♂ and 5♀♀) of *E. latitarsis*, one specimen of *E. obliquus* (♀), three specimens (1♂ and 2♀♀) of *E. pulchellus*, seven specimens (4♂♂ and 3♀♀) of *E. pupureus* and one specimen of the new species (♂). In addition, 91 specimens from various collections were examined.

The new species resembles *E. purpureus* but differs in the length of eye contiguity, the color of the basoflagellomere, and the posterior surstylar lobe of male genitalia (refer to Section 4). To test our morphological hypothesis, we followed a molecular approach based on one specimen of the new species and two specimens (1♂ and 1♀) of *E. purpureus*. Additionally, we generated and included the first known COI-5´ sequences of another three *Eumerus* species endemic to the Canaries (*E. canariensis*, *E. latitarsis*, and *E. nivariae*) and *E. hispidus*, from Madeira (Figure 3). Likewise, the first barcode sequences of *E. pulchellus* from the Canaries were also generated. The resulting NJ and ML-trees showed virtually the same topology. Both trees showed high support (>70) for the new species, supporting our morphological hypothesis (Figure 3). Therefore, based on all these evidences, the new species and the group to which it belongs are characterized.

3.1.1. Eumerus purpureus Group. Definition: Macaronesian group of species (*E. hispidus*, *E. macarius* sp. n., and *E. purpureus*) with eyes contiguous along a line (in males, as in Figure 4B) and pilose; basoflagellomere brown to black, simple (i.e., without modifications); vertex densely white pollinose and covered with black hairs; scutum with a pair of white pollinose vittae reaching the posterior margin of scutum; notopleural sulcus

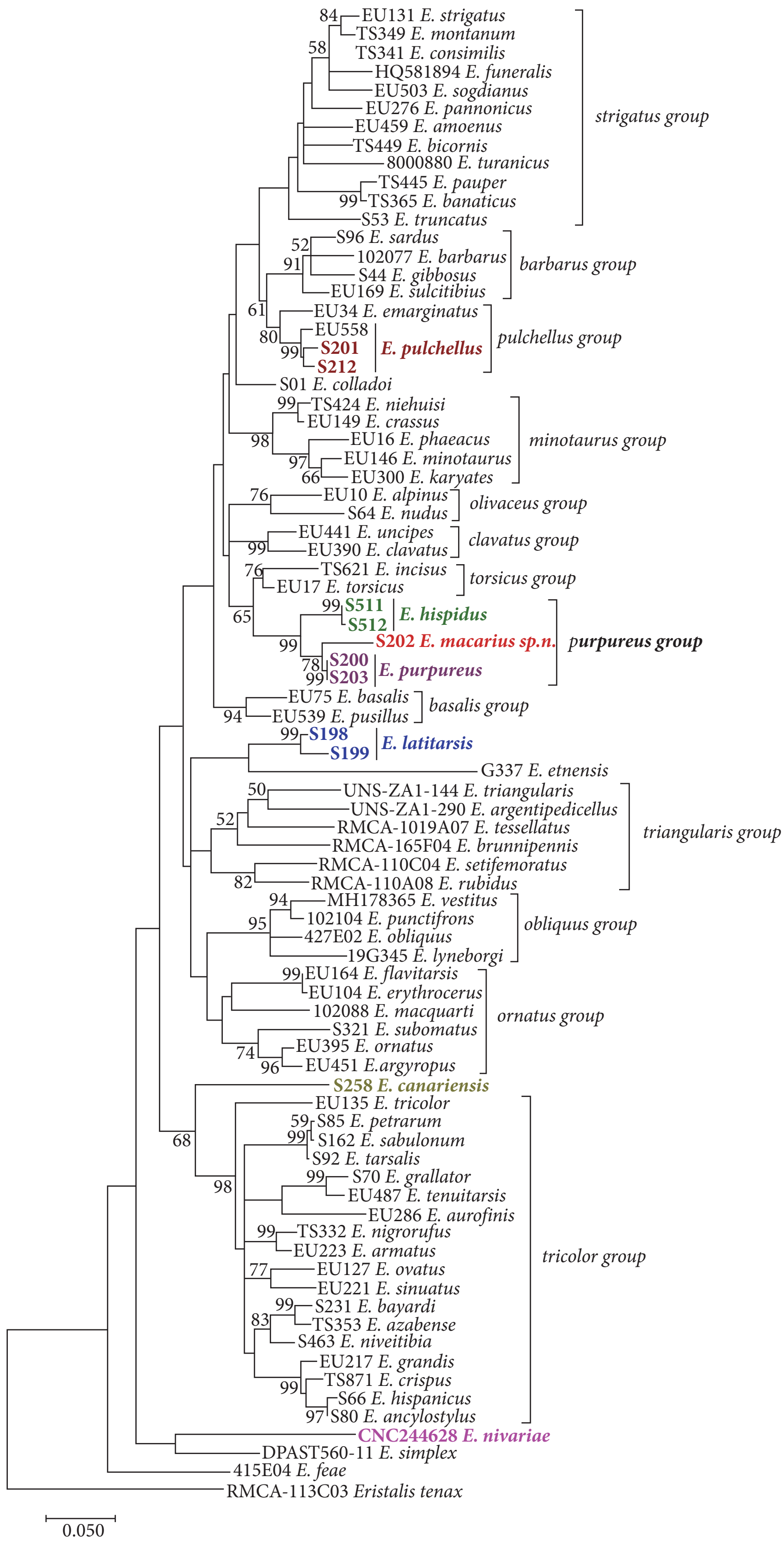

FIGURE 3: Maximum likelihood tree of *Eumerus* based on COI-5′. Barcodes generated from Macaronesian specimens are highlighted in bold, and a different color is used for each species. Bootstrap values >50 are shown near nodes. Branch lengths are measured in terms of the number of substitutions.

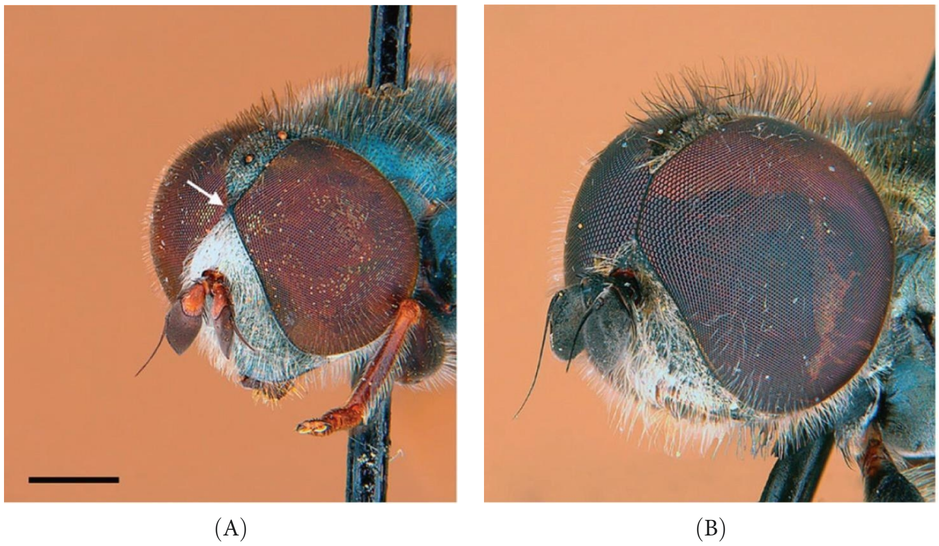

Figure 4: Males of *Eumerus*, eye contiguity: (A) *E. latitarsis*; (B) *E. purpureus*, neotype. Arrow indicates the eye proximity. Scale bar = 1 mm.

