

## Research Article

***Ehrharta erecta* Lam. (Poaceae, Ehrhartoideae): distribution in Italy and taxonomy of one of the most invasive plant species in the world**Adriano Stinca<sup>1,\*</sup> and Giacomo Mei<sup>2</sup><sup>1</sup>Department of Environmental, Biological and Pharmaceutical Sciences and Technologies, University of Campania Luigi Vanvitelli, Caserta, Italy<sup>2</sup>Department of Agricultural, Food and Environmental Sciences, Marche Polytechnic University, Ancona, Italy

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**Abstract**

*Ehrharta erecta* (Poaceae, Ehrhartoideae) is a neophyte native to South Africa and it is considered as one of the most invasive plant species in the world. The aim of the present work, based on bibliographic, herbarium and in the field researches, is to update the distribution of *Ehrharta erecta* in Italy. As long as the present researches were carried out, we eventually discovered the first population of the species in Sicily. Notes on taxonomy, relations with *Ehrharta delicatula*, features of the environment in which it was found and the status of naturalization of the species are here presented and discussed.

**Key words:** alien species, biodiversity, herbarium, invasiveness, vascular flora**Introduction**

*Ehrharta* Thunb. (Poaceae, Ehrhartoideae) is an African genus ranging from South Africa to Ethiopia and Yemen that includes approximately 35 species (Fish et al. 2015). Some species are alien in Australia, China, Indonesia, Mediterranean Basin, New Zealand, North and South America (e.g., Edgar et al. 1991; Barkworth 2007; Weiller 2017; Calvo and Moreira-Muñoz 2018; Valdés and Scholz 2018). The genus includes annual or perennial plants, with pedicellate solitary or sometimes clustered spikelets generally arranged on racemose or paniculiform inflorescences. Each spikelet has glumes 5–7-nerved and 3 florets, among which the lower 2 are sterile and reduced to lemmas, while the upper 1 is bisexual.

In the Euro-Mediterranean area three species are recorded (Valdés and Scholz 2018): *Ehrharta calycina* Smith, 1790 (Spain and Tunisia), *Ehrharta erecta* Lamarck, 1786 (France, Israel, Italian Peninsula, Morocco, Netherlands, Portugal, Sardinia and Spain) and *Ehrharta longiflora* Smith, 1790 (Canary Islands and Spain). All these species show a high relative growth rate (Verboom et al. 2004) which has probably facilitated their naturalization outside their native ranges.

**Table 1.** Morphological characters analyzed to compare *Ehrharta erecta* and *Ehrharta delicatula* (asterisk indicates the diagnostic characters).

	<i>Ehrharta erecta</i>	<i>Ehrharta delicatula</i>
*Biological form	Hemicryptophyta caespitosa	Terophyta scaposa
Plant height (cm)	30–88	7–60
Leaf lamina length (in the center of the stem, cm)	6.5–19.5	1.9–12.5
Leaf lamina width (in the center of the stem, cm)	0.6–1.5	0.1–0.85
Panicle length (cm)	7.5–22	2.1–17
*Spikelet length (mm)	3–4.2	1.8–2.8
Lower gluma length (mm)	1.7–2.8	1.1–2.2
Upper gluma length (mm)	2–3.1	1.6–2.5
*Number of sterile lemmas transversely ribbed	1 (rarely, also the second sterile lemma show 1–5 transversal ribs that are not very evident)	2
Number of ribbed on first sterile lemma	7–15	6–9
*Number of stamens	6	3

Aim of the present work is to clarify the distribution in Italy of *Ehrharta erecta* and to report its presence in Sicily for the first time. Its taxonomy, relations with *Ehrharta delicatula* Stapf (1897), features of the environment in which the species was found and status of naturalization are here also examined.

## Materials and methods

The study was based on researches of relevant literature, field surveys and analysis of herbarium samples stored in the main Italian herbaria. The identification of the analyzed samples was made on the basis of key and descriptions by Fish et al. (2015). Protologue by Lamarck (1786), as well as data reporting by Ricciardi and Anzalone (1988), Barkworth (2007) and Stapf (1897, 1900), were also examined. The floristic literature was also analysed to detect previous indications of the species in Italy and Sicily (e.g., Tenore 1835; Bertoloni 1838; Parlato 1848; Fiori 1923; Pignatti 1982; Ricciardi and Anzalone 1988; Giardina et al. 2007; Raimondo and Spadaro 2009; Banfi 2017; Galasso et al. 2018).

