Zootaxa 5507 (4): 549–564
https://www.mapress.com/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.5507.4.3
http://zoobank.org/urn:lsid:zoobank.org:pub:D3FA9A92-1850-4F5D-9875-602A793BE328

Unexpected complexity of the Embioptera (Insecta) fauna of the Tuscan Archipelago (Italy), with the disambiguation of two species of *Haploembia* Verhoeff, 1904 and description of a new species of *Embia* Latreille, 1825

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Abstract

Very little is known about the Embioptera of the Tuscan Archipelago, and no specific study has been published from there on this insect order. The study of literature and new material has allowed us to identify the presence of four species of Embioptera in the Tuscan Archipelago: *Haploembia solieri* (Rambur, 1842), *Haploembia tarsalis* Ross, 1940 (which was reported for the first time in Italy), Embia ramburi Rimsky-Korsakov, 1905 and *E. ilvana* n. sp., which is described here. As regards the species of the genus *Haploembia* Verhoeff, 1904, some bio-ethological aspects and the global distribution of the two species present in the archipelago are discussed.

Key words: Embioptera, taxonomy, Mediterranean, insularity, endemism, *Haploembia tarsalis*, *Haploembia solieri*, *Embia ramburi*, citizen science

Introduction

The order Embioptera, commonly known as webspinners, are insects with gregarious habits, living inside tubular tunnels that they build with the silk secreted by their front tarsi. They are widespread in tropical areas and hot climate regions. There are approximately 250 known species in the world with perhaps 750 already discovered and identified but not yet described (Ross, 2000). The order Embioptera was described only in 1900, by the Belgian entomologist Auguste Alfred Lucien Gaston Lameere (1864–1942) and these insects are among the least studied insects in Europe and in the Mediterranean basin. Many authors have given a more or less large contribution to the study of these insects, both from a systematic point of view and their biology, even if their publications have, in many cases, only minimally concerned the European and Mediterranean fauna. Among the entomologists who left significant publications on Embioptera we must remember, in chronological order, the Frenchman Jules Pierre Rambur (1801–1870), the German Hermann August Hagen (1817–1893), the Austrian Hermann August Krauss (1848 –1939) , the Spaniard Longinos Navás (1858–1938), the German Günther Enderlein (1872 –1968), the Italian Filippo Silvestri (1873–1949), the Russian Mikhail Nikolaievich Rimsky-Korsakow (1873–1951), the American Davis John June (1885–1965), the British John Obadiah Westwood (1805–1893) and the French Lucien Maurice Chopard (1885–1971), the American Edward Shearman Ross (1915–2016) and the Italian Renzo Stefani (1922–2007). The first species of embiopteran described with typical locality in Europe (France, Marseille) was *Haploembia solieri* (Rambur, 1842). The knowledge of the European Embioptera and the Mediterranean basin is essentially due to the studies of Ross (1966) and Stefani (1953a, 1955 and1959) and in recent decades these insects have been studied mainly in Italy with the description of some new species (Fontana, 2001, 2002,2024). Studies on Embioptera conducted in the Tuscan Archipelago National Park are part of a campaign of investigations aimed at

Accepted by E. Bernard: 31 Jul. 2024; published: 16 Sept. 2024

providing broader and more in-depth knowledge of this order of insects in Italy, where the most complex contingent of species occurs.

The Tuscan Archipelago covers approximately 300 km². It is located between the coasts of Tuscany and Corsica, and is composed of seven larger islands (Elba, Giglio, Capraia, Montecristo, Pianosa, Giannutri and Gorgona) and a few smaller islets. It is bordered by four seas: Ligurian, Tyrrhenian, Piombino Channel and Corsica Channel. The islands have widely varied geomorphological conformation, spanning from Pianosa Island, where the highest elevation is 29 m above sea level, to the summit of Mount Capanne (Elba Island), 1019 m above sea level. Geological origin and composition are also heterogeneous and different for each island (Aringoli *et al.* 2009). As a consequence, each island has its own peculiar and delicate vegetation communities (Foggi & Pancioli 2008, Foggi & Grigioni 1999, Viciani *et al.* 2011, Foggi *et al.* 2006, 2011).

Tuscan Archipelago National Park was established in 1996. This protected area includes approximately 50% of the territory of Elba Island, 40% of Giglio Island, 80% of Capraia Island and 100% of the smaller islands. The vascular flora of the Archipelago includes about 1,400 taxa (Foggi *et al.* 2014), of which 1098 occur on Elba Island alone (Carta *et al.* 2018); as many as sixteen of these vascular plants are endemic to the Archipelago and of great conservation importance (Foggi *et al.* 2014). The terrestrial fauna of this area has been the subject of numerous studies, both for vertebrates (Amori *et al.* 2015; Angelici *et al.* 2009; Marinis *et al.* 1996; Arrigoni degli Oddi & Damiani 1911–1912; Di Carlo 1976) and invertebrates (Dapporto and Cini 2007, Ceccolini *et al*. 2012, Rocchi *et al*. 2014, Fattorini *et al.* 2017, Barbato *et al*. 2018, Forbicioni et al 2019). This large group of living organisms is represented in the Tuscan Archipelago by some key species for conservation efforts, such as e.g. *Eurythyrea quercus* (Herbst, 1780) (Buprestidae) recently reported in Elba (Forbicioni et al 2024) and numerous endemic species, including gastropods, e.g. *Oxychilus oglasicola* Giusti, 1968 (Oxychilidae) and *Tacheocampylaea tacheoides* (Pollonera, 1909) (Helicidae); spiders such as *Nemesia ilvae* Caporiacco, 1950 (Nemesiidae); and numerous insects including the curculionid weevils *Pseudomeira zanichelliae* Bellò, Forbicioni & Ruzzier, 2019, *Meira tedeschii* Pierotti, 2014 and *Otiorhynchus laurae* Solari & Solari, 1907, as well as *Zerynthia cassandra linnea* Bryk, 1932 (Papilionidae).

FIGURE 1. Map of the Tuscan Archipelago (Tuscany, Italy).

Material and methods

Collection and breeding. The collection of the specimens was carried out in the protected area of the Tuscan Archipelago National Park (Italy, Tuscany) thanks to the authorization for entomological investigations on the Tuscan Archipelago Islands for the three-year period 2022–2024 (L. 394/91; Presidential Decree 07/22/96), issued to the authors by the Park Director Dr.. Maurizio Burlando.

Some immature specimens of the new species collected at Porto Azzurro (Elba Island, Livorno) were placed in breeding following the techniques recommended to the author by Edward S. Ross (Fontana *et al.* 2002, 2022).

