

# About the occurrence of *Elatine macropoda* and *E. gussonei* (Elatinaceae) in Sicily and lectotypification of their names

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**Abstract** – Morphological and nomenclatural investigations for two critical Mediterranean species of *Elatine*, i.e., *E. macropoda* and *E. gussonei*, as well as their correct distribution in Sicily, are discussed. These two names are lectotypified on herbarium specimens kept, respectively, at NAP and FI. The morphological investigations carried out on both the types, as well as on several living and dried material collected in southern Sicily, Lampedusa, and Malta (*loci classici* included), allowed to individuate reliable diagnostic characters that can be used for a correct identification of the two species. The most relevant differential features are: ratio petal/sepals, size and shape of the seed testa pits, and their arrangement in row number. According to our results, only *E. macropoda* occurs in the Hyblaean territory (Sicily), which is the *locus classicus*, whereas *E. gussonei* occurs on Lampedusa and Maltese islands only. However, further and in-depth morphological research is necessary to clarify their overall distribution in the Mediterranean area. Finally, an analytic key to the Mediterranean *Elatine* is provided.

**Keywords:** analytic key, *Elatine*, ephemeral aquatic habitat, Mediterranean flora, subsection Macropodae

## Introduction

The genus *Elatine* L. (*Elatinaceae* Dumort.) is represented by small, usually amphibious, herbaceous ephemero-phytes mainly occurring in the temperate regions of both hemispheres, where they grow in stands temporarily flooded with fresh water, such as ponds, rocky pools, edges of lakes or marshes, and rise field (e.g., Razifard 2016, Sramkó et al. 2016). Within this genus, which is prevalently autogamous with self-pollination, hybridization is usually hindered (Razifard 2016, Razifard et al. 2017). Currently, *Elatine* includes 25–30 species with worldwide distribution (Razifard 2016, Popiela et al. 2017, POWO 2021). The taxonomy of some species are still quite controversial or poorly known, due to the high morphological variability of the populations, as well as the circumscriptions and distribution of the various recognized species, especially in the Mediterranean areas (Uotila 2009, Popiela and Łysko 2010, Sramkó et al. 2016, Popiela et al. 2017, Takács et al. 2017,

2018). Actually, the whole genus taxonomy is characterized by a phenotypic plasticity, scattered distribution, hardly observable diagnostic characters, as well as often ephemeral and clonal life. All this involves a considerable variability in the habit and in many morphological traits, which have led to diverging opinions from a systematic and then nomenclatural viewpoints (Seubert 1845, Cook 1968, Cjruiano and Velayos 1993, Mifsud 2006, Sramkó et al. 2016, Razifard 2016, Molnár et al. 2014, 2015).

Among the Mediterranean species, *Elatine macropoda* Guss. and *E. gussonei* (Sommier) Brullo, Lanfr., Pavone & Ronsiv. are particularly critic from the taxonomic point of view, since the various populations have been attributed indifferently to one or the other of them, with the consequent variation of their putative geographical ranges (Cook 1968, Mifsud 2006, Uotila 2009, Molnár et al. 2014, 2015, Sramkó et al. 2016, Razifard 2016, Minissale and Sciandrello 2016, 2017, Popiela et al. 2017, Bellia et al. 2020). The two species

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were included by Sramkó et al. (2016), together with *E. campylosperma* Seubert, in the sect. *Elatinella* Seubert subsect. *Macropodae* Sramkó, A.Molnár & Popiela. According

to Kalinka et al. (2014, 2015), only *Elatine campylosperma* is diploid ( $2n = 2x = 18$ ), while the other two species are polyploid ( $2n = 6x = 54$ ).



Fig. 1. A – *Elatine macropoda*, Napoli Herbarium Collection “Gussone-Sicilia”, digital image! (lectotype). B – *Elatine macropoda*, detail of flower from lectotype.



*Elatine macropoda* was described by Gussone (1827) from south-eastern Sicily, where it was collected in the temporary inundated rocky ponds. Later, it was recorded for many localities throughout the Mediterranean area (Uotila 2009, Popiela and Łysko 2010). Populations of *Elatine* occurring in Lampedusa Island (Pelagic Archipelago, Channel of Sicily) were initially attributed to *E. macropoda* by Solla (1884) and Lojacono Pojero (1885, 1889), while Ross (1884) referred them to *E. campyloperma* Seuber. Later, Sommier (1907) emphasized that these plants differed markedly from *E. macropoda* mainly in having seeds very curved and petals subequal to sepals. Conversely, this author believed that *E. macropoda*, due to the seed shape, should have a closer relationship with *E. hydro Piper* L., a species widespread in the central-northern Europe. Therefore, he treated this taxon as var. *gussonei* Sommier of *E. hydro Piper*. Afterwards, Sommier and Caruana Gatto (1915) ascribed also the populations occurring in the Maltese Islands to *E. hydro Piper* var. *gussonei*. More recently, due to its morphological peculiarities, this taxon was raised to the specific rank by Brullo et al. (1988), as *E. gussonei*. Later, Molnár et al. (2014) reported *E. gussonei* from the surroundings of Modica and Ispica in southern Sicily, which are two of the classical localities of *E. macropoda* according to Gussone (1827). This identification was based exclusively on the shape of seed morphology, since Molnár et al. (2014) stated that *E. gussonei* displays seeds much more curved than *E. macropoda*, also showing a slight difference in the seed coat reticulations. As a surprising consequence, both species (*E. gussonei* and *E. macropoda*) would coexist in the same habitat and in the same places. This casts therefore some doubts about the correct attribution of these Sicilian populations to *E. gussonei*.

In order to better clarify the aforementioned issue, we proceed with the typification of the two names, which are not yet proposed (Peruzzi et al. 2015, 2019) and a consequent revision of available material.