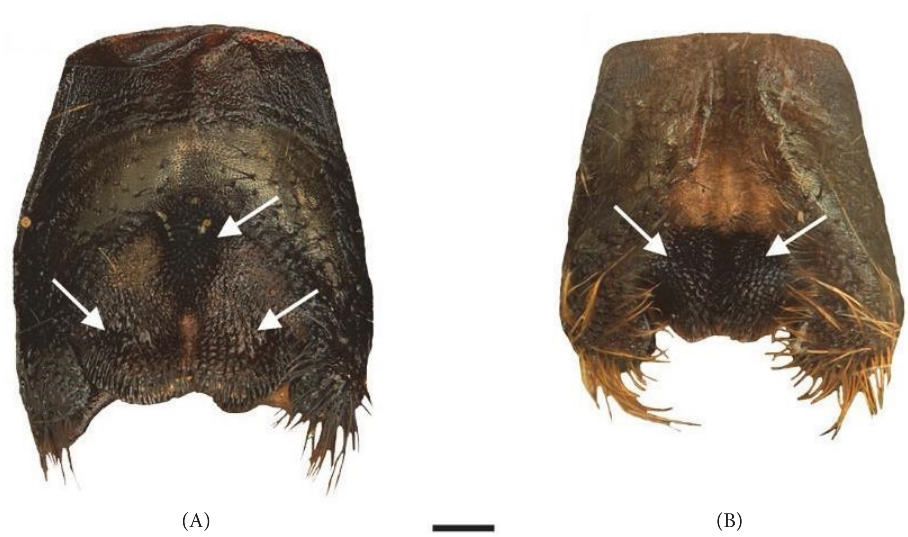

Figure 5: Males of the *E. purpureus* group, sternum IV, ventral view: (A) *E. hispidus*; (B) *E. macarius* sp. n. Arrows indicate the position of the lobes. Sternum IV of *E. purpureus* shows no substantial differences with that of *E. macarius* sp. n.. Scale bar = 250 µm.

absent; hind trochanter simple; hind tibia with an inconspicuous baso-ventral ridge covered with reclined and black setulae; in males, length of the hind basotarsomere similar to that of tarsomeres II–V together; sternum IV with black lobes posteromedially (Figure 5, marked with arrows); hypandrium of male genitalia with a triangular expansion laterally (Figure 6A,C, marked with arrow; Figure 7A, te).

3.1.2. Eumerus macarius Ricarte and Aguado-Aranda, sp. n. (Figures 5B, 7–9A). = *Eumerus* aff. *purpureus*

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Holotype

SPAIN ● 1♂—La Palma, P.N. Caldera de Taburiente, Barranco de Las Traves, 03-08/VIII/1999, 1068 m, Leg. T. Domingo-Quero // SYRPHIDAE, *Eumerus purpureus* Macquart, 1838, Det. Mª Á. Marcos-García/M1-030899, T. Malais {hand written} // CEUA00017719 (CEUA-CIBIO).

Paratype

SPAIN ● 1♂—La Palma, Roque de los Muchachos, 06/05/2022, Leg. David Miró // DNA CEUA_S202 // CEUA00113425 (CEUA-CIBIO).

Diagnosis: This species (only males, female unknown) can be distinguished from the other described *Eumerus* species by the following combination of characters: eyes pilose and touching along a line (as in Figure 4B); vertical triangle entirely gray pollinose (more obvious in lateral view and under artificial white lighting); pollinose vittae on the scutum reaching its posterior margin; hind basotarsomere longer than tarsomeres II–V together; terga black; sternum IV with two black lobes

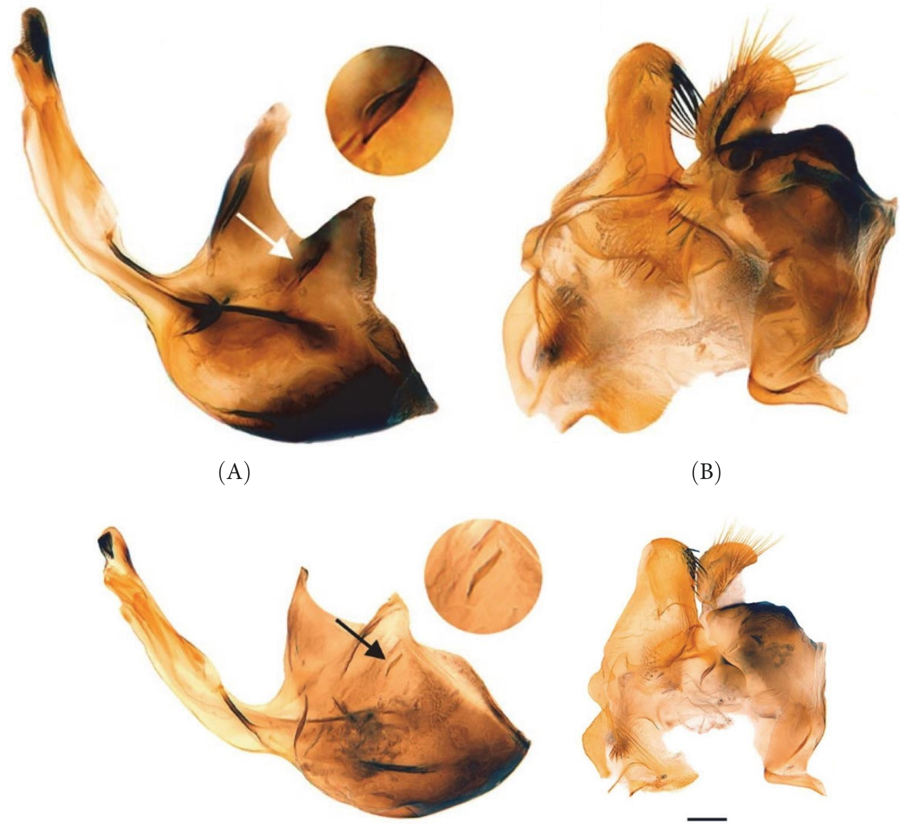


Figure 6: Male genitalia of the Macaronesian *Eumerus*, lateral view, *E. purpureus*: (A) epandrium; (B) hypandrium. *E. hispidus*: (C) hypandrium; (D) epandrium. Arrows indicate the triangular expansion (an amplification of the expansion is shown near the hypandrium). Scale bar = 250 µm.

postero-medially (Figure 5B); hypandrium with a triangular expansion antero-laterally (Figure 7A, te). This species belongs to the *E. purpureus* group (defined in the present study), and it can be distinguished from the other species of this group by a posterior surstylar lobe spatula-shaped and inclined towards the cercus (Figure 7B, psl).

Description: MALE (holotype). Body length = 12.1 mm. *Head*. Eyes contiguous. Eye hairs are moderately long, covering the entire eye surface except for the posterior area and the area close to the eye contiguity. Face and frontal triangle white pollinose, covered with white hairs. Vertical triangle black, gray pollinose over the entire surface (more obvious in lateral view and under artificial white lighting) and gray pollinose at its apex; vertical triangle covered with long, erect black hairs. Ocellar triangle isosceles, with black hairs. Occiput black, white pollinose; occiput with yellow hairs which become shorter than those on the vertical triangle towards the lateral sides of the occiput. Scape and pedicel are darkish brown with long, black hairs dorsally and white hairs ventrally. Basoflagellomere oval (length:width ratio = 1:1.1); basoflagellomere predominately light brown. Pedicel and basoflagellomere sparsely white pollinose (pollinosity more obvious under artificial white lighting). Arista black and bare.

