Italian Botanist 15: 1–8 (2023)
doi: 10.3897/italianbotanist.15.91193
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

Epimedium alpinum subsp. *albanicum* new subspecies for the flora of Kosovo

Zeqir Hashani[1], Xhavit Mala[2], Qenan Maxhuni[3], Lulzim Zeneli[1]

1 *University of Gjakova "Fehmi Agani" Str. Ismail Qemali, 50000 Gjakova, Kosovo* **2** *Directorate of National Park "Sharri", Str. Flamuri n.n., 20000 Prizren, Kosovo* **3** *College of Medical Sciences Rezonanca, Str. Glloku te Shelgjet "Veternik", 10000 Prishtine, Kosovo*

Corresponding author: Xhavit Mala (xhavitmala@hotmail.com)

Academic editor: Sandro Bogdanović | Received 3 August 2022 | Accepted 30 December 2022 | Published 9 January 2023

Citation: Hashani Z, Mala X, Maxhuni Q, Zeneli L (2023) *Epimedium alpinum* subsp. *albanicum* new subspecies for the flora of Kosovo. Italian Botanist 15: 1–8. https://doi.org/10.3897/italianbotanist.15.91193

Abstract

This paperwork provides data on the endemic taxa *Epimedium alpinum* subsp. *albanicum* Kit Tan, Shuka & Hallaçi, which is observed and identified for the first time for the territory of Kosovo. This taxon was found in Qafë Morine (Pass of Morina) within the locality of Devë, and Qafë Prush Municipality of Gjakova, on the road toward the border with Albania. *Epimedium alpinum* subsp. *albanicum*, is found in serpentine substrates which has a limited extent of presence in the investigated areas. This research includes the presence, description and distribution of this new taxa for the flora of Kosovo.

Keywords

endemic, *Epimedium alpinum* subsp. *albanicum*, flora, Kosovo, new taxon

Introduction

Kosovo is characterized by a small territorial area compared to other Balkan countries and beyond. Within the Balkan peninsula, in spite of its small territorial area Kosovo is very rich in its floristic and vegetation aspect, due to its continental and modified sub-Mediterranean climate, topography, geology, as well as the geographical position of the mountain massifs of Kosovo, especially Mali Sharr and the Albanian Alps (Rexhepi 1982; Hashani et al. 2014).

Given the natural and floristic values of Kosovo country, we have made continuous expeditions to areas that are distinguished by richer floristic diversity, and in the

Copyright *Zeqir Hashani et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

course of such expeditions, we have explored the hilly areas of Devë and Qafë Prush areas which is located in the Municipality of Gjakova and lies along the Morina pass in the border area with Albania.

During 2018 and 2022 we conducted several floristic field trips in this areas and identified the endemic taxon *Epimedium alpinum* subsp. *albanicum* Kit Tan, Shuka & Hallaçi. (Figs 1, 2) that occurs mainly on serpentine substrates. Serpentine substrates are of particular importance for the flora and diversity of species in Kosovo and beyond. They are located in the central and northern part of the serpentine massifs of the western Balkans. Biodiversity in this substrate is high with a large number of endemic species interesting for both local and regional levels (Stevanović et al. 2003; Shuka and Jahollari 2007; Słomka et al. 2015, 2017; Krause et al. 2022).

The floristic reaches of the serpentine substrates has attract the attention of many botanists due to its uniqueness and diversity as well as for the modification that plants undergo in order to adapt to the toxic effect of the heavy metals of this substrate (Shuka et al. 2010; Słomka et al. 2014, 2017, 2018). Most of plant species that are growing in serpentine substrate have adapted mechanisms which tolerate the high concentrations of Cr, Ni, Fe, Al, Co, Mg or Mn (Stevanović et al. 2003; Dudić et al. 2007; Shuka and Jahollari 2007; Shuka 2009).

Edaphic isolation resulted in the development of a richness of local endemic species on serpentine soils. Among these, distinguished several monotypic obligate serpentine genera such as: *Halacsya sendtneri* (Boiss.) Dörfl., *Bornmuellera emarginata* (Boiss.) Rešetnik or *Paramoltkia doerfleri* (Wettst.) Greuter & Burdet (Stevanović et al. 2003) which are tertiary relicts. Some other species such as *Aristolochia merxmuelleri* Greuter & E. Mayer, have survived several glacial and postglacial cycles in this area (Krause et al. 2022). In its distribution range, southwest Kosovo and the serpentine massifs of Albania *E. alpinum* subsp. *albanicum* is companied with other interesting serpentine obligate species such as *Aster albanicus* (Degen) Degen, *Centaurea melanocephala* Pančić, *C. kosaninii* Hayek, *C. vlachorum* Hartvig, *Dioscorea balcanica* Košanin, *Euphorbia spinosa* L. subsp. *glabriflora* (Vis.) Frajman, *Forsythia europaea* Degen & Bald., *Genista hassertiana* (Bald.) Buchegger, *Minuartia baldaccii* (Halácsy) Mattf., *Paramoltkia doerfleri* (Wettst.) Greuter & Burdet, *Sanguisorba albanica* András. & Jáv., *Sedum album* L. subsp. *serpentine* (Janch.) Barina, *Klasea radiata* (Waldst. & Kit.) Á. Löve & D. Löve subsp. *cetinjensis* (Rohlena) Greuter & Wagenitz, *Stipa mayeri* Martinovsky, *Tulipa albanica* Kit Tan & Shuka, *T. kosovarica* Kit Tan, Shuka & Krasniqi and *Veronica barrelieri* H. Schott ex Roem. & Schult. subsp. *andrasovszkyi* (Jáv.) Albach (Rakaj 2009; Shuka and Tan 2009; Shuka et al. 2012; Millaku et al. 2013, 2018; Shuka et al. 2020).

Epimedium is a genus of perennial herbs in the family Berberidaceae, the majority have four-parted "spider-like" flowers in spring, which are eminent in Chinese ethno pharmacology due to varied pharmaceutical properties, is a unique and rare perennial medicinal herb that has not been researched and exploited much in terms of phytochemistry and molecular aspects. One of the species used as a dietary supplement is *E. grandiflorum* C. Morren. The majority of the species are endemic to China, with smaller numbers elsewhere in Asia, and a few in the Mediterranean region-internet (Sajad 2018).

Material and methods

Collection and herbarisation of plant material in the new location of *Epimedium alpinum* subsp. *albanicum* was performed with the classical technique, as well as for other plant species taken in the study. Herbarised plant materials were collected during the years 2018 and 2022, in several floristic expeditions, carried out in the hilly areas of Morina and the surrounding areas, namely in the locality Devë, and locality Qafë Prush, Municipality of Gjakova (Fig. 3) 650 m, with coordinates 42°20'7.296"N, 20°22'12.5148"E, and 750 m with coordinates 42°19'0.7104"N, 20°21'44.6976"E. During the field expeditions, relevant records were kept on the type of vegetation and habitat, the composition of the substrate and the direction where the species is located. Digital photographs have also been taken of the species found along the transects. As basic literature for the determination of plant species, we used the Flora Europaea (Tutin et al. 1964, 1980), the Red Book of Vascular Flora of Kosovo (Millaku et al. 2013), as well as other articles published on the endemic flora of the Balkans and Albanian flora (Barina 2017; Shuka et al. 2020). The herbarised plants of *E. alpinum* subsp. *albanicum* have been stored in the National Herbarium of Tirana (TIR-0021475).

Results and discussion

Epimedium alpinium subsp. *albanicum* is a perennial plant that usually grows from an underground rhizome in shady places, and completely dominates the ground floor, accompanied by woody species such as *Quercus frainetto* Ten. and *Quercus cerris* L., while in terms of substrate this species grows in serpentine substrates of the areas

Figure 1. *Epimedium alpinum* subsp. *albanicum* with leaves, flowers and fruits (photos by Z. Hashani).

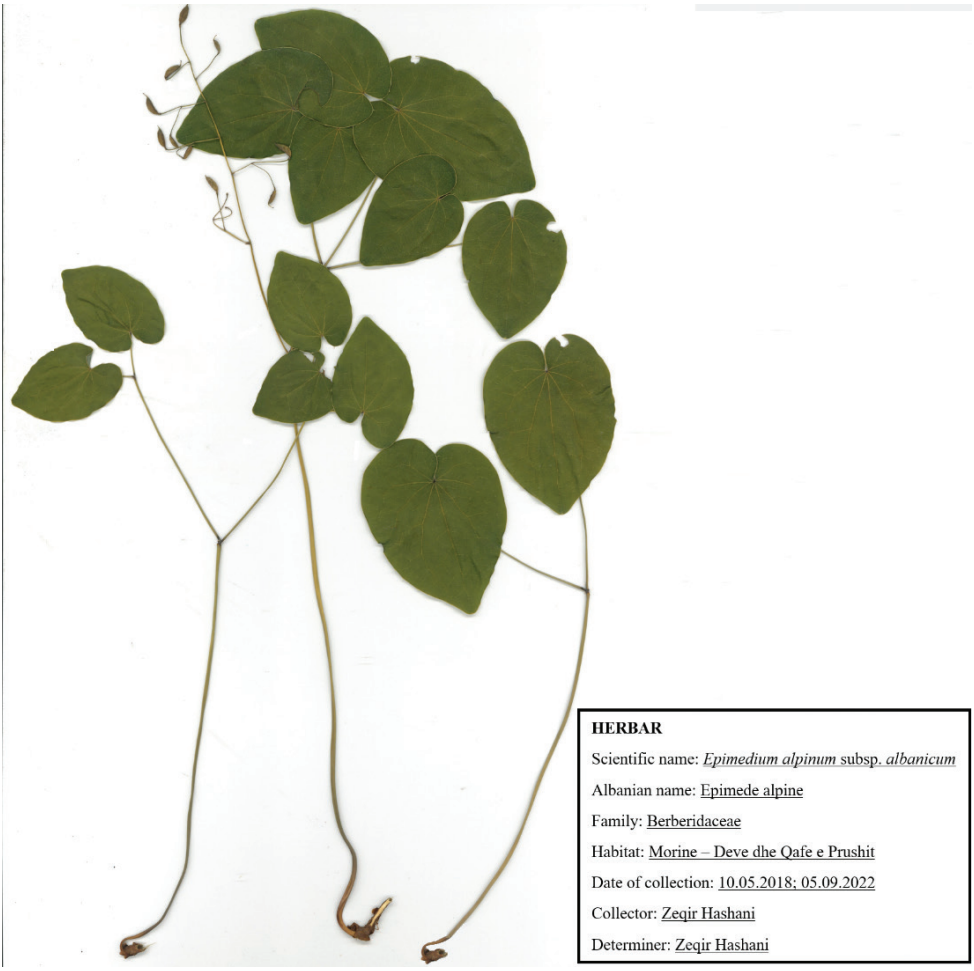

Figure 2. Herbarium of specimens of *Epimedium alpinum* subsp. *albanicum* (photo by Z. Hashani).

which we have explored. In Kosovo it grows mostly in subalpine zones, at altitudes from 480 m up to 750 m, in wet meadows where it was found with *Lilium albanicum* Griseb., *Centaurea kosaninii* Hayek, *Genista hassertiana* (Bald.) Buchegger, *Sanguisorba minor* Scop., *Ranunculus millefoliatus* Vahl, *Ornithogalum umbellatum* L., *Doronicum columnae* Ten., *Primula veris* L., *Genista tinctoria* L. and others. *Epimedium alpinum* subsp. *albanicum* flowers early in spring, from May to beginning of June and fruits during the June and July, depends from the exposition and altitudes. In the study areas *E. alpinum* subsp. *albanicum* firstly were recorded on May 10, 2018 near Devë village, on the right side of the road toward the border with Albania (Fig. 3). The species grows in the hilly area of this location at an altitude of 650 m, which in this period of our observation, has been in the vegetative period, just before the flowering phase (Figs 1, 2).

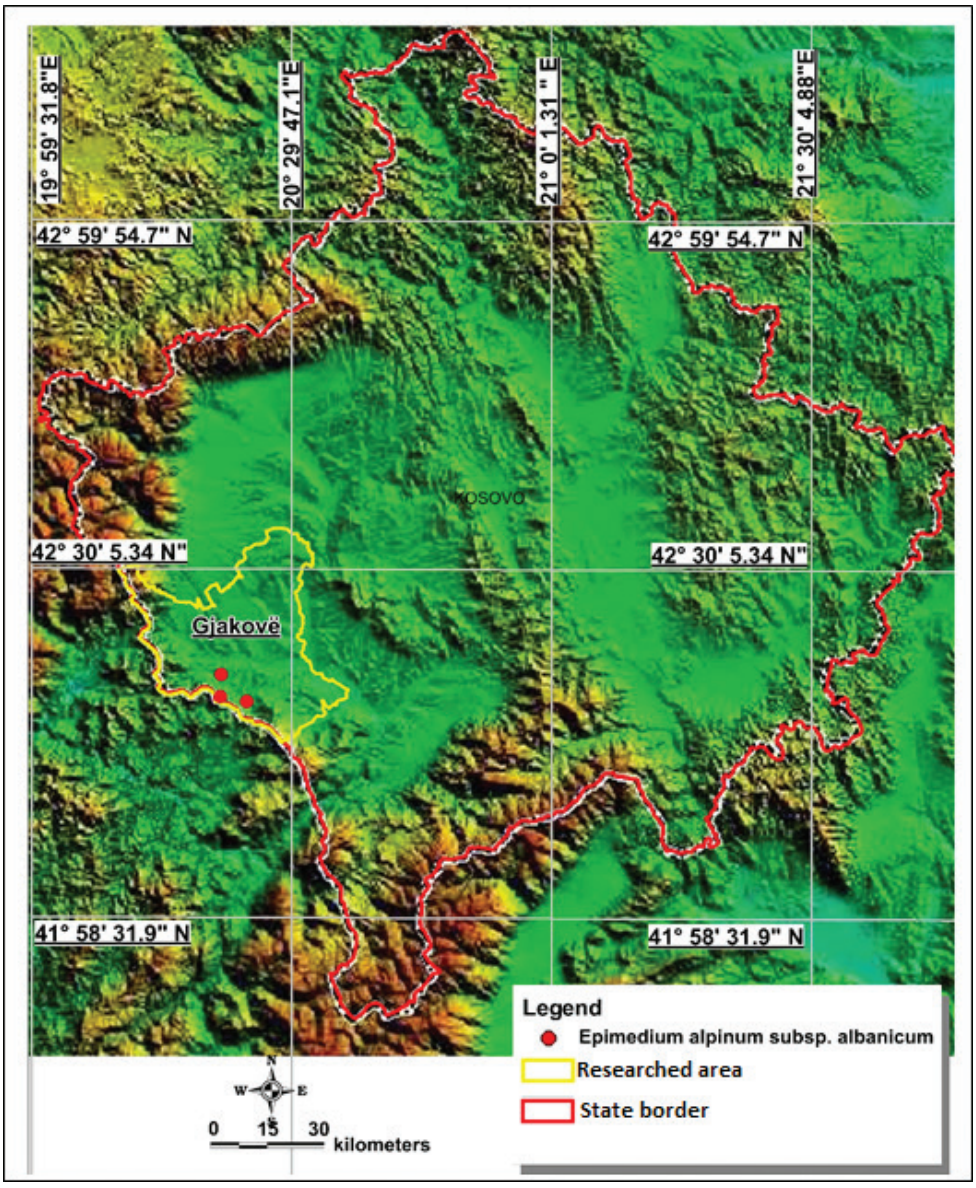

Figure 3. Distribution of *Epimedium alpinum* subsp. *albanicum* in Kosovo.

After searching in local and regional literature, we concluded that *E. alpinum* subsp. *albanicum* is a new finding for the country of Kosovo, than we have continued ducted other expeditions during the years 2018/2020. Therefore on May 19, 2020 we have observed *E. alpinum* subsp. *albanicum*, in the same locality, in Devë along the hill of Morina pass with the surroundings, in the serpentine substrate at an altitude of 750 m which was in the full stage of flowering (Figs 1, 2).

The third field trip was carried out during the beginning of August and September, 2022 and this taxon was recorded in between the borders of Qafë e Prushit (Fig. 3). In this locality, the taxon forms carpets on the ground below the woody species of *Quercus pubescens* Willd. and *Fraxinus ornus* L. Other species found with *E. alpinum* subsp. *albanicum* in this locality are *Eryngium palmatum* Pancic & Vis., *Linum elegans* Spruner ex Boiss., *Polygala doerfleri* Hayek, *Sanguisorba albanica* Andras. & Javorka, *Aster albanicus* (Degen) Degen, *Galatella linosyris* (L.) Rchb.f., *Tulipa sylvestris* L., *Genista hassertiana* (Bald.) Buchegger, *Allium albanicum* Brullo, C. Brullo, Cambria, Giusso & Salmeri, *Centaurea kosaninii* Hayek, *Satureja montana* L., *Bolanthus spergulifolius* (Jaub. & Spach) Hub.-Mor., *Potentilla rupestris* Falk var. *mollis* L., *Rosa arvensis* Huds., *Rosa gallica* L., *Betonica scardica* Griseb., *Betonica officinalis* L., *Allium moschatum* L., *Potentilla recta* L., *Campanula glomerata* L., *Achillea millefolium* L., *Plantago argentea* Chaix, *Prospero autumnale* (L.) Speta, *Erythronium dens-canis* L., *Saponaria sicula* Raf. subsp. *intermedia* (Simmler) Chater and *Siler zerny* (Hayek) Thell.

Specimens examined. Albania. Kukësi municipality, NE Albania: Kukësi district, Livadhet e Laskit, ca. 1.3 km above Kalimashi tunnel, serpentine substrate, 1300 m, 14 May 2010, *Hallaçi & Shuka s.n.* (Holotype).

Conclusions

According to the literature and the current database of the flora of Kosovo, *Epimedium alpinum* subsp. *albanicum* can be considered as new taxon for the flora of Kosovo. This taxon is known only in steppe and rocky serpentine substrates. Considering the small extent of occurrence as well as the great negative impact from surface mining activities, mainly chromium excavation and overgrazing, *E. alpinum* subsp. *albanicum* should be assessed as threatened species of Kosovo.

References

Barina Z [Ed.] (2017) Distribution Atlas of Vascular Plants in Albania. Hungarian Natural History Museum, Budapest, 466 pp.

Dudić B, Rakić T, Šinžar-Sekulić J, Atanacković V, Stevanović B (2007) Differences of metal concentrations and morpho-anatomical adaptions between obligate and facultative serpentinophytes from Western Serbia. Archives of Biological Sciences, Belgrade 59(4): 341–349. https://doi.org/10.2298/ABS0704341D

Hashani Z, Maxhuni Q, Shuka L (2014) Distribution of plant species of the Koritnik and Brod Mts. based on substrate preference. Newsletter of Natural Sciences, University of Tirana, Tirana, 18: 25–37.

Krause C, Oelschlägel B, Mahfoud H, Frank D, Lecocq G, Shuka L, Neinhuis Ch, Pablo V, Tosunoglu A, Thiv M, Wanke S (2022) The evolution of the *Aristolochia pallida* complex

(Aristolochiaceae) challenges traditional taxonomy and reflects large-scale glacial refugia in the Mediterranean. Ecology and Evolution 12(4): e8765. [14 pp.] https://doi.org/10.1002/ece3.8765

Millaku F, Elezaj I, Berisha N (2018) Sympatric area and ecology of some *Tulipa* species in the West Balkan Peninsula. Thaiszia Journal of Botany 28(1): 035–047.

Millaku F, Rexhepi F, Krasniqi E, Pajazitaj Q, Mala Xh, Berisha N (2013) The Red Book of Vascular Flora of the Republic of Kosovo. Prishtina, 174 pp.

Rakaj M (2009) Floristic and chorological news from north Albania. Botanica Serbica 33(2): 177–183.

Rexhepi F (1982) Balkan endemics in the high-mountian flora of Kosovo. Sci. Res. Bull. FNS Prishtina 8: 211–219.

Sajad A Lone, Ajai P, Malik M, Suphla G (2018) *Epimedium elatum* (Morr & Decne): A Therapeutic Medicinal Plant from Northwestern Himalayas of India. New Delhi, 619 pp. https://doi.org/10.1007/978-3-319-93997-1_17

Shuka D, Tan K, Hallaçi B, Shuka L (2021) Additions to the flora of North Albania. Phytologia Balcanica 26(3): 507–512.

Shuka L (2009) New taxonomic data for the flora of Albania recorded on the serpentine substrate (Southeast Albania). Natura Montenegrina, Podgorica 8(1): 5–10.

Shuka L, Hallaçi B (2010) Is Determined Flora and Vegetation of Mirusha (Kosovo) and Kolshi (Albania) area from the Serpentine Substrate. Balwois 2010 - Ohrid, Republic of Macedonia – 25, 29 May 2010.

Shuka L, Jahollari N (2007) Rare and endangered plant species from Gjergjevica Valley (Korçë, Albania). BMSH (UT) 4: 116–125.

Shuka L, Tan K, Hallaçi B (2020) Report 129. In: Vladimirov V, Velev N (comp.) New floristic records in the Balkans: 40. Phytologia Balcanica 25(3): 319–321.