Identification. For taxonomic study of collected Embioptera, specimens were mounted on slides following as previously described (Fontana *et al.* 2002, 2022a, 2022b). Briefly, specimens and the relative anatomical details here illustrated and studied were mounted on slides in Canadian balm. Photos were taken with a camera C-Mount—High resolution Kern ODC 841 camera (Kern & Sohn, Balingen, Germany) mounted on a stereomicroscope (Optech GZ 808). All measurements were taken with an ocular micrometer on a stereomicroscope Optech EMX-210-2. The nomenclature adopted for the different anatomical parts of the Embioptera (Fig. 2) follows the monograph by Ross (1966).

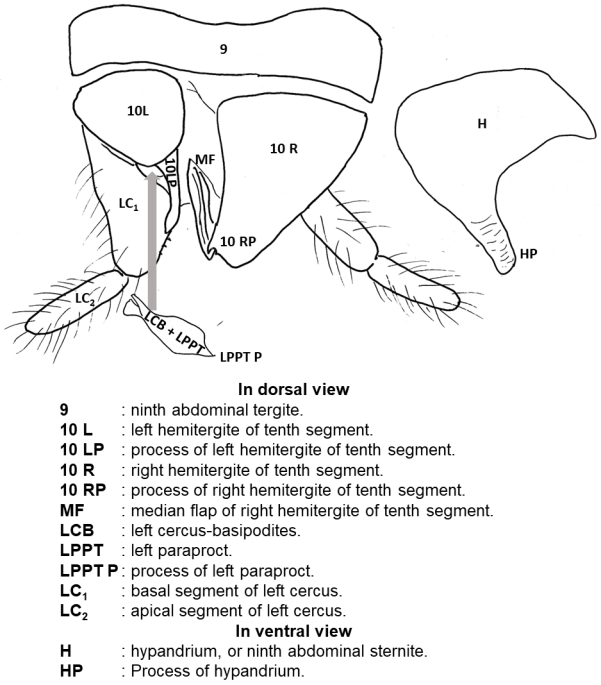

FIGURE 2. Nomenclature adopted for the different anatomical parts of the Embioptera from Ross (1966). *Embia ilvana* **n. sp.**, male holotype, Elba island, Porto Azzurro, Buraccio, "I Giardini di Poseidone farm" (Livorno).

Conservation of specimens. The specimens, object of this study, are preserved at the Fondazione Museo Civico di Rovereto (FMCR, Paolo Fontana coll.) located in the Parolari Palace (Rovereto, Italy), the Museo di Storia Naturale Giacomo Doria of Genova (MSNG) and from Lucija Šerić Jelaska (LSJpc) private collection (Zagreb, Croatia)

Specimens of *Embia* discussed in this article are listed below together with species not yet found in the Tuscan Archipelago, but which have been used for comparison to the material under study.

E. tyrrhenica Stefani, 1953 (winged form): Italy, Sardinia, Gonnesa (Carbonia—Iglesias), leg. R. Stefani, 2 paratype males,1 in alcohol and 1 on slide (MSNG).

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).

E. girolamii Fontana, 2001: Italy, Tuscany (Lucca), Nature Reserve "La Lecciona", Viareggio, Marina di Levante, leg. P. Fontana, male holotype, on slide (FMCR, Paolo Fontana coll.).

E. cynthiae Fontana, 2002: Italy, North-eastern Sardinia (Sassari), Capo Ceraso, Olbia, leg. P. Fontana, male holotype, on slide (FMCR, Paolo Fontana coll.).

E. minapalumboi Fontana, 2024; Italy, Sicily, Parco Naturale Regionale delle Madonie, Petralia Sottana (Palermo), leg. P. Fontana, male holotype, on slide (FMCR, Paolo Fontana coll.).

Results

Embioptera of the Tuscan Archipelago National Park

Knowledge about the Embioptera of the Tuscan Archipelago is scarce and fragmentary. Most of the reports concern the genus *Haploembia* Verhoeff, 1904. The only report for *Embia* (Latreille, 1825) is that of Battiston & Fontana (2007), who reported the presence of *Embia ramburi* Rimsky-Korsakov, 1905 on Isola del Giglio. Concerning *Haploembia*, Stefani (1955, 1956, 1983) and Ross (1966) that the amphigonic and parthenogenetic populations of *H. solieri* coexist on the same island and even in the same locality. Recently, these two populations were assigned to two distinct species (Hodson *et al.* 2014, and Kelly *et al*. 2018): *H. solieri* (Rambur, 1842) and *H. tarsalis* (Ross, 1940). It is therefore necessary to reconstruct the taxonomic history of these two species before referring to the various citations of *Haploembia* to one species or another.

Taxonomy

Family Oligotomidae Enderlein, 1909

Haploembia Verhoeff, 1904

Among the European Embioptera the genus *Haploembia* Verhoeff, 1904 is characterized by having, both in males and females (in the juvenile and adult stages) the basitarsus of the hind legs with two callosities and not just one as in the genera *Embia* Latreille, 1825, *Oligotoma* Westwood, 1837 and *Cleomia* Stefani, 1953, and for always having apterous males. The genus *Parembia* Davis 1939, recently cited for Cyprus (Fontana & Bardiani, 2023) is also characterized by having two callosities in the basitarsus of the hind legs but in this genus the males are always winged while in the genus *Haploembia*, in the amphigonic species, the males are always apterous. *Haploembia* was first described as a subgenus of *Embia* Latreille, 1825 by Verhoeff (1904) and then elevated to the rank of genus by Enderlein (1909). The type species of the genus is *H. solieri* (Rambur, 1842), described on a juvenile form (also lacking head and legs) collected around Marseille (France). A detailed description and therefore the identity of this species was given by Stefani (1955), based on the examination of an adult male from Civitavecchia (Italy, Rome). This definition was confirmed by Ross (1966) and subsequent authors. The genus *Haploembia* belongs to the family Oligotomidae Enderlein, 1909 and now includes only three species, since most of the species originally placed this genus have been assigned to other genera over the years. For example, *H. clypeata* Navas, 1923 and *H. verhoeffi* Friederichs, 1907 (Zaire and East Africa), as well as *H. megacephala* Krauss, 1911 (Syria), were transferred by Ross (1999) and Hodson *et al*. (2014) to different genera. The three species now assigned with certainty in *Haploembia* are *H. solieri* (Rambur, 1842), *H. tarsalis* (Ross, 1940) and *H. palaui (*Stefani, 1955).