Thorax: Mesonotum and pleura black. Postpronotum and lateral margins of the anterior and medial third of the scutum are white pollinose. Scutum with yellowish white and black hairs intermixed on its anterior and posterior third, hairs on the anterior third of the scutum of similar length, length of yellowish white hairs in the posterior third of the scutum not exceeding half the length of the black hairs; medial third of the scutum completely covered with black hairs; scutum with two white pollinose vittae, reaching its posterior margin; width of the vittae equal to 1/8 of the total width of the scutum. Notopleural sulcus absent. Disc of scutellum with yellowish white and black hairs intermixed; length of white hairs slightly exceeding that of the black ones; posterior margin of the scutellum with small teeth-like protuberances, each bearing mainly a white hair apically. Posterior anepisternum bearing long, yellowish white hairs. Katepisternum on its posterolateral area, anterior and posterior anepimeron bearing densely-arranged long white hairs. Katatergum with a discrete bunch of white hairs. Pleuron gray pollinose except the posterolateral margins of the anterior anepimeron and katepisternum, and the basal margin of the posterior anepimeron. Femora black, apices light brown. Tibiae black, basal third light brown. Fore and hind basotarsomeres are dark brown dorsally, mid basotarsomere yellowish brown dorsally. Tarsomeres are dark brown dorsally. Tarsi are yellow ventrally. Fore and mid femora with long, backward-directed, white hairs on their posterior sides. Hind trochanter flat, without expansions. Hind

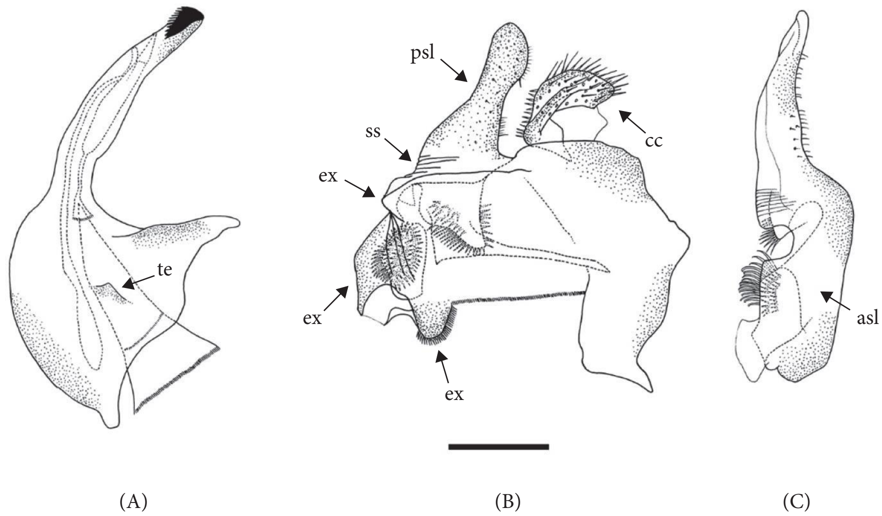


Figure 7: *Eumerus macarius* sp. n., paratype, genitalia: (A) hypandrium, lateral view; (B) epandrium, lateral view; (C) epandrium, ventral view. Legend: asl, anterior surstylar lobe; cc, cercus; ex, expansion; psl, posterior surstylar lobe; ss, striations; te, triangular expansion. Scale bar = 500 μm.

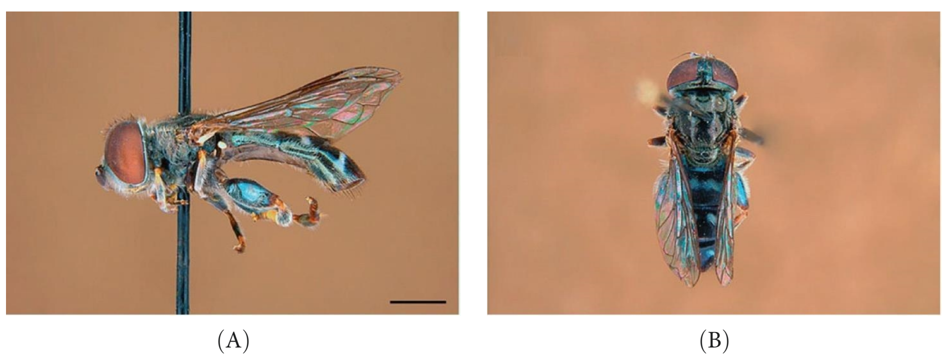


Figure 8: *Eumerus macarius* sp. n., holotype, overall appearance: (A) lateral view; (B) dorsal view. Scale bar = 2.5 mm.

femur is densely covered with yellow hairs. Hairs on the ventral side of the hind femur are of a similar length to that on the scutellum medially. Hind femur with an anterior row of six spinae and a posterior row of eight spinae apico-ventrally. Hind tibia with an inconspicuous baso-ventral ridge covered with short, reclined, and black setulae. Hind basotarsomere slightly longer than tarsomeres II–V together. Wing membrane extensively microtrichose; posterior margin of the wing with dense, short, and brown hairs. Margin of ventral calypter with rather long and yellow hairs; hairs on the margin of dorsal calypter shorter than those on the ventral calypter; halter brownish yellow.

Abdomen: Terga I–IV black. Terga II–IV with a pair of slightly curved, white pollinose maculae. The middle area of terga II–IV is covered with short, semi-reclined black hairs. Lateral margins of tergum I are densely white pollinose. Tergum II with yellowish white hairs on lateral margins (hairs at the anterior corners rather long). Terga III–IV with short, white hairs on the lateral margins. Tergum IV with black hairs posteriorly. Sterna I–III brown; anterior margin of sternum I–II black. Sterna with white hairs. Sternum IV is rectangular-shaped and dark brown; sternum IV with a V-shaped incision postero-medially; the posterior margin of sternum IV with two black lobes medially (Figure 5B).