Shuka L, Tan K, Krasniqi E (2012) *Tulipa kosovarica* (Liliaceae), a new species of Tulip from Kosovo. Phytotaxa 62: 1–9. https://doi.org/10.11646/phytotaxa.62.1.1

Słomka A, Bohdanowicz J, Poznańska E, Kwiatkowska M, Pilarska M, Struebig M, Shuka L, Kuta E (2014) Usefulness and limitations of pollen characters in environmental studies based on *Viola* L. species (sect. *Melanium* Ging.). Modern Phytomorphology 5: 31–34.

Słomka A, Godzik B, Szarek-Łukaszewska G, Shuka L, Kerstin Hoef-Emden K, Bothe H (2015) Albanian violets of the section *Melanium*, their morphological variability, genetic similarity and their adaptations to serpentine or chalk soils. Journal of Plant Physiology, 174: 110–123. https://doi.org/10.1016/j.jplph.2014.09.010

Slomka A, Kwiatkowska M, Bohdanowicz J, Shuka L, Jędrzejczyk-Korycińska M, Borucki W, Kuta E (2017) Insight into "serpentine syndrome" of Albanian, endemic violets (*Viola* L., *Melanium* Ging. section) – Looking for unique, adaptive microstructural floral, and embryological characters. Plant Biosystems 151(6):1022–1034. https://doi.org/10.1080/11263504.2016.1219418

Słomka A, Zabicka J, Shuka L, Bohdanowicz J, Kuta E (2018) Lack of correlation between pollen aperture number and environmental factors in pansies (*Viola* L., sect. *Melanium* Ging.) – pollen heteromorphism re-examined. Journal of Plant Biology 20(3): 555–562. https://doi.org/10.1111/plb.12689

Stevanović V, Tan K, Iatrou G (2003) Distribution of the endemic Balkan flora on Serpentine I. – obligate serpentine endemics. Plant Systematics and Evolution 242: 149–170. https://doi.org/10.1007/s00606-003-0044-8

Tutin TG, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM, Webb DA (1964–1980) Flora Europaea. Vol. 1–5, – Cambridge University Press, London, 77–77.

Italian Botanist 15: 9–20 (2023)
doi: 10.3897/italianbotanist.15.97630
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

Changes in the flora of Lobbia Alta, a peak of the Adamello-Presanella Alps (Trento, Italy) between 1935 and 2021

Filippo Prosser[1], Alessio Bertolli[1], Giulia Tomasi[1]

1 *Fondazione Museo Civico di Rovereto, Borgo S. Caterina 41 38068, Rovereto (Trento), Italy*

Corresponding author: Filippo Prosser (prosserfilippo@fondazionemcr.it)

Academic editor: Lorenzo Peruzzi | Received 16 November 2022 | Accepted 1 March 2023 | Published 15 March 2023

Citation: Prosser F, Bertolli A, Tomasi G (2023) Changes in the flora of Lobbia Alta, a peak of the Adamello-Presanella Alps (Trento, Italy) between 1935 and 2021. Italian Botanist 15: 9–20. https://doi.org/10.3897/italianbotanist.15.97630

Abstract

Global warming is causing an enrichment of summit flora worldwide. This article presents the case of a peak in the southeastern Alps (Lobbia Alta, 3,196 m a.s.l., Adamello, Trento, Italy), for which a complete list of tracheophytes dating back to 1935 was available. As this peak is well delimited by glaciers and vertical cliffs, it has been possible to faithfully repeat this floristic inventory. We made three surveys, in 1991, 2006 and 2021, exploring the whole area. It resulted that in 86 years the species present on this peak have tripled, increasing from 17 to 51, with an acceleration in recent years. The biological forms have increased from two to six. The average temperature and the nutritional indexes according to Ellenberg have increased as well. We found that as many as six species reach their elevation record in the Alps on the Lobbia Alta, suggesting that this area is particularly prone to species ascension. Particularly interesting is the discovery of a 35 cm-tall specimen of *Larix decidua* at 3,130 m a.s.l., which seems to be the elevational record of the species.

Keywords

Climate change, flora of Trentino, southeastern Alps, summit flora

Introduction

In the Alps, the climate has warmed by about 1.8 °C since 1880, almost double the global average. Models are especially pessimistic for the southern Alps, where at the end of the current century an increase of more than 4 °C compared to the period

Copyright *Filippo Prosser et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

1981–2010 is expected in a worst-case scenario (Kotlarski et al. 2022). Evidence for the consequent enrichment of the summit vascular flora in the Alps was presented already many years ago (Braun 1913; Braun-Blanquet 1955). More recently, numerous medium- and long-term monitoring activities have confirmed that climate change is causing an upward expansion of species, particularly in the summit areas of the Alps (Hofer 1992; Grabherr et al. 1994; Pauli et al. 2012; Unterluggauer et al. 2016; Lamprecht et al. 2018). A research extended to 302 European peaks has shown that this speed is increasing in each of the nine mountain areas considered, including the Alps (Steinbauer et al. 2018). The upward movement of the species should cause new elevation records, but these have generally received little attention. There is no shared and recognized initiative dedicated to archiving recent elevation records at the Alpine (or European) level. Only some sources highlight elevational records (for example Flora della Valle d'Aosta 2022+; Swiss National Forest Inventory 2022+), but they are limited in terms of territory and/or plant group considered. On the contrary, a large body of historical data is available thanks to the research of elevation records in vogue in the past (e.g., Heer 1885; Vaccari 1901; Reisigl and Pitschmann 1958). Elevational records at alpine level were reported, for example, by Fenaroli (1955). Unfortunately, an updated version of this work is not available.

The aim of this research was to investigate the changes in the summit flora of a peak on the southern slope of the eastern Alps, an area particularly prone to global warming. We also sought to establish whether the plants found there constituted an elevational record.

Materials and methods

Study area description

The Lobbia Alta (3,196 m a.s.l.; 46.1704°N, 10.5674°E; Fig. 1) is a peak located in the Adamello-Presanella Alps in the southern Rhaetian Alps (Adamello-Brenta Natural Park, Trento, Italy). The rock is made up of Tonalite. The average annual temperature is between -2 and -4 °C for the period 1981–2010. Compared to the valley bottoms, the temperature here is growing more rapidly, as shown by the data from the nearby station of Cima Presena (3,015 m a.s.l.), which in the period 1998–2008 saw the average temperature rising by 0.5 °C/year (by 0.7–0.8 °C if only summer temperatures are considered). Annual rainfall amounts to approximately 1,300 mm, with summer maximum and winter minimum (Climatrentino 2022+). The vegetation is typical of the upper part of the alpine belt, very discontinuous, made up, as regards vascular plants, of sparse individuals mostly rooting in rock crevices.

Nino Arietti (Bardolino 1902; Brescia 1979), one of the most important botanists in Brescia, noticed that the Lobbia Alta corresponded to what botanists at the time called the "glacial island" and for this reason, in 1935, he surveyed its flora (Arietti 1936). This prompted us to undertake the survey of the flora of the Lobbia Alta in 1991. As already observed by Arietti (1936), the west side of the Lobbia Alta, covered

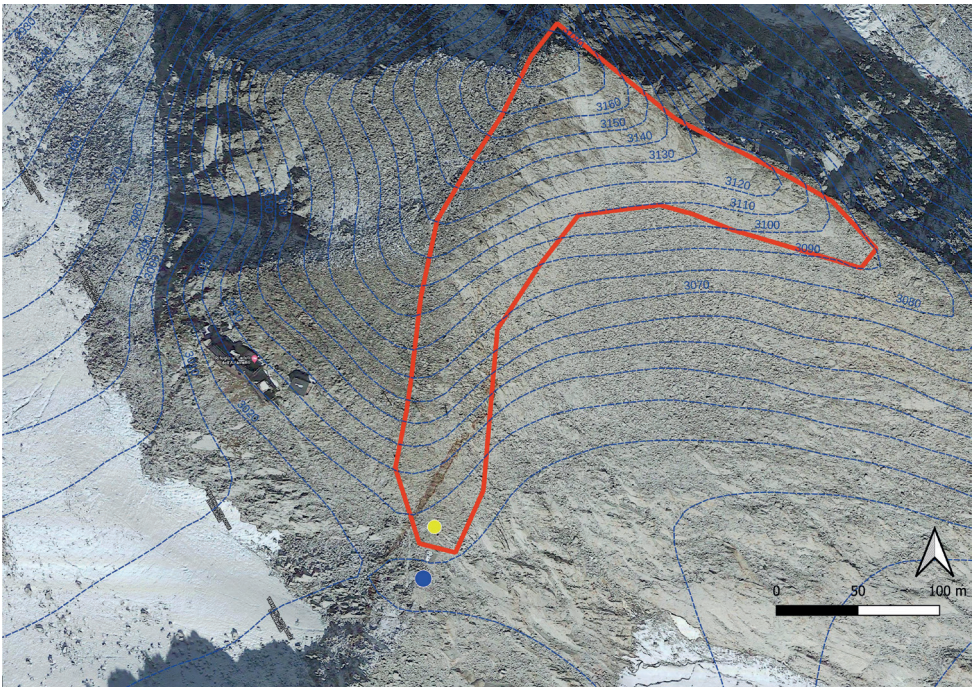

Figure 1. Lobbia Alta (Trento, Italy). In red, delimitation of the study area. The blue dot is the helicopter pad, the yellow one is the altar. On the left is the Rifugio Caduti dell'Adamello. Map data (C) 2015 Google.

with boulders that do not allow the accumulation of humus, is unsuitable for hosting vascular plants. The bedrock emerges on the southern and northern sides, the latter consisting of nearly vertical walls exposed to the north-east and north-west, and not explored due to the evident danger and the unlikelihood of finding plants. The most suitable site for the presence of vascular plants, according also to Arietti (1936), is the south side with an almost perfect southern exposure and an inclination of *ca*. 40°. Here Tonalite outcrops are cracked and dark due to surface weathering caused by cryptogams (mainly lichens) with organic soil present in the cracks, indicating that the area was not covered by perennial snow or ice since a long time. The investigated area, of approximately 2 ha, includes this slope with dark rocks; it starts from the Lobbia Pass, precisely from the altar (3,025 m a.s.l.) to the top (3,196 m a.s.l.), and extends to the east ridge down to 3,090 m a.s.l. (Fig. 1). The lower part of the southern slope, excluded from the investigated area, is characterized by rocks and boulders with little alteration on the surface, and with very scarce plant colonization.

Analysis of Arietti's "Florula della Lobbia Alta" (1936)

The herbarium of Nino Arietti, kept at the Civic Museum of Natural Sciences of Brescia (HBBS, Thiers 2022), has been catalogued and published (Tagliaferri and Bona 2006). His collections range from 1931 to 1978 (Tagliaferri and Bona 2006)

and the "Florula della Lobbia Alta" is his first scientific publication (La Redazione di Natura Bresciana 1979). Arietti (1936) described his floristic survey of the Lobbia Alta as a "list which, although limited to the product of the observations of a few days, can almost entirely include the local Florula". Clearly Arietti was staying at the Caduti dell'Adamello Refuge for mountaineering reasons and was able to study the flora of the summit just above the refuge. Arietti's list consists of 16 species. In his herbarium there are 12 samples collected here, five of which determined by the eminent botanist Adriano Fiori. Of these 12 samples, however, one does not appear in the Florula, namely *Festuca intercedens* (Hack.) Lüdi ex Bech.; it is a critical species that was determined by Fiori as *F. halleri* All. and then by Rossi and Foggi in 2006 who, more precisely, referred it to *F. intercedens*. By also considering *F. intercedens*, the total number of species detected by Arietti on Lobbia Alta is 17. Doubts still exist regarding two of the five species without herbarium samples, namely *Myosotis alpestris* F.W.Schmidt and *Saxifraga seguieri* Biehler. We presume that they are *Eritrichium nanum* (L.) Schrad. ex Gaudin subsp. *nanum* and *Saxifraga exarata* Vill. subsp. *exarata*, respectively, both common on the top of Lobbia Alta; we attribute Arietti's error to his as yet scarce floristic experience.

Data collection

In all of our three surveys (1991, 2006 and 2021), the entire area (Fig. 1) was carefully explored with the aim of drawing up the most complete inventory possible of the species present. In the last survey (2021) occurrences were geolocalized using the smartphone application described by Andreatta et al. (2017) with the aim of recording accurate maximum elevations reached by the species. The average localization error given by the instrument was ±2.3 m. The elevation was deduced from the coordinates using the digital terrain model. The elevation error, considering the inclination of the area, should not exceed the localization error.

The sampling effort of our surveys was as follows: on 25 August 1991, Lobbia Alta was visited by one of the authors of this paper (FP) and three operators; we estimate that the survey took about 6 hours. On 23 August 2006 it was investigated by two of the authors of this paper (AB and FP) and five operators (Prosser 1997); they dedicated 5 hours to the survey (Prosser et al. 2008). On 26 August 2021 two of the authors (AB and GT) repeated the survey in 4 hours, therefore with a minor sampling effort (see Burg et al. 2015).

Biological forms follow Pignatti et al. (2017–2019). Temperature and nutrient indexes of the species follow Ellenberg et al. (2001) with few integrations with Pignatti (2005). Nomenclature follows Bartolucci et al. (2018) and subsequent updates (Portal to the Flora of Italy 2022+). The elevation records were first verified at the local level, on the basis of "Flora del Trentino" (Prosser et al. 2019), then at the alpine and, sometimes, European level, referring to databases available on the web (e.g., GBIF 2022; Infoflora 2022+), bibliographic data (see references) and other information obtained from botanists interested in summit flora were also used.

Results and discussion

The number of species surveyed on Lobbia Alta in 86 years has risen from 17 to 55 (Suppl. material 1), of which however four, recorded in 2006, were not found in 2021. The variation in the number of species over time and the variation of biological forms are shown in Fig. 2.

Variability of the temperature index and nutrients index for each survey are shown in Figs 3, 4, respectively.

In the period 1935–1991, the number of species grew from 17 to 36 (Suppl. material 1). No species disappeared. The entry rate was 0.34 species / year. Some of the species not detected by Arietti were quite widespread in 1991: this is the case, for example, of *Facchinia herniarioides* (Rion) Dillenb. & Kadereit and *Primula daonensis* (Leyb.) Leyb. The biological spectrum becomes more complex with the entry of the first therophyte (*Euphrasia minima* Jacq. ex DC.) alongside hemicryptophytes and chamaephytes. The first fruticose chamaephyte is *Vaccinium uliginosum* L. subsp. *microphyllum* (Lange) Tolm.; its presence is clearly excluded by Arietti (1936): "shrubs

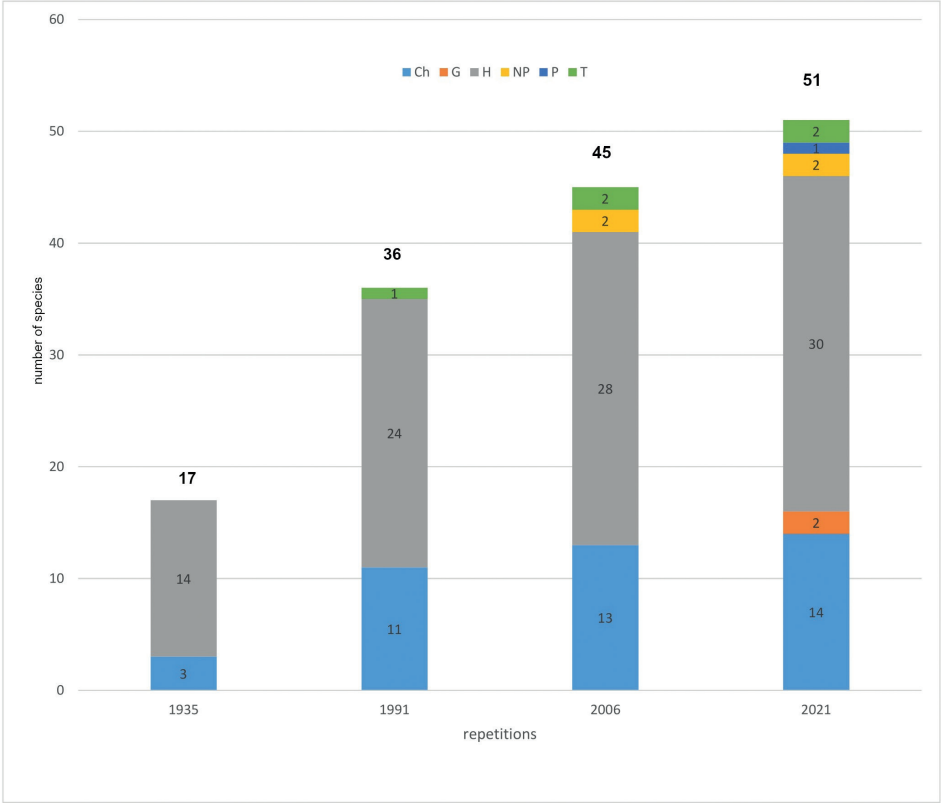

Figure 2. Variation over time of the flora of the Lobbia Alta with biological spectra (Ch: Chamaephytes; G: Geophytes; H: Hemicryptophytes; NP: Nanophanerophytes; P: Phanerophytes; T: Therophytes).

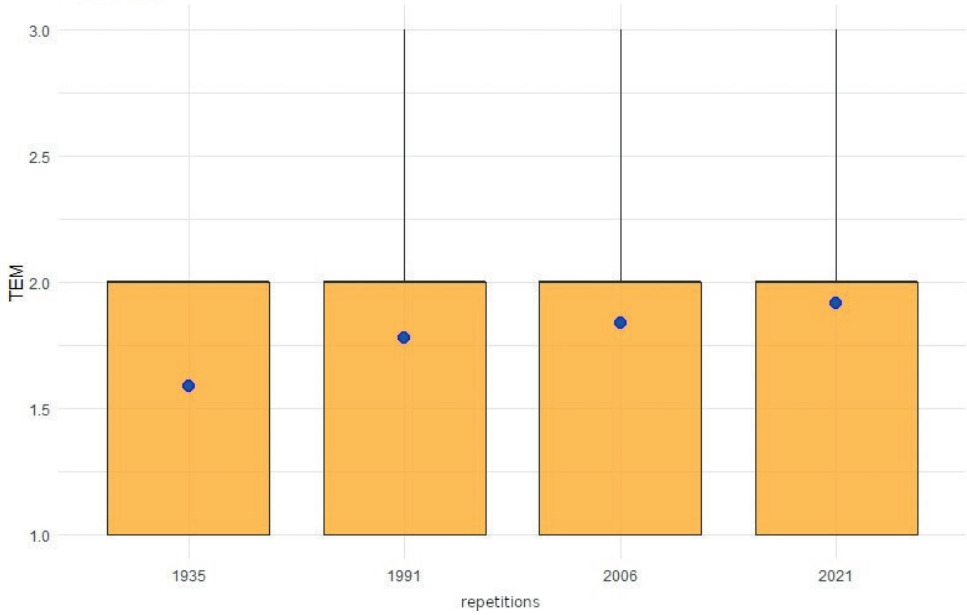

Figure 3. Variability of temperature index (TEM) according to Ellenberg et al. (2001) with indication of mean (blue dot) and of median (black line).

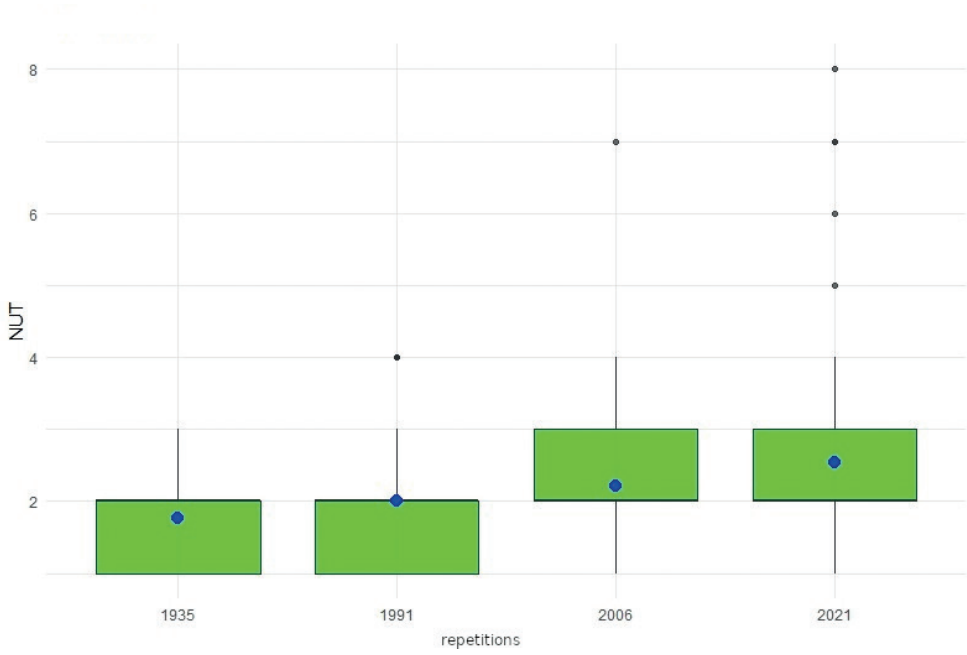

Figure 4. Variability of nutrients index (NUT) according to Ellenberg et al. (2001) with indication of mean (blue dot) and of median (black line).

are completely missing, including fruticose and suffruticose". The average temperature index (Fig. 3) and the nutrient index (Fig. 4) increased by about 0.2 points.