Field work was conducted in the period 2001–2018 in Italian locations where this species was reported to reside in the past (Caserta, Portici and Naples in Campania, Caffarella Valley in Lazio, Cagliari in Sardinia), as well as in Catania (Sicily).

Herbarium researches were carried out in the following Italian collections: ANC, APP, BI, CAG, CAT, FI, HFLA, LEC, MSNM, NAP, P, PAD, PAV, PI, PORUN, RO, SAF, TO, URT, UTV (see Supplementary material Appendix 1; acronyms according to Thiers 2018).

In order to investigate the differences between *Ehrharta erecta* and *Ehrharta delicatula*, 11 morphological characters (Table 1) were examined in 40 herbarium selected specimens (25 from *Ehrharta erecta* and 15 from *Ehrharta delicatula*). The variability of collected data was analyzed using

the t-test and expressed by box plots. For a comparative study, we also analyzed the African specimens stored in BLFU, KSAN, MSNM, P, PRU, RO and TO (Appendix 1).

For what concerns the newly Sicilian population, geocoding of the locality was performed with the use of a portable GPS device (GPS map 60CSx, Garmin, USA), calibrated beforehand (geographic system UTM WGS84). The climatic characterization of the area of discovery was performed by processing the rainfall and temperature data from Fontanarossa meteorological station (17 m a.s.l., about 6.5 km from the analysed site) for the period 1961–2016 (Fick and Hijmans 2017; Ministero della Difesa 2018). Data about the habitat and the population size of *Ehrharta erecta* were based on personal observations in the field. The evaluation of the status of naturalization was defined according to the terminology of Pyšek et al. (2004).

