



A new species of the genus *Embia* Latreille, 1825 (Insecta, Embioptera) from the Madonie Regional Natural Park (Sicily, Italy)

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Abstract

Embia minapalumboi n. sp., a new species of the genus *Embia* Latreille, 1925, was collected during an excursion in the Madonie Regional Natural Park that took place at the conclusion of the XXVII Italian National Congress of Entomology celebrated in Palermo from 12 to 16 June 2023. In the location of discovery, at an elevation of just under 1400 m and therefore unusual for European Embioptera, the new species was found to be very rare and for this reason most of the few juvenile specimens found were kept in breeding by the author. The new species was compared with all 36 species known to date for the genus and in particular with the 21 species from the Mediterranean area and the 8 known from Europe. The author also presents the general distribution of all species of the genus. *Embia tyrrhenica*, Stefani, 1953 is also reported for the Madonie and reconfirmed for Sicily.

Key words: Embioptera, *Embia tyrrhenica*, taxonomy, Mediterranean, endemism

Introduction

Embioptera, also known as webspinners or footspinners, are a small order of polyneopteran insects with interesting anatomical, biological and ethological characteristics (Ross 2000). Their study is quite simple both from a morphological and bio-ethological point of view, as they can be bred and therefore observed with great ease. The discovery of new species of Embioptera is quite frequent but many species are still known only from the original description. In Europe and in the Mediterranean basin these insects are really little-studied; with the exception of the two species described by Fontana (2001, 2002), all the others were described prior to 1967, mainly due to the Italian zoologist Renzo Stefani (1922–2007) and the American entomologist Edward Shearman Ross (1915–2016). Stefani was the author of numerous in-depth studies on the biology and ethology of these insects and of the descriptions of some Mediterranean species, while Ross described most of the species known to date from the Mediterranean basin (Ross 1966). Currently in Europe there are no specialists (apart from the writer) dedicated to the study of this insect order and both taxonomic and chorological knowledge of Embioptera is incomplete.

Embioptera are insects with gregarious habits, often showing maternal behavior (Edgerly 1987). Neotenic females and individuals of both sexes and all stages are capable of weaving tubular tunnels with the silk secreted by their anterior tarsi (Edgerly *et al.* 2020). The order is widespread in tropical areas and hot climate regions, with approximately 250 known species, but Ross (2000) estimated that at least 2000 species likely exist worldwide. In Europe only five genera with 14 species of Embioptera have been reported so far, while in Italy are known seven species which nevertheless constitute the largest number in Europe (Fontana 2021 and 2023). Some species of Embioptera show today an eccentric distribution due to passive transport by humans. As far as the species gravitating in the Mediterranean basin are concerned, some species of the genera *Oligotoma* Westwood, 1837, *Haploembia* Verhoeff, 1904 and *Parembia* Davis 1939 can be considered “weed” species, “spread about during centuries of caravan traffic” (Ross 1981). Current knowledge relating to the genus *Embia*, on the contrary, seems to highlight that these species of Embioptera are in general not very inclined to be passively transported and their distribution in the Mediterranean basin seems to correspond largely to biogeographical factors (Fig. 1).