## Material and methods

Morphological investigations on *E. macropoda* and *E. gussonei* were mainly carried out on living material coming from several localities of southern Sicily, Lampedusa Island and Malta Archipelago, including almost all the *loci classici* of both the species. In addition, herbarium specimens kept at CAT and in some virtual herbaria (L, M, PAL, WAG) were also checked. For the typification purpose, all the relevant literature was examined (protologue included). Original material was searched at BM, BOLO, CAT, FI, G, K, NAP, P, PAL, and PI. The articles cited throughout the text follows Shenzhen Code (Turland et al. 2018), ICN hereafter.

Seed testa micro-morphology was examined on mature and dried seeds by using a scanning electron microscope (SEM) Zeiss EVO LS10, according to the protocol reported by Stork et al. (1980). Terminology of the seed coat sculpturing follows Barthlott (1981), Lersten and Gunn (1982), and Gontcharova et al. (2009). Seed samples of *Elatine macropoda* and *E. gussonei* were taken from voucher specimens preserved at CAT.

## Results

### Typification of the name *Elatine macropoda*

*Elatine macropoda* was described by Gussone (1827: 475) with a short diagnosis in Latin, indication of habitat (“In calcareis hyeme inundatis” = “In calcareous places flooded in winter”), flowering time (“Martio, Aprili”), biological form (annual, as “O”) and emphasizing its morphological differences towards *E. hydro Piper* L. and *E. hexandra* (Lapierre) DC. Besides, he listed the following Sicilian localities: Modica, Scicli, Spaccaforno [= nowadays Ispica], Ragusa, Siracusa, Noto. All these localities are part of the Hyblaean territory (the last two are in Syracuse province, the others in Ragusa province). Notice that Gussone (1827: 475) indicated an illustration which will be printed within the first volume of *Flora Sicula* (“*Fl. sic. t. 204. f. 1*”). Unfortunately, as already noted in similar cases (i.e., De Leonardis et al. 1999, Erben et al. 2018), it was never published, as happened to the whole work, except the first fascicule (Pasquale 1871). In a next more detailed treatment of the taxon Gussone (1843), did not mention such illustration, but, doubtfully, just the one provided by Moris for his *E. hydro Piper* var. *pedunculata*. Currently, only two specimens from Sicily are available at NAP (collection “Gussone-Sicilia”), where original material for Sicilian taxa described by Gussone is usually preserved. One specimen was collected in Mondello (PA) by Todaro in 1842 (quoted by Gussone 1843, but not part of the original material since not reported in the protologue), and another one collected by Gussone himself (Fig. 1A). This latter bears the “representative label” (Santangelo et al. 2017) and includes several fragments and/or individuals with some flowers. Three labels in Gussone’s handwriting occur: “Ragusa = Maggio [May]”; “*Elatine hydro Piper* [barred] | Cor. 4-petala[?], calyce duplo brevior, alba, petalis ovatis obtusis sessilibus pellucido-diaphanis = Stam. Octo, filam. albis, antheris nigrescentibus = Pistilli quatuor ex [?] capsulae umbilicatae, virides, divergentes | Maggio = Ragusa”. The “representative label” reports “*I. Elatine macropoda* ~~Nob.~~ Guss. prodr. P. 475 | Martio, Aprili O | In calcareis hyeme inundatis”. A further label, probably wrote by Pasquale, simply indicates the definitive identification: “*Elatine macropoda*”. Comparing information provided by the examination of NAP and by the biographies based on his herbarium (Pasquale 1871) and manuscripts (Trotter 1948), we found that the locality “Ragusa” is associated with certainty only to May 1820 (Trotter 1948). Besides, the few specimens at NAP collected by Gussone himself in Ragusa do not report a date, and, likely, were mainly gathered in 1820. This is confirmed by the fact that in “Gussone – Sicilia” collection, the indication of a year is increasingly rare in specimens collected before 1824, and apparently always absent before 1821. Therefore, the specimen of our interest was likely collected in May 1820 (see Trotter 1948) and must be regarded as original material. Mature seeds are not visible, but the tetramerous flowers show petals about as long as half of the calyx (Fig. 1B). On one hand, these features perfectly agree with the protologue (Gussone 1827); on the other hand, they allow to

identify the specimen with the plant currently named *E. macropoda* (see Seubert 1845, Cook 1968, Cjruiano and Velayos 1993), supporting the use of the name.

**Taxonomic treatment of *E. macropoda***

*Elatine macropoda* Guss., Fl. Sic. Prod. 1: 475. 1827 [Oct-Dec] ≡ *E. paludosa* subsp. *macropoda* (Guss.) Bonnier & Layens, Tabl. Syn. Pl. Vasc. France: 53. 1894 [May-Jun] (cf. Art. 35.2 Ex. 7 of ICN) ≡ *E. major* subsp. *macropoda* (Guss.) P.Fourn., Quatre Fl. Fr.: 442. 1936 [27 April] ≡ *E. hydropiper* subsp. *macropoda* (Guss.) O.Bolòs & Vigo, Fl. Països Catalans 2: 228. 1990. (Fig. 2).