## Results and discussion

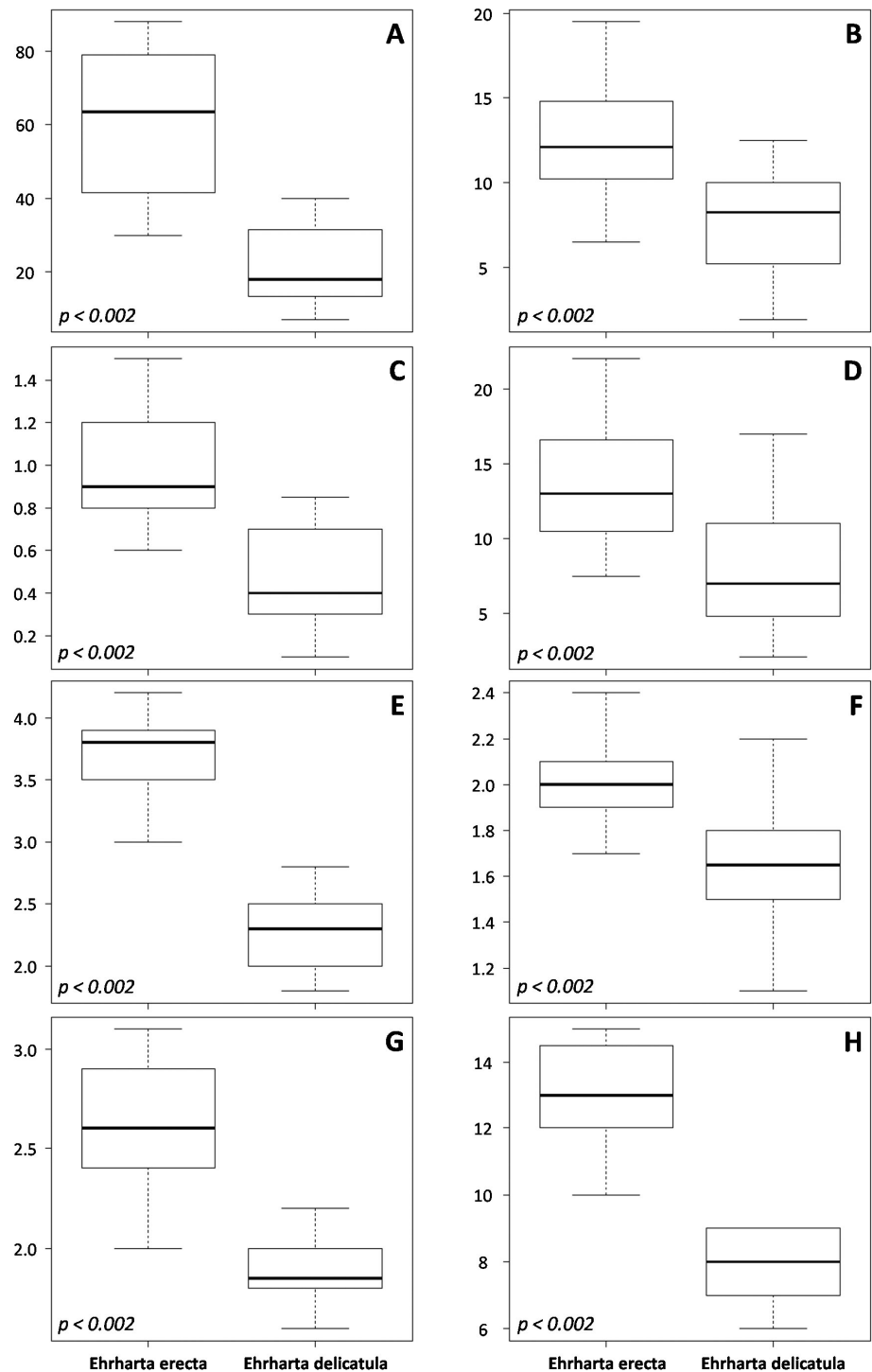
### *Native range and taxonomic notes*

*Ehrharta erecta*, commonly known as “panic veldtgrass” or “erect veldtgrass”, is a perennial grass native to South Africa (Fish et al. 2015). In its native range the species grows from arid habitats to tropical forests and grasslands, spreading from sea level to 2600 m a.s.l. To date it is considered as one of the most invasive plant species in the world (Weber 2017). According to Ray et al. (2018), effective management of this alien is possible using either mechanical or chemical removal methods, though especially the herbicide application could have strong negative impact at the level of the entire ecosystem.

### ***Ehrharta erecta* Lam., Encycl. 2(1): 347. 1786 [16.X.1786].**

- *Ehrharta delicatula* auct. Fl. Ital., non Stapf.
- = *Ehrharta panicea* Sm., Pl. Ic. Ined. t. 9. 1789.
- = *Ehrharta deflexa* (Guss.) Pignatti, Archiv. Bot. Forlì 34: 5. 1958.
- = *Panicum deflexum* Guss., in Ten. Fl. Nap. 5: 320(–321). 1835.
- = *Ehrharta erecta* Lam. var. *abyssinica* (Hochst.) Pilg., in R.E.Fries & T.C.E.Fries Notizbl. Bot. Gart. Berlin-Dahlem 9(87): 508. 1926.
- = *Ehrharta abyssinica* Hochst., Flora 38(13): 193(–194). 1855.
- = *Ehrharta erecta* Lam. var. *natalensis* Stapf, in W.T. Thiselton-Dyer Fl. Cap. 7(4): 671(–672). 1900.

Within the genus *Ehrharta*, this species has been classified in *Erecta* group by Gibbs Russell and Ellis (1987) for the presence of small spikelets, short glumes, lemmas characterized by glabrous sides, lack of appendages and first sterile lemma, well developed and typically constricted at the base. *Ehrharta erecta* is similar to *Ehrharta delicatula* (belonging to the *Calycina* group according to Gibbs Russell and Ellis 1987) native to South Africa and it was previously recorded in Italy by Pignatti (1958), Zangheri (1976), Pignatti (1982) and Anzalone (1984). According to our data, significant



**Figure 1.** Variation in selected morphological characters in *Ehrharta erecta* and *Ehrharta delicatula*. Rectangles define 25<sup>th</sup> and 75<sup>th</sup> percentiles, horizontal lines show median values, whiskers indicate extreme values (A: plant height, cm; B: leaf lamina length, cm; C: leaf lamina width, cm; D: panicle length, cm; E: spikelet length, mm; F: lower gluma length, mm; G: upper gluma length, mm; H: number of ribbed on first sterile lemma).

statistical differences ( $p$  value  $< 0.002$ ) exist between the two taxa concerning all examined characters (Figure 1, Table 1). Particularly, the two species are easily distinguished because *Ehrharta erecta* is a perennial herb with spikelets 3–4.2 mm long, only one sterile lemmas transversely ribbed (with the second sterile lemma only rarely showing 1–5 transversal