Ross (1940) had described a population of Embioptera composed of only parthenogenetic females from many locations in California and Arizona (USA). Until then these Embioptera had been attributed to *Embia californica* Banks, 1906, a species subsequently synonymized with *Oligotoma nigra* Hagen, 1885. After breeding many female specimens, Ross demonstrated that they were parthenogenetic and described it as *Gynembia tarsalis* Ross, 1940. He also treated *Gynembia* as a "*genus incertae sedis*", being not able to attribute it to any known family. Ross (1940) initially considered *Gynembia tarsalis* a native species of western America, from California to the border with Mexico. A few years later Ross (1944) noted that the hind tarsus chaetotaxy of *G. tarsalis* was nearly identical to that of Mediterranean *Haploembia*. A few years later, Stefani (1953a) mentioned having found a parthenogenetic female assignable to *Haploembia solieri*. From this report arose an exchange of letters and specimens between Stefani and Ross after which Stefani, in his revision of the genus *Haploembia* (Stefani, 1955), established the

synonymy between *G. tarsalis* and *H. solieri*, which was subsequently accepted by Ross himself (1957). In the same publication Stefani (1955) described *H. palaui* known only from the Balearic Islands, the Iberian Peninsula and some Greek islands (Ross, 1966; Murányi, 2013).

Throughout the 1950s and early 1960s, Stefani carried out significant in-depth research on the amphigonic and parthenogenetic populations of *H. solieri*, studying their morphological, ethological, cariological and parasitological aspects. He described in detail the peculiar mating behaviour of the amphigonic populations (Stefani, 1953b), addressed the problem of parthenogenesis in a substantial monograph (Stefani, 1956), investigated the relationships between parasitosis and male sterility (Stefani, 1960a), and identified the presence of a strong reproductive isolation between amphigonic and parthenogenetic populations (1960b). Later he identified numerous distinctive morphological characters in the amphigonic and parthenogenetic forms, both at the level of adult females and of the eggs laid by them (Stefani & Contini, 1961).

Initially, when the parthenogenetic populations of *Haploembia solieri* seemed confined to Sardinia and Corsica, Stefani had assumed that it was a case of geographical parthenogenesis and therefore a Sardinian-Corsican endemism, transferred anthropically to North America. But after parthenogenetic populations were found in many other areas of the Mediterranean (Elba Island, Giglio Island, Argentario, Capri Island, Rome, in various locations along the Ligurian coasts, Balearic Islands, Albania, Canary Islands, on the Spanish Mediterranean, Lebanon, in California, Texas and Arizona), Stefani considered it more probable that parthenogenesis had arisen independently within amphigonic populations in the various localities (Stefani, 1983), following a greater degree of infestation by the coelomatic gregarine *Diplocystis clerci* Léger, 1904 (Eugregarinorida: Diplocystidae) (Dini *et al.* 1995). This protist parasitizes both males and females of *H. solieri* but causes sterility only in males (Stefani, 1960a, 1960c and 1962). For many years the amphigonic and parthenogenetic populations were considered as belonging to a single species, *H. solieri*, making *Gynembia tarsalis* its synonym. After the discovery of an amphigonic population of *H. solieri* in California (Redwood City), Ross (1984) once again considered it plausible that the parthenogenetic form was a distinct species for its lighter pigmentation, its egg-form distinctions, and the absence of sexual relationships with males of typical *solieri*. About thirty years later, the discovery in the USA of other amphigonic populations of *H. solieri* examined with molecular techniques, demonstrated that amphigonic and parthenogenetic populations were two distinct species, namely *H. solieri* and *H. tarsalis* (Hodson *et al*., 2014; Kelly *et al*., 2018).

Haploembia solieri **(Rambur, 1842)**

H. solieri, despite being a species characterized by apterous males, highlights at first sight a marked sexual dimorphism given primarily by the notable difference in size between females and males. This characteristic is generally evident, as regards European species, especially for species with winged males, much smaller than females, while in species with apterous males (in the genus *Embia*) the difference in size between the sexes is much smaller. In addition to the much smaller size, the males of *H. solieri* show a much more intense colour and are two-colored with reddish pronotum and front and middle legs and the rest of the body blackish. As regards the females, Stefani & Contini (1961) had highlighted several distinctive characteristics between the females of *H. solieri* and *H. tarsalis* (parthenogenetic form) and these were largely confirmed by Hodson *et al*. (2014) and then by Kelly *et al*., (2018). The most evident and constant character is a more marked pigmentation in the females of *H. solieri*, which are dark amber in colour (often with the pronotum and partly the head of a lighter colour), while those of *H. tarsalis* are light straw in colour. *H. solieri* can be easily separated from *H. palaui* Stefani, 1955 (as regards the males) due to the marked longitudinal prominence along the dorsal margin of the mandibles while as regards the structures of the terminalia no significant differences are highlighted (Stefani, 1959).

H. solieri has a wide distribution in the Mediterranean area and has also been more recently introduced into North America. Amphigonic populations of this species are known from the Coastal regions of Portugal, Canary Islands, Madeira, Spain, southern France, Italy, islands of Tyrrhenian Sea, Yugoslavia, Albania, Greece, Crete, Bulgaria, Ukraine (Crimea), southern Russia, Turkey, Egypt, California, Arizona, Texas (Ross, 1966; Hodson *et al*. 2014 and Kelyy *et al*. 2018). *H. solieri* has also been reported in Russia (Dagestan) (Temreshev, 2015) and has been recently discovered in Georgia (Seropian *et al*., 2023).

H. solieri was for a long time the only embiopteran known from the Tuscan Archipelago but it is also known from other islands and localities: Elba and Pianosa (Stefani, 1955); Porto Azzurro (Elba), Porto Ferraio (Elba), Marina di

campo (Elba) and Giglio Island (Stefani, 1956); islands of the Tyrrhenian Sea (Ross, 1966) and Montecristo Island (Battiston & Fontana, 2007).

Examined Material. Italy, Tuscany, Tuscan Archipelago, Portoferraio (Livorno), Forte Inglese, 42°48'59.72"N 10°19'5.64"E, 25.V.2022, 2 adult males and 1 adult female, leg. P. Fontana (FMCR, Paolo Fontana coll., in alcool).