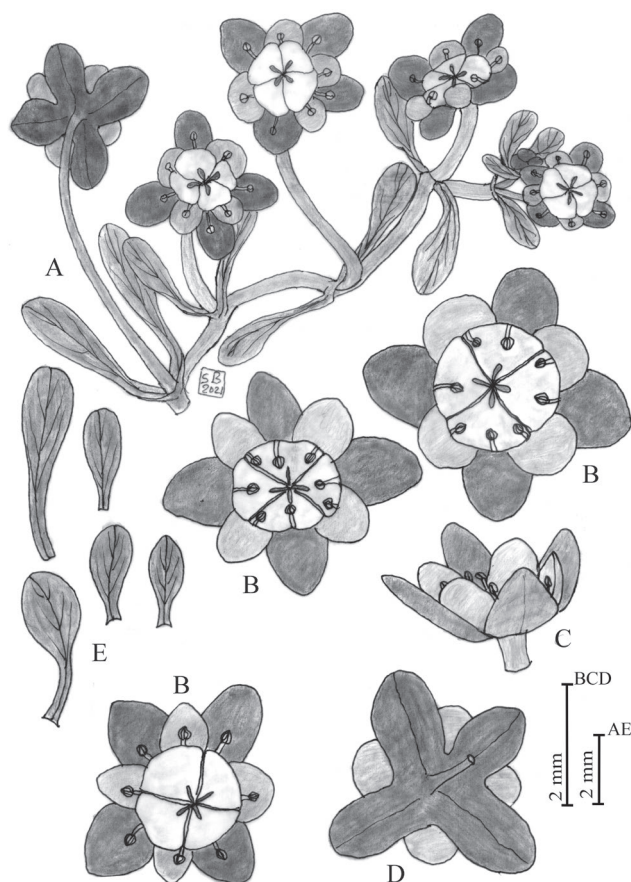
**Type.** ITALY, Sicily, Ragusa, Maggio (probably 1820), [G. Gussone s.n.] (Lectotype: NAP, Collection “Gussone-Sicilia”!, designated here).

**Description.** Annual herb, submersed, 2–10 cm. Stems prostrate, branched. Leaves green, opposite, oblong, pinnate, 2–6 × 0.6–2 mm, margins entire, apex rounded, petiole 0.5–2 mm. Flowers tetramerous, solitary, axillary; pedicel 2–10(20) mm long, lower ones longer, upper ones gradually shorter; sepals green, 1.5–2 × 0.8–1.2 mm, oblong to ovate, fused to the base; petals white to pinkish, ovate to subrounded, about half shorter than sepals, 0.8–1.3 × 0.6–

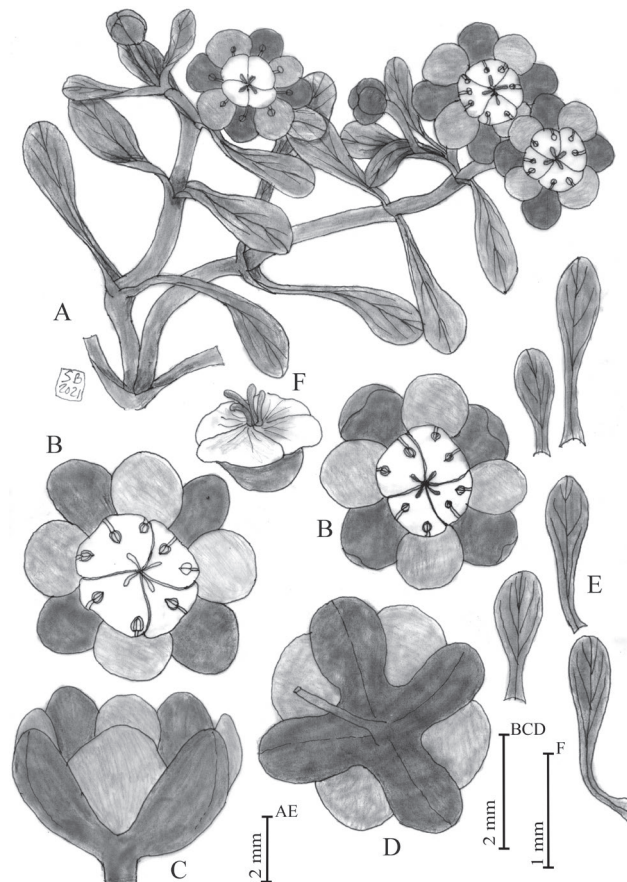
1.4 mm, stamens 8; styles 4. Capsules compressed-subglobose, 4-locular, 1.7–2.3 mm diam. Seeds 0.5–0.6 mm long, subcylindrical to U-shaped, almost straight or slightly curved on one end, often markedly curved on the back and with a semilunar membrane on the concave side, which is absent or sub-null in almost straight seeds; pits rectangular or slightly hexagonal, 64.8–86.5 × 18.9–35.1 μm, with length 2–3.5 times width, arranged in 8 rows.

**Additional specimens examined**

*Italy.* Sicily, Siracusa, April 1832, s.c. (PAL79142); Siracusa, sito archeologico presso la citta, 23 April 2021, S. Cambria s.n. (CAT); Siracusa, Scala Greca, 9 April 2021, S. Cambria, P. Minissale, S. Sciandrello & G. Tavilla s.n. (CAT); Modica ad calcarea humida, Marzo-Aprile, F. Tornabene s.n. (CAT00368); Modica (Pirato), 2 April 1988, G. Bartolo & S. Brullo s.n. (CAT035005); Pozza su affioramenti carbonatici in c.da Nacalino (Modica), 11 April 2019, S. Sciandrello & P. Minissale s.n. (CAT); Pozze umide su affioramenti calcarei in Contr. Nacalino, 23 April 2021, S. Cambria s.n. (CAT); Modica, pozze su affioramento carbonatico presso l’abitato (Ispica), 11 April 2019, S. Sciandrello & P. Minissale s.n. (CAT); Ispica, pozze umide su affioramento carbonatico in Contr. Scalaricotta, 23 April 2021, S. Cambria s.n. (CAT).



**Fig. 2.** *Elatine macropoda*. A – habit, B – flowers, above view, C – flower, lateral view, D – flower, below view, E – leaves, F – pistil. Drawing by Salvatore Brullo.



**Fig. 3.** *Elatine gussonei*. A – habit, B – flowers, above view, C – flower, lateral view, D – flower, below view, E – leaves, F – pistil. Drawing by Salvatore Brullo.