In the period 1991–2006, the number of species rose to 45 with the confirmation of all the species surveyed in 1991 (Suppl. material 1). The entry rate increased to 0.6 species / year, values compatible with those reported for European mountain regions by Steinbauer et al. (2018). Among the nine additional species, there are the first woody ones: *Juniperus communis* L., *Rhododendron ferrugineum* L., and *Salix herbacea* L. The first two are classified as nanophanerophytes, and this biological form adds to the spectrum (Fig. 2). The temperature and the nutrient indices rose slightly in that period (Figs 3, 4).

In the period 2006–2021, the total number of species rose to 51, with an entry rate of 0.4 species / year. As many as 10 species were found for the first time; however, compared to 2006, four species are not confirmed (*Potentilla frigida* Vill., *Rhododendron ferrugineum*, *Salix herbacea* and *Solidago virgaurea* L. subsp. *minuta* (L.) Arcang.). The first phanerophyte, *Larix decidua* Mill., and the first geophytes, *Agrostis schraderiana* Bech. and *Coeloglossum viride* (L.) Hartm., appear. Among the nanophanerophytes, *R. ferrugineum* is not confirmed, but *Salix helvetica* Vill. appears. Furthermore, among the fruticose chamaephytes, the lack of confirmation of *S. herbacea* is compensated by the addition of *Empetrum hermaphroditum* Hagerup. The temperature index approaches 2 (Fig. 3) due to the entry of thermophilic species. A similar trend is shown by the nutrients index (Fig. 4) due to the entry of nitrophilous species (e.g., *Cirsium spinosissimum* (L.) Scop.).

The elevations recorded in the 2021 survey show that for about 20 species the elevation record published in "Flora del Trentino" had been exceeded (Prosser et al. 2019). The following species would seem to set an elevational record at least at the alpine level.

Coeloglossum viride, a circumboreal species present at 3,150 m a.s.l. on the Lobbia Alta, is probably the highest known orchid in Europe, including the Caucasus (Bertolli et al. 2021).

Gentiana nivalis L., a species widespread mainly in the European mountains, was found at 3,123 m on the Lobbia Alta, just above the known elevations in the Alps. The second known record is 3,110 m in Val di Cogne in the Pousset valley (2001, Poggio and Gerard in Flora della Valle d'Aosta 2022+), but already Fenaroli (1955) indicated it in the Alps up to 3,100 m. For the Caucasus, there is a record at *ca*. 3,145 m in August 2018 by D.S. Shilnikov (iNaturalist 2022+).

Gentianella anisodonta (Borbás) Á.Löve & D.Löve, an endemic species to the eastern Alps, found at 3,145 m on the Lobbia Alta, is most likely the record for the elevation of the species. Braun-Blanquet and Rübel (1932–1935) indicate it in the Grisons (Switzerland) up to 2,780 m.

We found a 35-cm tall specimen of *Larix decidua* on Lobbia Alta (Fig. 5) at 3,130 m and it seems to be the elevation record of the species. The previous maximum elevation that we have been able to trace for this species is 2,995 m in the French Alps (Gilles André, personal communication). Other notable finds are at 2.990 m on Cima Paier in the Adamello-Presanella Alps (1991, Bronzini and Prosser,

Figure 5. A specimen of *Larix decidua* photographed at 3,130 m near the summit of Lobbia Alta (Trento, Italy). Currently it may be the elevation record of the species (photo GT).

archive of the flora of Trentino of the Civic Museum of Rovereto), at 2,971 m in Switzerland (Wiwannihorn, Ausserberg), where, in 2015, Egon Feller found a 21-cm tall specimen (Swiss National Forest Inventory 2022+), and the one at 2,970 m for Las Sours by Anders Björken (Wifp, personal communication). Fenaroli (1955) gave a maximum elevation for the Alps of 2,660 m. The record for the highest tree in the Alps (and in Europe) is *Pinus cembra* found by Andrè (2016) at 3,200 m on the Italian side of Monte Viso: it is a 1.1-m tall specimen in a rocky position. The larch found on Lobbia Alta is the second highest tree in the Alps and in Europe. In the Caucasus, it seems that trees do not grow beyond 3,100 m (Dolukhanov 1978; Gigauri, personal communication).

Primula daonensis, an endemic species to a small sector of the eastern Alps, was found up to 3,151 m on the Lobbia Alta; it confirms an earlier record for the species, which was always on the Lobbia Alta at 3,110 m (Prosser et al. 2019). Previously, the elevation record of the species was indicated by Becherer (1976) at 2,960 m on Piz Rims in Val Müstair (obs. Nicolin Bischoff, 04/07/1975). Fenaroli (1955) indicated it in the Alps up to "2,800 (2,900?) m".

Salix helvetica, a species with alpine distribution, was found at 3,111 m on the Lobbia Alta, but the specimen is little more than a seedling. The second highest record is at 3,010 m in Val di Cogne, under the Lauson glacier (Mainetti et al. 2016 in Flora della Valle d'Aosta 2022+). The highest record for Switzerland by Infoflora (2022+) is 2,919–2,922 m at Saas-Grund (obs. Jasmin Ducry, 04/08/2017). Fenaroli (1955) indicated it in the Alps up to 3,000 m.

Conclusions

Our results are in agreement with the general trend of enrichment of the flora of the high alpine peaks. Various species have managed to reach the Lobbia Alta, despite being a rather isolated peak surrounded by ice and inhospitable cliffs. Seed dispersal by wind (e.g., *Larix decidua*) and birds (e.g., *Empetrum hermaphroditum*) has made it possible to colonize these peaks. More and more often, seedlings and saplings find suitable conditions for their establishment due to the increasingly longer period without snow, consequent to climate warming. Lobbia Alta, and in particular its southern side, appears suitable for the settlement of species from lower elevations, as shown by elevation records also for some species that are widespread in the western Alps (*Gentiana nivalis*, *Larix decidua*, *Salix helvetica*) where, due to the mass effect, species usually reach their highest elevation in the Alps (see e.g., Ellenberg 1996). It seems surprising to find as many as six alpine elevation records on a single peak of the Alps. It could even be hypothesized that the southern Rhaetian Alps are subject to a more intense upwelling of species due to climate warming than other Alpine areas. Further research is needed to test this hypothesis.

In 2021, the presence of some species, recorded after 1935, has not been confirmed, i.e., *Potentilla frigida*, *Rhododendron ferrugineum*, *Salix herbacea*, and *Solidago virgaurea* subsp. *minuta*; this would suggest that the colonization process is not linear, but is "trial and error". On a peak of more than 3,000 m a.s.l. such as Lobbia Alta, it is the newcomers who are more likely to disappear, rather than the species that have been established there since a long time. Nonetheless, the latter could also be undermined by further global warming.

Acknowledgements

We thank Gilles André, Elena Barni, Enzo Bona, Jasmin Ducry, Khatuna Gigauri, Michael Jutzi, Harald Pauli, Jean-Louis Polidori, Jean-Paul Theurillat, Thomas Wilhalm, Sonja Wipf for providing data on elevation records of species; Luca Bronzini, Sara Tamanini and Massimo Tambosi for the help offered during the survey of 1991; Elena Guella, Maurizio Odasso, Lucio Sottovia, Mauro Tomasi and Luca Bronzini again for the help offered during the survey of 2006. Finally, we thank the anonymous reviewers who contributed to greatly improve the text.

References

André G (2016) Découverte, jusqu'à 3200 m d'altitude, de stations rupicoles de *Pinus cembra* L. dans la région Queyras – Haute-Ubaye – Viso. Bulletin de la Société Linnéenne de Provence 67: 147–158. https://www.youscribe.com/BookReader/Index/3023300/?documentId=3402546

Andreatta S, Festi F, Prosser F (2017) Un'applicazione Android per rilievi floristici con smartphone nelle province di Trento e Verona. Annali del Museo Civico di Rovereto 31: 125–135. http://www.fondazionemcr.it/UploadDocs/18710_Art06_Andreatta_Festi_Prosser.pdf

Arietti N (1936) Florula della Lobbia Alta nel gruppo dell'Adamello. Comm. Ateneo Brescia 134. A. A., 13. E. F. (1935): 257–261.

Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, Astuti G, Bacchetta G, Ballelli S, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Cecchi L, Di Pietro R, Domina G, Fascetti S, Fenu G, Festi F, Foggi B, Gallo L, Gottschlich G, Gubellini L, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Conti F (2018) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 179–303. https://doi.org/10.1080/11263504.2017.1419996

Becherer A (1976) Neue Beiträge zur Flora des Münstertals und des Vintschgaus. Bauhinia 5(4): 175–184. https://botges.ch/bauhinia/Bauhinia_5_0175-0184.pdf

Bertolli A, Tomasi G, Prosser F, Perazza G (2021) Ritrovamento di *Coeloglossum viride* (L.) Hartm. sulla Lobbia Alta in Trentino (Italia) − nuovo record altitudinale per le Orchidaceae europee? Journal Europäischer Orchideen 53(2–4): 286–300.

Braun-Blanquet J, Rübel E (1932–1935) Flora von Graubünden – Vorkommen, Verbreitung und ökologisch-soziologisches Verhalten der wildwachsenden Gefässpflanzen Graubündens und seiner Grenzgebiete. Veröffentlichungen des Geobotanischen Institutes Rübel in Zürich 7: 1–1695. [4 Lieferungen] https://www.e-periodica.ch/digbib/view?pid=gbi-001%3A1932%3A7#51

Braun-Blanquet J (1955) Die Vegetation des Piz Languard, ein Massstab für Klimaänderungen. Svensk Botanisk Tidskrift 49(1–2): 1–8. http://www.diva-portal.org/smash/get/diva2:1202232/FULLTEXT01.pdf

Braun J (1913) Die Vegetationsverhältnisse der Schneestufe in den Rhätisch-Lepontischen Alpen. Ein Bild des Pflanzenleben an seinen äusseren Grenzen. Neue Denkschriften der Schweizerischen Naturforschenden Gesellschaft 48: 1–339.

Burg S, Rixen C, Stöckli V, Wipf S (2015) Observation bias and its causes in botanical surveys on high-alpine summits. Journal of Vegetation Science 26(1): 191–200. https://doi.org/10.1111/jvs.12211

Climatrentino (2022+) Climatrentino. Provincia Autonoma di Trento. http://www.climatrentino.it/ [Accessed on 23/12/2022]

Dolukhanov AG (1978) The Timberline and the Subalpine Belt in the Caucasus Mountains, USSR. Arctic and Alpine Research 10(2): 409–422. https://doi.org/10.2307/1550771

Ellenberg H (1996) Vegetation Mitteleuropas mit den Alpen. 5. Auflage. Ulmer, Stuttgart, 1096 pp.

Ellenberg H, Weber H E, Düll R, Wirth V, Werner W (2001) Zeigerwerte von Pflanzen in Mitteleuropa. 3. durchgesehene Auflage. Scripta geobotanica 18: 1–262.

Fenaroli L (1955) Flora delle Alpi. Ed. Martello, Milano, 369 pp.

Flora della Valle d'Aosta (2022+) Flora vascolare della Valle d'Aosta, a cura della Société de la Flore Valdôtaine. http://floravda.it/it/ [Accessed on 15.11.2022]

GBIF (2022) Global Biodiversity Information Facility. Free and open access to biodiversity data. https://www.gbif.org [Accessed on 15.11.2022]

Grabherr G, Gottfried M, Pauli H (1994) Climatic effects on mountain plants. Scientific correspondence. Nature 369: e448. https://doi.org/10.1038/369448a0

Heer O (1885) Über die nivale Flora der Schweiz. Neue Denkschr. Naturwissenschaftlicher Anzeiger der Allgemeinen Schweizerischen Gesellschaft für die Gesammten Naturwissenschaften 24: 4–114. https://www.sac-cas.ch/de/die-alpen/uebersicht-der-nivalen-flora-der-schweiz-7613/

Hofer HR (1992) Veränderungen in der Vegetation von 14 Gipfeln des Berninagebietes zwischen 1905 und 1985. Berichte des Geobotanischen Institutes der Eidg. Techn. Hochschule Stiftung Rübel 58: 39–54. http://doi.org/10.5169/seals-377771

iNaturalist (2022+) iNaturalist Research-grade Observations. iNaturalist.org. https://doi.org/10.15468/ab3s5x [Accessed via GBIF.org on 2022-11-15]

Infoflora (2022+) Infoflora. The National Data and Information Center on the Swiss Flora. https://www.infoflora.ch/it/ [Accessed on 15.11.2022]

Kotlarski S, Gobiet A, Morin S, Olefs M, Rajczak J, Samacoïts R (2022) 21st Century alpine climate change. Climate Dynamics. https://doi.org/10.1007/s00382-022-06303-3

La Redazione di Natura Bresciana (1979) L'opera scientifica di Nino Arietti, naturalista botanico. «Natura Bresciana» Annali del Museo Civico di Storia Naturale di Brescia 15 (1978): 222–227. https://www.comune.brescia.it/servizi/arteculturaeturismo/museoscienze/Documents/1978_15_222-227_La_Redazione.pdf

Lamprecht A, Semenchuk PR, Steinbauer K, Winkler M, Pauli H (2018) Climate change leads to accelerated transformation of high-elevation vegetation in the central Alps. New Phytologist 220(2): 447–459. https://doi.org/10.1111/nph.15290

Pauli H, Gottfried M, Dullinger S, Abdaladze O, Akhalkatsi M, Alonso JLB, Coldea G, Dick J, Erschbamer B, Fernández Calzado R, Ghosn D, Holten JI, Kanka R, Kazakis G, Kollár J, Larsson P, Moiseev P, Moiseev D, Molau U, Molero Mesa J, Nagy L, Pelino G, Puşcaş M, Rossi G, Stanisci A, Syverhuset AO, Theurillat J-P, Tomaselli M, Unterluggauer P, Villar L, Vittoz P, Grabherr G (2012) Recent Plant Diversity Changes on Europe's Mountain Summits. Science 336: 353–355. https://doi.org/10.1126/science.1219033

Pignatti S (2005) Valori di bioindicazione delle piante vascolari della Flora d'Italia. Braun-Blanquetia 39: 1–97.

Pignatti S, Guarino R, La Rosa M (2017–2019) Flora d'Italia (2nd edn., 4 volls). Edagricole, New Business Media, Milano.

Portal to the Flora of Italy (2022+) Portale della Flora d'Italia/Portal to the Flora of Italy. [2021.2.] http://dryades.units.it/floritaly/ [Accessed on 15.11.2022]

Prosser F (1997) Ricerche botaniche sulla vegetazione periglaciale e sulla flora d'alta quota nel Gruppo Adamello-Presanella. Atti del 1° Seminario Nazionale di aggiornamento per esperti ed operatori naturalistici del Club Alpino Italiano, Brentonico 20–21 giugno 1992. Comitato Scientifico del C. A. I., ed. Azimut: 24–32. https://csc.cai.it/wp-content/uploads/2018/04/ATTI-GIUGNO-1992-BRENTONICO.pdf

Prosser F, Bertolli A, Bronzini L (2008) Cambiamenti climatici e flora: il caso della Lobbia Alta. Poster presentato al convegno «Trentino Clima 2008: evoluzione del clima, tendenze, effetti e scenari futuri», Trento, 21–22 febbraio 2008.

Prosser F, Bertolli A, Festi F, Perazza G (2019) Flora del Trentino. Ed. Osiride/Fondazione Museo Civico, Rovereto, 1211 pp.

Reisigl H, Pitschmann H (1958) Obere Grenzen von Flora und Vegetation in der Nivalstufe der Zentralen Ötztaler Alpen (Tirol). Vegetatio 8(2): 93–129. https://doi.org/10.1007/BF00419154

Steinbauer MJ, Grytnes J, Jurasinski G, Kulonen A, Lenoir J, Pauli H, Rixen C, Winkler M, Bardy-Durchhalter M, Barni E, Bjorkman AD, Breiner FT, Burg S, Czortek P, Dawes MA, Delimat A, Dullinger S, Erschbamer B, Felde VA, Fernández-Arberas O, Fossheim KF, Gómez-García D, Georges D, Grindrud ET, Haider S, Haugum SV, Henriksen H, Herreros MJ, Jaroszewicz B, Jaroszynska F, Kanka R, Kapfer J, Klanderud K, Kühn I, Lamprecht A, Matteodo M, Morra di Cella U, Normand S, Odland A, Olsen SL, Palacio S, Petey M, Piscová V, Sedlakova B, Steinbauer K, Stöckli V, Svenning J-C, Teppa G, Theurillat J-P, Vittoz P, Woodin SJ, Zimmermann NE, Wipf S (2018) Accelerated increase in plant species richness on mountain summits is linked to warming. Nature 556: 231–234. https://doi.org/10.1038/s41586-018-0005-6

Swiss National Forest Inventory (2022+) Logbook of elevation records. https://www.lfi.ch/resultate/meldungen/logbuch-it.php [Accessed on 15.11.2022]

Tagliaferri F, Bona E (2006) L'erbario di "Nino" Arietti conservato al Museo Civico di Scienze Naturali di Brescia. Monografie di "Natura Bresciana" 28(2006): 1–252.

Thiers B (2022) Index Herbariorum: A Global Directory of Public Herbaria and Associated Staff. New York Botanical Garden's Virtual Herbarium. https://sweetgum.nybg.org/science/ih/ [accessed on 13.12.2022]

Unterluggauer P, Mallaun M, Erschbamer B (2016) The higher the summit, the higher the diversity changes. Results of a long-term monitoring project in the Dolomites. Gredleriana 16: 5–34. https://www.natura.museum/it/ricerca/pubblicazioni/

Vaccari L (1901) Flora cacuminale della Valle d'Aosta. Nuovo Giornale Botanico Italiano, nuova serie 8: 416–439; 527–542. https://bibdigital.rjb.csic.es/viewer/12808/?offset=#page=417&viewer=picture&o=bookmar

Supplementary material 1

Floristic occurrences of the flora of the Lobbia Alta (Trento, Italy) between 1935 and 2021

Authors: Filippo Prosser, Alessio Bertolli, Giulia Tomasi

Data type: table (excel file)

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/italianbotanist.15.97630.suppl1

Italian Botanist 15: 21–33 (2023)
doi: 10.3897/italianbotanist.15.101748
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

The vascular flora of Empoli (Tuscany, central Italy)

Lorenzo Peruzzi[1]

1 *PLANTSEED Lab, Department of Biology, University of Pisa, Pisa, Italy*

Corresponding author: Lorenzo Peruzzi (lorenzo.peruzzi@unipi.it)

Academic editor: Fabrizio Bartolucci | Received 10 February 2023 | Accepted 14 March 2023 | Published 22 March 2023

Citation: Peruzzi L (2023) The vascular flora of Empoli (Tuscany, central Italy). Italian Botanist 15: 21–33. https://doi.org/10.3897/italianbotanist.15.101748

Abstract

A list of the vascular flora occurring in the municipality of Empoli (province of Firenze, Tuscany) is provided. The list is based on a bibliographic analysis and on field studies carried out in the years 2018–2022. A total of 757 specific and subspecific taxa currently occur in the study area (including 117 aliens), plus 51 cultivated taxa. *Azolla filiculoides* Lam., *Prunus cerasifera* Ehrh., and *Veronica filiformis* Sm. should be considered as naturalized aliens in Tuscany.

Keywords

alien species, biodiversity, endemics, floristic data, Italy, phytogeography, Tuscany

Introduction

A flora is a useful source of information for biogeographical, ecological, and evolutionary studies (D'Antraccoli et al. 2022b). For these reasons, a satisfactory floristic knowledge of a territory is crucial for many other applications in plant science (Peruzzi 2018). In floristic studies, it is very important to have a 'starting hypothesis' concerning the number of taxa expected in a study area. To achieve this, Species-Area Relationships (SARs) are an excellent tool (D'Antraccoli et al. 2019). In addition, since no floristic study can be considered to be exhaustive (D'Antraccoli et al. 2020), a Map of Relative Floristic Ignorance and a Virtual Floristic List (D'Antraccoli et al. 2022a) are also useful to plan future floristic research in the study area. With these tools, one can represent the spatial distribution of the lack of floristic knowledge and obtain a list of taxa potentially occurring in the area with an associated probability of occurrence.

Copyright *Lorenzo Peruzzi*. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

The territory in the municipality of Empoli (Tuscany, central Italy; Fig. 1) was hitherto never studied by botanists. Between 1860 and 2003, only 26 floristic records are available (Caruel 1860; Baroni 1897–1908; Fiori 1943; Pignotti 2003; Arrigoni 2018). More recently, Peruzzi (2021) presented a first draft of a flora in a popular book, listing 672 taxa.

The aim of this study is to present a complete and updated floristic inventory of the vascular flora of Empoli, in the framework of a series of contributions whose goal is to improve the floristic knowledge of Tuscany (Pierini et al. 2008; Peruzzi et al. 2011; Gestri and Peruzzi 2012, 2013, 2014; Ciccarelli et al. 2015; Gei et al. 2016; Pierini and Peruzzi 2014; Roma-Marzio et al. 2016; Carta et al. 2018; Roma-Marzio et al. 2020).