Additional material. Italy, Liguria, Liguria, Cervo (Imperia), macerie, 15.VII.2004, leg. R. Fabbri, 2 adult males (on slide) (MSNG); Liguria, Diano Castello, Varcavello (Imperia), 100 m—bosco (= wood), 2.VI–15.VII.2004, leg. R. Fabbri, 1 male (on slide) (MSNG); Liguria, Poggi (Imperia), via del Colle,200 m, leg. O. Maioglio1 male (FMCR, Paolo Fontana coll., in alcohol); Tuscany, Piombino, Baratti (Livorno), coastal pine forest, 42°59'32.38"N 10°30'40.82"E, 10.VII.2022, 2 adult males and 1 adult female, leg. P. Fontana (FMCR, Paolo Fontana coll., in alcool); Campania, Felitto, Agriturismo L'Occhiaio, 40°23'0.70"N 15°14'56.54"E, 16.X.2021 (nymps), 9.VI.2022 (adults), 2 males, , leg. P. Fontana (FMCR, Paolo Fontana coll., in alcool); Apulia, Corato (Bari), 21.VI.1999, 1 adult male, leg. P. Fontana (FMCR, Paolo Fontana coll., on slide); Apulia, Gravina on Puglia (Bari), 23.VI.2000, 1 adult male, leg. P. Fontana (FMCR, Paolo Fontana coll., on slide); Lazio, S. Felice Circeo, Quarto caldo (Latina), 12.IV.2000, 1 adult females, leg. P. Fontana (FMCR, Paolo Fontana coll., on slide); Sicily, Monreale, Borgo Molara (Palermo), XI.2000 (nymph), V.2001 (adult male), leg. and rearing. P. Fontana (FMCR, Paolo Fontana coll., on slide); Sicily, Monreale, Borgo Molara (Palermo), 13.VI.2023 1 adult male, leg. P. Fontana (FMCR, Paolo Fontana coll., on slide); Sicily, Campofelice di Roccella, Torre Roccella (Palermo) 38° 0'3.30"N 13°53'16.26"E, 19.VI.2023, 1 adult female, leg. P. Fontana (FMCR, Paolo Fontana coll., in alcool); **Croatia**, Istria, Pula, Premantura, 18.VI.2000, 1 adult male, leg. P. Fontana (FMCR, Paolo Fontana coll., on slide); Krka National Park, Brnjica greben, dry grasslands, 05.VII.2012, leg. Šerić Jelaska L., 2 adult males (in alcohol) (LSJpc); same locality and habitat, 28.VII.2012, leg. Šerić Jelaska L., 1 adult male, 1 adult female and 3 immatures (in alcohol) (LSJpc).

Haploembia tarsalis (Ross, 1940)

Haploembia tarsalis is a parthenogenetic species (the only one known to date in the Mediterranean Basin and almost the only one in the world) and therefore the most evident and constant specific character (in addition to those relating to the *Haploembia* genus) is given by the poor pigmentation of the females, which are light straw in colour while those of *H. solieri* are dark amber. *H. tarsalis* is known only from parthenogenetic populations, distinguishable by morphological characteristics and with molecular analysis. Based on reports of parthenogenetic populations, the species is known from the USA (California, Arizona, Texas, Washington State and Oregon), France (Corsica), Italy (Sardinia, Isle of Capri, peninsular Italy), Spain (Spanish Mediterranean coast, Balearic Islands, Canary Islands), Portugal (Madeira) and Albania (Ross, 1940 and 1966; Stefani, 1955, 1956 and 1983; Hodson *et al*., 2014; Kelyy *et al*. 2018; Curtiss *et al*., 2022). The parthenogenetic populations from Abrau Peninsula in Russian Caucasus (Gilyarov & Arnoldi 1958; Gongalsky *et al*. 2006) and from Azerbaijan (Samedov 1996; Guseinov 2006; Shelton 2010) must also be referred to *H. tarsalis*.

In the Tuscan Archipelago, the species is known from Elba Island (Porto Azzurro, Mola), Pianosa Island, Giglio Island (Stefani 1956), Elba and Giglio (Ross 1966, Stefani 1983). This report with the name of *Haploembia tarsalis* is the first for Italy and Europe, where this species has always been considered as the parthenogenetic form of *H. solieri*.

Examined Material. Italy, Tuscany, Isola d'Elba, Porto Longone (= Porto Azzurro), 1898, leg. G. Doria, 4 adult females and 1 immature female (in alcohol, MSNG); Tuscany, Isola del Giglio, March 1900, leg. G. Doria, 3 adult females and 7 immature females (in alcohol, MSNG).

Additional material. Italy, Sardinia, Bancali (Sassari), 25.VI.2004, 1 adult female, leg. S. Pinna (FMCR, Paolo Fontana coll., on slide). Sardinia, Bancali (Sassari), 9.VII.2004, 1 adult female, leg. S. Pinna (FMCR, Paolo Fontana coll., on slide); Sardinia, Esterzili, Riforn. Di Betilli, 15.V.1902, leg. A. Dodero, 1 adult female (in alcohol, MSNG).

Family Embiidae Burmeister, 1839

Genus *Embia* Latreille, 1825

The genus *Embia* Latreille, 1825 is the most widespread in Europe and in the Mediterranean Basin, counting for approximately 65% of the known species in Europe and over 80% of the species in the Euro-Mediterranean area. Males are winged or apterous and are characterized by having the basal segment of the left cervix (LC1) with a simple lobe, unlike males of the genus *Cleomia*. The genus *Embia* currently contains 37 species distributed from Southern Europe into northern, sub-Saharan and eastern Africa, western Asia and India (Fontana, 2024). Europe and the Mediterranean basin host 22 species of *Embia* (Fig. 6), making this area the most species-rich as well as a centre of endemism (Fontana 2024). Unlike some species of *Oligotoma* Westwood, 1837, *Haploembia* Verhoeff, 1904 and *Parembia* Davis 1939, which apparently are easily dispersed by humans (Ross 1984; Fontana & Bardiani, 2023), *Embia* spp. seem less subject to passive transport; their distribution seems to correspond largely to biogeographic factors (Fontana, 2024). The complexity of this genus may well be expressed with Ross's words (Ross 1966, p. 282): "The genus *Embia* promises to be one of the largest and most difficult of the order due to much apparent current evolutionary activity manifested by recognizable, but difficult-to-define, differentiation in various populations." This genus is not well studied in the Mediterranean area and despite the contributions by Ross (1966) and Stefani (1953a,1955), little more was discovered until recently, mainly in Italy, allowing the description of some new species (Fontana 2021, 2022, 2024).

Embia ramburi *Rimsky-Korsakov, 1905*

Embia ramburi occurs in southern France (type locality Villafranche sur Mer), Spain, Italy and some islands in the western Mediterranean (Ross, 1966). The species is also known in Tunisia, where it was collected and identified by E. S. Ross (Beron, 2015). In Italy *E. ramburi* is present along the Tyrrhenian and Adriatic coasts and has been recently recorded on Lampedusa Island (Fontana *et al*., 2021).

An adult male *E. ramburi* reported in the Tuscan Archipelago by Battiston & Fontana (2007) was collected on Giglio Island in May 1900 by G. Doria and preserved in the Natural History Museum of Genoa. A recent discovery of this species near Forte Inglese (Elba, Portoferraio) not only confirms the presence of this species in the Tuscan Archipelago but given the current great abundance of this species in this site, bordering on swarming, highlights how recent weather patterns may make these particularly thermophilic insects more visible.