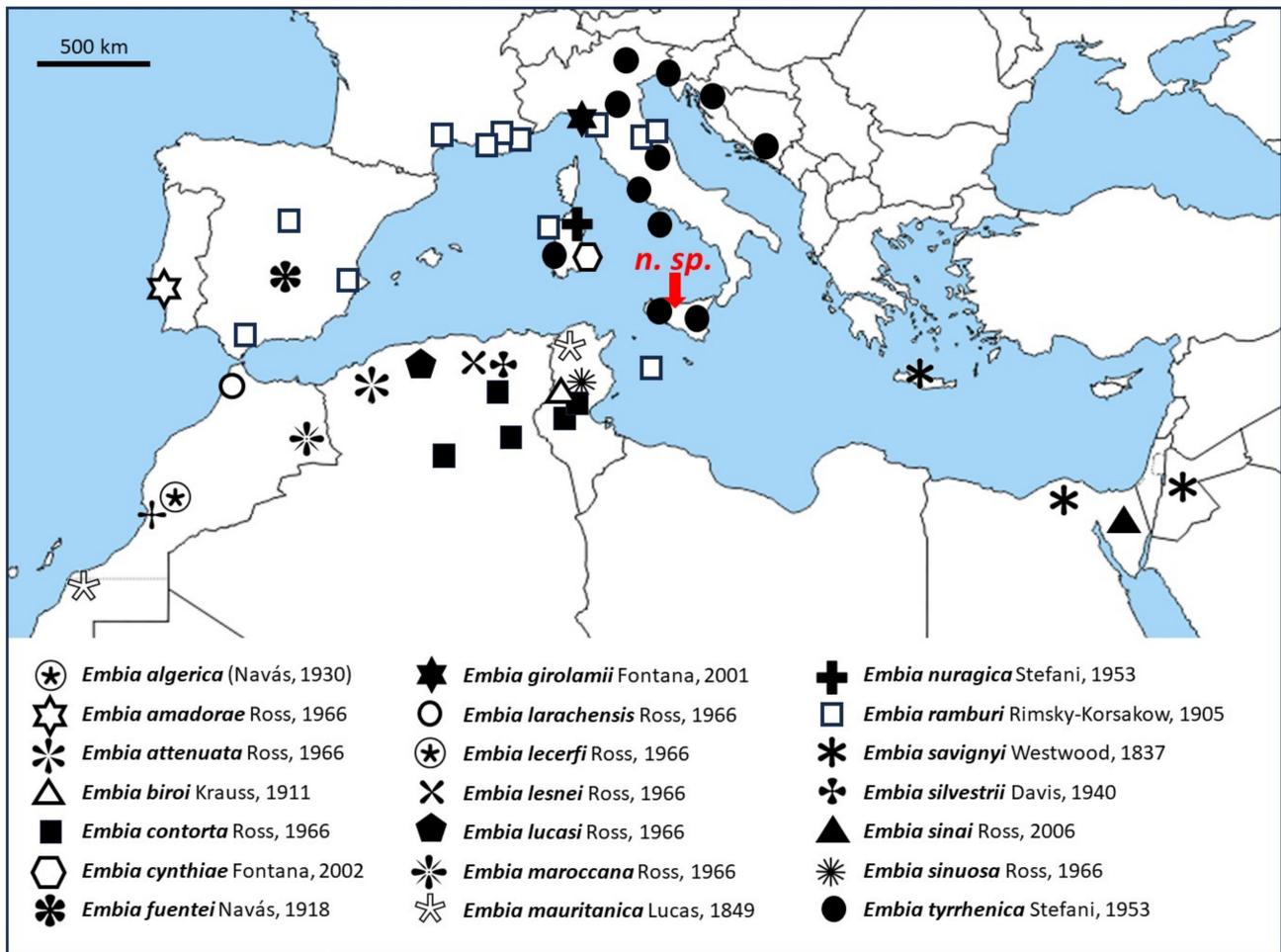


FIGURE 1. Current distribution of the Mediterranean species of the genus *Embia*; the red arrow indicates the location of the new species described below.

The genus *Embia* Latreille, 1825 contains to date 36 species (Tab. 1), 19 of which were described by Ross (Ross 1950, 1951, 1966, 1981, 2006); of the 21 Euro-Mediterranean species, 10 were described by Ross (1966, 2006). The eight known European species are *E. amadorae* Ross, 1966, *E. cynthiae* Fontana, 2002, *E. fuentei* Navás, 1918, *E. girolamii* Fontana, 2001, *E. nuragica* Stefani, 1953, *E. ramburi* Rimsky-Korsakow, 1905, *E. savignyi* Westwood, 1837 and *E. tyrrhenica* Stefani, 1953. Five of these species are known from Italy: *E. cynthiae*, *E. girolamii*, *E. nuragica*, *E. ramburi* and *E. tyrrhenica* (Fontana *et al.* 2022a, 2022b). *Embia tyrrhenica* (Fontana *et al.* 2022b) occurs in Sicily and *E. ramburi* is known from the island of Lampedusa (Fontana *et al.* 2021). A probable new species of *Embia* from eastern Sicily, characterized by large, apterous males, has been under study for many years (Fontana *et al.* 2022b).

The analysis of the scarce bibliography on the genus *Embia* clearly highlights that the distribution and probably the taxonomy of these insects is totally insufficient, since, for example, from the eastern Mediterranean there are very little data. To have a realistic picture of the distribution of the Euro-Mediterranean species of *Embia* it is necessary to rely only on scientific papers written by Embioptera experts; it is very likely that tentative identifications have generated scarcely credible distribution data. For this reason, in defining the distribution map (Fig. 1), only the papers of Ross (1966, 1981, 2006), Stefani (1953, 1959), Fontana (2001, 2002), Battiston & Fontana (2007a, 2007b), Fontana *et al.* (2021, 2022) and the material examined directly have been considered. Examination of the bibliography shows that only in rare cases were species cited after their description, which means that for some species the original description is the only reference to their distribution. An exception to this general situation is Italy, where studies on Embioptera resumed at the beginning of the third millennium and have increased in recent years. The results of these studies in Italy should encourage entomologists to intensify the study of these insects

in the Mediterranean area, given that the probability of finding new species seems high. It will also be necessary to have a better picture of the distribution of already known species to verify how endemic they really are and to evaluate any conservation problems.