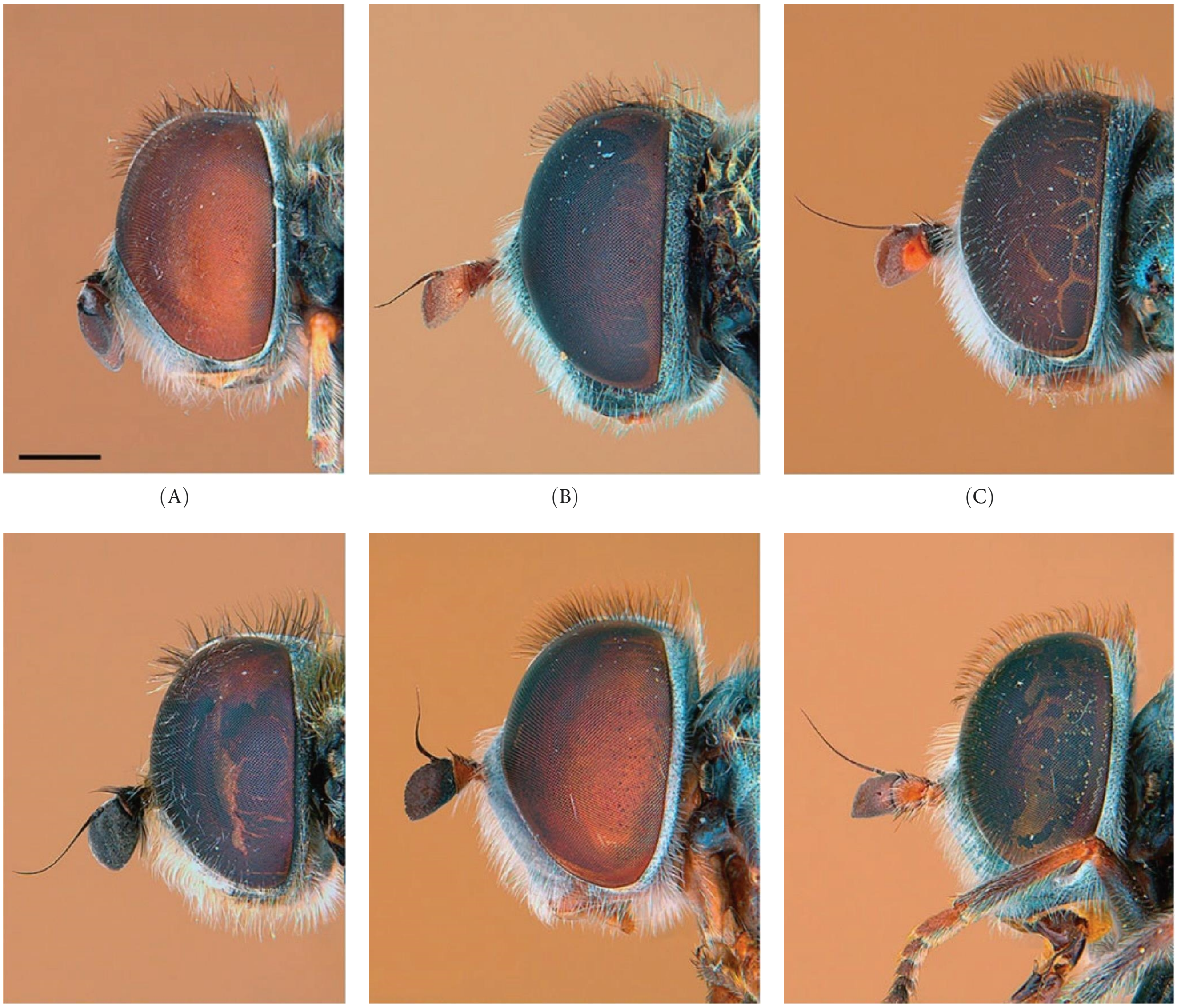
Genitalia: Epandrium with a posterior surstylar lobe elongated, spatula-shaped, striated at its base, and slightly inclined toward the cercus; the anterior margin of the posterior surstylar lobe covered with hairs (Figure 7B). Anterior surstylar lobe with three expansions (Figure 7B,C, ex). Cercus with long hairs. The interior accessory lobe is densely covered with long, black hairs. Hypandrium with a triangular expansion antero-laterally (Figure 7A, te).

FEMALE: Unknown.

Etymology: The specific epithet “macarius” derives from the Latinized Greek word “makárōn” (fortunate or the blessed) and comes from Macaronesia, the biogeographic origin of the new species. The specific epithet should be treated as an adjective in the nominative singular.

Biology: The two adults were collected from early May to early August, at high altitudes (from 1000 to 2000 m asl), in the Laurel and pine forest of *P. canariensis*.

Distribution: La Palma.



(A) (B) (C) (D) (E) (F)

FIGURE 9: Males of *Eumerus*, head, lateral view: (A) *E. macarius* sp. n., (B) *E. purpurariae*; (C) *E. canariensis*; (D) *E. purpureus*, neotype; (E) *E. nivariae*; (F) *E. latitarsis*. Scale bar = 1 mm.

3.2. Remarks on the Other Eumerus From the Canaries

3.2.1. Eumerus amoenus Loew, 1848 (Figures 10 and 11B). *Eumerus lejops* Rondani, 1857:94. Synonymized by Belcari et al. [39].

Eumerus liops Bezzi and Stein, 1907:135. Unjustified emendation for *E. lejops*.

Eumerus terminalis Santos Abreu, 1924:136. Synonymized by Báez and Barkemeyer [40].

Distribution on the Canaries: Western Canaries [29]: Gran Canaria, La Palma, Tenerife.

Examined specimens: 8♂♂ and 8♀♀. New material from Fuerteventura (1♀), Gran Canaria (2♀♀), and Tenerife (3♀♀).

3.2.2. Eumerus canariensis Báez, 1982 (Figures 9C, 12–14A). Distribution on the Canaries: Eastern Canaries [22]: Fuerteventura, Lanzarote.

Examined specimens: 3♂♂ and 1♀ (all of them are new material from Lanzarote).

3.2.3. Eumerus dubius Báez, 1982. Distribution on the Canaries: Western Canaries [22]: Gran Canaria.

3.2.4. Eumerus latitarsis Macquart in Webb and Berthelot, 1839 (Figures 4A, 9F, 14B–16). Distribution on the Canaries: Western Canaries: El Hierro [29], Gran Canaria [29], La Gomera [29], La Palma [29, 41, 42], Tenerife [29, 43].

Examined specimens: 12♂♂ and 24♀♀. New material from Gran Canaria (2♂♂ and 4♀♀), La Palma (2♀♀), and Tenerife (6♂♂ and 11♀♀).

3.2.5. Eumerus nivariae Báez, 1982 (Figures 9E and 17). Distribution on the Canaries: Western Canaries [22]: Tenerife.

Examined specimens: 1♂ (new material from Tenerife).

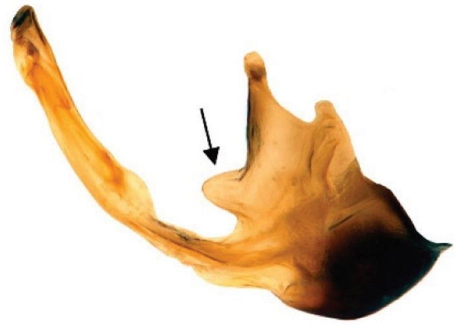
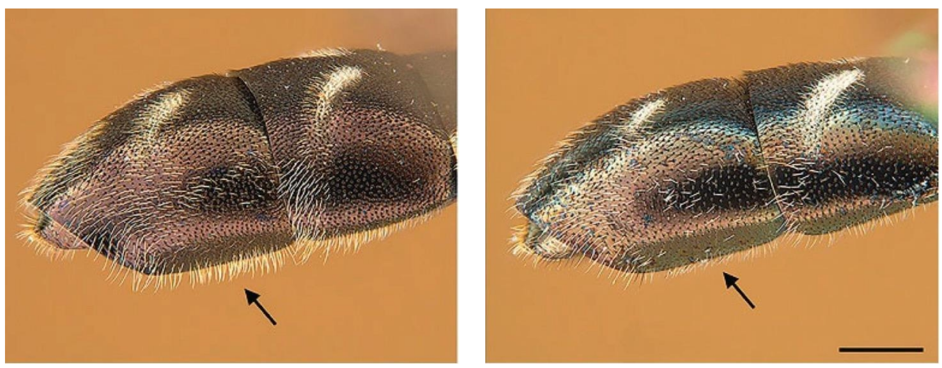


Figure 10: *Eumerus amoenus*, hypandrium, lateral view. Arrow indicates the projection.



(A) (B)

Figure 11: Terga III–IV, female, lateral view: (A) *E. pulchellus*; (B) *E. amoenus*. Scale bar = 500 µm. Source (CC-BY): Aguado-Aranda et al. [38].

Figure 12: *Eumerus canariensis*, male, hind leg, lateral view. Arrow indicates the expansion.