The specimens of *E. ramburi* collected at Forte Inglese of Portoferraio (Elba), correspond to the characteristics of the species according to the literature and collection material available, but appear to have reduced size and live colouration of an intense black, unlike the dark mahogany colouring of the populations identified in France and Italy (references).

Examined Material. Italy, Tuscany, Tuscan Archipelago, Portoferraio (Livorno), Forte Inglese, 42°48'59.72"N 10°19'5.64"E, 25.V.2022, 2 adult males and 2 adult females, leg. P. Fontana (FMCR, coll.Paolo Fontana, mounted on slides).

Additional material. Italy, Liguria, Cervo (Imperia), macerie (= rubble), 15.VII.2004, leg. R. Fabbri, 2 adult males and 3 adult female (1 male on slide and 1 male and 3 females in alcohol, MSNG); Tuscany, Viareggio, Marina di Levante, riserva naturale "La Lecciona" (Lucca), 20.IX.2000, leg. P. Fontana, 7 adult males on slide and 2 adult males in alcool (obtained after rearing), (FMCR, coll. P. Fontana); Marche, Marotta (Pesaro-Urbino), 2 m, coastal habitat, 43° 45' 0,97'' N, 13° 10' 03,1'' E, 26.03.2021, leg. P Fontana, 1 adult male on slide and 4 adult males in alcohol, (FMCR, coll. P. Fontana); Marche, Villafurlo, Fermignano (Pesaro-Urbino), 170 m, 4.06.2004, leg. P. Fontana, 2 males on slide, (FMCR, coll. P. Fontana); Marche, San Martino del Piano, Fossombrone (Pesaro-Urbino), 120 m, 4.06.2004, leg. P. Fontana, 2 males on slide, (FMCR, coll. P. Fontana); Lazio, Roma, Villa dei Quintili—Parco Archeologico dell'Appia Antica (Roma), 41°49'46.66"N 12°33'4.72"E, 7.XI.2021 (nymphs), 9.VI.2022 (adults), 3 males and 1 female, leg. and rearing P. Fontana (FMCR, coll. P. Fontana in alcool); Sardinia, Bancali (Sassari), 4.VII.2004, leg. S. Pinna, 2 males on slide (FMCR, coll. P. Fontana); Sicily, Lampedusa island (Agrigento), 4.IV.1990, legg. Agnelli & Borri (Crocera Nave Oceanografica Bannock), 1 adult male on slide (FMCR, coll. P. Fontana); **France**, Hérault, Montferrier sur Lez (Montpellier), in the garden of Heliotel, 22.02.2001, leg. P. Fontana, 3 males on slide (FMCR, coll. P. Fontana).

FIGURE 3. *Embia ilvana* **n. sp.**, male holotype, Isola d'Elba, Porto Azzurro, Buraccio, "I Giardini di Poseidone" farm (Livorno), 25 May 2022: a) specimen mounted on slide in full; b) head from above, c) basal segments of right antenna, d) mandibles viewed obliquely from the right.

Embia ilvana n. sp.

Numerous specimens of *E. ramburi* and *H. solieri* were identified and collected in the square in front of Forte Inglese of Portoferraio on 25 May 2022, during a natural beekeeping course organized by the World Biodiversity Association. This activity included a visit to an apiary near Porto Azzurro (Elba) in the Buraccio locality, at the "I Giardini di Poseidone" farm of Davide Fabbri. During a break the authors took the opportunity to look for Embioptera. Under a small pile of plant residue, numerous tunnels were identified and some adult and immature individuals of a species were found that at first sight were assignable to *Embia* but with striking dissimilarities from the specimens collected at Forte Inglese. These individuals were characterized by a uniform brown colour. Some apparent adults and several juveniles were collected. These specimens were placed in breeding containers and one adult male was preserved in alcohol. Unfortunately, the breeding was unsuccessful, but the examination of the one adult male allowed the identification of a new species of *Embia*, described below. The discovery of a new species in a protected area such as the Tuscan Archipelago National Park is important as it adds to the species richness of this area.

Type material. Male holotype mounted on slide, is preserved in the Paolo Fontana collection in Rovereto (FMCR).

Holotype data. Italy, Tuscany, Tuscan Archipelago, Porto Azzurro, Buraccio (Livorno), "I Giardini di Poseidone" farm, 42°46'01,3'' N 10°22'09,0'' E, 25.V.2022, 1 adult male, leg. P. Fontana.

Description of holotype male. Of medium size, apterous (Fig. 3a), in life uniformly brown with dark hairs.

Mounted specimen 10.2 mm long, from the apex of the mandibles to the apex of the terminalia (LC2). Cranium sub-oval, elongate, lacking dorsal pattern, 1.45 mm long, 1.09 mm wide (Figs. 3b, 5a). Antennae brown with apex of each antennal segment colourless. First antennal segment stout, clearly larger than the following and as long as

the third one; third antennal segment less than twice as long as the second one. Eyes small, not projecting (Fig. 3c). Labium sub-pentagonal with anterior margin slightly angularly protruding and apical half lighter than basal half. Mandibles almost completely hidden by the labium, stout, elongate with outer anterior margin widely curved; each mandible with two teeth, each mandible with a robust, protruding subapical tooth in its dorsal side and an apical tooth curved ventrally (Figs. 3b, 5b), apex of each mandible somewhat forked. (Fig. 3d). Terminalia with caudal margin of left hemitergite of tenth segment (10 L) convex from which the process (10LP) is clearly separated. Left process (10 LP) long and slender, slightly curved outwards, slightly dilated at the base, narrowed in the median portion, and clearly dilated at the apex, which is pointed but not sharp (Figs. 4a, 4b, 4e). Right hemitergite (10 R) subtrapezoidal with the basal portion approximately three times wider than the apical one. Right process (10 RP) pointed, slightly sclerotized and barely perceptible except for the more substantial apex (Figs. 4a and 5e). Median flap (MF) slightly sclerotized and clearly delineated; very elongated ogival shape, marked by a central thickening in the longitudinal direction and with parallel margins (Figs. 4a, 4b and 5e). Left cercus-basipodites and left paraproct (LCB + LPPT) rhomboidal, well-sclerotized and darkly pigmented; process of left paraproct (LPPT P) not clearly distinguished from the rest of the structure, with an acute angled outline (Figs. 4a–c, 5d). Basal segment of left cercus (LC_1) roughly triangular and expanded inward; with slightly concave internal basal portion, very expanded median margin and gradually tapered apical portion; inner expanded margin bears short subconical spines (Figs. 4c, 5f), of which 12 are conspicuous; The basal segment of left cercus (LC1) is 0.72 mm long and 0.26 mm width at its maximum subapical dilatation. Apical segment of left cercus (LC_2) subcylindrical, very long, a little longer than half of LC_1. Left and right cerci with long hairs, longer than cercus diameter; LC1 with hairs only on outer side. Hypandrium (ninth abdominal sternite) (H) sickle-shaped (Fig. 5c) with long process (HP). Hind basitarsus with one papilla, scarcely projecting.