The objective of this paper is to describe a new high-elevation species of *Embia* from the Madonie mountain range of Sicily.

Material and methods

The collection of the specimens was carried out in the protected area of the Madonie Regional Natural Park (Italy, Sicily) thanks to a special collection permit (Authorization No. 2 of 12 May 2023) granted by the park itself to the participants to the excursion as part of the XXVII Italian National Congress of Entomology (Palermo, 12–16 June 2023). The Madonie Park Authority expressly granted this permission to increase knowledge of the Park's entomofauna and with the stipulation that the park receive any publications on material collected during the excursion.

The immature specimens of the new species were collected at Piano Farina (Madonie) and maintained in culture according to techniques recommended to the author by Ross (Fontana *et al.* 2002, 2022). Specimens were mounted on slides in Canadian balsam and photos were taken with a high resolution KERN ODC 841 camera mounted on an Optech GZ 808 stereomicroscope. All measurements were taken with a micrometric ocular applied on an Optech EMX-210-2 stereomicroscope. The nomenclature adopted for the different anatomical parts of the Embioptera terminalia (Fig. 2) follows that of Ross (1966). The specimens are preserved at the Fondazione Museo Civico di Rovereto (FMCR, Paolo Fontana coll.) located in the Parolari Palace, Rovereto, Italy. The specimens collected after the donation of the Paolo Fontana collection to the FMCR, such as the holotype of the new species here described and other material, will be deposited in the same public collection. In addition to the material of the Paolo Fontana collection, specimens from the Museo di Storia Naturale Giacomo Doria of Genova (MSNG) were examined and are listed below:

E. tyrrhenica Stefani, 1953 (winged form): Italy, Sardinia, Gonnese (Carbonia-Iglesias), leg. R. Stefani, 2 paratype males (1 in alcohol and 1 on slide, MSNG); Sicily, Madonie Mountains, Pian Zucchi, 21.VI.1961, leg. L. Tamanini (FMCR, Paolo Fontana coll.).

E. tyrrhenica Stefani, 1953 (apterous form): Italy, Sardinia, Mandas (Sud Sardegna), leg. R. Stefani, 2 paratype males (1 in alcohol and 1 on slide, MSNG).

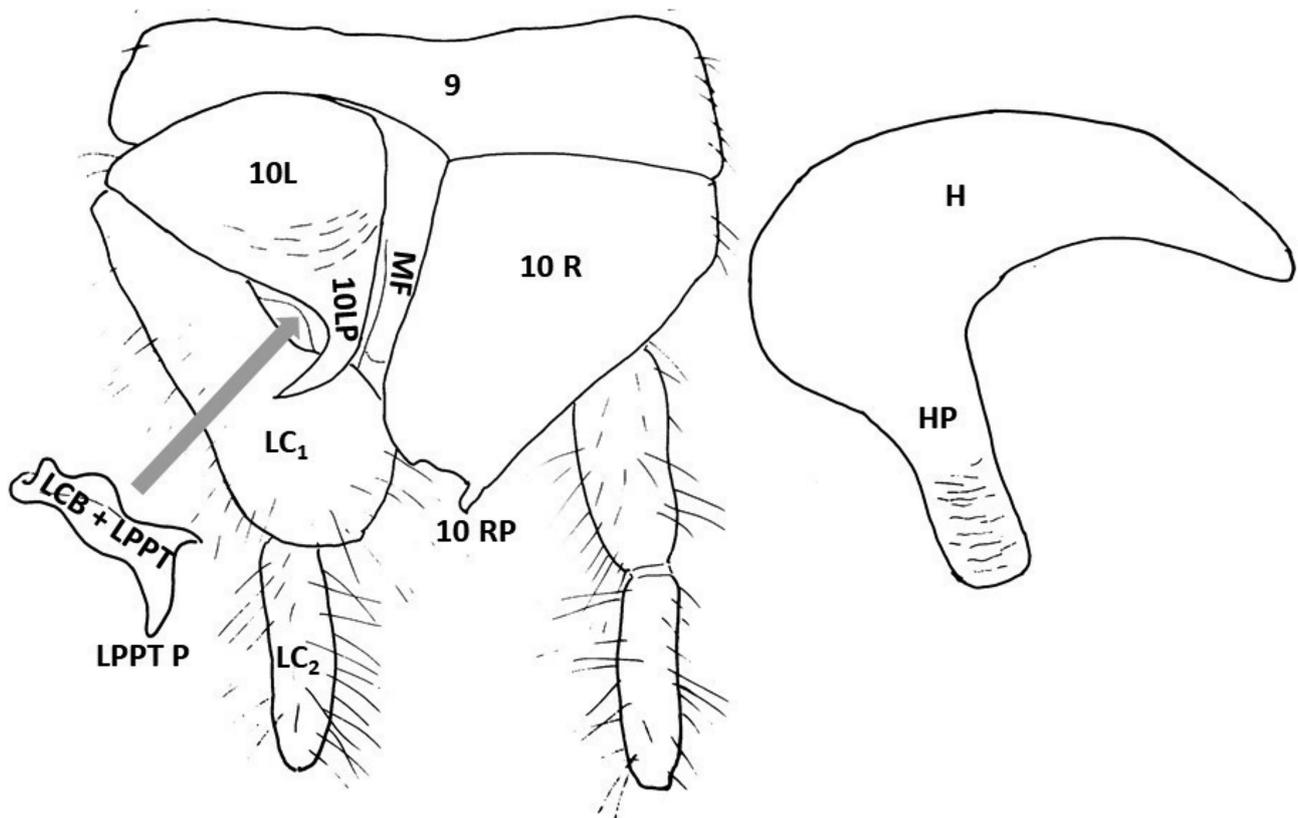
E. nuragica Stefani, 1953: Italy, Sardinia, Macomer (Nuoro), leg. R. Stefani, 2 paratype males (1 in alcohol and 1 on slide, MSNG).