### Typification of the name *Elatine hydropiper* var. *gussonei*

Sommier (1907: App. 76) validly published the name *Elatine hydropiper* var. *gussonei* providing a description and diagnosis (both in Latin) distinguish it for plants with pedunculated flowers. Sommier pointed out the the new name was erroneously identified as *E. macropoda* by Solla (1884) and Lojacono Pojero (1885, 1889), and reported as *E. campylosperma* by Ross (1884). In his opinion, even if the closest taxon would be *E. campylosperma*, the typical variety of this last species shows longer peduncles and petals shorter than sepals (*vs.* petals subequal to sepals for var. *gussonei* according to Sommier 1907). In addition, Sommier (1907) emphasized that the new taxon differed markedly from *E. macropoda* mainly in having seeds very curved and petals subequal to sepals. He added several notes (in Italian) about habitat, taxonomy, and literature. More important, he also cited several syntypes: the plants he collected and preserved in his personal herbarium and at FI (indicated by an exclamation mark, see Sommier 1907: 57), those ones collected by Zodda (see Sommier 1907: 58), and a number of the series *Plantae Italicae selectae* (no. 26). Due to neither holotype nor isotypes were indicated in the protologue, a lectotype must be chosen among these cited specimens (ICN, Art. 9.12). Among the duplicate of specimens collected by Lojacono and quoted by Sommier (1907), we were able to locate only one of them at G (barcode G00421147) which includes three well preserved individuals with flowers and fruit, perfectly matching the protologue and a label handwritten by Lojacono himself. In addition, several specimens by Zodda (labelled as *E. macropoda* and collected in 1905) are available at PI [barcode PI044461 (image available at <https://pi.jacq.org/PI044461>) and PI044462 (image available at <https://pi.jacq.org/PI044462>)] and FI (barcodes FI064049, FI064050, and FI064051). FI064051, in addition, bears a label handwritten by Sommier ("*Elatine hydropiper* L. var. *Gussonei* Somm. | Flor. Lamp. P. 76") and includes some parts of *Elatine* in fruit and several seeds. Also, in the same FI herbarium, two specimens collected by Sommier himself there are (barcodes FI001581 and FI064052; image at <http://parlatore.msn.unifi.it/types/search.php>) and they perfectly concurring with the data of the protologue. Among the cited syntypes, FI001582 is the richest one, as it is represented by three individuals with flowers and bearing the following labels by Sommier: (1) "*Elatine Hydropiper* L. var. *Gussonei* Somm. | Somm. Fl. Lamp. P. 76 | Insula Lampedusa (olim Lopadusa) [printed row] | Pozzanghere non ancora prosciugate | In vari punti dell'isola generalmente associata alla *Bulliarda* | 9-13 [handwritten] Martii 1906 legi [printed]" (a fragment of plant is scotch-taped on the label); (2) "Cala francese andando a Punta Sottile"; (3) A modern label by Brullo reporting the current identification. The detail of the date on the first label is very relevant, because indicates that the material did not originate by a single gathering (Art. 8.2 of ICN). However, on FI001582 there are also three envelopes including material collected in single days and therefore belonging to single gatherings (Art. 8 of ICN). More-

over, a further envelope includes "comparison material" from Malta and Favignana islands, as reported by Sommier himself on it. On the other hand, FI001581 includes a single envelope referring to a single gathering on 9<sup>th</sup> March 1906 and a similar handwritten label by Sommier. For this reason, it is a suitable choice for the lectotype, although lacking seeds. As the publication date of the protologue regards, the *Flora delle Isole Pelagiche* was published as a separate appendix after the fascicules 3–4 of the no. 5 of the *Bollettino del real orto botanico di Palermo*, which reports "31 Dicembre 1906" on the frontispiece. However, at p. 174 of fasc. 4, one of the last articles reports January 1907. Therefore, the *Flora* was reliably published within the first months of 1907. The work was also separately published as a book in 1908 in Florence, as reported in the colophon (Sommier 1908).

### Taxonomic treatment of *E. gussonei*

*Elatine gussonei* (Sommier) Brullo, Lanfr., Pavone & Ronsiv., Giorn. Bot. Ital. 122, Supp. 1: 45. 1988. ≡ *E. hydropiper* L. var. *gussonei* Sommier, Boll. Reale Orto Bot. Palermo 5: App. 76. 1907 [«1906»] (Fig. 3).

**Type.** ITALY, Sicily, Insula Lampedusa (olim Lopadusa), Pozzanghere non ancora prosciugate tra il porto e Cala Francese, 9 March 1906, S. Sommier *s.n.* (Lectotype: FI 001581!, designated here).

**Description.** Annual herb, submersed, 3–15 cm. Stems prostrate, branched. Leaves green, opposite, oblong, pinnate, 2.5–6.5 × 0.7–1.5 mm, margins entire, apex rounded, petiole 0.5–3 mm. Flowers tetramerous, solitary, axillary; pedicel 0.5–3 mm long, lower ones longer, upper ones subsessile; sepals green, 1.8–2 × 1–1.2 mm, oblong, fused to the base; petals pinkish-white to pink, obovate to subrounded, subequal to the sepals, 1.4–1.7 × 0.9–1.5 mm, stamens 8; styles 4. Capsules compressed-subglobose, 4-locular, 1.8–2 mm diam. Seeds 0.6–0.7 mm long, U-shaped, usually with a quite developed semilunar membrane on concave side; pits more or less isodiametric and usually showing a typically hexagonal shape, 48.6–67.5 × 40.5–64.8 μm, with length 1–1.5 times width, arranged in 10–12 rows.