Female. unknown.

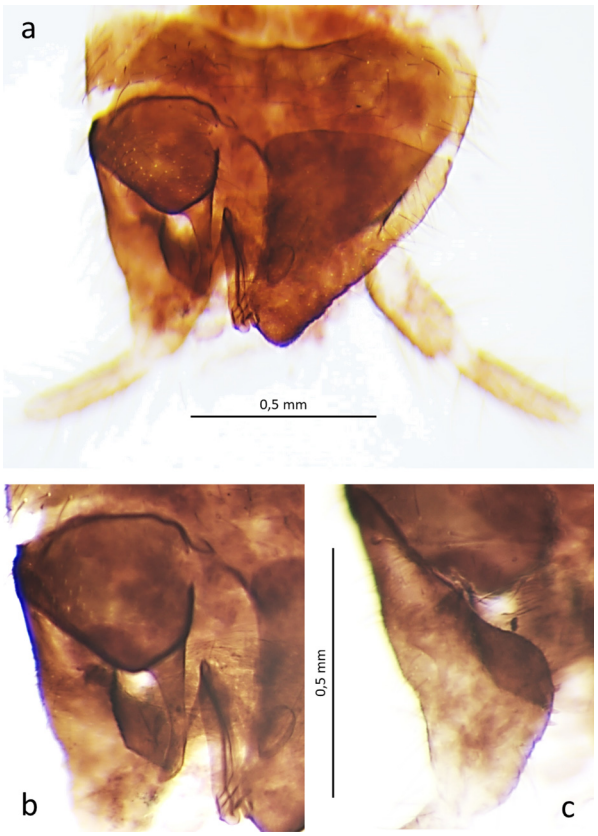

FIGURE 4. *Embia ilvana* **n. sp.**, male holotype Isola d'Elba, Porto Azzurro, Buraccio, "I Giardini di Poseidone" farm (Livorno), 25 May 2022: a) male terminalia in dorsal view; b) left hemitergite of tenth segment (10L) and its process (10LP) in dorsal view; c) basal segment of left cercus (LC1) in dorsal view.

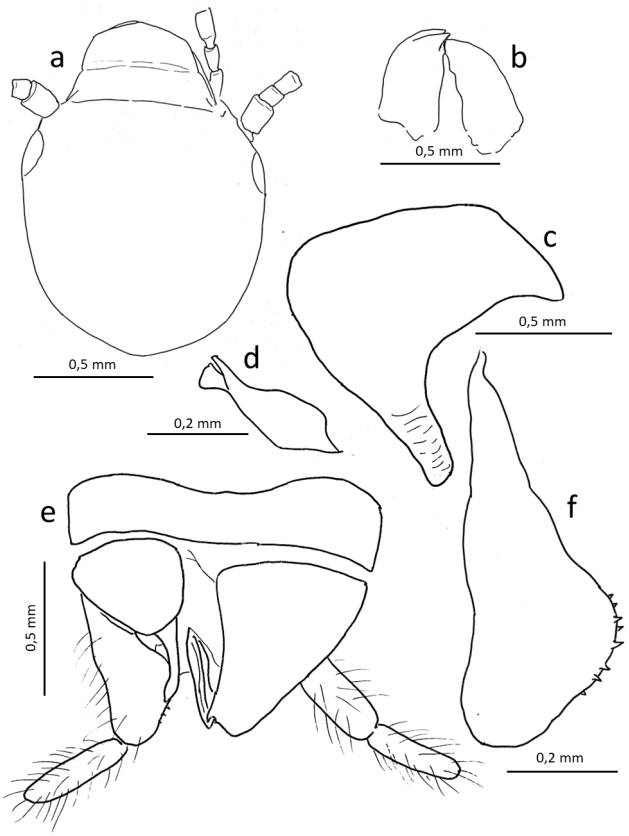

FIGURE 5. *Embia ilvana* **n. sp.**, male holotype, Isola d'Elba, Porto Azzurro, Buraccio, "I Giardini di Poseidone" farm (Livorno), 25 May 2022: a) head from above, b) mandibles, c) right hemitergite of tenth segment (H) and its process (HP) in ventral view d) left paraproct (LPPT) in dorsal view; e) male terminalia in dorsal view; f) basal segment of left cercus (LC1) in dorsal view.

Habitat. *Embia ilvana* **n. sp.** was found within the "I giardini di Poseidone" farm, managed according to the best principles of respect for biodiversity by Davide Fabbri. The area is not located within the Tuscan Archipelago National Park but is naturally valuable due to the land management practices. The vegetation is represented by a patchwork of olive trees, fruit trees, Mediterranean scrub and garrigue. The new species was collected under a light layer of organic matter among the olive trees.

Diagnosis. *Embia ilvana* **n. sp.** has a combination of characters that set it apart from other *Embia* spp. The characters that most differentiate *E. ilvana* n. sp. from other species of the genus are present in the mandibles and terminalia of the male (the only sex known to date). The mandibles bear a robust dorsal-subapical tooth, a structure absent in all other known species of the genus. The process of the left hemitergite of the tenth segment (10LP) is slightly curved, narrowed in the median portion and clearly dilated at the apex and, although it is somewhat comparable in shape to other species, it has a unique overall conformation. The characteristic of the male terminalia that is unmistakable in *E. ilvana* n. sp. is the complex of the left cercus-basipodites, left paraproct and the process of the left paraproct (LCB+LPPT), which form a very simplified sub-rhomoidal structure, well-sclerotized and darkly pigmented. Of particular diagnostic value is the process of left paraproct (LPPTP) that is quite inconspicuous, very small, simplified and without hooks or projections.