To this material must be added a specimen recently found in my collection of dry specimens, which has been mounted on a slide:

E. tyrrhenica Stefani, 1953 (winged form): Italy, Sicily, Madonie Mountains, Pian Zucchi, 21.VI.1961, leg. L. Tamanini, 1 adult male on slide (FMCR, Paolo Fontana coll.).

The Madonie Regional Natural Park

With an area of 40,000 hectares and an elevational range of near sea level to nearly 2000 meters, the Madonie Regional Natural Park represents a cross-section of the natural history of Sicily, showing climatic, geological, vegetational and faunal variation of enormous ecological and anthropological interest and significance. The Madonie mountains are broken into a mosaic of blocks, whose physical uniformity is only apparent. The central areas are of a calcareous nature, with a harsh and hard morphology, while the peripheral areas, of a clayey-sandy nature, are characterized by a decidedly softer morphology. The Madonie represents approximately 2% of the surface of the whole of Sicily but is home to more than half of the 2,600 plant species known to the island. There are several endemic or characteristic species of the highest Mediterranean peaks. The Madonie hosts all the species of mammals that live in Sicily, almost 70% of the species of nesting birds and a percentage close to 60% of the Sicilian invertebrate species. This important



In dorsal view

- 9** : ninth abdominal tergite.
- 10 L** : left hemitergite of tenth segment.
- 10 LP** : process of left hemitergite of tenth segment.
- 10 R** : right hemitergite of tenth segment.
- 10 RP** : process of right hemitergite of tenth segment.
- MF** : median flap of right hemitergite of tenth segment.
- LCB** : left cercus-basipodites.
- LPPT** : left paraproct.
- LPPT P** : process of left paraproct.
- LC₁** : basal segment of left cercus.
- LC₂** : apical segment of left cercus.

In ventral view

- H** : hypandrium, or ninth abdominal sternite.
- HP** : Process of hypandrium.

FIGURE 2. Nomenclature used for the different anatomical parts of the Embioptera (from Ross 1966).

mountain complex alone would therefore allow a reliable reconstruction of the natural history of the Sicilian fauna. Karst is well represented in the Madonie and has given rise to one of the most characteristic landscapes of these mountains, including sinkholes, dead valleys, caves, wells and real abysses. The karst processes are still active, both due to the climatic characteristics determined by historically high rainfall (reduced in recent years) and by the persistence of the snow cover at higher elevations, which allows prolonged erosion. A particularly interesting form of karst is that of Piano Battaglia and the nearby Piano Farina (Fig. 7), featuring sinkholes at the bottom; they represent the most extensive and evocative karst landscape of the Carbonara complex, among the most important in Italy.

TABLE 1. List of species of the genus *Embia* and relative general distribution. The species in bold are those from the Mediterranean area.