**Figure 2.** Comparison between (A) *Ehrharta erecta* (Campania. Bosco inferiore di Portici [inselvaticita], 21 June 1907, Pellanda, FI 53987 sub *E. panicea* Sm.) and (B) *Ehrharta delicatula* (Pr. Piqueenerskloof, in arenosis, 283.3 m a.s.l., 21 August 1894, Schlechter, TO) with detail of the respective spikelets (a, b, scale bars 5 mm). Herbarium Universitatis Florentinae (A, a) and Herbarium Universitatis Taurinensis (B, b).

ribs that are not very evident) and 6 stamens, while *Ehrharta delicatula* is an annual plant with spikelets 1.8–2.8 mm long, both sterile lemmas transversely ribbed and 3 stamens (Figures 1–2, Table 1). Concerning chromosome numbers, both species presented diploid counts  $2n = 2x = 12$  (Hoshino and Davidse 1988; Spies et al. 1989).

Based on our research, *Ehrharta delicatula* must be excluded from the Italian vascular flora, due to the fact that all the samples collected in Italy and examined by us are to be referred to *Ehrharta erecta*. This result is fully in accordance with Ricciardi and Anzalone (1988) and Galasso et al. (2018).

Gibbs Russell and Ellis (1987) and Fish et al. (2015) recognized two variety within *Ehrharta erecta*: var. *abyssinica* (Hochst.) Pilg. and var. *natalensis* Stapf. All the examined Italian specimens can be attributed to the var. *erecta*. However, this taxa are poorly distinguished from *Ehrharta erecta* s.s. by some characters concerning the spikelet and treated as synonyms by *Ehrharta erecta* according to The Plant List (2018).

#### *Site location, features of the environment and status of naturalization in Sicily*

During field surveys in Sicily, the presence of *Ehrharta erecta* was ascertained in the urban area of Catania. Here, a small population of the species was

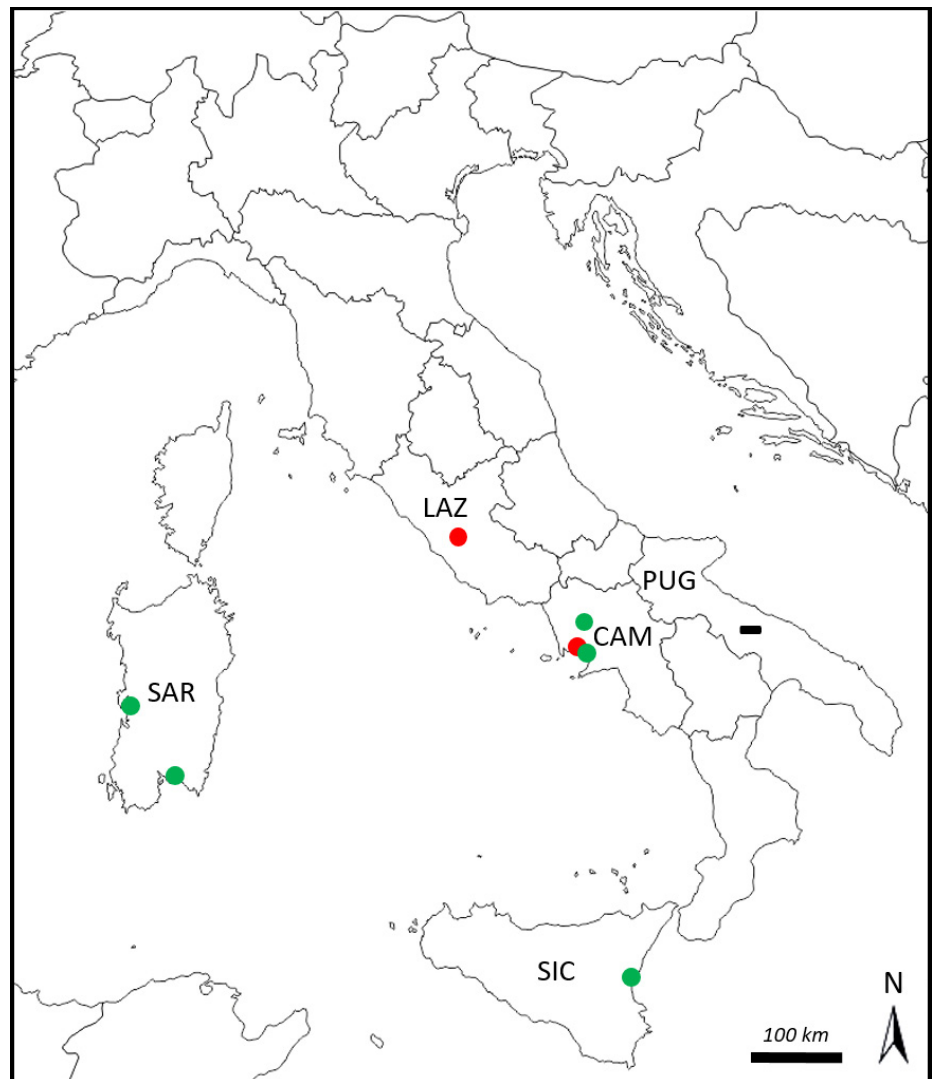
found in the historical area of the city, that is placed on the southeastern foothills of Mt. Etna, at 28 m a.s.l. (UTM WGS84: 33 S 507689E and 4151863N). The finding of the species in the core of the urban area is perfectly in line with what is highlighted by various authors (e.g., Stinca et al. 2017; Scafidi and Raimondo 2018), who show how the urban environments in Italy are constantly subjected to new introductions of exotic species, with more or less trumpery and damaging effects on the native flora. The climate of the city can be referred to as thermo-Mediterranean type, with an average annual air temperature of 17.8 °C and rainfall of 567 mm. The bioclimatic definition of the area derived from the bioclimatic map of Italy (Pesaresi et al. 2014, 2017) is as a mediterranean macrobioclimate, pluvisseasonal oceanic bioclimate, upper thermo-mediterranean thermotypes (Rivas-Martínez et al. 2011).