3.2.6. Eumerus obliquus (Fabricius, 1805) (Figure 18). Eumerus lugens Wiedemann, 1830:112. Synonymized by Lyneborg et al. [44].

Eumerus cilitarsis Loew, 1848:120. Synonymized by Peck [45].

Eumerus crassitarsis Costa, 1885:30. Synonymized by Peck [45].

Distribution on the Canaries: Western Canaries: Gran Canaria [46], La Palma [42].

Examined specimens: 1♀ (new material from La Palma).

3.2.7. Eumerus pulchellus Loew, 1848 (Figure 11A). Eumerus delicatae Rondani, 1850:127. Synonymized by Peck [45].

Distribution on the Canaries: Western Canaries [29]: El Hierro, La Palma, Tenerife.

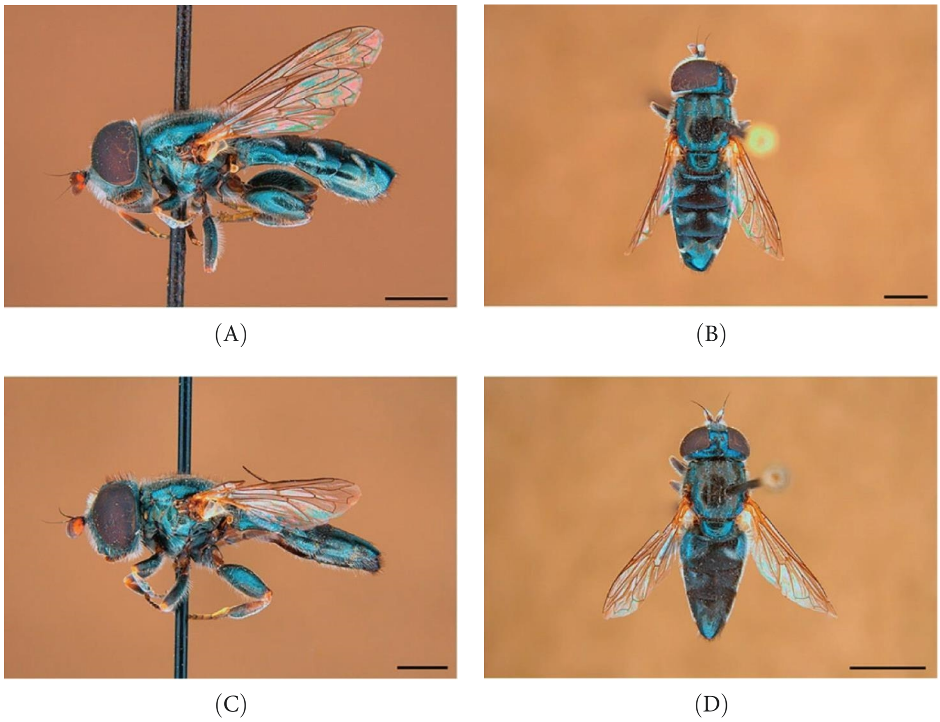
Examined specimens: 5♂♂ and 8♀♀. New material from El Hierro (1♂ and 3♀♀), Gran Canaria (2♀♀), La Palma (1♂), and Tenerife (3♂♂ and 3♀♀).

3.2.8. Eumerus purpurariae Báez, 1982 (Figures 9B, 19, and 20). Distribution on the Canaries. Eastern Canaries [22]: Fuerteventura, Lanzarote.

Examined specimens: 2♂♂ (new material from Lanzarote).

3.2.9. Eumerus purpureus Macquart in Webb and Berthelot, 1839 (Figures 4B, 6A, B, 9D, 14C, and 21). Eumerus aquilius Walker, 1849, syn. n.

Neotype



(A) (B) (C) (D)

Figure 13: *Eumerus canariensis*, overall appearance, male: (A) lateral view; (B) dorsal view. Female: (C) lateral view; (D) dorsal view. Scale bars = 2.5 mm.

SPAIN ● 1♂, Tenerife, Ctra. Monte del Agua, Las Lagunetas, 18/4/2022, Leg. David Miró // SYRPHIDAE, *Eumerus purpureus* Macquart in Webb and Berthelot (1839), Det. P. Aguado-Aranda, 2025 // CEUA00113445 (CEUA-CIBIO).

Distribution on the Canaries: Western Canaries: El Hierro [22], Gran Canaria [29], La Gomera [29], La Palma [29, 41, 42], Tenerife [29].

Examined specimens: 16♂♂ and 12♀♀. New material from El Hierro (1♀), Gran Canaria (1♂), La Palma (3♀♀), and Tenerife (8♂♂ and 3♀♀).

Taxonomic notes: Following Article 75.3 of the International Code of Zoological Nomenclature [47], we designate a neotype for *E. purpureus* in order to stabilize this species concept, given that there are species similar to *E. purpureus* (i.e., *E. hispidus* and *E. macarius* sp. n.). *Eumerus pupureus* can be distinguished from the males of other species belonging to *E. purpureus* group mainly by the shape and disposition of the posterior surstylar lobe of male genitalia (Figures 6 and 7). *Eumerus purpureus* was described apparently based on a single female from the Canary Islands, without further details [20]. According to Horn and Kahle [48], the main section of Macquart's collection was destroyed, and the remaining part is preserved between the "Museum d'Historie Naturelle" (MHNL) in Lille, the "Museum National d'Historie Naturelle" (MNHNP) in Paris, and the Museum of Natural History of the Oxford University (OUMNH). No specimens of this species were found neither in the MNHNL (O. Boilly, in litt.) nor in the OUMNH (R. Douglas, in litt.), and the MNHNP (M. Báez, in litt.). Therefore, the type of *E. purpureus* was apparently in the large part of Macquart's collection that was destroyed. Females were identified by comparing specimens with the original description of the species [20]; males were associated by morphological association with the studied females and corroborated based on the molecular results (Figure 3).

As a result of reviewing the literature, we also decided to examine the lectotype of *E. aquilius*, a male preserved in the collection of the NHM (Figure 22), due to its morphological affinity to *E. purpureus*. The lectotype of *E. aquilius* was designated by Thompson [49] in a paper devoted to hoverflies described from unknown localities. Thompson [49] redescribed *E. aquilius* and figured its genitalia (see Thompson [49]: figures 1–3), stating the putative Afrotropical origin of the species based on its morphological separation with any other Oriental or Palaearctic species. After the examination and comparison of the studied specimens of *E. purpureus* with the lectotype of *E. aquilius*, no significant morphological differences were found between these species. Thus, based on this evidence, *E. aquilius* is proposed as a junior synonym of *E. purpureus*.

3.2.10. Eumerus santosabreui (Santos Abreu, 1924). Eumerus auratus Santos Abreu, 1924:133. Junior primary homonym of *Eumerus auratus* (Walker, 1856).

Distribution: Western Canaries: El Hierro [22], La Gomera [22], La Palma [21, 29], Gran Canaria [22].

Taxonomic notes: Santos Abreu [21] described *E. santosabreui*, originally under the name of *E. auratus*, without specifying the number of specimens studied. However, this author mentioned in the original description that the material was collected "*in the spring and summer months*" in La Palma.