SPECIES	KNOWN DISTRIBUTION
<i>Embia adenensis</i> Ross, 1981	Yemen
<i>Embia algerica</i> (Navás, 1930)	Morocco
<i>Embia alomatae</i> Ross, 2006	Ethiopia
<i>Embia amadora</i> Ross, 1966	Portugal
<i>Embia asmarae</i> Ross, 2006	Eritrea
<i>Embia attenuata</i> Ross, 1966	Algeria
<i>Embia biroi</i> Krauss, 1911	Tunisia
<i>Embia brevispina</i> Ross, 2006	Ethiopia
<i>Embia colliger</i> Enderlein, 1909	Eritrea
<i>Embia contorta</i> Ross, 1966	Algeria and Tunisia
<i>Embia conula</i> Ross, 2006	Ethiopia
<i>Embia cynthiae</i> Fontana, 2002	Italy (Sardinia)
<i>Embia dobhali</i> Ross, 1950	India
<i>Embia fuentei</i> Navás, 1918	Spain
<i>Embia girolamii</i> Fontana, 2001	Italy (Tuscany)
<i>Embia larachensis</i> Ross, 1966	Morocco
<i>Embia lecerfi</i> Ross, 1966	Morocco
<i>Embia lesnei</i> Ross, 1966	Algeria
<i>Embia lucasi</i> Ross, 1966	Algeria
<i>Embia luridiceps</i> Enderlein, 1912	Eritrea
<i>Embia maroccana</i> Ross, 1966	Morocco
<i>Embia mauritanica</i> Lucas, 1849	Algeria, Tunisia and Libya
<i>Embia minor</i> Mukerji, 1927	India
<i>Embia nigriceps</i> Ross, 2006	Eritrea
<i>Embia nigrula</i> Ross, 1981	Yemen
<i>Embia nuragica</i> Stefani, 1953	Italy (Sardinia)
<i>Embia pallida</i> Ross, 1951	Sudan
<i>Embia rabaulti</i> Navás, 1934	India
<i>Embia ramburi</i> Rimsky-Korsakow, 1905	France, Spain, Balearic Islands, and Tunisia
<i>Embia savignyi</i> Westwood, 1837	Egypt, Palestine, Jordan, Crete, Sudan, Ethiopia, Sahel, Cameroon, Nigeria and Benin
<i>Embia shoa</i> Ross, 2006	Ethiopia
<i>Embia silvestrii</i> Davis, 1940	Algeria
<i>Embia sinai</i> Ross, 2006	Egypt
<i>Embia sinuosa</i> Ross, 1966	Tunisia
<i>Embia tartara</i> Saussure, 1896	Kirghizistan, Tagikistan, Turkmenistan, Uzbekistan and Kazakhstan
<i>Embia tyrrhenica</i> Stefani, 1953	Italy and Croatia

Taxonomy

***Embia minapalumboi* n. sp.**

(Table 1; Figs. 1–8)

The new species is described from a single male that became adult in the laboratory, a few weeks after collecting a small group of immature Embioptera living gregariously within a dense network of silk tunnels (Fig. 3) under a small



FIGURE 3. *Embia minapalumboi* n. sp. a) gynopaedium; b) immature female; c) male nymph inside a silk tunnel; d) male nymph.



FIGURE 4. *Embia minapalumboi* n. sp. a) living adult male holotype; b) female. Both specimens collected as nymphs and reared to the adult stage.



FIGURE 5. *Embia minapalumboi* n. sp. a) male holotype mounted on slide in full (collected as nymph and become adults after rearing); a) b) head from above, c) male terminalia in dorsal view, d) male terminalia in ventral view.