The Sicilian *Ehrharta erecta* population covers an area of approximately 25 m<sup>2</sup> and consists of eight individuals that grow among basaltic stones of the urban area of Catania, a nitrophilous and trampled site. The population is characterized by ruderal native such as *Antirrhinum siculum* Miller (1768), *Cymbalaria muralis* G.Gaertner, B.Meyer and Scherbius (1800) subsp. *muralis*, *Oloptum miliaceum* (Linnaeus, 1753) Röser and H.R. Hamasha (2012), *Oxalis corniculata* Linnaeus (1753), *Parietaria judaica* Linnaeus (1756) and *Parietaria lusitanica* Linnaeus (1753) subsp. *lusitanica*, as well as alien plant species (*Erigeron sumatrensis* Retzius, 1788, *Ficus microcarpa* Linnaeus filius, 1782, *Oxalis debilis* Kunth, 1822 and *Symphotrichum squamatum* (Sprengel, 1826) G.L. Nesom 1995). The specific composition of this phytocoenosis highlights the human impact on the area.

The vector of introduction of *Ehrharta erecta* is unknown. At the current state of knowledge, in Italy, and thus in Sicily as well, the plant is not utilized in gardens as an ornamental plant and ethnobotanical uses are unknown. Our hypothesis is that this neophyte was accidentally introduced as soil contaminant in pots of ornamental exotic plants or in the gardens of Catania. As all the examined plants produced caryopses, the diffusion of this species depends on sexual reproduction. We hypothesize that this exotic plant has been introduced recently on the island. According to Pyšek et al. (2004), the observation period is too short to understand the real success of propagation and declare a state of naturalized species. Therefore it must be considered a casual alien plant in Sicily.

### *Occurrence in Italy*

According to Tenore (1835, sub *Panicum deflexum* Guss.), the first finding of this species in Italy was done by Gussone in the Royal Park of Portici near Naples. Today, in Italy *Ehrharta erecta* is certainly present only in Campania (Royal Parks of Portici [Stinca and Motti 2009 and other references



**Figure 3.** Current distribution map of *Ehrharta erecta* in Italy (green circles) with indication of the of recently unconfirmed (red circles) and excluded (–) localities, based on the studied herbarium specimens and field surveys (LAZ: Lazio; CAM: Campania; PUG: Puglia; SIC: Sicily; SAR: Sardinia). For details see Supplementary material Table S1.

cited therein; Stinca et al. 2014] and Caserta [Terracciano 1872, sub *Ehrartha* (sic!) *panicea* Smith; Stinca et al. 2013]), Sardinia (Oristano in locality Torre Grande [Scrugli et al. 1990]) and Sicily (Catania, as shown above) (Figure 3, Table S1). Unfortunately, no exsiccata indicated by Ricciardi and Anzalone (1988) has been traced in NAP (R. Vallariello *in verbis* 2018).