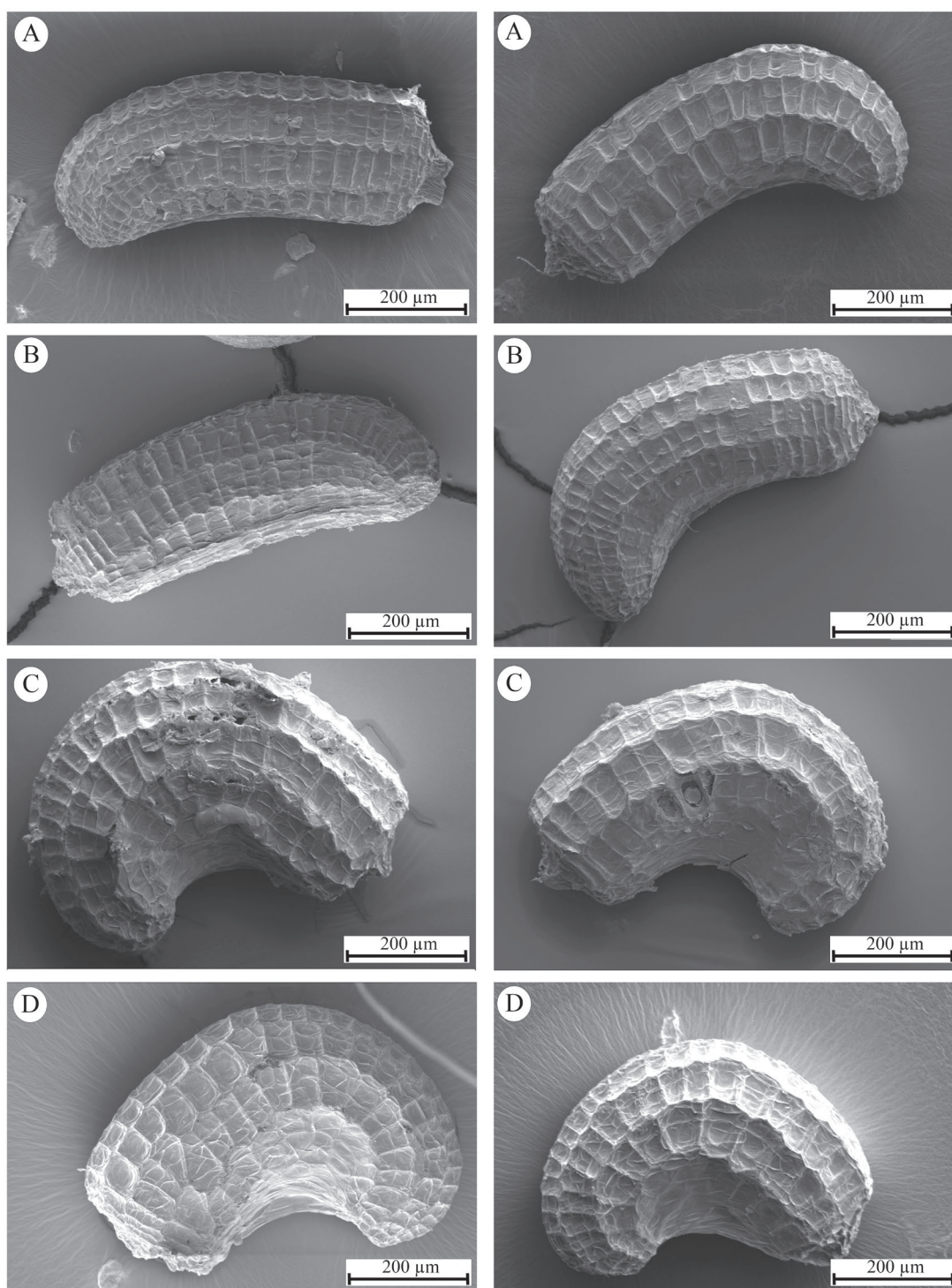
### Additional specimens examined

*Italy.* Lampedusa in calcareis hieme inundatis reg. infer. ex seminibus lopadusanis cultis, May 1910, *H. Ross* 710 (L2450958; WAG1181677; M0112435); Lampedusa, May 1904, *H. Ross s.n.* (L2450858); Insula Lampedusae, ipso hyeme inundatis, April 1889, *M. Lojacono* 26 (G00421147); Insel Lampedusa, Capo Ponente, 18 April 1884, *R.F. Solla s.n.* (L2450859); Lampedusa, April 1905, *G. Zodda s.n.* (FI064050); In umidiis: Lampedusa a Cala Croce e alla Madonna, April 1905, *G. Zodda s.n.* (FI064049, FI064051, PI044461, PI044462); Insula Lampedusa (olim Lopadusa), Pozzanghere non ancora prosciugate in vari punti dell'isola, generalmente associata alla *Bulliarda*, 9-13 March 1906, *S. Sommier s.n.* (FI001582); Lampedusa, 12 March 1906, *S. Sommier s.n.* (FI001582); Cala Francese andando a Punta Sottile (*Elatine* ♀ *Builladia*), *S. Sommier s.n.* (FI001582);

Lampedusa, Cala Madonna, pozze umide, 15 March 2021, *S. Cambria s.n.* (CAT); Malta. Gozo Ta Cen, 13 April 1987, *S. Brullo, P. Pavone & G. Ronsisvalle s.n.* (CAT035003); Gozo Xlendi Valley, 13 April 1987, *S. Brullo, P. Pavone & G. Ronsisvalle s.n.* (CAT034999); Malta Qrejtjen Point, 9 April 1984, *S. Brullo & G. Ronsisvalle s.n.* (CAT035000); Malta Naxxar, 16 April 1987, *S. Brullo, P. Pavone & G. Ronsisvalle s.n.* (CAT035002); Comino, 14 April 1987, *S. Brullo, P. Pavone & G. Ronsisvalle s.n.* (CAT035004).

## Discussion

Scholars substantially agree in disregarding vegetative and floral features to discriminate taxa within *Elatine* sect. *Elatinella* subsect. *Macropodae*, while recently value has been given only to the size, shape, and ornamentation of the seeds as greatly informative features (Popiela and Łysko 2010, Molnár et al. 2014, 2015, Sramkó et al. 2016, Takács et al. 2017). This has led authors to re-identify many specimens



**Fig. 4.** SEM micrographs of seeds of *Elatine macropoda*: A – archeological site near Syracuse (Sicily), B – Contrada Pirato near Scicli (Sicily), C – Contrada Nacalino near Modica (Sicily), D – Contrada Scalaricotta near Ispica (Sicily).