Material and methods

Study area

The municipality of Empoli (province of Firenze) lies at an elevation between 22 and 205 m a.s.l., and covers an area of 62.28 km^2. The Arno river constitutes its northern administrative limit, while the western limit is the Elsa river. Less obvious are the eastern and southern limits, with the municipalities of Montelupo Fiorentino, Montespertoli, and Castelfiorentino. From a geological point of view, the hills are made by middle Pliocenic and Pleistocenic sediments (clays, conglomerates, sands), while the plain by Holocenic alluvial sediments (Ghezzi and Ghezzi 1998).

The hills have a temperate bioclimate and belong to the preapenninic neutrobasiphilous Turkey oak vegetation series of central and northern Italy (*Lonicero xylostei-Querco pubescentis sigmetum*), while the plain shows a temperate transition towards a Mediterranean bioclimate, belonging to the hygrophilous geosigmetum of the riparian vegetation of the Italian peninsula (*Salicion albae*, *Populion albae*, *Alno-Ulmion*) (De Dominicis et al. 2010a, 2010b). Concerning the actual land use, most of the territory is cultivated, mainly with olive orchards (*Olea europaea* L.) and vineyards (*Vitis vinifera* L.). The overbuilding rate is 18% (Munafò 2020), and the spontaneous vegetation is restricted to a few relictual sites, among which a small forest area well visible in Fig. 1. This is not particularly surprising, given that Empoli experienced a growing urbanization since 1119. Starting from the 16th century, the original courses of the Arno and Elsa rivers were modified, by cutting some of their meanders (Lastraioli 2014). Moreover, the human presence has been continuous in the last 100,000 years (Pagli 2019).

Methods

Besides the analysis of the few literature sources available (see Introduction), field investigations were carried out in the last 20 years, more intensively in the years 2018–2022. The most interesting findings were published during the course of this research (Peruzzi 2004, 2014; Peruzzi et al. 2007; Atzori et al. 2008; Peruzzi et al. 2017, 2018,

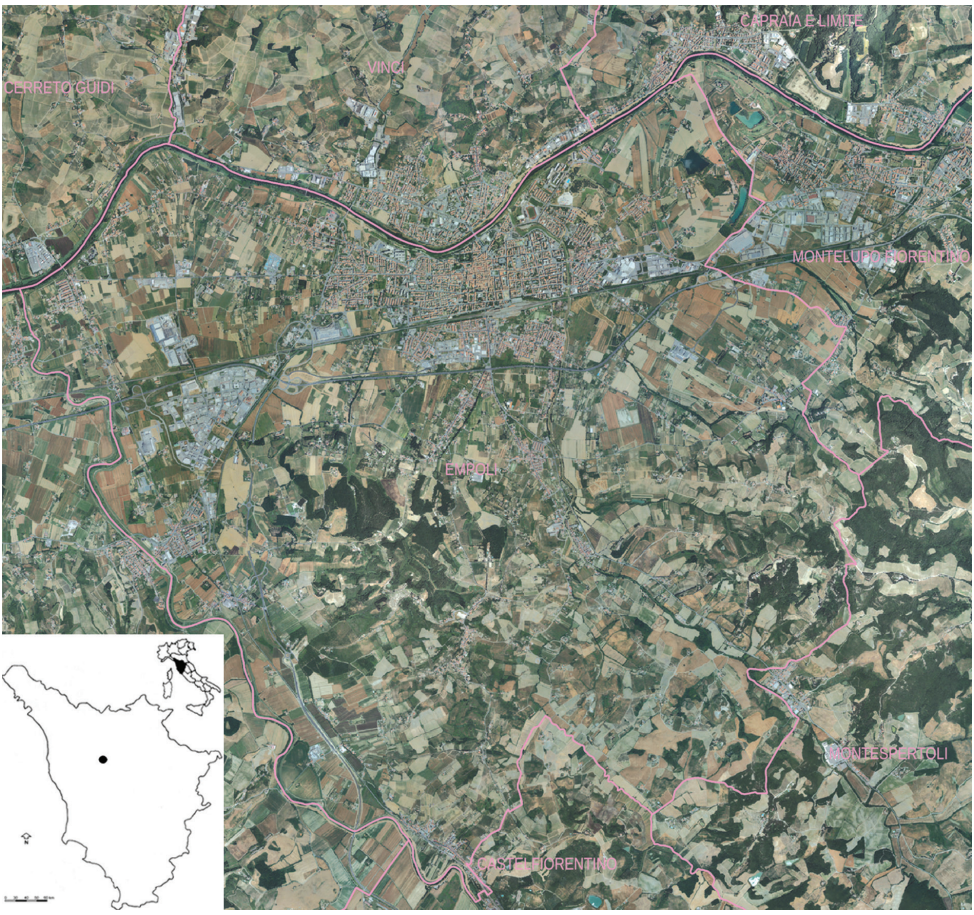

Figure 1. Localisaton and delimitation of the municipality of Empoli (province of Firenze, Tuscany, central Italy). The dominance of cultivated and urbanized areas is evident. The image (2019 AGEA orthophoto) was obtained by means of Cartoteca del Geoscopio della Regione Toscana (http://www502.regione.toscana.it/geoscopio/cartoteca.html).

2019, 2020, 2021, 2022; Roma-Marzio et al. 2018; Bartolucci et al. 2021, 2022). These data were complemented by field observations, which have been stored in Wikiplantase #Toscana (Peruzzi and Bedini 2013 onwards).

Nomenclature and circumscription of the taxa follows Bartolucci et al. (2018), Galasso et al. (2018) and their updates periodically appearing in the Portal to the Flora of Italy (https://dryades.units.it/floritaly/index.php; Martellos et al. 2020). Angiosperm families are arranged according to APG IV (2016). Within families, genera, species and subspecies are listed in alphabetical order. Life forms and chorotypes were attributed according to Pignatti (2017a, 2017b, 2018), not considering casual aliens and cultivated species. We also highlighted those taxa included in the National Red List (Rossi et al. 2013, 2020). Chorotypes were simplified as follows: Eurosiberian,

Eurosiberian-Mediterranean, Mediterranean, wide distribution, Italian endemic, alien. The endemicity status was based on Peruzzi et al. (2014, 2015). The complete dataset assembled for the present study is available in Suppl. material 1.

To calculate the expected number of species/subspecies, genera, families, and aliens we followed the approach published by D'Antraccoli et al. (2019), which relied on SAR relationships adjusted by environmental modeling. At the end of the study, the method proposed by D'Antraccoli et al. (2022a) was applied to obtain a final Map of Relative Floristic Ignorance and a Virtual Floristic List of the study area. This allows a proper planning of possible further floristic investigations of the area. In particular, all the floristic records (11,858) available in Peruzzi and Bedini (2013 onwards) for Empoli (6,791, i.e. 57% of the total number of records) and surrounding municipalities (Capraia e Limite, Castelfiorentino, Cerreto Guidi, Montelupo Fiorentino, Montespertoli, San Miniato, Vinci) were used.

Results

The expected number of species/subspecies, genera, families, and alien taxa was 834, 474, 101, and 38, respectively. A total of 757 specific and subspecific taxa were documented for the study area, including 117 aliens. Cultivated plants are 51. These taxa belong to 462 genera and 108 families.

Three families alone cover more than 30% of the total vascular flora (Asteraceae 99 taxa, Fabaceae 77, and Poaceae 71). The most represented genera are *Trifolium* (17 taxa), *Lathyrus* (14 taxa), *Crepis* (9 taxa), and *Allium* (7 taxa).

The biological spectrum highlights that hemicryptophytes (34%) and therophytes (32%) are the most represented life forms, followed by phanerophytes (15%), geophytes (14%), chamaephytes (3%), and hydrophytes (2%). As far as the chorological spectrum is concerned, the most frequent chorotypes are Mediterranean (35%) and Eurosiberian (25%), with 8% of Eurosiberian-Mediterranean taxa. A wider distribution is shown by 17% of taxa, while Italian endemics are only 1%. On the contrary, aliens are 14% of the established flora.

The Italian endemics are seven: *Artemisia caerulescens* L. subsp. *cretacea* (Fiori) Brilli-Catt. & Gubellini, *Crocus biflorus* Mill., *Daucus broteroi* Ten., *Ophrys classica* Devillers-Tersch. & Devillers, *Polygala flavescens* DC. subsp. *flavescens*, *P. vulgaris* L. subsp. *valdarnensis* (Fiori) Arrigoni, and *Scabiosa uniseta* Savi.

Further 23 taxa are of phytogeographical interest. Among them, there are species which usually grow at higher elevations, such as *Lilium martagon* L., *Physospermum cornubiense* (L.) DC., and *Scilla bifolia* L., and others that mark their innermost distribution in Tuscany, as *Asphodelus fistulosus* L., *Imperata cylindrica* (L.) Raeusch, *Ophrys speculum* Link, and *Sisymbrium irio* L. (this latter species representing a new record for the province of Firenze). Other species rare in Tuscany and found in the study area are: *Allium pallens* L., *Bolboschoenus glaucus* (Lam.) S.G.Sm., *Butomus umbellatus* L., *Cyperus flavescens* L., *C. michelianus* (L.) Delile, *Lathyrus tuberosus* L., *Lycopus exaltatus* L.f.,

Lythrum tribracteatum Spreng., *Eriolobus florentinus* (Zuccagni) Stapf, *Melampyrum cristatum* L. subsp. *cristatum*, *Onopordum acanthium* L. subsp. *acanthium*, *Rorippa palustris* (L.) Besser, *Securigera cretica* (L.) Lassen, *Spirodela polyrhiza* (L.) Schleid., *Taraxacum noterophilum* Kirschner, Sonck & Štěpánek, *Tripleurospermum inodorum* (L.) Sch.Bip., and *Tulipa sylvestris* L.

The most frequently observed species are: *Plantago lanceolata* L. (117 records), *Daucus carota* L. subsp. *carota* (110), *Trifolium nigrescens* Viv. subsp. *nigrescens* (107), *Cichorium intybus* L. (98), *Dittrichia viscosa* (L.) Greuter subsp. *viscosa* (93), *Acer campestre* L. (73), *Avena barbata* Pott ex Link and *Picris hieracioides* L. subsp. *hieracioides* (72), *Rubus ulmifolius* Schott (69), and *Convolvulus arvensis* L. (64) among natives; *Artemisia verlotiorum* Lamotte (194), *Arundo donax* L. (141), *Robinia pseudoacacia* L. (70), *Sorghum halepense* (L.) Pers. (56), and *Erigeron canadensis* L. (43) among aliens; *Vitis vinifera* L. (97), *Olea europaea* L. subsp. *europaea* (60), *Cupressus sempervirens* L. (47), *Pinus pinea* L. (29), and *Sorghum bicolor* (L.) Moench (21) among cultivated plants.

Among alien taxa, 28 are invasive and some of them are listed in European regulations UE 2016/1141, 2017/1263 and 2019/1262: *Alternanthera philoxeroides* (Mart.) Griseb. and *Ludwigia peploides* (Kunth) P.H.Raven subsp. *montevidensis* (Spreng.) P.H.Raven, both massively occurring along the banks of the Arno river, and *Ailanthus altissima* (Mill.) Swingle.

Eight species recorded by previous authors have not been found, and could be possibly extinct at the local level: *Carex caryophyllea* Latourr., *Epipactis helleborine* (L.) Crantz, *Hippocrepis biflora* Spreng., *Isolepis cernua* (Vahl) Roem. & Schult., *Persicaria amphibia* (L.) Delarbre, *Pyrus cordata* Desv., *Roemeria hispida* (Lam.) Stace, and *Salvinia natans* (L.) All.

Discussion

With respect to the predicted richness based on species-area relationships, the number of families is just slightly above the expected value, the number of genera is 3% less, while the number of species/subspecies is 10% below the theoretical prediction. This could be explained both by undersampling (see below) or by the scarce environmental variability/high overbuilding of the study area. On the contrary, the number of alien taxa is 207% above the expected value, fully confirming the high human impact on this territory. Indeed, more that 60% of the flora was observed in fields, meadows, olive orchards, and vineyards.

The Virtual Floristic List calculated on all available records for Empoli and surrounding territories includes 789 taxa, of which 619 show a percentage of spatio-temporal probability of occurrence above 95%, while 18 are below the 10% (Suppl. material 2).

The Map of Relative Floristic Ignorance highlights the cells hosting the relictual forest areas as the best known on floristic grounds (Fig. 2). Given that the sampling effort (i.e. number of floristic records) there and in the surrounding areas was comparable, these areas can be effectively interpreted as those hosting the highest species

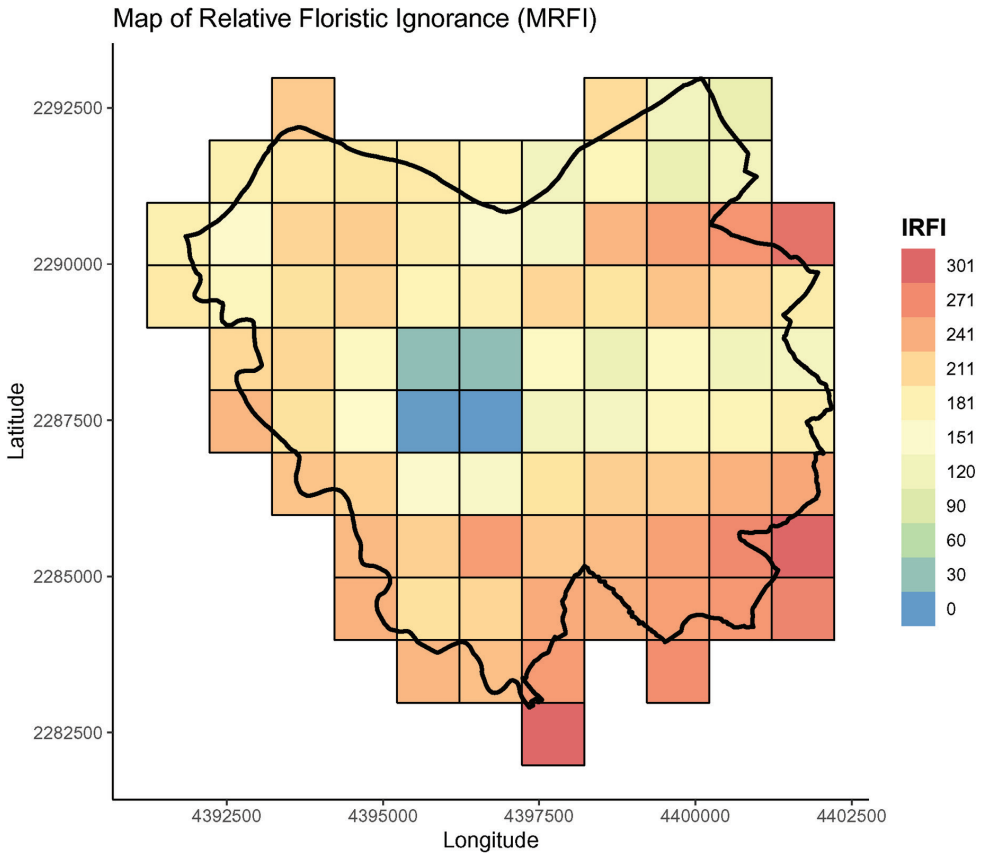

Figure 2. Maps of Relative Floristic Ignorance of the municipality of Empoli, computed with a cellsize = 1000 m and a temporal coefficient tau = 20. The colour scale represents values of Index of Relative Floristic Ignorance (IRFI), ranging from 0 (blue) to a maximum value (red) representing the cells showing lowest and highest relative ignorance, respectively. Coordinates are projected in EPSG 3035: ETRS89/ETRS-LAEA.

richness in Empoli. The cells near the eastern and southern border of the municipality that show the highest relative floristic ignorance, on the contrary, also correspond to areas that are less studied as compared to others. In this case, it is likely that more intensive studies may change the picture, so that these areas cannot safely be interpreted merely as less rich on floristic grounds.

On phytogeographical grounds, the area clearly shows a Mediterranean affinity, while the life forms are more suggestive of a temperate bioclimate. A similar, but opposite, situation was observed in the geographically close hills of Montalbano (Gestri and Peruzzi 2013). There, a phytogeographical Eurosiberian affinity is coupled with life forms more typical of the Mediterranean bioclimate.

The species showing some conservation interest are 42, among which the most important is certainly *Butomus umbellatus*, vulnerable at national level (Rossi et al. 2013). This species is very rare in Tuscany and, outside the province of Firenze, it has been

recently found only in the province of Arezzo (Lastrucci and Raffaelli 2006). Moreover this species grows, together with other native taxa, such as *Lysimachia vulgaris* L. and *Schoenoplectus tabernaemontani* (C.C.Gmel.) Palla, along the banks of the Arno river, i.e. exactly in the area most impacted by invasive aliens. The abundance of aliens in riparian habitats is well known also for other areas in Tuscany (Bonari et al. 2021).

The relictual forest areas still occurring in Empoli are of special conservation interest. Indeed, in these small areas, more than half of the plants known for the studied territory are found, including interesting species such as *Barlia robertiana* (Loisel.) Greuter, *Eriolobus florentinus*, *Galanthus nivalis* L., *Hypericum australe* Ten., *Lilium martagon*, *Melampyrum cristatum* subsp. *cristatum*, *Physospermum cornubiense*, *Polygala flavescens* subsp. *flavescens*, and *Polygala vulgaris* subsp. *valdarnesis*.

Finally, concerning aliens, based on their occurrence in this flora, the regional alien status for Tuscany of *Azolla filiculoides* Lam., *Prunus cerasifera* Ehrh., and *Veronica filiformis* Sm. should be changed from casual (Galasso et al. 2018; Lastrucci et al. 2019) to naturalized. The impressive amount of aliens (14%) is comparable to that found in large Italian urban areas such as Roma (Celesti-Grapow et al. 2013; ca. 14%), Palermo (Domina et al. 2020; 16%), or the historical centre of Bologna (Salinitro et al. 2018; 30%).

Acknowledgements

Marco D'Antraccoli (Botanic Garden and Museum, University of Pisa) is gratefully acknowledged for having calculated the SAR predictions, the Map of Relative Floristic Ignorance, and the Virtual Floristic List. The financial support by Fondazione per la Flora Italiana for the publication fee is also gratefully acknowledged.

References

Angiosperm Phylogeny Group (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society 181(1): 1–20. https://doi.org/10.1111/boj.12385

Arrigoni PV (2018) Flora analitica della Toscana. Vol. 4. Edizioni Polistampa, Firenze.

Atzori S, La Rosa M, Peruzzi L (2008) Notulae alla checklist della flora vascolare italiana, 6: 1492. Informatore Botanico Italiano 40(2): 255.

Bartolucci F, Domina G, Adorni M, Andreatta S, Angiolini C, Bacchetta G, Banfi E, Barberis D, Bertani G, Bonari G, Buccomino G, Calvia G, Caputo P, Cavallaro V, Conti F, Cuena-Lombraña A, D'Aleo F, D'Amico FS, De Fine G, Del Guacchio E, De Matteis Tortora M, De Santis E, Fois M, Di Pietro F, Di Pietro R, Fanfarillo E, Fiaschi T, Forte L, Galasso G, Laface VLA, Lallai A, Lonati M, Longo C, Longo D, Magrini M, Mei G, Menghi L, Menini F, Morabito A, Musarella CM, Nota G, Palermo DC, Passalacqua NG, Pazienza G, Peruzzi L, Pierini B, Pinzani L, Pisani G, Polverelli L, Prosser F, Salerno G, Salerno P, Santi F, Selvaggi A, Spampinato G, Stinca A, Terzi M, Valentini F, Vitale S, Wagensommer

RP, Lastrucci L (2022) Notulae to the Italian native vascular flora: 14. Italian Botanist 14: 119–131. https://doi.org/10.3897/italianbotanist.14.97813

Bartolucci F, Domina G, Andreatta S, Argenti C, Bacchetta G, Ballelli S, Banfi E, Barberis D, Barberis G, Bedini G, Bolpagni R, Bonali F, Bovio M, Briozzo I, Brusco A, Caldarella O, Campus G, Cancellieri L, Carotenuto L, Cheli E, Dagnino D, Del Guacchio E, Farris E, Ferretti G, Filibeck G, Foggi B, Gabellini A, Galasso G, Gianguzzi L, Gottschlich G, Gubellini L, Hofmann N, Iamonico D, Laface VLA, Lonati M, Lucarini D, Lupoletti J, Marchianò R, Marenzi P, Martignoni M, Mei G, Menini F, Merli M, Musarella CM, Orsenigo S, Peccenini S, Pennesi R, Peruzzi L, Pica A, Pinzani L, Piovesan G, Pittarello M, Podda L, Ravetto Enri S, Roma-Marzio F, Rosati L, Spampinato G, Stinca A, Tonelli S, Trenchi M, Turcato C, Viciani D, Lastrucci L (2021) Notulae to the Italian native vascular flora: 11. Italian Botanist 11: 77–92. https://doi.org/10.3897/italianbotanist.11.68048

Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, Astuti G, Bacchetta G, Ballelli S, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Cecchi L, Di Pietro R, Domina G, Fascetti S, Fenu G, Festi F, Foggi B, Gallo L, Gottschlich G, Gubellini L, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Conti F (2018) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 199–303. https://doi.org/10.1080/11263504.2017.1419996

Baroni E (1897–1908) Supplemento generale al "Prodromo della Flora toscana di T. Caruel". Firenze.