In Sardinia this exotic plant is also reported in the Botanical Garden of Cagliari [Viegi 1993; A. Stinca *pers. obs.* 2009; L. Podda *pers. obs.* 2018] and immediately outside of it (E. Banfi *pers. obs.* 2010). In this place it was reported for the first time by Viegi (1993) on the basis of a sample collected in 1978 by Zedda and Mascia. To date, this specimens has not been traced in CAG (L. Podda *in verbis* 2018).

In Puglia *Ehrharta erecta* was reported as casual alien by Celesti-Grapow et al. (2010) and Galasso et al. (2018), but we did not find specific bibliographic references and samples in the consulted herbaria. Therefore,

its presence in this territory is very doubtful and we suggest to exclude the species from the regional flora.

Furthermore, we confirm the local extinction of the species in the Caffarella Valley (known in the past as Ninfa Egeria Valley) in Lazio (Chiovenda 1898; Buccomino and Stanisci 2000) and in the city centre of Naples (Tenore 1835, sub *Panicum deflexum* Guss; De Rosa, sub *Erharta* (sic!) *panicea* Sm.; De Natale and La Valva 2000; Stinca et al. 2013).

As for the stations in the Royal Parks of Portici and Caserta, the species grows mainly inside the holm oak forests and its edges. However, it is also sporadically present in the more disturbed grassy places. In these two localities *Ehrharta erecta* was recorded, and still present, from 20 to 95 m a.s.l. and from 70 to 160 m a.s.l., respectively. Conversely, the *Ehrharta erecta* populations of Sardinia and Sicily live exclusively in very anthropized environments, such as road edges (Oristano) or among basaltic stones in urban areas (Catania), at an altitude of 5 and 28 m a.s.l., respectively. On the basis of our observations on the Italian growth environments, *Ehrharta erecta* seems to be able to tolerate drought and high shade. These ecological characteristics are fully in accordance with what reported in the international literature (McIntyre and Ladiges 1985).

Based on our in the field observations, this neophyte in Campania and Sardinia can be considered as naturalized, while it must be considered as casual alien plant in Sicily. Then, Galasso et al. (2018) correctly report this weed as naturalized in Italy. According to Frey (2005), we observed that the species in Campania reproduces mostly by seed but also vegetatively by rhizomes rooting at nodes. As observed in Australia (Bidwell et al. 2006), it is likely that also in the Italian invaded sites this neophyte constitutes a persistent soil seed bank. Of note, polyploidy was proposed as an important determinant of invasiveness in plants because this may allow polyploids to succeed in strongly fluctuating environments and/or effectively colonize new habitats and, thus, increase their potential to be invasive (te Beest et al. 2012). However, this theory does not explain the invasiveness of *Ehrharta erecta*. In fact, Stebbins (1985), in a long term field experiment performed in USA, induced autotetraploids in this species and showed that diploid plants were demographically successful in most study sites. On the other hand, similarity in climate with native range of *Ehrharta erecta* may in part explain its rapid establishment in the Mediterranean Basin (South Africa being one of the five regions in the world with a Mediterranean climate).

## Conclusion

Recently, Galasso et al. (2018) recorded 1500 non-native species and subspecies (4 undefined status, likely casual aliens; 705 casual; 570 naturalized; 221 invasive) in Italy. However the number of alien species is



steadily increasing (e.g., Stinca et al. 2019), also in Sicily (Guarino et al. 2018; Badalamenti and La Mantia 2018; Scafidi and Raimondo 2018). Indeed, throughout the Italian territory the long-lasting human presence has promoted the spread of many alien species whose occurrence may negatively affect the structure and functioning of natural habitats. In this context, discovery of new alien plants as *Ehrharta erecta* in Sicily, and evaluation of their distribution and naturalization status in Italy, are a crucial issue for their correct management.

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### Supplementary material

The following supplementary material is available for this article:

#### Appendix 1. Specimina visa selecta.

This material is available as part of online article from:

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