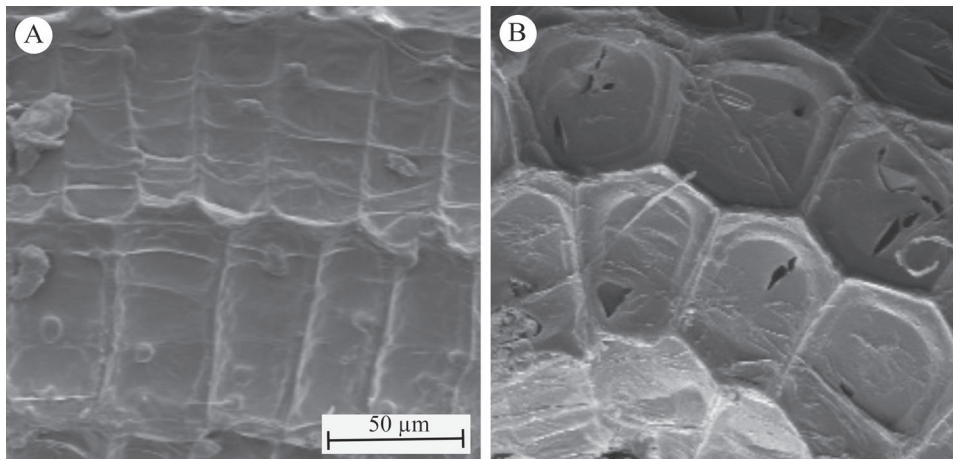


Fig. 5. SEM micrographs of seed detail of *Elatine macropoda* from Syracuse (A) and *E. gussonei* from Malta (B).

or living populations and to redesign the distribution ranges of hitherto very rare-reputed species, such as *Elatine gussonei* and *E. macropoda* (Takács et al. 2017). However, it should be noted that seed morphology does not provide sufficient information on the correct identification of these species, since it is usually a quite variable trait even within the single populations (e.g., Sramkó et al. 2016). In the case of the two species at issue, the characters that seem to have a greater taxonomic weight are the ratio length petal/sepals, the shape of the pits in the seed ornamentation, and their arrangement in row number.

In particular, our SEM analyses on original material and populations from *loci classici* show a marked variability in seed micro-morphology, as regards their size and shape. In fact, the seeds of *E. macropoda* can be slightly J-curved to U-curved, showing often on the concave side a semilunar membrane, which is absent or sub-null in almost all straight seeds (Fig. 4). Indeed, the seed testa reticulation represents a quite constant and distinctive character, especially for the shape and size of the pits, which in *E. macropoda* are rectangular or slightly hexagonal,  $64.8\text{--}86.5 \times 18.9\text{--}35.1 \mu\text{m}$ , 2.0–3.5 times longer than wide, and arranged in 8 rows (Fig. 5A). Conversely, the seeds of *E. gussonei* (Fig. 6) are usually very curved dorsally, with a quite developed semilunar membrane on the concave side, while the pits are more or less isodiametric and usually hexagonal,  $48.6\text{--}67.5 \times 40.5\text{--}64.8 \mu\text{m}$ , only 1.0–1.5 times longer than wide, and arranged in 10–12 rows (Fig. 5B).

In addition, as highlighted by other authors (Gussone 1827, Sommier 1907, Pignatti 2017), floral features show a relevant taxonomic value. In our opinion, the floral traits cannot be linked exclusively to environmental conditions or flowers age, as hypothesized by Mifsud (2006). In fact, based on our observations, *E. gussonei* (Lampedusa and Malta) is morphologically distinct from the typical *E. macropoda* of the Hyblaean territory, especially on account of the petals (equalling or slightly longer than sepals), while in *E. macropoda* petals are always very reduced (Fig. 7).

In addition, *E. macropoda* is clearly distinct from the Lampedusa plants in having flowers with pedicels 2–10(20) mm long, with petals about half as long as sepals.

Our observations concur with the protologues of the two species by Sommier (1907) and Gussone (1827), but surprisingly not with the images of flowers published by Takács et al. (2018, Fig. 3). Moreover, the pictures regarding the flowering plants of *Elatine* published by Sramkó et al. (2016, Fig. 1J-K), in our opinion, cannot be attributed to *E. gussonei* but rather to *E. macropoda*, showing flowers with petals subequal to sepals.

Therefore, the recent records of *E. gussonei* from Hyblaean territory is to be regarded as erroneous, as well as, probably, those from other Mediterranean areas (Molnár et al. 2014, Takács et al. 2017). Based on the above indicated diagnostic characters, we verified that all the populations occurring in the Hyblaean territory (Ragusa, Modica, Ispica, Syracuse, and Scicli) must be all ascribed to *E. macropoda*, while only those of Lampedusa and the Maltese islands belong to *E. gussonei* (Fig. 8).

Our treatment seems well supported by the molecular investigation (ITS and plastid sequences) on the *Elatine* genus by Sramkó et al. (2016). According to their phylogenetic trees, the populations attributed to *E. macropoda* and *E. gussonei* are split in well distinct clades. It can be easily deduced that these substantial genetic differences between the various populations deserve an accurate and further morphological study, and a different taxonomic treatment could be probably recognized (Sramkó et al. 2016).