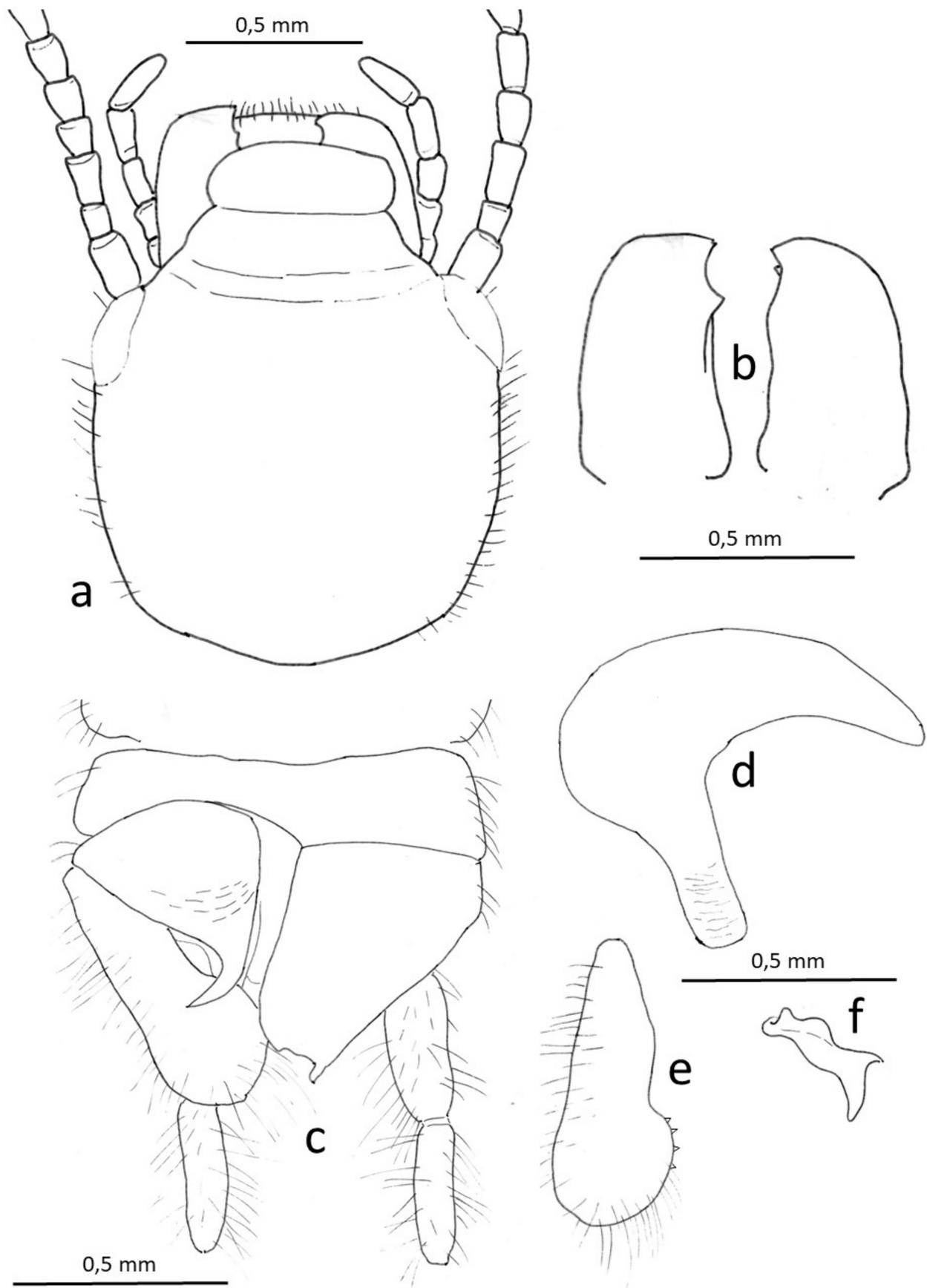


FIGURE 6. *Embia minapalumboi* n. sp. Holotype male mounted on slide. a) head from above; b) mandibles; c) male terminalia in dorsal view; d) right hemitergite of tenth segment (10R) in ventral view; e) basal segment of left cercus (LC₁) in dorsal view; f) left paraproct (LPPT) in dorsal view.



FIGURE 7. Type locality of *Embia minapalumboi* n. sp.: Piano Farina, Parco Naturale Regionale delle Madonie, Petralia Sottana (Palermo), elev. 1380 m, 16 June 2023.

stone about 20 cm long (Fig. 3a). This aggregation likely was derived from the offspring of a fertile female. This sort of “pedotrophic nest” where the female, at least at the beginning, provides her maternal care to the offspring, is termed a *gynopaedium*. At least some specimens were close to becoming adults as evidenced by their size, color (Figs. 3b, 3c) and especially by the presence of a young male with wing buds (Fig. 3d). The collected individuals were maintained in the laboratory as a breeding population, from which one male was selected for taxonomic study to avoid decimating the small population. This new species seems to be quite rare in Piano Farina, given that in several hours of intense research only a single group was found. The male exhibited such distinctive characteristics that it was decided to describe the new species as soon as possible, with the additional aim of undertaking a path for its protection.

Type material. Male holotype on slide: ITALY, Sicily, Parco Naturale Regionale delle Madonie, Petralia Sottana (Palermo), 1380 m, 37°51'44.64"N 14° 4'26.70"E ,16.VI.2023 (nymph became an adult male after rearing and was collected 20.VII.2023), leg. and rearing P. Fontana, deposited in the Paolo Fontana collection in Rovereto (FMCR).

Description of holotype male. Living specimen of medium size, winged, uniformly dark brown with dark hairs (Figs. 4a, 5a).

Mounted specimen 11,68 mm long, from the apex of the mandibles to the apex of the terminalia (LC2). Cranium sub-rectangular, elongate, lacking dorsal pattern; 1,65 mm long and 1,24 mm wide (Figs. 5b, 6a).