Bonari G, Fiaschi T, Fanfarillo E, Roma-Marzio F, Sarmati S, Banfi E, Biagioli M, Zerbe S, Angiolini C (2021) Remnants of naturalness in a reclaimed land of central Italy. Italian Botanist 11: 9–30. https://doi.org/10.3897/italianbotanist.11.62040

Carta A, Forbicioni L, Frangini G, Pierini B, Peruzzi L (2018) An updated inventory of the vascular flora of Elba island (Tuscan Archipelago, Italy). Italian Botanist 6: 1–22. https://doi.org/10.3897/italianbotanist.6.26568

Caruel T (1860–1864) Prodromo della Flora toscana. Firenze.

Celesti-Grapow L, Capotorti G, Del Vico E, Lattanzi E, Tilia A, Blasi C (2013) The vascular flora of Rome. Plant Biosystems 147(4): 1059–1087. https://doi.org/10.1080/11263504.2013.862315

Ciccarelli D, Di Bugno C, Peruzzi L (2014) Checklist della flora vascolare psammofila della Toscana. Atti della Società Toscana di Scienze Naturali, Memorie, serie B 121: 37–88.

D'Antraccoli M, Bedini G, Peruzzi L (2022a) Maps of relative floristic ignorance and virtual floristic lists: an R package to incorporate uncertainty in mapping and analysing biodiversity data. Ecological Informatics 67: 101512. https://doi.org/10.1016/j.ecoinf.2021.101512

D'Antraccoli M, Bacaro G, Tordoni E, Bedini G, Peruzzi L (2020) More species, less effort: designing and comparing sampling strategies to draft optimised floristic inventories. Perspectives in Plant Ecology and Systematics 45: 125547. https://doi.org/10.1016/j.ppees.2020.125547

D'Antraccoli M, Bedini G, Peruzzi L (2022b) Next Generation Floristics: a workflow to integrate novel methods in traditional floristic research. Plant Biosystems 156(2): 594–597. https://doi.org/10.1080/11263504.2022.2056650

D'Antraccoli M, Roma-Marzio F, Carta A, Landi S, Bedini G, Chiarucci A, Peruzzi L (2019) Drivers of floristic richness in the Mediterranean: a case study from Tuscany. Biodiversity and Conservation 28: 1411–1429. https://doi.org/10.1007/s10531-019-01730-x

De Dominicis V, Angiolini C, Gabellini A (2010a) Le serie di vegetazione della regione Toscana. In: Blasi C (Ed.) La vegetazione d'Italia. Palombi & Partner S.r.l., Roma, 205–230.

De Dominicis V, Angiolini C, Gabellini A (2010b) Carta delle serie di vegetazione della regione Toscana. In: Blasi C (Ed.) La vegetazione d'Italia, Carta delle Serie di Vegetazione, scala 1:500.000. Palombi & Partner S.r.l., Roma.

Domina G, Di Gristina E, Scafidi F, Calvo R, Venturella G, Gargano ML (2020) The urban vascular flora of Palermo (Sicily, Italy). Plant Biosystems 154(5): 627–634. https://doi.org/10.1080/11263504.2019.1651787

Fiori A (1943) Flora Italica Cryptogama, 5. Pteridophyta. Firenze.

Galasso G, Domina G, Azzaro D, Bagella S, Barone G, Bartolucci F, Bianco M, Bolzani P, Bonari G, Boscutti F, Buono S, Cibei C, Conti F, Di Gristina E, Fanfarillo E, Franzoni J, Giacanelli V, Gubellini L, Hofmann N, Laface VLA, Latini M, Liccari F, Lonati M, Longo D, Lunesu L, Lupoletti J, Magrini S, Mei G, Mereu G, Miconi F, Musarella CM, Nicolella G, Olivieri N, Peruzzi L, Pica A, Pinzani L, Pittarello M, Prosser F, Ranno V, Ravetto Enri S, Rivieccio G, Roma-Marzio F, Scafidi F, Spampinato G, Stinca A, Tavilla G, Tiburtini M, Villa V, Wellstein C, Zerbe S, Nepi C (2020) Notulae to the Italian alien vascular flora: 10. Italian Botanist 10: 57–61. https://doi.org/10.3897/italianbotanist.10.60736

Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E, Celesti-Grapow L, Albano A, Alessandrini A, Bacchetta G, Ballelli S, Bandini Mazzanti M, Barberis G, Bernardo L, Blasi C, Bouvet D, Bovio M, Cecchi L, Del Guacchio E, Di Pietro R, Domina G, Fascetti S, Gallo L, Gubellini L, Guiggi A, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Podda L, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Bartolucci F (2018) An updated checklist of the vascular flora alien to Italy. Plant Biosystems 152(3): 556–592. https://doi.org/10.1080/11263504.2018.1441197

Gei F, Fastelli D, Maetzke FG, Gestri G, Peruzzi L (2016) Calvana e Monte Morello. Due rilievi a confronto. Geografia, geologia, climatologia, rimboschimenti, vegetazione e flora vascolare. Accademia Italiana di Scienze Forestali, Tipografia Linari, Firenze, 233 pp.

Gestri G, Peruzzi L (2012) La flora vascolare del Monte Pelato (Colline Livornesi, Toscana). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 118(2011): 25–38.

Gestri G, Peruzzi L (2013) I fiori di Leonardo. La flora vascolare del Montalbano in Toscana. Aracne editrice, Roma.

Gestri G, Peruzzi L (2014) La flora vascolare di Monte Le Coste e Poggio alle Croci (Prato, Toscana). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 120(2013): 13–34.

Ghezzi G, Ghezzi P (1998) Indagine geologica nell'ambito del Piano Regolatore Generale. Comune di Empoli, Empoli (Firenze).

Lastraioli G (2014) Empoli. Mille anni in cento pagine. Editori dell'Acero, Empoli (Firenze), 135 pp.

Lastrucci L, Fiorini G, Lunardi L, Viciani D (2019) Herbarium survey on the genus *Azolla* (Salviniaceae) in Italy: distributive and taxonomic implications. Plant Biosystems 153(5): 710–719. https://doi.org/10.1080/11263504.2018.1549601

Lastrucci L, Raffaelli M (2006) Contributo alla conoscenza della flora delle zone umide planiziarie e collinari della Toscana orientale: la provincia di Arezzo (Italia centrale). Webbia 61(2): 271–304. https://doi.org/10.1080/00837792.2006.10670807

Martellos S, Bartolucci F, Conti F, Galasso G, Moro A, Pennesi R, Peruzzi L, Pittao E, Nimis PL (2020) FlorItaly – the portal to the Flora of Italy. Phytokeys 156: 55–71. https://doi.org/10.3897/phytokeys.156.54023

Munafò M [Ed.] (2020) Consumo di suolo, dinamiche territoriali e servizi ecosistemici. Edizione 2020. Report SNPA 15/20.

Pagli M (2019) La storia di Empoli. Dalla preistoria ai giorni nostri. Typimedia editore, Roma, 219 pp.

Peruzzi L (2004) Su alcune piante notevoli rinvenute nella Toscana Centro-Settentrionale. Atti della Società Toscana di Scienze Naturali, Memorie, serie B 110(2003): 23–24.

Peruzzi L (2010) Checklist dei generi e delle famiglie della flora vascolare italiana. Informatore Botanico Italiano 42(1): 151–170.

Peruzzi L (2014) Segnalazione 236. In: Peruzzi L, Viciani D, Bedini G (Eds) Contributi per una flora vascolare di Toscana. IV (181–246). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 119(2013): 23–32.

Peruzzi L (2018) Floristic inventories and collaborative approaches: a new era for checklists and floras? Plant Biosystems 152(2): 177–178. https://doi.org/10.1080/11263504.2017.1419997

Peruzzi L (2021) Flora Empolese – Elenco della flora vascolare della terra d'Empoli. Edizioni ETS, Pisa.

Peruzzi L, Barbo M, Bartolucci F, Bovio M, Carta A, Ciccarelli D, Conti F, Costalonga S, Di Pietro R, Galasso G, Gestri G, Lattanzi E, Lavezzo P, Marsili S, Peccenini S, Pierini B, Tardella FM, Terzo V, Turrisi RE, Bedini G (2011) Contributo alla conoscenza floristica delle Colline Pisane: resoconto dell'escursione del Gruppo di Floristica (S.B.I.) nel 2009. Informatore Botanico Italiano 43(1): 3–27.

Peruzzi L, Bedini G [Eds] (2013 onwards) Wikiplantbase #Toscana. http://bot.biologia.unipi.it/wpb/toscana/index

Peruzzi L, Caparelli KF, Cesca G (2007) Contribution to the systematic knowledge of the genus *Ornithogalum* L. (Hyacinthaceae): morpho-anatomical variability of the leaves among different taxa. Bocconea 21: 257–265.

Peruzzi L, Conti F, Bartolucci F (2014) An inventory of vascular plants endemic to Italy. Phytotaxa 168(1): 1–75. https://doi.org/10.11646/phytotaxa.168.1.1

Peruzzi L, Domina G, Bartolucci F, Galasso G, Peccenini S, Raimondo FM, Albano A, Alessandrini A, Banfi E, Barberis G, Bernardo L, Bovio M, Brullo S, Brundu G, Brunu A, Camarda I, Carta L, Conti F, Croce A, Iamonico D, Iberite M, Iiriti G, Longo D, Marsili

S, Medagli P, Pistarino A, Salmeri C, Santangelo A, Scassellati E, Selvi F, Soldano A, Stinca A, Villani M, Wagensommer RP, Passalacqua NG (2015) An inventory of the names of vascular plants endemic to Italy, their loci classici and types. Phytotaxa 196(1): 1–217. https://doi.org/10.11646/phytotaxa.196.1.1

Peruzzi L, Viciani D, Adami M, Angiolini C, Astuti G, Bonari G, Bonaventuri G, Castagnini P, de Simone L, Domina G, Fanfarillo E, Fedeli R, Ferretti G, Festi F, Fiaschi T, Foggi B, Franzoni J, Gabellini A, Gennai M, Gestri G, Giacò A, Gottschlich G, Maccherini S, Mugnai M, Pierini B, Pinzani L, Roma-Marzio F, Sarmati S, Vannini A, Zangari G, Bedini G (2021) Contributi per una flora vascolare di toscana. XIII (813–873). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 128: 85–94.

Peruzzi L, Viciani D, Agostini N, Angiolini C, Ardenghi NMG, Astuti G, Bardaro MR, Bertacchi A, Bonari G, Boni S, Chytrý M, Ciampolini F, D'Antraccoli M, Domina G, Ferretti G, Guiggi A, Iamonico D, Laghi P, Lastrucci L, Lazzaro L, Lazzeri V, Liguori P, Mannocci M, Marsiaj G, Novák P, Nucci A, Pierini B, Roma-Marzio F, Romiti B, Sani A, Zoccola A, Zukal D, Bedini G (2017) Contributi per una flora vascolare di Toscana. VIII (440–506) Atti della Società Toscana di Scienze Naturali, Memorie, Serie B 123(2016): 71–82.

Peruzzi L, Viciani D, Angiolini C, Apruzzese M, Banfi E, Bonini I, Bonari G, Calvia G, Carta A, Castagnini P, Chierchini F, D'Antraccoli M, Ferretti G, Ferruzzi S, Festi F, Fröhner S, Franzoni J, Galasso G, Gestri G, Gottschlich G, Lazzaro L, Lazzeri V, Mannucci N, Marchetti D, Mugnai M, Pasquinelli P, Pinzani L, Reduron J-P, Roma-Marzio F, Romanacci G, Romano O, Selvi F, Soldano A, Stinca A, Verloove F, Bedini G (2020) Contributi per una flora vascolare di Toscana. XII (739–812). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 127: 101–111.

Peruzzi L, Viciani D, Angiolini C, Astuti G, Banfi E, Bardaro MR, Bianchetto E, Bonari G, Cannucci S, Cantini D, Castagnini P, D'Antraccoli M, Esposito A, Ferretti G, Fiaschi T, Foggi B, Franceschi G, Galasso G, Gottschlich G, Lastrucci L, Lazzaro L, Maneli F, Marchetti D, Marsiaj G, Mugnai M, Roma-Marzio F, Ruocco M, Salvai G, Stinca A, Bedini G (2018) Contributi per una flora vascolare di Toscana. X (606–663). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 125: 17–29.

Peruzzi L, Viciani D, Angiolini C, Astuti G, Banfi E, Brandani S, Bonari G, Cambria S, Cannucci S, Castagnini P, D'Antraccoli M, De Giorgi P, Di Natale S, Ferretti G, Fiaschi T, Gonnelli V, Gottschlich G, Lastrucci L, Lazzaro L, Misuri A, Mugnai M, Pierini B, Pinzani L, Roma-Marzio F, Sani A, Selvi F, Spinelli A, Bedini G (2019) Contributi per una flora vascolare di Toscana. XI (664–738). Atti della Società Toscana di Scienze Naturali, Memorie, Serie B 126: 35–46.

Peruzzi L, Viciani D, Astuti G, Bandinelli A, Bettini D, Carta A, Cutroneo A, Domina G, Fontana D, Franzoni J, Gavazzi C, Gestri G, Giacò A, Mo A, Pierini B, Pinzani L, Roma-Marzio F, Selvi F, Stinca A, Vangelisti R, Bedini G (2022) Contributi per una flora vascolare di toscana. XIV (874–958). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 129: 57–69.

Pignotti L (2003) *Scirpus* L. and related genera (Cyperaceae) in Italy. Webbia 58(2): 281–400. https://doi.org/10.1080/00837792.2003.10670754

Roma-Marzio F, Harpke D, Peruzzi L (2018) Rediscovery of *Crocus biflorus* var. *estriatus* (Iridaceae) and its taxonomic characterisation. Italian Botanist 6: 23–30. https://doi.org/10.3897/italianbotanist.6.28729

Pierini B, Garbari F, Peruzzi L (2009) Flora vascolare del Monte Pisano (Toscana nord–occidentale). Informatore Botanico Italiano 41(2): 147–213.

Pierini B, Peruzzi L (2014) Prodromo della flora vascolare della Provincia di Lucca (Toscana nord-occidentale). Informatore Botanico Italiano 46(1): 3–16[+ electronic appendix (500 pp.)].

Pignatti S, Guarino R, La Rosa M (2017a) Flora d'Italia 1, Ed. 2. Edagricole di New Business Media: Milano, Italy, 1064 pp.

Pignatti S, Guarino R, La Rosa M (2017b) Flora d'Italia 2, Ed. 2. Edagricole di New Business Media: Milano, Italy, 1178 pp.

Pignatti S, Guarino R, La Rosa M (2018) Flora d'Italia 3, Ed. 2. Edagricole di New Business Media: Milano, Italy, 1286 pp.

Piussi P, Stiavelli S (1995) Storia dei boschi delle Cerbaie. In: Prosperi A (Ed.) Il Padule di Fucecchio. Roma, 123–136.

Roma-Marzio F, Bedini G, Müller, Peruzzi L (2016) A critical checklist of the woody flora of Tuscany. Phytotaxa 287(1): 1–135. https://doi.org/10.11646/phytotaxa.287.1.1

Roma-Marzio F, D'Antraccoli M, Angeloni D, Bartolucci F, Bernardo L, Cancellieri L, Caruso G, Conti F, Dolci D, Gestri G, Gubellini L, Hofmann N, Laface VLA, Lattanzi E, Lavezzo P, Maiorca G, Montepaone G, Musarella CM, Noto D, Perrino EV, Proietti E, Masin RR, Scoppola A, Stinca A, Tiburtini M, Tilia A, Peruzzi L (2020) Contribution to the floristic knowledge of Sillaro, Santerno, and Senio high valleys (Tuscany, Italy). Italian Botanist 10: 101–111. https://doi.org/10.3897/italianbotanist.10.60118

Rossi G, Montagnani C, Gargano D, Peruzzi L, Abeli T, Ravera S, Cogoni A, Fenu G, Magrini S, Gennai M, Foggi B, Wagensommer RP, Venturella G, Blasi C, Raimondo FM, Orsenigo S (2013) Lista Rossa della Flora Italiana. 1. Policy Species e altre specie minacciate. Comitato Italiano IUCN e Ministero dell'Ambiente e della tutela del Territorio e del Mare.

Rossi G, Orsenigo S, Gargano D, Montagnani C, Peruzzi L, Fenu G, Abeli T, Alessandrini A, Astuti G, Bacchetta G, Bartolucci F, Bernardo L, Bovio M, Brullo S, Carta A, Castello M, Cogoni D, Conti F, Domina G, Foggi B, Gennai M, Gigante D, Iberite M, Lasen C, Magrini S, Nicolella G, Pinna MS, Poggio L, Prosser F, Santangelo A, Selvaggi A, Stinca A, Tartaglini N, Troia A, Villani MC, Wagensommer RP, Wilhalm T, Blasi C (2020) Lista Rossa della Flora Italiana. 2 Endemiti e altre specie minacciate. Ministero dell'Ambiente e della tutela del Territorio e del Mare.

Salinitro M, Alessandrini A, Zappi A, Melucci D, Tassoni A (2018) Floristic diversity in different urban ecological niches of a southern European city. Scientific Reports 8: 15110. https://doi.org/10.1038/s41598-018-33346-6

Supplementary material 1

Floristic list and records
Authors: Lorenzo Peruzzi
Data type: PDF file
Explanation note: 1. Floristic list and records. 2. References cited only in the supplementary materials.
Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.
Link: https://doi.org/10.3897/italianbotanist.15.101748.suppl1

Supplementary material 2

Virtual floristic list
Authors: Lorenzo Peruzzi
Data type: Excel .xslx file
Explanation note: Virtual Floristic List, elaborated according to D'Antraccoli (2022a).
Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.
Link: https://doi.org/10.3897/italianbotanist.15.101748.suppl2

Italian Botanist 15: 35–47 (2023)
doi: 10.3897/italianbotanist.15.103781
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

Notulae to the Italian flora of algae, bryophtes, fungi and lichens: 15

Sonia Ravera[1,2], Marta Puglisi[3], Alfredo Vizzini[4], Cecilia Totti[5], Mattia M. Azzella[6], Giulia Bacilliere[3], Rossano Bolpagni[7], Othmar Breuss[8], Annalena Cogoni[9], Antonio B. De Giuseppe[10], Zuzana Fačkovcová[11], Felix Faltner[12], Gabriele Gheza[13], Paolo Giordani[14], Deborah Isocrono[15], Petra Mair[16], Jiří Malíček[17], Pasquale Marino[18], Helmut Mayrhofer[19], Juri Nascimbene[13], Silvia Ongaro[15], Luca Paoli[20], Nicodemo G. Passalacqua[10,21], Silvia Poponessi[9], Domenico Puntillo[10], Francesco Maria Raimondo[22], Giovanni Sicoli[21], Wilhelm Tratter[23]

1 *Dipartimento di Scienze e Tecnologie Biologiche Chimiche e Farmaceutiche (STEBICEF), Università di Palermo, Via Archirafi 38, 90123, Palermo, Italy* **2** *NBFC, National Biodiversity Future Center, Palermo 90133, Italy* **3** *Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Sezione di Biologia vegetale, Università di Catania, Via A. Longo 19, 95125, Catania, Italy* **4** *Institute for Sustainable Plant Protection (IPSP) – CNR, Viale P.A. Mattioli 25, 10125, Torino, Italy* **5** *Dipartimento di Scienze della Vita e dell'Ambiente, Università Politecnica delle Marche, via Brecce Bianche, 60131, Ancona, Italy* **6** *Dipartimento di Pianificazione, Design, Tecnologia dell'Architettura – La Sapienza Università di Roma, Via Emanuele Gianturco 2, 00196, Roma, Italy* **7** *Dipartimento di Scienze Chimiche, della Vita e della Sostenibilità Ambientale dell'Università degli Studi di Parma, Parco Area delle Scienze 33/A, 43124, Parma, Italy* **8** *Department of Botany and Biodiversity Research, University of Vienna, Rennweg 14, 1030, Vienna, Austria* **9** *Dipartimento di Scienze della Vita e dell'Ambiente, Università di Cagliari, Viale S. Ignazio, 09123, Cagliari, Italy* **10** *Museo di Storia Naturale della Calabria ed Orto Botanico, Università della Calabria, 87036 Arcavàcata di Rende (Cosenza), Italy* **11** *Plant Science and Biodiversity Centre, Slovak Academy of Sciences, Dúbravská cesta 9, SK-84523, Bratislava, Slovakia* **12** *Reinthalstraße 4a, 39031, Bruneck/Reischach, Italy* **13** *BIOME Lab, Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Alma Mater Studiorum, Università di Bologna, Via Irnerio 42, 40126, Bologna, Italy* **14** *Dipartimento di Farmacia (DIFAR), Università di Genova, viale Cembrano 4, 16148, Genova, Italy* **15** *Dipartimento di Scienze Agrarie, Forestali e Alimentari, Università degli Studi di Torino, Largo Paolo Braccini, 10095, Grugliasco (Torino) Italy* **16** *Museo di Scienze Naturali dell'Alto Adige, via dei Bottai 1, 39100, Bolzano, Italy* **17** *Institute of Botany, The Czech Academy of Sciences, Zámek 1, CZ-252 43, Průhonice, Czech Republic* **18** *Bona Furtuna LLC, P.O. Box 277 95031 Los Gatos, CA, USA* **19** *Division of Plant Sciences, Institute of Biology, NAWI Graz, University of Graz, Holteigasse 6, 8010, Graz, Austria* **20** *Dipartimento di Biologia, Università di Pisa, Via Luca Ghini 13, 56126, Pisa, Italy* **21** *Dipartimento di Biologia, Ecologia e Scienze della Terra, Università della Calabria, 87036, Arcavàcata di Rende (Cosenza), Italy* **22** *PLANTA/Centro autonomo di Ricerca, Documentazione e Formazione, Via Serraglio Vecchio 28, 90123, Palermo, Italy* **23** *Alpreid 77, 39010, St. Pankraz (Bolzano), Italy*

Corresponding author: Sonia Ravera (sonia.ravera@unipa.it)

Copyright *Sonia Ravera et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Academic editor: Lorenzo Peruzzi | Received 23 March 2023 | Accepted 11 April 2023 | Published 19 April 2023

Citation: Ravera S, Puglisi M, Vizzini A, Totti C, Azzella MM, Bacilliere G, Bolpagni R, Breuss O, Cogoni A, De Giuseppe AB, Fačkovcová Z, Faltner F, Gheza G, Giordani P, Isocrono D, Mair P, Malíček J, Marino P, Mayrhofer H, Nascimbene J, Ongaro S, Paoli L, Passalacqua NG, Poponessi S, Puntillo D, Raimondo FM, Sicoli G, Tratter W (2023) Notulae to the Italian flora of algae, bryophtes, fungi and lichens: 15. Italian Botanist 15: 35–47. https://doi.org/10.3897/italianbotanist.15.103781

Abstract

In this contribution, new data concerning algae, bryophytes, fungi and lichens of the Italian flora are presented. It includes new records and confirmations for the algal genus *Nitella*, for the bryophyte genera *Anthoceros*, *Dicranodontium*, *Fontinalis*, and *Riccia*, the fungal genera *Inocybe* and *Xerophorus*, and the lichen genera *Bagliettoa*, *Biatora*, *Calicium*, *Cladonia*, *Coniocarpon*, *Lecanora*, *Opegrapha*, *Placynthium*, *Rhizocarpon*, *Scytinium*, *Solenopsora*, *Stereocaulon*, and *Verrucaria*.