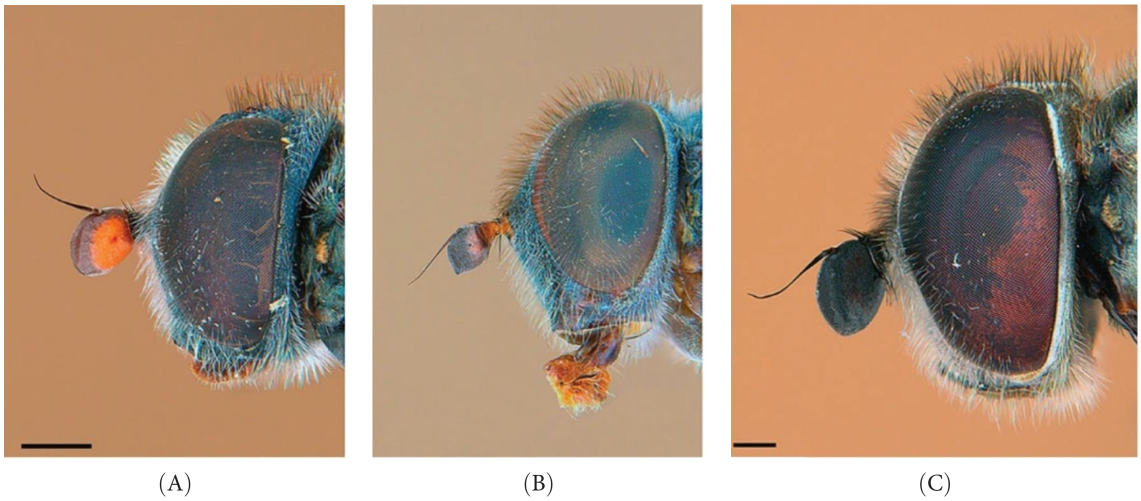


Figure 14: Females of *Eumerus*, head, lateral view: (A) *E. canariensis*; (B) *E. latitarsis*; (C) *E. purpureus*. Scale bars = (A, B) 1 mm; (C) 500 µm.

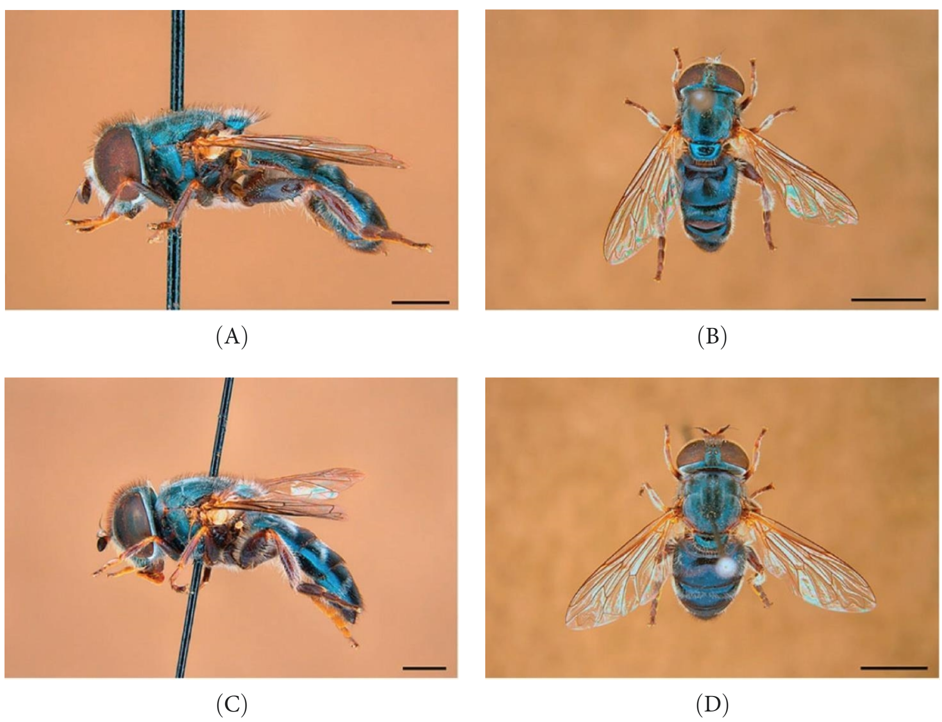
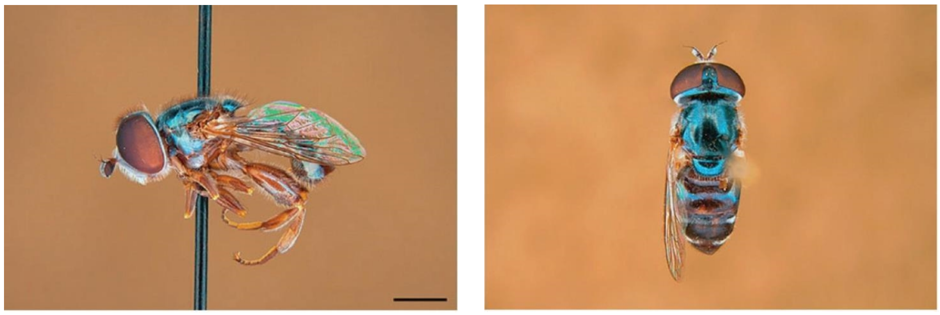


Figure 15: *Eumerus latitarsis*, overall appearance, male: (A) lateral view; (B) dorsal view. Female: (C) lateral view; (D) dorsal view. Scale bars = 2.5 mm.

Figure 16: *Eumerus latitarsis*, female, hind femur, lateral view. Red circle indicates the spinae.



(A) (B)

Figure 17: *Eumerus nivariae*, male, overall appearance: (A) lateral view; (B) dorsal view. Scale bar = 2.5 mm.

Figure 18: *Eumerus obliquus*, male, overall appearance, dorsal view. Arrow indicates the posterior margin of the scutellum.

(A) (B)

Figure 19: *Eumerus purpurariae*, male, overall appearance: (A) lateral view; (B) dorsal view. Scale bars = 2.5 mm.

Figure 20: *Eumerus purpurariae*, male, hind leg, lateral view.

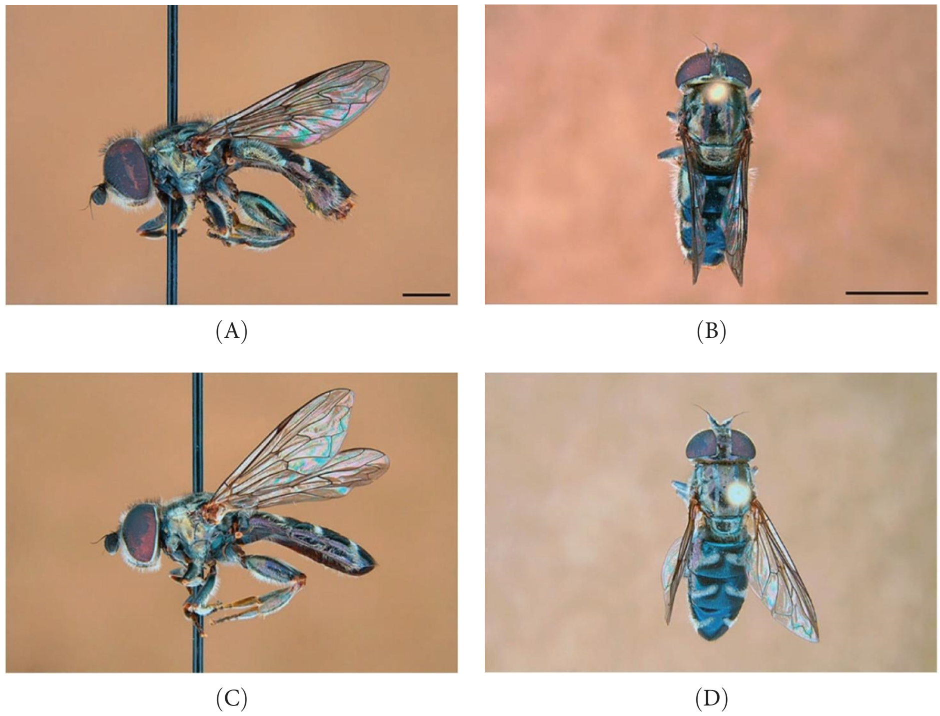


FIGURE 21: *Eumerus purpureus*, overall appearance, male, neotype: (A) lateral view; (B) dorsal view. Female: (C) lateral view; (D) dorsal view. Scale bars = (A, C) 2.5 mm; (B, D) 2.5 mm.