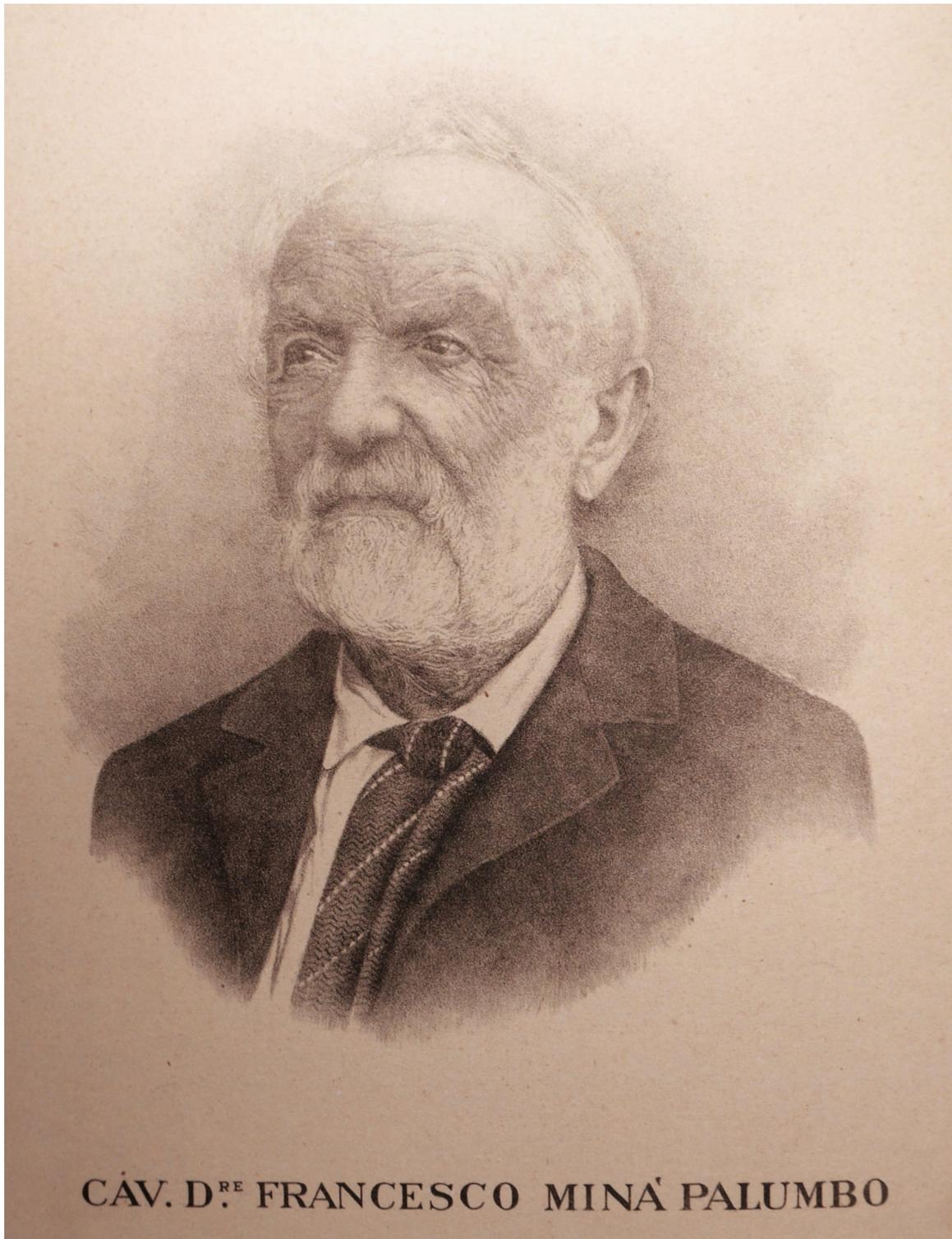


FIGURE 8. Portrait of Francesco Minà Palumbo at 50 years of age, distributed by him to his closest friends.

Antennae dark brown with apex of each antennal segment colourless. First antennal segment clearly larger than the second and shorter than the third one; third antennal segment twice as long as the second segment. Eyes well developed, not projecting (Fig. 5b). Labium with anterior margin almost straight and apical half lighter than basal half. Mandibles elongate with three teeth on the left mandible and two on the right one (Figs. 5b, 6a, 6b). Wings in the living specimen light brown in color, not covering the terminalia; wings in the slide-mounted specimen with smoky interveinal spaces; fore right wing 5,54 mm long, 1,44 mm wide; hind right wing 5,04 mm long,