Keywords

Ascomycota, Basidiomycota, Biodiversity, Bryidae, Charophyceae

How to contribute

The text of the records should be submitted electronically to: Cecilia Totti (c.totti@univpm.it) for algae, Marta Puglisi (mpuglisi@unict.it) for bryophytes, Alfredo Vizzini (alfredo.vizzini@unito.it) for fungi, Sonia Ravera (sonia.ravera@unipa.it) for lichens. Each text should be within 1,000 characters (spaces included).

Floristic records

Algae

***Nitella capillaris* (Krocker) J.Groves & Bullock-Webster (Characeae)**

+ **LAZ**: Ceprano (Frosinone), tiny temporary pool on the southern side of the via Sfratti woodland (WGS84: 33T 371658.4600583), 130 m, 25 February 2023, leg. *R. Bolpagni*, det. *M.M. Azzella* (RO). – Species confirmed for the flora of Lazio.

Both female and male individuals were found growing sparsely in a small (not more than 1 m^2) temporary pool not very far from the highway crossing (via Carl Vepu). In Italy, *Nitella capillaris* has been recently confirmed for Sicilia (Romanov et al. 2019), while the reports for peninsular Italy date back to more than 50 years ago (Bazzichelli and Abdelahad 2009). This record is a confirmation of the species for the flora of Lazio 60 years after the last reports (Corillion and Guerlesquin 1963).

M.M. Azzella, R. Bolpagni

Bryophytes

Anthoceros agrestis Paton (Anthocerotaceae)

+ **TAA**: Walchhorn, E of Reischach, Brunico, Val Pusteria (Bolzano), on the edge of a stubble cornfield, near hedges on siliceous soil (UTM WGS84: 32T 726187.5184209), 1038 m, 24 September 2022, *F. Faltner*, conf. *P. Mair* (Herb. Faltner; BOZ BRYO 8353). – Species new for the flora of Trentino-Alto Adige.

Anthoceros agrestis is quite similar to *A. punctatus* L., from which it can be distinguished essentially for the size of the mature antheridia, mostly about 80 µm long. It is mainly distributed in the temperate zone of central Europe but is rather rare in the Mediterranean-Atlantic parts (Hodgetts and Lockart 2020). In Italy, *A. agrestis* is signaled with old records for Piemonte, Toscana, Campania, and Sardegna, while more recent data (after 1968) are available for Lombardia (Brusa 2019), Lazio, Vatican City State, Calabria, and Sicilia (Aleffi et al. 2020). In the new locality it was found with *Riccia* sp. pl. and *Tortula truncata* (Hedw.) Mitt. This species is assessed as Near Threatened in Europe (Hodgetts et al. 2019).

F. Faltner, P. Mair

Dicranodontium asperulum (Mitt.) Broth. (Leucobryaceae)

+ **EMR**: Passo della Scalucchia, Alpe di Succiso (Reggio Emilia) (UTM WGS84 32T 5979945.4912109), 1346 m, 21 July 2018, *S. Poponessi* (Bryo/AR002). – Specie new for the flora of Emilia-Romagna.

Dicranodontium asperulum is a Boreal-montane species with main distribution in North America, SE Asia (China, Japan Nepal, India), and central Europe, while it is very rare in the Mediterranean countries (Hodgetts and Lockart 2020). In Italy it occurs only in Piemonte, Veneto, Umbria, and was recorded before 1968 in Lombardia and Trentino-Alto Adige (Aleffi et al. 2020). The species prefers sheltered moist sites where it grows on acidic soils in montane heath, on ledges or crevices among acidic rocks. It is easily recognized by the wide-spreading leaves, standing out from the stem at 45° or more when wet, the serrate to serrulate shoulders of the leaf bases and the long arista which is serrate all around. In the new locality, *D. asperulum* was found on acidic soil at the base of *Fagus sylvatica* L., together with *Plagiotecium denticulatum* (Hedw.) Schimp. var. *denticulatum*, *Radula complanata* (L.) Dumort., *Brachytheciastrum velutinum* (Hedw.) Ignatov & Huttunen, and *Pterygynandrum filiforme* Hedw.

S. Poponessi, G. Bacilliere

Fontinalis hypnoides var. *hypnoides* C.Hartm. (Fontinalaceae)

+ **SAR**: Rio Santa Lucia, Assemini (Cagliari) (UTM WGS84 32T 50226.4338222), on riverbed rocks of the river Rio Santa Lucia, 82 m, 24 September 2020, *S. Poponessi*, *A. De Agostini*, *A. Cogoni* (CAG SA2.2.3). – Variety confirmed for the flora of Sardegna.

Fontinalis hypnoides var. *hypnoides* is an aquatic moss growing submerged in standing or slow-moving water, including slightly eutrophic lakes, slow flowing rivers, or in reed-beds, normally attached to stones and wood. It is quite common in Europe (Hodgetts and Lockart 2020). According to Aleffi et al. (2020), *F. hypnoides* var. *hypnoides* is known in Italy from Veneto, Abruzzo, Puglia, Calabria and, with old records, Lombardia, Lazio and Sardegna. In Sardegna it was previously signalled more than a century ago from a few sites located in the eastern part of the island (Cardot 1882; Barbey 1884; Fleischer 1893). *Fontinalis hypnoides* var. *hypnoides* is distinguished from other species in the genus by its medium size and monomorphic leaves consistently plane at the apices.

S. Poponessi, A. Cogoni

***Riccia breidleri* Jur. ex Steph. (Ricciaceae)**

+ **TAA**: Oberer Hintergratsee, Sulden, Stilfser Joch/Stelvio National Park, Ortler Alps (Bozen/Bolzano), on damp, muddy, fine sandy shores (calcareous morainic material on phyllitic bedrock) of the small remnant of this alpine lake, partly drying out in summer (UTM WGS84: 32T 621420.5150986), 2650 m, 7 July 2017, *W. Tratter* (BOZ BRYO 8351); ibidem, 12 September 2022, *leg. P. Mair*, conf. *H. Köckinger* (BOZ BRYO 8352); East side of the Unterer Hintergratsee, Sulden, Stilfser Joch/Stelvio National Park, Ortler Alps (Bozen/Bolzano), on damp and dry, muddy shore edges, (UTM WGS84: 32T 621585.5150646), 2596 m, 12 September 2022, *P. Mair*. – Species new for the flora of Trentino-Alto Adige.

Riccia breidleri is endemic to Alps (Hodgetts et al. 2020), growing above 2000 m of elevations. This species grows on acidic soil in temporary pools that fill with melting snow water in the spring. In Italy it is only known for Piemonte, Valle d'Aosta, and Lombardia (Aleffi et al. 2020). *Riccia breidleri* is included in Annex II of the Habitats Directive of the EU and in the Appendix I of the Bern Convention, and considered Vulnerable in the European red list of bryophytes (Hodgetts et al. 2019).

P. Mair, W. Tratter

Fungi

***Inocybe langei* R.Heim (Inocybaceae)**

+ **CAL**: Botanical Garden, University of Calabria, Rende (Cosenza), on the ground under the crown of downy oak (*Quercus pubescens* Willd.) trees (UTM WGS84: 33S 605921.435728), 210 m, 5 September 2022, *G. Sicoli*, *A.B. De Giuseppe*, *N.G. Passalacqua* (CLU F323). – Species new for the flora of Calabria.

A group of solitary, but gregarious, basidiomata belonging to *Inocybe langei* was observed on the ground among the litter of *Quercus pubescens* trees. The pilei were broadly conical and slightly umbonate when young, then almost applanate with age, less than 3 cm wide, straw-coloured, but a bit darker ochre in the centre, and fibrillose.

The stipe was pale, rather short and robust, with a slightly bulbose base, covered by crested caulocystidia especially along the upper half. The gills were beige-gray, the edge showing ventricose-lageniform and crested cheilocystidia. Spores were amygdaliform and 6.5–8.5 × 3.5–5 µm in size, thus shorter than those belonging to the closely-related species *I. hirtella* Bres., which is also characterised by the smell of almonds not recorded in our samples (Printz 1992; Courtecuisse and Duhem 1995). So far, *Inocybe langei* has been reported only in northern Italy (Onofri et al. 2013).

G. Sicoli, A.B. De Giuseppe, N.G. Passalacqua

***Xerophorus donadinii* (Bon) Vizzini, Consiglio & M.Marchetti (Callistosporiaceae)**

+ CAL: Botanical Garden, University of Calabria, Rende (Cosenza) (UTM WGS84: 33S 605857. 4357281), on the ground under the crown of a pedunculate oak tree (*Quercus robur* L.), 200 m, 21 October 2022, *A.B. De Giuseppe*, *N.G. Passalacqua*, *G. Sicoli* (CLU F325). – Species new for the flora of Calabria.

A group of six small, gregarious and collybioid basidiomata was observed on the ground on the litter under a planted tree of *Quercus robur*. The youngest pilei were hemisphaeric convex and with an involute edge; the most mature ones were more applanate, matt, smooth, dark brown with a reddish tone in the centre, paler at the edge, and 1.0–2.5 cm wide. The lower side of the pileus showed distant, emarginated and pale yellowish gills supported by a lemon-yellow, slender, flexuose and fibrillose stipe with white rhizomorphs attached at the base. Spores were amygdaliform, smooth, hyaline, and 7–9 × 4–5 µm in size. Cheilocystidia were scattered and cylindrical, no pleurocystidia were observed. Smell and taste resulted indistinct. Based on the above characters and ecology, this fungus was identified as *Xerophorus donadinii*. This species, was first described as *Callistosporium olivascens* var. *donadinii* Bon, ecologically distinct from the proper *C. olivascens* (Boud.) Bon, currently *X. olivascens* (Bon) Vizzini, Consiglio & M.Marchetti, which prefers association with cedar trees. Further differences are also morphological: *X. donadinii* has pilei with smaller diameters, without an evident umbo, with a more reddish shade in the centre, and a paler and more involute edge; the stipe is also slenderer than in *X. olivascens* (Courtecuisse and Duhem 1995; Vizzini et al. 2020). In Italy, *X. donadinii* has so far been reported always on broadleaved trees, only in Emilia-Romagna, Marche, and Puglia (Vizzini et al. 2020).

A.B. De Giuseppe, N.G. Passalacqua, G. Sicoli

Lichens

***Bagliettoa baldensis* (A.Massal.) Vězda (Verrucariaceae)**

+ CAL: Campotenese, E Monte Pollino (Cosenza) (UTM WGS84 33S 592440.441491), on limestone, c. 1000 m, 30 May 1979, *H. Mayrhofer* (no. 22024 GZU). – Species confirmed for the flora of Calabria.

This species is widespread in Italy on compact calcareous rocks with optimum in the submediterranean belt (Nimis 2016; Nimis and Martellos 2023). The only previous record in Calabria was from Valle di Fiume Argentino (Halda 2003: 35, sub *Verrucaria baldensis*) but it is currently not included in the Information System on Italian Lichens (Nimis and Martellos 2023).

H. Mayrhofer, O. Breuss

***Biatora mendax* Anzi (Ramalinaceae)**

+ **LOM**: Bagni di Masino, Valmasino (Sondrio), on bark of *Fagus sylvatica* L. in an old-growth beech forest (UTM WGS84: 32T 546327.5121063), 1137 m, 23 August 2019, leg. *G. Gheza*, det. *H. Mayrhofer* (PAV). – Species confirmed for the flora of Lombardia.

Biatora mendax was previously known from Lombardia only from Val di Tartano, Val del Bitto and Val Malenco (Anzi 1862; Anzi Lich. Rar. Lang. Exs. n.168: Printzen 1995); its distribution is now extended to Val Masino. It was collected in a moist, old-growth beech stand (Natura 2000 Habitat 9110 "Luzulo-Fagetum beech forests"), which is coherent with it having its optimum in humid beech forests (Nimis and Martellos 2023). It is listed in the Red List of Italian epiphytic lichens as "endangered" (Nascimbene et al. 2013).

G. Gheza, H. Mayrhofer

***Calicium denigratum* (Vain.) Tibell (Caliciaceae)**

+ **ITA** (**TAA**): Fiè allo Sciliar (Bolzano) (UTM WS84: 32T 694257.5153572), on bark of *Pinus sylvestris* L., 1165 m, 4 May 2012, *J. Nascimbene*, conf. *J. Hafellner* (CLU No. 18230). – Species new for the flora of Trentino-Alto Adige.

Calicium denigratum is recognizable for its tall, thin, and shiny black ascomata with stalk of sclerotized, dark, irregularly interwoven hyphae and distinct bell-shaped capitulum lacking pruina. Spores have a coarsely cracked surface (Tibell 1999). The species could be confused with *C. glaucellum* Ach. and *C. abietinum* Pers. but the former has an obovoid to lenticular capitulum with white pruina and coarsely cracked spores with ridges and the latter has a black lenticular capitulum with minutely warted spores. This species occurs in open canopy woodlands in Europe and Siberia (Tibell 1999). It is reported also for North America (McMullin et al. 2012). This is the first Italian collection but the species is likely widespread throughout the Italian Alps.

J. Nascimbene, D. Puntillo

***Cladonia trassii* Ahti (Cladoniaceae)**

+ **LOM**: Valle delle Messi, Ponte di Legno (Brescia), on soil above siliceous rock in an open larch stand (UTM WGS84: 32T 614582.5129878), 1686 m, 19 August 2020, *G. Gheza* (BOLO). – Species confirmed for the flora of Lombardia.

Cladonia trassii is an arctic-alpine species with squamulose verticillate podetia with very narrow scyphi (Gheza and Nimis 2021). It was previously recorded in Lombardia only from the high elevation coniferous forests of Mount Confinale, in Valtellina (Anzi 1868, as "*Cladonia stricta*", cited by Rivellini and Valcuvia Passadore 1996). Our specimen contains fumarprotocetraric acid and atranorin. It was collected together with *Cladonia arbuscula* (Wallr.) Flot., *C. chlorophaea* (Sommerf.) Spreng., *C. furcata* (Huds.) Schrad., *C. macroceras* (Delise) Hav., *C. pleurota* (Flörke) Schaer., and *C. rangiferina* (L.) F.H.Wigg. (Gheza et al. 2022).

G. Gheza, H. Mayrhofer

***Coniocarpon fallax* (Ach.) Grube (Arthoniaceae)**

+ **LOM**: road between Dezzo di Scalve and Passo della Presolana, Colere (Bergamo) (UTM WGS84: 32T 585785.5090970), on bark of *Alnus incana* (L.) Moench in a sheltered and moist broadleaved stand within a mixed forest, 810 m, 4 January 2023, *G. Gheza* (BOLO). – Species confirmed for the flora of Lombardia.

Coniocarpon fallax is an oceanic crustose lichen harbouring a trentepohlioid photobiont characterized by the orange-rusty red pruina along the margin of confluent elongated or stellate lirellae (Frisch et al. 2020). The only previous record from Lombardia was from the surroundings of Como by Anzi (1860); a collection by the latter author (*Lich. Min. Rar. Ital.* n. 317) was also reported in Stizenberger (1882) and Sundin and Tehler (1998).

G. Gheza

***Lecanora subcarpinea* Szatala (Lecanoraceae)**

+ **SAR**: along a road in pasture, Gavoi (Nuoro) (UTM 32T 515790.4448723), on bark of *Prunus* sp., 850 m, 1 May 2012, *J. Malíček* (PRA). – Species new for the flora of Sardegna.

Lecanora subcarpinea is a crustose epiphytic lichen belonging to the *L. carpinea-L. leptyrodes* complex, found on smooth and base-rich bark of isolated trees, which occurs also in well-lit or sparse forests, from the mesomediterranean to the subalpine belt. According to Nimis and Martellos (2023), it appears that this species has not always been correctly identified, and the Italian material collected so far would need revision. This sample, collected in the typical habitat of *L. subcarpinea*, is characterized by strongly pruinose apothecia and a distinct Pd+ bright yellow reaction of the apothecial margin, which is coherent with the taxon description.

J. Malíček, S. Ravera

***Opegrapha vermicellifera* (Kunze) J.R.Laundon (Opegraphaceae)**

+ **TAA**: Toblino lake, path in the holm oak forest above the lake, eastern slope (Trento) (UTM WGS84 32T: 651601.5102080), on *Quercus ilex* L., 200 m, 25 May 2005, *P. Giordani*, *F. Cristofolini* (GE). − Species new for the flora of Trentino-Alto Adige.

Opegrapha vermicellifera is a crustose lichen with *Trentepohlia* as photobiont, characterized by a pale grey to whitish thallus. Thalli without apothecia, such as the one found in Toblino, have numerous and prominent pycnidia. In Italy, the species usually colonises large trees in humid areas, especially along large rivers and lakes, both in the Padanian and subalpine regions (Nimis and Martellos 2023) and in the Mediterranean (Nascimbene et al. 2021).

P. Giordani

***Placynthium nigrum* (Huds.) Gray (Placynthiaceae)**

+ **VDA**: Val Veny, Courmayeur (Aosta) (UTM WGS84: 32T 341129.5075178), on north-east facing walls, 1353 m, 8 November 2021, *S. Ongaro*, *D. Isocrono* (ORO). – Species confirmed for the flora of Valle d'Aosta.

Placynthium nigrum is a saxicolous species distinguished by its dark thallus with a conspicuous bluish-black prothallus. Despite being a widespread species in the Alps (Nimis et al. 2018), *P. nigrum* is rarely collected in Valle d'Aosta (Piervittori and Isocrono 1999), where it is uncommon due to the regional climatic and geological characteristics. The only two previous records for this region were from a coniferous forest in Valpelline (Henry 1910), and from broad-leaved forest in Arnad (Henry 1914).

D. Isocrono, S. Ongaro

***Rhizocarpon norvegicum* Räsänen (Rhizocarpaceae)**

+ **LOM**: ridge between Monte Pagano and Monte Pianaccio, Monno (Brescia), on *Pleopsidium flavum* (Trevis.) Körb. on a schist rock outcrop (UTM WGS84: 32T 604483.5123088), 2170 m, 12 August 2022, *G. Gheza* (BOLO); ridge between Monte Tonale Occidentale and Cima Cadì, Ponte di Legno (Brescia), on *P. flavum* on a schist rock outcrop (UTM WGS84: 32T 620459.5126438), 2610 m, 4 June 2022, *G. Gheza* (Herb. Gheza). – Species new for the flora of Lombardia.

Rhizocarpon norvegicum is a yellow-greenish crustose chlorolichen, which often starts its life cycle on thalli of Acarosporaceae on schistaceous rocks (Nimis and Martellos 2023). In Italy, it was reported so far only from Friuli Venezia Giulia and Trentino-Alto Adige (Nimis and Martellos 2023), but it is likely more widespread in the Italian Alps.

G. Gheza, J. Nascimbene

***Scytinium fragrans* (Sm.) Otálora, P.M.Jørg. & Wedin (Collemataceae)**

+ **SIC**: Corleone (Palermo), on *Ulmus minor* subsp. *canescens* Bartolucci & Galasso (UTM WGS84: 33S 350022.4180983), 625 m, 28 June 2022, leg. *P. Marino*, *F.M. Raimondo*, *S. Ravera*, det. *S. Ravera* (PAL). – Species confirmed for the flora of Sicilia.

Scytinium fragrans is a small-foliose to subsquamulose epiphytic cyanolichen occurring in natural or semi-natural habitats, extremely rare or extinct in northern Italy

(Nimis and Martellos 2023), whose last report in Sicilia dates back to the beginning of the 1900s (Jatta 1909–1911).