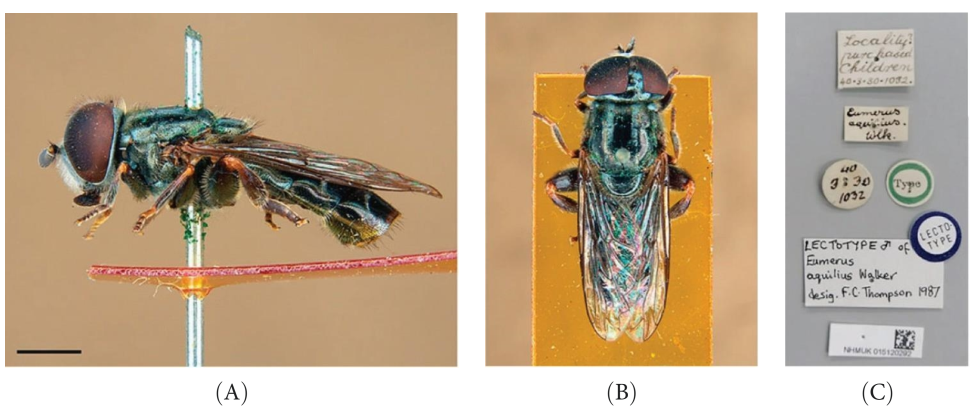


FIGURE 22: *Eumerus aquilius*, lectotype, male: (A) overall appearance, lateral view; (B) overall appearance, dorsal view; (C) Labels. Scale bar = 2.5 mm.

According to this information, it makes sense that the type series of *E. santosabreui* comprised, at least, two specimens. Furthermore, Santos Abreu [21] stated in the original description that *E. santosabreui* resembles *E. purpureus*. However, Báez [29] examined a single male of *E. santosabreui* preserved in the private collection of Elías Santos Abreu (La Palma). In his monograph, Marcos Báez highlighted the affinity of this male with *E. pulchellus*, and not with *E. purpureus*, establishing that dissection of the male genitalia is mandatory for species identification. In addition, and to the best of our knowledge, the genitalia represented by Báez [29] looks like a modified or altered genitalia of a typical *E. pulchellus*. On the other hand, Santos Abreu [21] mentioned in his monograph that *E. pulchellus* also resembles his new species (i.e., *E. santosabreui*). These facts may indicate that the type series of *E. santosabreui* could include more than one species. Based on all these evidences, the species concept of *E. santosabreui* is unclear and, therefore, should remain as a *nomem dubium*.

3.3. Key to the Eumerus Species From the Canaries. The present dichotomous key is adapted from that of Báez [22]. *Eumerus santosabreui* was excluded from the key due to its uncertain taxonomic status.

Males

1. Eye bare … 2.
    1. – Eye pilose … 3.
2. Apex of hind tibia with a characteristic brush of orange hairs (as in Figure 20). Tergum II black, with two triangular orange maculae laterally … *E. purpurariae*.
    1. – Apex of the hind tibia without a brush of hairs. Tergum II unicolorous (besides the white pollinose maculae) … *E. nivariae*.
3. Eyes slightly dichoptic, separated by a distance equivalent to the width of the frontal ocellus (Figure 4A) … *E. latitarsis*.
    1. – Eyes holoptic (as in Figure 4B) … 4.
4. Disc of scutellum is white pollinose all over its posterior margin (Figure 18). Hind basotarsomere with a dorsal ridge … *E. obliquus*.
    1. – Disc of scutellum without pollinosity over its posterior margin. Hind basotarsomere without a ridge … 5.
5. Hind trochanter with a triangular expansion (Figure 12) … 6.
    1. – Hind trochanter without expansions … 7.
6. Eye densely pilose (Figure 9C). Sternum IV with a postero-medial incision, reaching the anterior margin of the sternum … *E. canariensis*.
    1. – Eye sparsely pilose (as in Figure 9E). Sternum IV with a postero-medial incision equal to half the total length of the sternum (see Báez [22]: figure 7 of plate II) … *E. dubius*.
7. Terga III–IV with remarkably long hairs laterally (see Speight et al. [50]: figure 18b) … *E. pulchellus*.
    1. – Terga III–IV without such hairs laterally … 8.
8. Pollinose vittae on the scutum not reaching its posterior margin. Genitalia with a hypandrium bearing a basal projection on its inner side (Figure 10) … *E. amoenus*.
    1. – Pollinose vittae on the scutum reaching its posterior margin. Genitalia with a hypandrium bearing a triangular expansion antero-laterally (as in Figure 13A) … 9.
9. Eye contiguity is longer than the height of the frontal triangle (as in Figure 4B). Epandrium with a posterior surstylar lobe straight (Figure 8B) … *E. purpureus*.
    1. – Length of eye contiguity, at most, equal to the height of the frontal triangle. Epandrium with a posterior surstylar lobe inclined towards the cercus (Figure 7B) … *E. macarius* sp. n.

Females

1. Hind femur with an apico-ventral lamina (as in Figure 20) … 2.
    1. – Hind femur without an apico-ventral lamina … 3.
2. Eye bare: Disc of scutellum without pollinosity over its posterior margin … *E. purpurariae*.
    1. – Eye pilose (as in Figure 14). Disc of scutellum with pollinosity over its posterior margin (as in Figure 18) … *E. obliquus*.
3. Hind femur with an apico-ventral row of 2–4 black spinae (as in Figure 16) … *E. latitarsis*.
    1. – Hind femur with an apico-ventral row of, at least, five black spinae … 4.
4. Pollinose vittae on the scutum reaching its posterior margin … *E. purpureus*.
    1. – Pollinose vittae on the scutum not reaching its posterior margin … 5.
5. Ventral side of hind femur with hairs 4× longer than spinae. Lateral margins of terga III–IV with hairs usually as long as the width of their own pollinose maculae at their midpoints (Figure 11A) … *E. pulchellus*.
    1. – Ventral side of hind femur with short hairs, at most, 3× longer than the spinae. Lateral margins of terga III–IV with hairs usually clearly shorter than the width of their own pollinose maculae at their midpoints (as in Figure 11B) … 6.
6. Scutum with long hairs, longer than half the length of the hairs on the dorsal side of the head … *E. canariensis*.
    1. – Scutum with short hairs, shorter than half the length of the hairs on the dorsal side of the head … *E. amoenus*.