According to the most recent literature (Uotila 2009, Sramkó et al. 2016, POWO 2021), the genus *Elatine* is represented in the Mediterranean area by the following nine species: *E. alsinastrum* L., *E. brochonii* Clavaud, *E. campylosperma* Seuber, *E. triandra* Schkuhr, *E. macropoda*, *E. gussonei*, *E. hydropiper*, *E. hexandra*, and *E. hungarica* Moesz. Based on both our observations and literature (Gorshkova 1974, Cjruiano and Velayos 1993, Qiner and Tucker 2007, Razifard 2016, Razifard et al. 2016, Popiela et al. 2017, Takács et al. 2018, Chamard et al. 2019), the following analytical key is proposed.

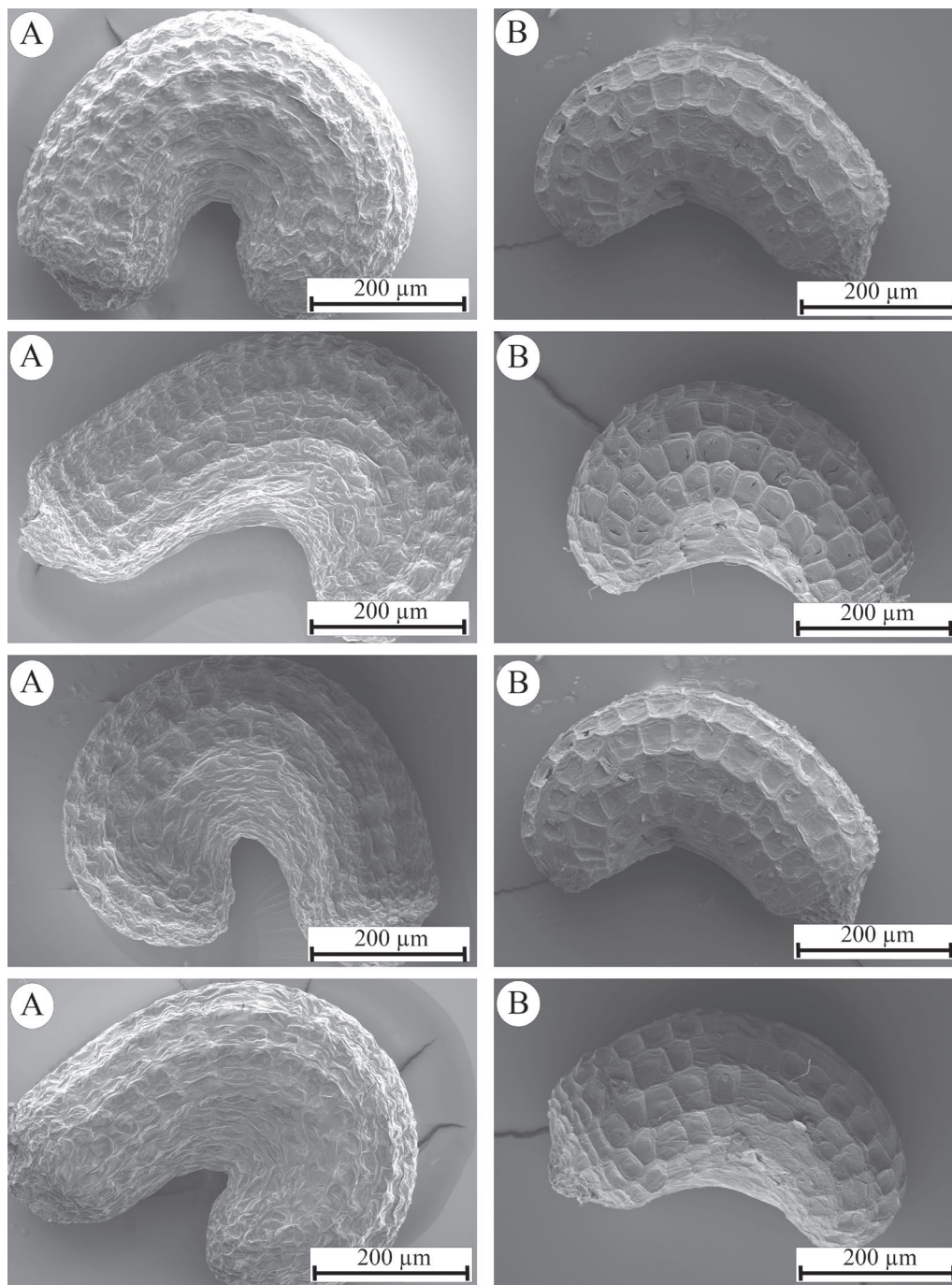


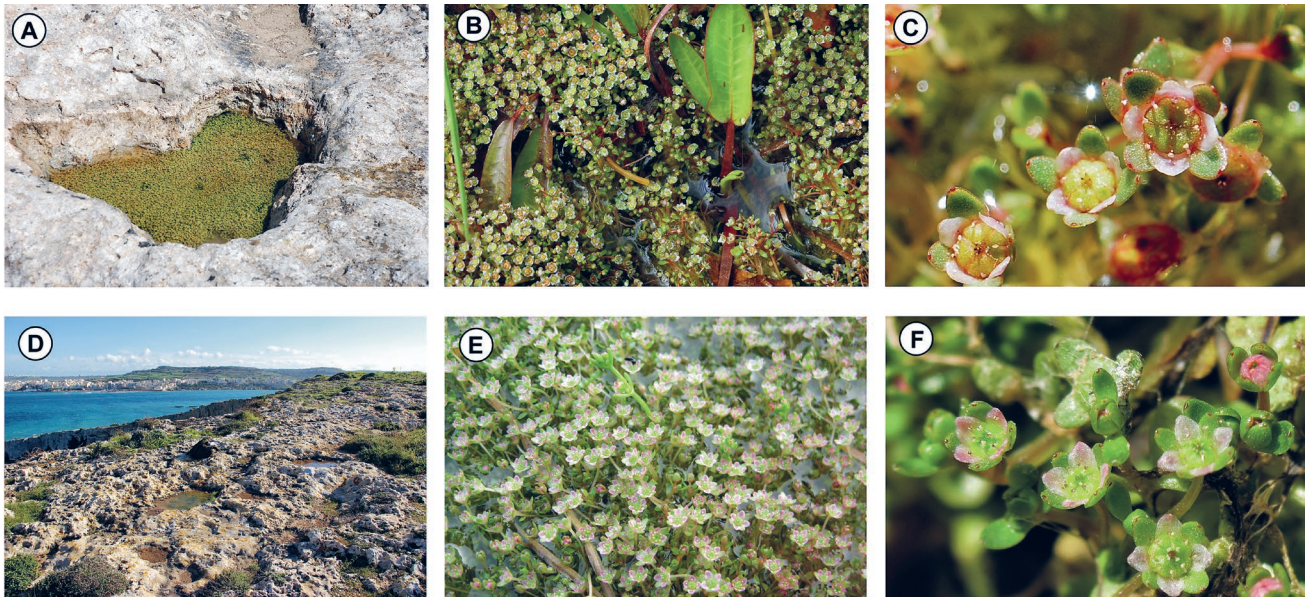
Fig. 6. SEM micrographs of seeds of *Elatine gussonei*: A – Lampedusa, B – Malta.