1,38 mm wide. Terminalia with caudal margin of left hemitergite of tenth segment (10 L) almost straight. Left process (10 LP) small, short, tapered and strongly outcurved, with sharp apex (Figs. 5c, 6c). Right hemitergite (10 R) subtrapezoidal. Right process (10 RP) pointed and visible from above (Figs. 5c, 6c). Median flap (MF) not sclerotized, not pigmented and scarcely developed. Left cercus-basipodites and left paraproct (LCB + LPPT) large, well-sclerotized and darkly pigmented; process of left paraproct (LPPT P) well developed and subconical (Figs. 6f). Basal segment of left cercus (LC₁) with inner side concave, abruptly and strongly expanded to the apex and with few (four are well visible) short subconical spines at the internal margin of the apical dilatation (Figs. 5c, 6c), 0,76 mm long and 0,25 mm wide at its maximum subapical dilatation. Apical segment of left cercus (LC₂) subcylindrical, about half length of LC₁. Left and right cerci with long hairs, longer than cercus diameter; LC1 with hairs only on outer side. Hypandrium, or ninth abdominal sternite (H), sickle-shaped (Fig. 6d) with very long process (HP). Hind basitarsus with one papilla (as usual in *Embia*), scarcely projecting.

Female. Only living females were observed. They are dark brown, almost resembling male but a little larger (Fig. 4b).

Habitat. *Embia minapalumboi* n. sp. was collected in a karst environment, in a prairie with abundant *Astragalus nebrodensis* (Guss.) Strobl and *Asphodelus microcarpus* Salzm. et Viv., with shrubs of *Rubus* sp., *Rosa* sp., *Crataegus* sp. and surrounded by *Quercus* cf. *pubescens* woods (Fig. 7).

Affinities. The adult winged male of *Embia minapalumboi* n. sp. is similar to the holopterous males of *E. tyrrhenica*. The new species differs from this species by its brown colour and brown wings; *E. tyrrhenica* is black with grey wings. However, the terminalia of the new species allow its separation from all other *Embia* spp. described up to date. The shape of the basal segment of the left cercus (LC1) of *E. minapalumboi* n. sp. is similar to that of *E. ramburi* (which has exclusively apterous males) but otherwise the morphology is quite different. Regarding the process of the left hemitergite of the tenth segment (10 LP), that of the new species is comparable only to that of *E. tyrrhenica*, which, however, has a different basal segment of the left cercus (LC1). Unique to *E. minapalumboi* n. sp. are the shape of the hypandrium (H) and the length of the process of hypandrium (PH), as well as the structure of the left cercus-basipodites and left paraproct (LCB + LPPT) which is quite large, well-sclerotized and darkly pigmented. The process of the left paraproct (LPPT P) is well developed but short and subconical, slightly curved and with a rounded apex, very different from the same structure of *E. tyrrhenica* in which it is much longer, hooked and sharp at the apex.

Derivatio nominis. The new species is named after the talented Sicilian doctor, botanist and naturalist Francesco Minà Palumbo (Castelbuono, 14 March 1814–12 March 1899) (Fig. 8), who dedicated his entire life to the study of nature, especially on the Madonie Mts., where he lived from birth to death (Fig. 8).

Conclusion

The discovery of *E. minapalumboi* n. sp. at nearly 1400 m elevation is quite exceptional given that most European species of Embioptera live at much lower elevations down to sea level. Only a few *Embia* spp. are known from mountain environments, such as *E. lecerfi* Ross, 1966, present in Morocco at 1500–1600 m, *E. brevispina* Ross, 2006 known from Ethiopia at 1600 m and *E. shoa* Ross, 2006, also from Ethiopia, where it lives at 3000 m. The presence of Embioptera at high elevations in the Madonie had already been reported by Battiston & Fontana (2007), who had cited two nymphs not identifiable even at the genus level, collected at 1100 m in Piano Zucchi (Palermo) on 8.V.1981 by Roberto Poggi. The presence of Embioptera in Piano Zucchi is confirmed by the study of an adult winged male, which must be clearly identified as *E. tyrrhenica* Stefani, 1953. Piano Zucchi is about 8 km as the crow flies from Piano Farina, the type locality of *E. minapalumboi* n. sp. but it is not surprising that multiple species of Embioptera, even of the same genus, can live sympatrically in close geographical locations and even in the same network of silken galleries. *Embia tyrrhenica* was known from Sicily by a photo taken in an unspecified location on Mount Etna (Fontana *et al.*, 2022b), but now that the species is confirmed with greater certainty in montane environments, this could indicate a wider presence of these insects on this mountain chain. The description of *E. minapalumboi* n. sp. increases the already large contingent of Italian Embioptera, which constitute the most complex and probably the best known in Europe. The description of this new species from the Madonie Regional Natural Park should provide a stimulus for future studies and above all to create the conditions for its protection within the natural reserve that hosts it.

Acknowledgments

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