S. Ravera, P. Marino, F.M. Raimondo

***Solenopsora liparina* (Nyl.) Zahlbr. (Leprocaulaceae)**

+ **LOM**: IlGroppo, Brallo di Pregola (Pavia), on serpentine outcrops close to the road Casone-Pregola (UTM WGS84: 32T 521498.4955086), 947 m, 17 September 2022, *Z. Fačkovcová*, *L. Paoli* (Herb. SAV) – Species new for the flora of Lombardia.

Solenopsora liparina has a crustose-placodioid thallus, forming orbicular (up to 2.5 cm) rosettes, with the central parts sometimes falling off and leaving semicircular arcs of olivaceous grey or grey-green lobes, with rounded white-pruinose margins. It is a Mediterranean species colonizing inclined surfaces of ultrabasic rocks such as serpentines, often preferring fissures, in shaded situations also on vertical faces, in habitats with low eutrophication. So far in Italy it was recorded only from Liguria and Toscana (Guttová and Nimis 2021; Nimis and Martellos 2023). The distribution of *S. liparina* along the Apennine Peninsula seems strongly associated to a combination of geology (i.e. presence of serpentine and other ultramafic outcrops) and climate (preference for localities with temperate climate and warm winters) and recently developed habitat suitability maps highlighted higher probabilities of occurrence along the Tyrrhenian side (Guttová et al. 2019).

L. Paoli, Z. Fačkovcová

***Stereocaulon incrustatum* Flörke (Stereocaulaceae)**

+ **PIE**: Sesia riverbed near Greggio (Vercelli) (UTM WGS84: 32T 452951.5032689), on siliceous sandy-pebbly soil in a dry grassland colonizing the riverbed, 157 m, 23 December 2020, *G. Gheza* (PAV). – Species confirmed for the flora of Piemonte.

Stereocaulon incrustatum typically grows on mineral oligotrophic soils, often near rivers (Nimis and Martellos 2023). It was reported from "the surroundings of Vercelli" with specimens collected in 1858 (Lamb 1977; Watson 2014; Oset 2015; TSB-25735; E.C.I. n. 194). This record confirms its occurrence in the area near Vercelli after more than 150 years since the latest record, and after more than a century since the last record from the same administrative region (Martel 1911). The analysed specimen contained only atranorin, which is reported as the most widespread chemotype by Oset (2015).

G. Gheza

***Verrucaria endocarpoides* Servít (Verrucariaceae)**

+ **MAR**: Badia di S. Pietro, Monte Conero, Sirolo (Ancona) (UTM WGS84: 33T 388234.4822510), in a *Quercus ilex* L. wood on limestone, c. 470 m, 5 June 1979, *H. Mayrhofer* (GZU no. 22022). – Species new for the flora of Marche.

+ **TOS**: along the lane from Carrara to Campocecina, E of the hill La Pizza, surroundings of Carrara (Massa-Carrara) (UTM WGS84: 32T 588905.4884717), E-facing limestone cliff, c. 800 m, 1 June 1978, *H. Mayrhofer* (GZU no. 22023). – Species new for the flora of Toscana.

Verrucaria endocarpoides is one out of many species with a thick, brown, areolate thallus. It is characterized by immersed perithecia with an involucrellum reaching down to exciple-base level, medium-sized ascospores, and stout periphyses. The species is apparently widespread but poorly known. In Italy it was previously reported from Friuli (Breuss 2008a) and from its type locality in Liguria (Breuss 2008b, Servít 1952).

H. Mayrhofer, O. Breuss

***Verrucaria lecideoides* (A.Massal.) Trevis. (Verrucariaceae)**

+ **CAL**: Campotenese, E Monte Pollino (Cosenza) (UTM WGS84 33S 592440.441491), on limestone, c. 1000 m, 30 May 1979, *H. Mayrhofer* (no. 22021 GZU). – Species new for the flora of Calabria.

Verrucaria lecideoides belongs to a small group of species with a distinctly areolate, epilithic, autonomous thallus and with perithecia mostly at the margins of, or between the areoles; its perithecia are encircled by an involucrellum that extends down to exciple-base level and incurves beneath. It does not fit within the (core group of) genus *Verruculopsis* that is morphologically different, lacks an involucrellum and is parasitic on Teloschistacean hosts (Navarro-Rosinés et al. 2007). The species is widespread in Italy on exposed calciferous rocks (Nimis 2016; Nimis and Martellos 2023).

O. Breuss, H. Mayrhofer

Acknowledgements

Sonia Ravera acknowledges the support of NBFC to University of Palermo, funded by the Italian Ministry of University and Research, PNRR, Missione 4 Componente 2, “Dalla ricerca all’impresa”, Investimento 1.4, Project CN00000033.

References

Aleffi M, Tacchi R, Poponessi S (2020) New checklist of the bryophytes of Italy. Cryptogamie, Bryologie 41: 147–195. https://doi.org/10.5252/cryptogamie-bryologie2020v41a13

Anzi M (1860) Catalogus Lichenum Quos in Provincia Sondriensi et Circa Novum-Comum Collegit et in Ordinem Systematicum Digessit Presbyter Martinus Anzi. Tipografia C. Franchi, Como, 126 pp.

Anzi M (1862) Manipulus lichenum rariorum vel novorum, quos in Longobardia et Etruria collegit et enumeravit Presb. Martinus Anzi. Commentari della Società Crittogamologica Italiana 1: 130–166.

Anzi M (1868) Analecta lichenum rariorum vel novorum Italiae superioris. Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 11: 156–181.

Barbey W (1884) Florae Sardoae Compendium. Catalogue raisonné des végétaux observes dans l'Ile de Sardaigne. George Bridel Editeur, Losanna.

Bazzichelli G, Abdelahad N (2009) Alghe d'acqua dolce d'Italia. Flora analitica delle Caroficee. Università degli Studi di Roma La Sapienza – Ministero dell'Ambiente e della Tutela del Territorio e del Mare, Roma, 73 pp.

Breuss O (2008a) Neue Funde pyrenocarper Flechten aus den Julischen Alpen (Slowenien und Italien). Herzogia 21: 85–92.

Breuss O (2008b) Bemerkungen zu einigen Arten der Flechtengattung *Verrucaria*. Sauteria 15: 121–138.

Brusa G (2019) L'epatica *Phaeoceros carolinianus* (Anthocerotophyta) nuova per l'Italia. Segnalazioni e brevi note. Pianura 37: 113–116.

Cardot J (1892) Monographie des Fontinalacées. Mémoires de la Société des Sciences Naturelles et Mathématiques de Cherbourg 28: 1–152.

Corillion R, Guerlesquin M (1963) Contribution à l'étude des végétations de Charophycées d'Italie péninsulaire (étage méditerranéen). Bulletin de la Société scientifique de Bretagne 38: 193–211.

Courtecuisse R, Duhem B (1995) Mushrooms and Toadstools of Britain and Europe. HarperCollinsPublishers, Ramsbury, Wiltshire, UK.

Fleischer M (1893) Contribuzioni alla Briologia della Sardegna. Malpighia 7: 313–344.

Frisch A, Moen VS, Grube M, Bendiksby M (2020) Integrative taxonomy confirms three species of *Coniocarpon* (Arthoniaceae) in Norway. MycoKeys 62: 27–51. https://doi.org/10.3897/mycokeys.62.48480

Gheza G, Nimis PL (2021) Keys to the lichens of Italy – 61) Cladoniaceae (*Cladonia*, *Pilophorus* and *Pycnothelia*). https://italic.units.it/flora/index.php?procedure=ext_key_home&key_id=3975

Gheza G, Vallese C, Nascimbene J (2022) Enhancing lichen inventories in Italy: new records of *Cladonia*, *Nephroma* and *Peltigera* from the mountains of Lombardia. Borziana 3: 5–17. https://doi.org/10.7320/Borz.003.005

Guttová A, Nimis PL (2021) The genus *Solenopsora* (Lichenized Ascomycetes, Leprocaulaceae) in Italy. Flora Mediterranea 31: 55–65. https://doi.org/10.7320/FlMedit31SI.055

Guttová A, Fačkovcová Z, Martellos S, Paoli L, Munzi S, Pittao E, Ongaro S (2019) Ecological specialization of lichen congeners with a strong link to Mediterranean-type climate: a case study of the genus *Solenopsora* in the Apennine Peninsula. Lichenologist 51: 75–88. https://doi.org/10.1017/S0024282918000543

Halda J (2003) A taxonomic study calcicolous endolithic species of the genus *Verrucaria* (Ascomycotina, Verrucariales) with the lid-like and radiately opening involucrellum. Acta Musei Richnoviensis Sect. Natur 10: 1–148.

Henry JM (1910) Contribution à la lichenologique valdôtaine. Bulletin de la Societé de la Flore Valdôtaine 6: 8–17.

Henry JM (1914) Campagne lichénique 1912. Bulletin de la Societé de la Flore Valdôtaine 9: 29–32.

Hodgetts N, Lockhart N (2020) Checklist and country status of European bryophytes – update 2020. Irish Wildlife Manuals, No. 123. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Ireland, 214 pp.

Hodgetts N, Cálix M, Englefield E, Fettes N, García Criado M, Patin L, Nieto A, Bergamini A, Bisang I, Baisheva E, Campisi P, Cogoni A, Hallingbäck T, Konstantinova N, Lockhart N, Sabovljevic M, Schnyder N, Schröck C, Sérgio C, Sim Sim M, Vrba J, Ferreira CC, Afonina O, Blockeel T, Blom H, Caspari S, Gabriel R, Garcia C, Garilleti R, González Mancebo J, Goldberg I, Hedenäs L, Holyoak D, Hugonnot V, Huttunen S, Ignatov M, Ignatova E, Infante M, Juutinen R, Kiebacher T, Köckinger H, Kučera J, Lönnell N, Lüth M, Martins A, Maslovsky O, Papp B, Porley R, Rothero G, Söderström L, Ştefănuţ S, Syrjänen K, Untereiner A, Váňa J, Vanderpoorten A, Vellak K, Aleffi M, Bates J, Bell N, Brugués M, Cronberg N, Denyer J, Duckett J, During HJ, Enroth J, Fedosov V, Flatberg K-I, Ganeva A, Gorski P, Gunnarsson U, Hassel K, Hespanhol H, Hill M, Hodd R, Hylander K, Ingerpuu N, Laaka-Lindberg S, Lara F, Mazimpaka V, Mežaka A, Müller F, Orgaz JD, Patiño J, Pilkington S, Puche F, Ros RM, Rumsey F, Segarra-Moragues JG, Seneca A, Stebel A, Virtanen R, Weibull H, Wilbraham J, Żarnowiec J (2019) A miniature world in decline: European Red List of Mosses, Liverworts and Hornworts. IUCN, Brussels. https://doi.org/10.2305/IUCN.CH.2019.ERL.2.en

Jatta A (1909–1911) Flora italica Cryptogama. Pars III. Lichenes. Tip. Cappelli, Rocca di S. Casciano, 958 pp.

Lamb IM (1977) A conspectus of the lichen genus *Stereocaulon* (Schreb.) Hoffm. Journal of the Hattori Botanical Laboratory 43: 191–355.

Martel E (1911) Contribuzione alla lichenologia del Piemonte. Memorie della Reale Accademia delle Scienze di Torino (2) 61: 135–176.

McMullin RT, Selva SB, Maloles JR, Newmaster SC (2012) *Calicium denigratum* (Vain.) Tibell, a new lichen record for North America. North America Fungi 7: 1–5. https://doi.org/10.2509/naf2012.007.011

Nascimbene J, Gheza G, Hafellner J, Mayrhofer H, Muggia L, Obermayer W, Thor G, Nimis PL (2021) Refining the picture: new records to the lichen biota of Italy. MycoKeys 82: 97–137. https://doi.org/10.3897/mycokeys.82.69027

Nascimbene J, Nimis PL, Ravera S (2013) Evaluating the conservation status of epiphytic lichens of Italy: a red list. Plant Biosystems 147: 898–904. https://doi.org/10.1080/11263504.2012.748101

Navarro-Rosinés P, Roux C, Gueidan C (2007) La genroj *Verrucula* kaj *Verruculopsis* (Verrucariaceae, Verrucariales). Bulletin de la Société Linnéenne de Provence 58: 133−180.

Nimis PL (2016) The lichens of Italy – A second annotated catalogue. EUT Edizioni Università di Trieste, Trieste, 740 pp.

Nimis PL, Martellos S (2023) ITALIC – The Information System on Italian Lichens. Version 7.0. University of Trieste, Dept. of Biology. www.italic.units.it [accessed 9.2.2023]

Nimis PL, Hafellner J, Roux C, Clerc P, Mayrhofer H, Martellos S, Bilovitz PO (2018) The lichens of the Alps – an annotated checklist. MycoKeys 31: 1–634. https://doi.org/10.3897/mycokeys.31.23568

Onofri S, Bernicchia A, Filipello Marchisio V, Padovan F, Perini C, Ripa C, Savino E, Venturella G, Vizzini A, Zotti M, Zucconi L (2013) Checklist of the macrobasidiomycetes of Italy. http://dryades.units.it/macrobasidiomiceti/index.php [accessed 2.3.2022]

Oset M (2015) The lichen genus *Stereocaulon* (Schreb.) Hoffm. in Poland. A taxonomic and ecological study. Monographiae Botanicae 104: 1–81. https://doi.org/10.5586/mb.2014.001

Piervittori R, Isocrono D (1999) I licheni della Valle d'Aosta. I. Museo Regionale di Scienze Naturali di Saint-Pierre, Monografie I. – Valle d'Aosta, 264 pp.

Printz P (1992) *Inocybe* (Fr.) Fr. In: Hansen L, Knudsen H (Eds) Nordic Macromycetes (Vol. 2). Nordsvamp, Copenhagen, Denmark.

Printzen C (1995) Die Flechtengattung Biatora in Europa. Bibliotheca Lichenologica 60: 1–275.

Rivellini G, Valcuvia Passadore M (1996) I licheni appartenenti ai generi *Cladonia* e *Stereocaulon* in provincia di Sondrio (Lombardia, Italia settentrionale). Il Naturalista Valtellinese. Atti del Museo Civico di Storia Naturale di Morbegno 7: 3–32.

Romanov R, Napolitano T, van de Weyer K, Troia A (2019) New records and observations to the Characean flora of Sicily (Italy). Webbia 74: 111–119. https://doi.org/10.1080/00837792.2019.1609258

Servít M (1952) Neue und weniger bekannte Arten der Familie Verrucariaceae und Dermatocarpaceae. Preslia 24: 347–390.

Stizenberger E (1882) Lichenes Helvetici eorumque stationes et distributio. Jahresbericht der St. Gallischen Naturwissenschaftlichen Gesellschaft 22: 225–522.

Sundin R, Tehler A (1998) Phylogenetic studies of the genus *Arthonia*. The Lichenologist 30: 381–413. https://doi.org/10.1006/lich.1998.0155

Tibell L (1999) Caliciales Nordic Lichen Flora 1. Bohuslän, Uddevalla.

Vizzini A, Consiglio G, Marchetti M, Alvarado P (2020) Insights into the *Tricholomatineae* (Agaricales, Agaricomycetes): a new arrangement of *Biannulariaceae* and *Callistosporium*, *Callistosporiaceae* fam. nov., *Xerophorus* stat. nov., and *Pleurocollybia* incorporated into *Callistosporium*. Fungal Diversity 101: 211–259. https://doi.org/10.1007/s13225-020-00441-x

Watson P (2014) Birmingham Botany Collections – Lichens. Birmingham Museums, Birmingham, 186 pp.

Italian Botanist 15: 49–63 (2023)
doi: 10.3897/italianbotanist.15.102133
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

Forest nurseries and the National Recovery and Resilience Plan: the case of Sicily and Apulia (Italy)

Raimondo Pardi[1], Giuseppe Venturella[2], Gianniantonio Domina[2], Emilio Di Gristina[2], Fortunato Cirlincione[2], Maria Letizia Gargano[1]

1 *Department of Soil, Plant and Food Sciences, University of Bari Aldo Moro, Via Amendola 165/A, 70126 Bari, Italy* **2** *Department of Agricultural, Food and Forest Sciences, University of Palermo, Viale delle Scienze Bldg. 5, 90128 Palermo, Italy*

Corresponding authors: Emilio Di Gristina (emilio.digristina@unipa.it);
Fortunato Cirlincione (fortunato.cirlincione@unipa.it)

Academic editor: Lorenzo Peruzzi | Received 17 February 2023 | Accepted 4 April 2023 | Published 24 April 2023

Citation: Pardi R, Venturella G, Domina G, Di Gristina E, Cirlincione F, Gargano ML (2023) Forest nurseries and the National Recovery and Resilience Plan: the case of Sicily and Apulia (Italy). Italian Botanist 15: 49–63. https://doi.org/10.3897/italianbotanist.15.102133

Abstract

In Italy, the National Recovery and Resilience Plan (NRRP) foresees the planting of *ca*. 6.6 million trees to establish urban and peri-urban forests in 14 metropolitan cities. This ambitious project requires a significant number of native trees and shrubs, currently unavailable in Italian public and private nurseries. This survey analyzes the state of forest nurseries in two administrative regions of southern Italy, i.e. the "Filici" forest nursery (province of Agrigento, Sicily) and the Gargano Mountain Reclamation Consortium (province of Foggia, Apulia), to evaluate the adequacy of Sicilian and Apulian forest nurseries as potential sources of plant material to meet the requirements of the NRRP. The census carried out at the "Filici" nursery revealed the presence of more than 22,000 seedlings in cultivation, comprising 55 species, 26 genera, and 26 families. The autochthonous species are 43 (78.2%), while the exotic ones are 12 (21.8%). The Gargano Mountain Reclamation Consortium forest nursery has 190,876 seedlings in cultivation. A total of 80 species are present, belonging to 59 genera and 32 families. Of these, 68 (85%) are native species, 12 (15%) are exotic. An analysis of the plant material being cultivated in these forest nurseries shows the presence of a share of autochthonous species of interest for urban reforestation initiatives, however these are still insufficient in number.

Keywords

Mediterranean area, native species, shrubs, southern Italy, trees

Copyright *Raimondo Pardi et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

The Italian National Recovery and Resilience Plan (NRRP), Mission 2, Component 4, Investment 3.1 "Protection and Enhancement of Urban and Suburban Green Areas" (approved by the EU Council of Ministers on 12 January 2021) foresees a series of widescale actions. The main objectives of the Plan are: a) improve the quality of life and well-being of citizens through the protection of existing green areas and the construction of new ones; b) preserve and enhance biodiversity and ecological processes related to the full functionality of ecosystems; c) preserve and enhance biodiversity, in line with the European Biodiversity Strategy; d) contribute to the reduction of air pollution in metropolitan areas; e) reduce the number of infringement procedures, related to air quality; f) curb land consumption and restore useful soils; g) restore man-made landscapes and improve protected areas contiguous to metropolitan areas. Besides, Article 4 of Decree-Law no. 111 of October 14, 2019, transposed with amendments into Law no. 141 of December 12, 2019, defines modalities for the design of tree planting in metropolitan cities. Specifically, the Urban and Suburban Forestation Plan establishes a series of actions, focused in the 14 Italian metropolitan cities, to fight air pollution and protect biodiversity. The goal is to establish and expand urban and peri-urban forests by planting about 6.6 million trees. All the initiatives that envisage the planting of trees and new reforestation, especially in urban and peri-urban areas, represent an important driving force for the relaunch of forest nurseries.

Starting in the 1930s, the main task of Italian foresters was to reforest vast degraded areas to counteract the widespread hydrogeological instability of the territory. This situation has favored the proliferation of many forest nurseries, which provided their product free of charge, as required by almost all subsequent Forest Laws until the 1960s (Mariotti et al. 2014; Martini et al. 2022). In the 1970s, the need to reforest Italy's mountainous territory became less pressing, and many forest nurseries ceased their activities (Mariotti et al. 2014). Nowadays, there is again the need and urgency to propose reforestation and tree-planting activities. Besides, there is a marked increase in the demand for ecosystem services to combat erosion, flooding, pollution, and heat islands and for green and forested areas, especially near urban populations. The purpose of these initiatives is to increase the quality of life and to focus on issues that correlate "green" areas and health, as widely witnessed in the period of pandemic restrictions (Martini et al. 2022).

The awareness that forest nursery activity is essential for the success of any intervention aimed at environmental requalification has stimulated interest in better understanding the state of this activity in southern Italy, especially in Apulia and Sicily. Currently, in Apulia, there are 20 forest nurseries distributed in the provinces of Foggia (3), Lecce (9), Bari (5), Taranto (2), and Brindisi (1). Seven regional forest nurseries are managed by the Regional Agency for Irrigation and Forestry Activities (ARIF), while the remaining 13 are private. In 1989, the Sicilian regional government , established the "Regional Nursery Center". Currently, the Center includes 16 forest nurseries distributed in the provinces of Agrigento (4), Palermo (3), Catania (2), Enna (2), and one in each of the remaining five provinces. Each one is specialized in a specific

production. In our study, for Apulia, the forestry nursery of the Gargano Mountain Reclamation Consortium of San Marco in Lamis (province of Foggia) was examined, as it is the most representative nursery in the Regional Register, both for the abundance of forest species produced and marketed and for its internal organization. As regards the Sicilian territory, we examined the "Filici" forest nursery of Cammarata (province of Agrigento).With the establishment of the Regional Nursery Center, it has become the largest forest nursery in terms of plant production in order to meet the needs of the Sicilian Forestry Administration (Candore and Girgenti 2019).