4. Discussion

4.1. Taxonomy and Systematics. In the only identification key to the *Eumerus* from the Canaries [22], *E. macarius* sp. n. would key out as *E. purpureus*. However, these two species can be distinguished in the length of the eye contiguity compared to the medial length of the frontal triangle, slightly longer in *E. macarius* sp. n. but remarkably longer in *E. purpureus* (as in Figure 4B; the color of the basoflagellomere, brown in *E. macarius* sp. n. (Figure 9A) but black in *E. purpureus* (Figure 9D); the striation at the base of the posterior surstylar lobe of the male genitalia, very conspicuous in *E. macarius* sp. n. (Figure 7B) but more inconspicuous in *E. purpureus*; and the disposition of the posterior surstylar lobe, inclined toward the cercus in *E. macarius* sp. n. (Figure 7B) but straight in *E. purpureus* (Figure 6B). As mentioned above, *E. santosabreui* resembles *E. purpureus* [21], so we also decided to compare our new species with the original description of *E. santosabreui*. *Eumerus macarius* sp. n. differs from *E. santosabreui* in the coloration of the fore tibia, yellow in its basal half in *E. santosabreui* but yellow in its basal third in *E. macarius* sp. n., coloration of the mid tibia, yellow only at the edges in *E. santosabreui* but yellow in its basal third in *E. macarius* sp. n., and the length of the hind tarsus, which are clearly longer than the hind tibiae in *E. santosabreui* (see Santos-Abreu [21]: figure 13) but shorter in *E. macarius* sp. n, confirming our morphological hypothesis. At present, *E. macarius* sp. n. should be considered as the eighth endemic species of *Eumerus* from the Canary Islands until further data become available to clarify the status of *E. santosabreui*.

Concerning the other *Eumerus* species from the Canaries, their systematic positions differ between them. The analysis of the barcodes did not reveal any clear association of either *E. nivariae* or *E. latitarsis* with any of the species groups known to date (Figure 3). Otherwise, *E. canariensis* appears to be related with the *E. tricolor* group. Nevertheless, this species differs from the main diagnostic features of the *E. tricolor* group [51]: the shape of the basoflagellomere, lacking the characteristic flattened ellipsoidal area distally and the striation; the coloration of the abdomen, without red parts (albeit some species of the *E. tricolor* group have a completely black abdomen); and the general shape of male genitalia (see Báez [22]: figure 2 of plate II). On the other hand, males of *E. canariensis* have a triangular-like expansion in the hind trochanter (Figure 12), which is also one of the diagnostic characters of the males of the *E. barbarus* group [15]. Furthermore, the posterior surstylar lobe of male genitalia is slender and hook-shaped apically in *E. canariensis*, also fitting that of the species of the *E. barbarus* group [15]. These facts appear to indicate that the association of *E. canariensis* with the *E. tricolor* group may just be an artifact of the molecular analysis. Likewise, the morphological affinities between *E. canariensis* and the species belonging to the *E. barbarus* group might be a result of convergence.

With regard to *E. purpurariae*, this species is allied with *Eumerus etnensis* van der Goot, 1964. In fact, *E. purpurariae* was proposed as a junior synonym of *E. etnensis* by Marcos-García and Pérez-Bañón [52] but reinstated as a valid species by Smit et al. [53] afterward. Males of these species can be distinguished mainly by the shape of the hind basotarsomere, incrassate at its base in *E. purpurariae* but uniform in width in *E. etnensis* [53]. The morphological similarity between *E. purpurariae* and *E. etnensis* may also suggest a phylogenetic affinity that should be explored in future studies.

As a result of the present work, the *E. purpureus* group is revealed as the thirteenth species group defined within the genus *Eumerus* worldwide [54–57]. However, the discovery of a new species, as well as the taxonomic status of *E. santosabreui*, which is still to be clarified, highlights that further research is required to complete the knowledge about *Eumerus* diversity on the Canary Islands.

4.2. Diversification and Conservation. The African continent, together with the Iberian Peninsula, represents the two putative sources of colonizers of the archipelagos located in Macaronesia [8]. Concerning *Eumerus*, hydrochory is the most plausible way that allowed the ancestor (or ancestors) arriving at the Canaries, since *Eumerus* tends to fly very close (<1 m) to the ground (e.g., [58]) and land on the soil, stones, or low vegetation in strong gusts of wind (A. Ricarte, pers. obs.), and the fact that *Eumerus* is not associated with any bird species. Likewise, the presence/absence of *Eumerus* on islands depends on the plants in which larvae develop on. For instance, the larva of *E. latitarsis* was found feeding on decomposing specimens of *Euphorbia canariensis* L. [29]. The ancestors of this *Euphorbia* L. are native to the African continent [59]. Thus, it is plausible that the ancestor of *Eumerus* from the Canaries originated in Africa and arrived as a larva inside plants on the archipelago.

On the other hand, our molecular study based on COI-5´ analysis did not reveal any grouping among *Eumerus* species from the Canaries, apart from those belonging to the *E. purpureus* group (Figure 3). The fact that all *Eumerus* species of the Canary Islands do not share a common ancestor suggests the existence of multiple colonization events from Africa. Based on these premises, a more exhaustive molecular study (with more molecular markers) is necessary to clarify the phylogenetic relationships between the species. Furthermore, no information is available of the immature stages of the *Eumerus* species endemic to the Canaries, apart from occasional sightings (e.g., larva feeding on decaying plant specimens) on the field [29]. The knowledge of immature stages and host plants is essential to unravel the diversification trends of *Eumerus* on the Canaries. This is because the evolutionary histories of *Eumerus* species from the archipelago are linked to those of their host plants. Therefore, further effort is necessary to complete the knowledge of *Eumerus* life cycles on the Canary Islands to reveal the diversification patterns of the genus in the archipelago.

La Palma harbors the highest alpha diversity in *Eumerus*, with up to seven species reported from the island. In contrast, the lowest diversity values are recorded in the Eastern Canaries, with only two species present on each island (Table 1). However, both Fuerteventura and Lanzarote have the highest levels of endemicity, since these are the only islands where *E. canariensis* and *E. purpurariae* are present. In contrast, *E. latitarsis* and *E. purpureus* are the most widespread species within the archipelago, with both recorded on up to five islands (Table 1). Despite this, the presence of species can be affected by geological events (e.g., volcanism) on islands [60], leading to variable levels of diversity, as seen on Fuerteventura and Lanzarote [61]. Likewise, the widespread presence of some species suggests that the trophic regimes of the immature stages are different among the *Eumerus* from the Canaries. For example, *E. amoenus* and *E. obliquus* are not endemic to the Canaries (e.g., [22]). Larvae of these species are saprophagous, developing on nine and six plant genera (respectively), mostly of commercial interest [17]. The endemicity of the other species appears to reflect a more restrictive diet of their larvae. However, as mentioned above, no information is available about the immature stages of *Eumerus* endemic to the Canaries.

At present, all species of *Eumerus* endemic to the Canaries are cataloged under one of the IUCN threatened categories [28]. In addition, habitat is affected by both the human activity (e.g., mass tourism) and the geological activity (e.g., [25]). For example, the small number of individuals of *E. macarius* sp. n. found could indicate a limited population size. The last volcanic eruptions on the Canaries took place in La Palma, in 1971 and 2021 (e.g., [62]). None of them affected the known populations of the new species. However, no information is available on the immature stages or the host/s plant/s of *E. macarius* sp. n..

Future samplings are needed to complete the knowledge of the life cycle and distribution range of *E. macarius* sp. n. in order to get an accurate view of its population trends. The finding of a new species only reinforces the need to carry out further fieldwork in the archipelago to complete the species inventory, update the distribution ranges, and establish conservation actions for all taxa.

Data Availability Statement

The data generated during and/or analyzed during the current study are available from the Supporting Information.

Ethics Statement

All applicable international and national guidelines for the care and use of animals were followed. This article does not contain any studies with human participants performed by any of the authors.

Conflicts of Interest

The authors declare no conflicts of interest.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. (*Supporting Information*) Supporting Information 1. List of examined material. Supporting Information 2. DNA vouchers and accession numbers for the COI-5´ sequences used in this study. Sequences highlighted in bold are new.

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