Affinities. The conformation of the 10LP of *E. ilvana* **n. sp.** resembles that of *E. maroccana* Ross, 1916, which, however, is much more curved; and, moreover, the latter species has a very complex left cercus-basipodites, left paraproct and the process of left paraproct (LCB+ LPPT and LPPTP) structure. Due to a general similarity in the conformation of all species characterized by having this terminalia structure that is not acuminate and more or less digitiform., *E. ilvana* **n. sp.** can be compared to *E. nuragica* Stefani, 1953 , *E. biroi* Krauss, 1911 and *E. lucasii* Ross, 1966. All of these species are characterized by having this terminalia structure not sharp and more or less digitiform. In *E. ilvana* **n. sp.**, however, this structure is clearly distinguishable from those of these last species; in addition, it differs in many other characteristics, especially the shape and appearance of the right hemitergite (10 R),

the median flap (MF) and the left cercus-basipodites, left paraproct (LCB + LPPT), as well the basal segment of left cercus (LC1). The new species is, therefore, clearly distinguished from other species of the genus and in particular from those that live in Italy, such as *E. ramburi* Rimsky-Korsakow, 1905, *E. nuragica* Stefani, 1953, *E. tyrrhenica* Stefani, 1953, *E. girolamii* Fontana, 2001, *E. cynthiae* Fontana, 2002 and *E. minapalumboi* Fontana, 2024 (Fig. 6).

Etymology. The common as well the scientific names of the new species was chosen through a public vote launched on the web by the Tuscan Archipelago National Park during which three different scientific names, indicated by the authors, were proposed and explained. The questionnaire, launched on 5 December 2023 and closed on 6 January 2024, saw the participation of 3,128 citizens who ultimately chose the adopted names (scientific and common). The name chosen by the citizens, *E. ilvana*, derives from the Latin name of the Island of Elba. The island of Elba was called Aithàle, Aithàleia and Aithalìa by the Greeks, all names deriving from the Greek term aithàle, "soot", in reference to the processing activities of the iron extracted in the Elban mines. But for the Latins it was instead *Ilva*, a toponym of probable pre-Roman origin referring to the Ligurian Ilvates population. Only in the Middle Ages *Ilva* was transformed first into *Ilba* and finally into *Helba*. The scientific nomenclature is largely based on the Latin language and therefore, wishing to dedicate the new species to the Island of Elba, *Ilva* is the name to refer to, adopting for the species the name *ilvana* meaning, precisely, from Elba Island. This new species will likely be found in the future on other islands of the archipelago.

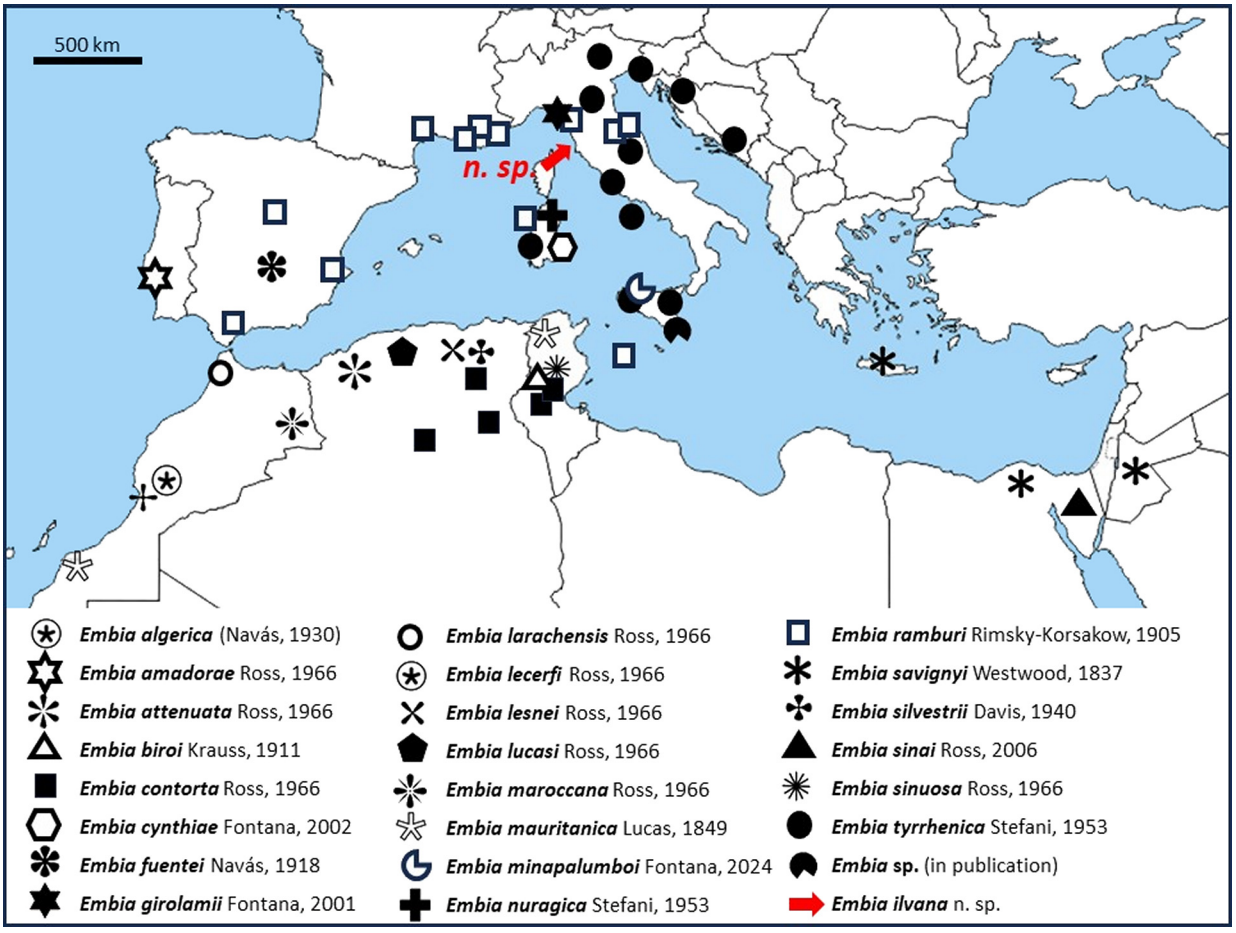

FIGURE 6. Known distribution of the Euro-Mediterranean species of *Embia* Latreille, 1825.

Discussion

The Embioptera population of the Tuscan Archipelago currently numbers 4 species: *Embia ramburi*, *E. ilvana* **n. sp.**, *Haploembia solieri* and *H. tarsalis*. If we consider the limited territorial expanse of these islands, this seems to be a comparatively rich fauna that can be studied thoroughly in place. Only four of the seven main islands of the Archipelago are known to host Embioptera (Fig. 7), but it seems likely that the remaining 3 islands also harbor Embioptera. The conformation, geological and natural history of the Tuscan Archipelago are ideal study conditions

for delving into many biological, biogeographical and evolutionary aspects that influence the lives of these insects. Aspects that can be investigated in the insular context include the frequency of apterous or winged species (only in males in the case of the Embioptera), the variability of the populations in relation to the area of an island and its distance from the coast and other islands of the archipelago, life cycles, ecological niches and environmental preferences. In the future, it will be extremely interesting to verify the presence of *Embia ilvana* **n. sp.** on the other islands of the archipelago.