**Key to the Mediterranean species of *Elatine***

- 1. Leaves verticillate; stem erect or ascending, branched only at the base ..... *E. alsinastrum*
- 1. Leaves opposite; stem usually procumbent, branched also in the distal part ..... 2
- 2. Flowers trimerous ..... 3
- 2. Flowers tetramerous ..... 5
- 3. Stamens 3, leaves up to 10 mm long ..... *E. triandra*
- 3. Stamens 6, leaves max 4 mm long ..... 4
- 4. Flowers 2–5 terminal, sessile; petals shorter than sepals; capsule globose, 1 mm in diameter; seed with pits arranged in 8 rows ..... *E. brochonii*

- 4. Flowers solitary at nodes, with pedicel 0.5–2.0 mm long; petals longer than sepals; capsule depressed-subglobose, 1.5 mm in diameter; seed with pits arranged in 5–6 rows ..... *E. hexandra*
- 5. Flower pedicel 0.1–0.3 mm long; sepals 0.6–0.9 mm long and about 0.3 mm wide, shorter than petals ..... *E. hydropiper*
- 5. Flower pedicel 0.5–10(20) mm long; sepals 1.5–2.0 mm long and 0.8–1.2 mm wide, longer than petals or subequal to petals ..... 6
- 6. Petals 1.4–1.7 mm long, subequal or equal to sepals ..... 7
- 6. Petals 0.8–1.3 mm long, shorter than sepals ..... 8





**Fig. 7.** *Elatine macropoda* from archeological ruins of Syracuse. A – calcareous rocky pools, B – habit of flowering plants, C – detail of flowers. *E. gussonei* from Lampedusa and Malta islands. D – calcareous rocky pools (Malta), E – habit (Malta), F – detail of flowers (Lampedusa). Photos: A-C – P. Minissale, D-E – S. Sciandrello, F – S. Cambria.

7. Flower pedicel 3–7 mm long; seed pits rectangular, 34.6–46.0  $\mu\text{m}$  long and 16.6–24.6  $\mu\text{m}$  wide; 2 times longer than wide ..... *E. campylosperma*
7. Flower pedicel 0.5–3.0 mm long; seed pits isodiametric hexagonal 48.6–67.5  $\mu\text{m}$  long and 40.5–64.8  $\mu\text{m}$  wide, 1.0–1.5 times longer than wide ..... *E. gussonei*
8. Lower flower pedicel up to 10–20 mm long; petals 0.6–1.4 mm wide, 1/2 as long as the sepals; seed almost straight up to curved, with pits length 2.0–3.5 times longer than wide ..... *E. macropoda*
8. Lower flower pedicel max 3(–6) mm long; petals 0.5–0.7 mm wide, 1/3 as long as the sepals; seed always marked curved, with pits length 1.5–2 times longer than wide ..... *E. hungarica*

## Conclusions

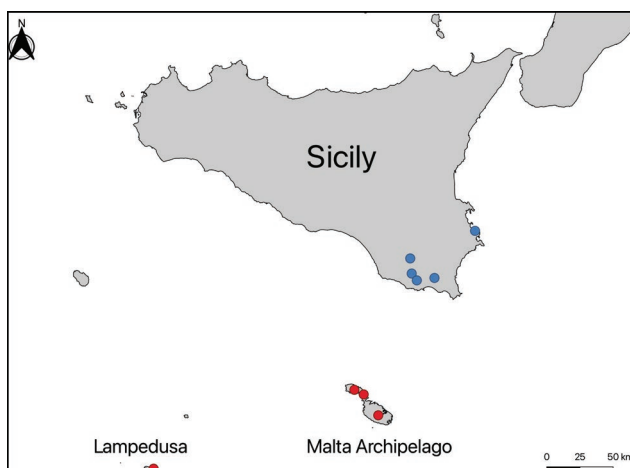
The identification of the diacritical characters between *Elatine macropoda* and *E. gussonei* has significant implications in the conservation policies of protected species. In fact, *E. gussonei* is listed in Annex II of the Habitats Directive (92/43/EEC) among those that require rigorous protection by the states of the European Union (European Commission 1992). Therefore, in the few areas where the species occurs, the commitment to adequate protection measures must be concrete and careful. This is especially true for the Maltese Islands where the strong anthropogenic pressure, especially in the form of pervasive urbanization, requires particular attention. On the other hand, both species grow in habitats of priority interest according to the first annex of the same Directive as temporary Mediterranean ponds (code 3170) (Brullo et al. 2020, 2022).

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## Author contributions

All authors contributed extensively to the work presented in this paper.



**Fig. 8.** Distribution map in Sicily and Malta of *Elatine macropoda* (blue dots) and *E. gussonei* (red dots) from herbarium materials.

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