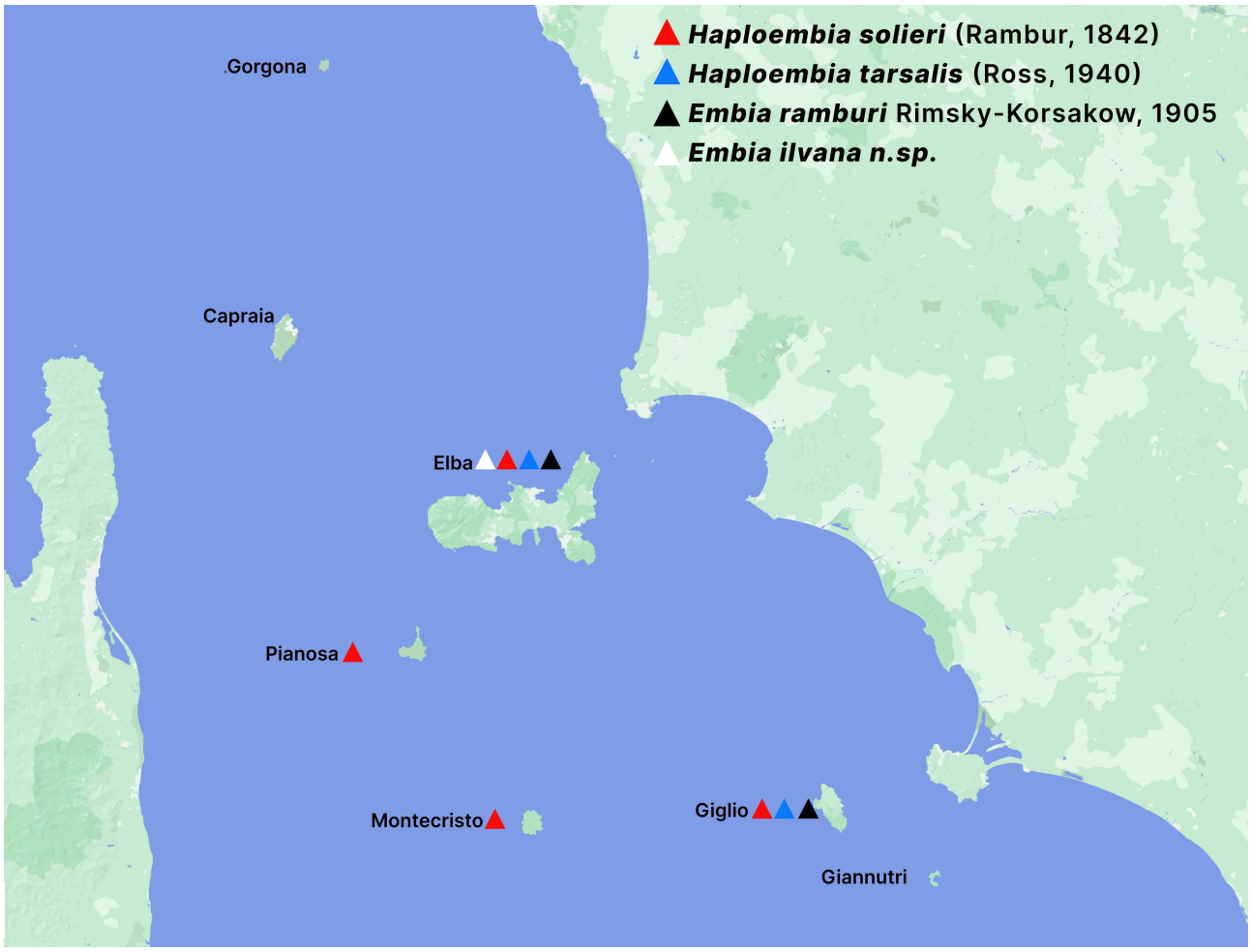

FIGURE 7. Known distribution of Embioptera in the Tuscan Archipelago.

The description of this new species increases the already large number of Embioptera species known in Italy to 10 of the 16 known in Europe, including the recent description of *Embia minapalumboi* Fontana, 2024 from the Madonie mountains in Sicily (Fontana 2024) , and the identification of *Haploembia tarsalis* as a species distinct from *Haploembia solieri* (Table 1).

The abundance of Embioptera species in the Italian fauna derives both from its natural species richness and from the intensity of studies relating to these insects in recent years. The scarcity of species from the Iberian Peninsula and from the Balkan area and the Middle East, which are equally as important as Italy for their faunal complexity, suggest that targeted research could lead to a significant increase in the diversity of Embioptera in the Mediterranean region.

TABLE 1. Updated checklist of the Embioptera of the Italian fauna (N = North, S = South, Sa = Sardinia, Si = Sicily, E = endemic).

Family, genus, species	Locations
Embiidae	
Embia Latreille, 1825	
E. ramburi Rimsky-Korsakow, 1905	S, Sa, Si
E. nuragica Stefani, 1953	Sa, E
E. tyrrhenica Stefani, 1953	N, S, Sa
E. girolamii Fontana, 2001	S, E
E. cynthiae Fontana, 2002	Sa, E
E. minapalumboi Fontana, 2024	Si, E
E. ilvana n. sp.	S, E
Cleomia Stefani, 1953	
C. guareschii Stefani, 1953	Sa, Si, E
Oligotomidae	
Haploembia Verhoeff, 1904	
H. solieri Rambur, 1842	N, S, Si
H. tarsalis (Ross, 1940)	S, Sa

Acknowledgments

We thank the Tuscan Archipelago National Park for all the support provided to the naturalistic research of the World Biodiversity Association. We thank the municipality of Portoferraio (Elba) for the important collaboration within the Nat Lab (Naturalistic Museum of the Tuscan Archipelago). A warm thank you goes to our friend Davide Fabbri who manages the "I Giardini di Poseidone" farm with great respect for biodiversity, so much so that it was the place where *E. ilvana* n. sp. was found. We are pleased to thank Roberto Poggi for allowing us to consult important materials, including some paratypes from the collections of the Museo di Storia Naturale Giacomo Doria in Genoa (Italy), Oscar Maioglio and Lucija Šerić Jelaska for providing specimens for this study. We are deeply grateful to Camilla Maria Fontana (Department of Agriculture, Chiang Mai University, Thailand) for critical revision of the text. Finally, we are grateful to Janice S. Edgerly (Department of Biology, Santa Clara University, USA) for helping us to better understand the topic relating to *Haploembia solieri* and *H. tarsalis* and for allowing us to complete the bibliography relating to this topic.

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