The purpose of our survey was to analyze the plants growing in the "Filici" nursery and in that of the Gargano Mountain Reclamation Consortium and to evaluate their adequacy as a potential source of plant material to meet the needs of the NRRP.

Case study 1: The "Filici" forest nursery

The "Filici" forest nursery falls in the municipality of Cammarata (CW-Sicily) in the province of Agrigento (Fig. 1). The nursery was established in the early 1950s at the same time as the reforestation work began on the slopes of Mount Cammarata. The nursery is under the direction of the "Regional Department of Rural and Territorial Development" and is managed by the Provincial Office Service n°8 of Agrigento. Currently, the staff is represented by one forestry technician who acts as construction manager, one team leader, and three seasonal forestry workers (on a fixed-term basis) with 51, 101, and 151 working days/year depending on their category. In the past, the seasonal workers engaged reached 10 units.

The farm area covers a total of 2 ha and has an average slope of 20%. Because of the slope, the entire productive area of the nursery (1.5 ha, about 75% of the entire area) is organized in plots arranged in steps with retaining walls lined with local limestone. Irrigation is done manually or through an automated sprinkler system. The nursery's main objective is to produce plants that have genetic, morphological, and health characteristics that can offer excellent guarantees of rooting, development, and adaptability, thus ensuring success for plantings from scratch or intended for eventual reforestation on state lands. The "Filici" nursery uses seeds collected in forests located in the neighboring areas that are included in the list of "Sicilian Seed Woods" established by the Sicilian Region, which lists the forests from where seeds can be taken for forest propagation. There are two cultivation practices: with a root ball, the most widely used as the use of containers guarantees planting, and bare-root cultivation, which, however, is little used. Average annual nursery production in the past reached 400,000 seedlings; currently, due to the significant decrease in funds assigned to the nursery, it does not exceed 50,000 seedlings. The average annual mortality is estimated at 10%.

Case study 2: The Gargano Mountain Reclamation Consortium Forest

The forest nursery belonging to the Gargano Mountain Reclamation Consortium is located in San Marco in Lamis, (Borgo Celano, province of Foggia) (Fig. 1). It is a public law body under Article 59 of Royal Decree No. 215 of February 13, 1933, Article 826

Figure 1. Geographical distribution of the forest nurseries "Filici" and "Gargano Mountain Reclamation Consortium".

of the Civil Code. It was established and regulated by Presidential Decree no. 6907 of March 13, 1957. The nursery was established in 2011 and its purpose was extended to include the conservation of plant biodiversity in the Gargano area. The aim is to produce native plants for reforestation, naturalistic engineering, recovery of degraded sites, and the protection of endangered fruit species. The nursery also houses a small botanical garden of rare and endangered species of the Gargano flora, and environmental education activities can be carried out. The nursery occupies a total area of 1.1 ha, 0.5 of which is for production purposes, with a 15% slope. Currently, irrigation is done manually through direct water supply from the aqueduct, but work is ongoing to build rainwater harvesting tanks. The nursery includes an office for tadministration, a laboratory for seed processing, a teaching room, and a seed storage room. In addition, the facility comprises an archive, a laboratory for direct seeding, and a greenhouse used for growing seedlings that do not tolerate low temperatures. There is also storage for tools and two sheds for farm machinery. The latter consist of 2 backpack brush cutters, and 2 electric wheelbarrows. The workforce comprises two full-time workers, and two part-time employees. Consistent with the Regional objectives, the nursery aims to produce suitable material, especially from phytosanitary, genetic, and morphological perspectives, to try to avoid the problems related to the pathogen *Xylella fastidiosa* (Raju et al. 1986). In most cases, the plants, are destined for reforestation projects in

the Apulian territory, so the choice of forest material, and its origin, is the main factor that ensures the success of the species' establishment. Cultivation practices are root ball and bare-root. The latter, however, is little used. The average annual production is 150,000 seedlings and the average mortality is around 20%.

Material and methods

The census was carried out between spring 2021 and autumn 2022, on the basis of *in situ* surveys and observations. For each taxon, the number of cultivated seedlings was counted (Table 1). Taxa are grouped by families and ordered alphabetically. Their biological form and chorology according to Raunkiaer (1934) and Pignatti (2017, 2018, 2019) are reported. The table also distinguishes between native and exotic taxa. Nomenclature and definition of native/exotic status follows Bartolucci et al. (2018a, b, c, 2019a, b, 2020a, b, 2021a, b, 2022) and Galasso et al. (2018a, b, c, 2019a, b, 2020a, b, 2021a, b, 2022).

Results

The census carried out at the "Filici" nursery revealed the presence of 22,360 seedlings in cultivation (Table 1). The taxa with at least 1,000 specimens are *Quercus ilex* L. (5,000) and *Q. pubescens* Willd. (5,000), followed by *Cupressus sempervirens* L. (2,000), *Olea europea* L. var. *sylvestris* (Mill.) Lehr (2,000), *Abies cephalonica* Loud. (1,000), and *Pyrus spinosa* Forssk. (1,000). In the "Filici" nursery there are 55 species, belonging to 26 genera and 26 families. The most represented families are Rosaceae (11 species and 7 genera), Pinaceae (5 species and 3 genera), Fagaceae (5 species and 2 genera), Fabaceae (4 species and 4 genera), and Oleaceae (4 species and 4 genera) (Table 1). The most frequent genera are *Quercus* L. (4 species) and *Prunus* L. (3 species). The autochthonous species are 43 (78.2%), while 12 are the exotics (21.8%) (Fig. 4). Among cultivated species, the presence of *Abies nebrodensis* (Lojac.) Mattei, an endangered species and Sicilian forest endemism (Mirabile et al. 2023), is noteworthy. However, the presence in cultivation of the exotic *A. cephalonica*, present with a large number of seedlings, should be excluded as it is potentially capable of hybridizing with the endemic Sicilian fir (Raimondo and Schicchi 2005).

The Gargano Mountain Reclamation Consortium nursery has 190,876 seedlings in cultivation (Table 1). The most abundant species are *Quercus ilex* (28,654), *Q. cerris* L. (25,968), *Q. pubescens* (17,780), and *Fraxinus ornus* L. (18,292), followed by *Spartium junceum* L. (13,031), *Salix alba* L. (6,611), *Acer campestre* L. (5,544), *Pinus halepensis* Mill. (4,690), *Castanea sativa* Mill. (4,501), and *Fagus sylvatica* L. (3,779) (Table 1). A total of 80 species are present, belonging to 59 genera and 32 families. The most representative families are: Rosaceae (14 species and 7 genera), Fabaceae (5 species and 4 genera), Fagaceae (5 species and 3 genera), Lamiaceae (5 species and 4

Table 1. Taxa growing at the forest nurseries "Filici" (Nursery 1) and "Gargano Mountain Reclamation Consortium" (Nursery 2).

Taxon	No. Phytocells Nursery 1	No. Phytocells Nursery 2	Family	Biological form	Chorology	Native/ exotic
Abies cephalonica Loudon	1000	–	Pinaceae	P scap	E-Medit.	Exotic
Abies nebrodensis (Lojac.) Mattei	10	–	Pinaceae	P scap	Endemic Sicily	Native
Acer campestre L.	100	5544	Sapindaceae	P scap	Europ.-Caucas.	Native
Acer negundo L.	10	–	Sapindaceae	P scap	N-America	Exotic
Acer opalus L.	–	1419	Sapindaceae	P caesp	W-Europ.	Native
Acer pseudoplatanus L.	–	2023	Sapindaceae	P scap	Europ.-Caucas.	Native
Anagyris foetida L.	–	50	Fabaceae	P caesp	S-Medit.	Native
Arbutus unedo L.	500	200	Ericaceae	P caesp	Stenomedit.	Native
Buxus sempervirens L.	20	–	Buxaceae	P caesp	Submedit.-subatl.	Native
Carpinus betulus L.	–	971	Betulaceae	P caesp	Europ.-Caucas.	Native
Carpinus orientalis Mill.	–	245	Betulaceae	P caesp	Pontic	Native
Castanea sativa Mill.	20	4501	Fagaceae	P scap	SE-Europ. (?)	Native
Cedrus atlantica (Endl.) Carrière	50	–	Pinaceae	P scap	N-Africa	Exotic
Celtis australis L.	300	2617	Cannabaceae	P scap	Eurimedit.	Native
Ceratonia siliqua L.	20	1872	Fabaceae	P scap	S-Stenomedit.	Exotic
Cercis siliquastrum L.	100	–	Fabaceae	P scap	S-Europ.	Native
Cistus creticus L.	–	938	Cistaceae	NP	Centromedit.	Native
Citrus ×aurantium L.	50	120	Rutaceae	P scap	Asia trop.	Exotic
Colutea arborescens L.	–	50	Fabaceae	P caesp	Euri-Medit.	Native
Cornus sanguinea L.	10	1266	Cornaceae	P scap	Eurasiat.	Native
Colutea arborescens L.	–	50	Fabaceae	P caesp	Euri-Medit.	Native
Cornus mas L.	–	805	Cornaceae	P caesp	SE-Europ.-Pontic	Native
Corylus avellana L.	10	533	Betulaceae	P caesp	Europ.-Caucas.	Native
Crataegus monogyna Jacq.	500	2844	Rosaceae	P caesp	Paleotemp.	Native
Cupressus sempervirens L.	2000	50	Cupressaceae	P scap	E.-Medit.	Exotic
Cydonia oblonga Mill.	15	90	Rosaceae	P scap	SW-Asia	Native
Diospyros kaki Thunb.	–	110	Ebenaceae	P scap	E-Asiat.	Exotic
Emerus major Mill. subsp. *emeroides* (Boiss. & Spruner) Soldano & F.Conti	–	1817	Fabaceae	NP	E-Medit.-Pontic	Native
Erica multiflora L.	–	67	Ericaceae	NP	Steno-Medit.	Native
Euonymus europaeus L.	–	2634	Celastraceae	P caesp	Eurasiat.	Native
Fagus sylvatica L.	–	3779	Fagaceae	P scap	Europ.	Native
Ficus carica L.	–	28	Moraceae	P scap	Medit.-Turan.	Native
Fraxinus ornus L.	500	18292	Oleaceae	P scap	S-Europ.-Sudsib.	Native
Ilex aquifolium L.	20	420	Aquifoliaceae	P caesp	Eurimedit.	Native
Juglans regia L.	100	1390	Juglandaceae	P scap	SW-Asia	Native
Juniperus macrocarpa Sm.	–	802	Cupressaceae	P caesp	Euri-Medit.	Native
Juniperus turbinata Guss.	–	408	Cupressaceae	P caesp	W-Medit.	Native
Laurus nobilis L.	200	2050	Lauraceae	P caesp	Stenomedit.	Native
Lavandula angustifolia Mill.	20	2001	Lamiaceae	NP	Stenomedit.	Native
Ligustrum lucidum W.T.Aiton	100	–	Oleaceae	P caesp	Asia or.	Exotic
Ligustrum vulgare L.	–	1000	Oleaceae	NP	Eurasiat.	Native
Matthiola incana W.T.Aiton	20	–	Brassicaceae	Ch suffr	Stenomedit.	Native
Mespilus germanica L.	–	254	Rosaceae	P caesp	Europ.	Native
Morus alba L.	–	1	Moraceae	P caesp	E-Asiat.	Exotic
Myrtus communis L.	200	1701	Myrtaceae	P caesp	Stenomedit.	Native
Olea europea var. *sylvestris* (Mill.) Lehr	2000	262	Oleaceae	P caesp	Stenomedit.	Native
Ostrya carpinifolia Scop.	–	3113	Betulaceae	P scap	S-Europ.	Native
Paliurus spina-christi Mill.	–	40	Rhamnaceae	P caesp	SE-Europ.	Native
Phillyrea angustifolia L.	–	472	Oleaceae	P caesp	Stenomedit.	Native
Phillyrea latifolia L.	10	2000	Oleaceae	P caesp	Stenomedit.	Native

Taxon	No. Phytocells Nursery 1	No. Phytocells Nursery 2	Family	Biological form	Chorology	Native/ exotic
Pinus halepensis Mill.	100	4690	Pinaceae	P scap	Stenomedit.	Native
Pinus pinea L.	500	–	Pinaceae	P scap	Eurimedit.	Exotic
Pistacia lentiscus L.	10	1563	Anacardiaceae	P caesp	S-Stenomedit	Native
Pistacia terebinthus L.	500	2008	Anacardiaceae	P caesp	Eurimedit.	Native
Pistacia vera L.	–	1322	Anacardiaceae	P scap	E-Medit.	Exotic
Populus alba L.	–	17	Salicaceae	P scap	Paleotemp.	Native
Populus nigra L.	50	–	Salicaceae	P scap	Paleotemp.	Native
Populus tremula L.	–	26	Salicaceae	P scap	Eurosib.	Native
Prunus armeniaca L.	–	24	Rosaceae	P scap	Asiat.	Exotic
Prunus avium L.	10	–	Rosaceae	P scap	Pontic (? Europ.-Caucas.)	Native
Prunus cerasus L.	–	18	Rosaceae	P scap	Pontica	Exotic
Prunus domestica L.	–	218	Rosaceae	P caesp	SW-Asiat.	Exotic
Prunus dulcis (Mill.) D.A.Webb.	200	–	Rosaceae	P caesp	S-Europ.-Sudsib.	Exotic
Prunus mahaleb L.	–	2271	Rosaceae	P caesp	S-Europ.	Native
Prunus spinosa L.	500	1398	Rosaceae	P caesp	Europ.-Caucas.	Native
Prunus webbii (Spach) Vierh.	–	630	Rosaceae	P caesp	E-Medit.	Native
Punica granatum L.	20	1941	Lythraceae	P scap	SW-Asia	Exotic
Pyracantha coccinea M. Roem.	30	–	Rosaceae	P caesp	Stenomedit.	Native
Pyrus spinosa Forssk.	1000	3116	Rosaceae	P caesp	Stenomedit.	Native
Quercus coccifera L.	200	–	Fagaceae	P caesp	W-Stenomedit.	Native
Quercus cerris L.	–	25968	Fagaceae	P scap	Eurimedit.	Native
Quercus ilex L.	5000	28654	Fagaceae	P scap	Stenomedit.	Native
Quercus pubescens Willd.	5000	17780	Fagaceae	P scap	Europ.-Subpontic	Native
Quercus suber L.	100	–	Fagaceae	P scap	W-Eurimedit.	Native
Rhamnus alaternus L.	200	320	Rhamnaceae	P caesp	Stenomedit.	Native
Rhamnus saxatilis Jacq.	–	52	Rhamnaceae	P caesp	SE-Europ.	Native
Ribes uva-crispa L.	–	76	Grossulariaceae	NP	Eurasiat.	Native
Robinia pseudoacacia L.	100	–	Fabaceae	P scap	N-America	Exotic
Rosa canina L.	50	402	Rosaceae	NP	Paleotemp.	Native
Rosa sempervirens L.	50	–	Rosaceae	NP	W.-Medit.-Mont.	Native
Ruscus aculeatus L.	–	85	Asparagaceae	Ch frut (G rhiz)	Eurimedit.	Native
Salix alba L.	–	6611	Salicaceae	P scap	Paleotemp.	Native
Salix babylonica L.	15	–	Salicaceae	P scap	Subtrop.-Asiat.	Exotic
Salix ×fragilis L.	–	117	Salicaceae	P caesp	Eurisiber.	Exotic
Salvia officinalis L.	–	200	Lamiaceae	Ch suffr	Stenomedit.	Native
Salvia rosmarinus Spenn.	20	1540	Lamiaceae	NP	Steno-Medit.	Native
Sambucus nigra L.	–	1080	Viburnaceae	P caesp	Europ-Caucas.	Native
Smilax aspera L.	50	130	Smilacaceae	NP (G rhiz)	Paleosubtrop.	Native
Sorbus aria (L.) Crantz	500	17	Rosaceae	P caesp	Paleotemp.	Native
Sorbus domestica L.	200	114	Rosaceae	P scap	Eurimedit.	Native
Sorbus torminalis (L.) Crantz	–	442	Rosaceae	P caesp	Paleotemp.	Native
Spartium junceum L.	30	13031	Fabaceae	P caesp	Eurimedit.	Native
Stachys major (L.) Bartolucci & Peruzzi	–	30	Lamiaceae	Ch frut	Stenomedit.	Native
Tamarix africana Poir.	–	2000	Tamaricaceae	P scap	W-Medit.	Native
Tamarix gallica L.	10	–	Tamaricaceae	P caesp	W-Stenomedit.	Native
Teucrium fruticans L.	–	1026	Lamiaceae	NP	Stenomedit.	Native
Thymus vulgaris L.	20	–	Lamiaceae	Ch frut	Stenomedit.	Native
Tilia cordata Mill.	10	–	Malvaceae	P scap	Europ.-Caucas.	Native
Tilia platyphyllos Scop.	–	161	Malvaceae	P caesp	Europ.-Caucas.	Native
Ulmus minor Mill.	–	26	Ulmaceae	P caesp	Europ.-Caucas.	Native
Viburnum tinus L.	–	2905	Viburnaceae	P caesp	Stenomedit.	Native
Ziziphus jujuba Mill.	–	88	Rhamnaceae	P caesp	E-Asiat.	Exotic

Figure 2. View of the nursery "Filici" (Cammarata, province of Agrigento).

Figure 3. View of the nursery "Gargano Mountain Reclamation Consortium" (Borgo Celano, province of Foggia).

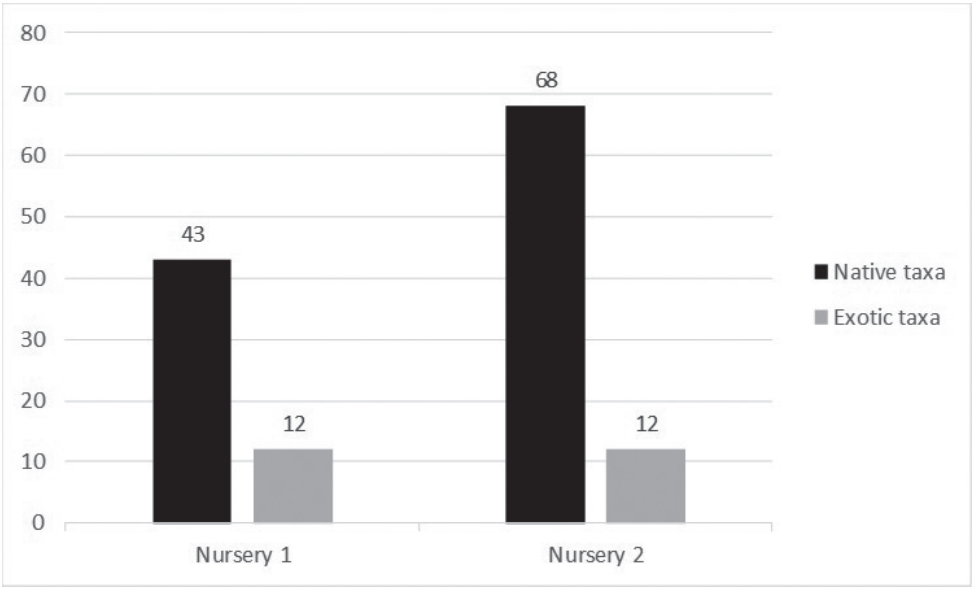

Figure 4. Number of native and exotic taxa cultivated at "Filici" (Nursery 1) and "Gargano Mountain Reclamation Consortium" (Nursery 2).

genera), and Oleaceae (5 species and 4 genera). *Prunus* (6 species), *Acer* L. (3), *Quercus* (3), and *Sorbus* L. (3) are the most frequent genera (Table 1). The autochthonous taxa are 68 (85%), while the exotic ones are 12 (15%) (Fig. 4).

In both nurseries, native species clearly dominate over exotic ones. Most of the latter are not invasive and, indeed, have a long list of traditional uses of ethnobotanical interest (*Citrus* ×*aurantium*, *Diospyros kaki*, *Morus alba*, *Punica granatum*, *Ziziphus jujuba*, etc.). However, alongside these taxa, there are others, such as *Acer negundo*, *Ligustrum lucidum*, and *Robinia pseudoacacia* capable of becoming invasive if planted in natural areas. It would be advisable to stop the production of these three species.

The age of the plants produced in the two forest nurseries range from 1 to 5 years old and, overall, the phytosanitary status of the plants is good.

Discussion

A few decades after the first plantings, forest nursery production began to have difficulties in maintaining native forest biodiversity. The most important reason for these failures is the use of allochthonous genotypes of unproven adaptability (Mariotti et al. 2014). In fact, for the proper implementation of reforestation, forest reconstitution of degraded forest stands, and wood arboriculture plantings, the quality of the forest propagation material to be used is crucial (Konnert et al. 2015).

These activities require the use of plant material adapted to the microclimatic and soil conditions of individual localities. This also helps to preserve biodiversity, enhance

taxonomic entities and ecotypes of high genetic value, safeguard endangered species, and avoid genetic pollution. In this regard, forest nurseries play an important role as they should meet this requirement by supplying seedlings produced from seed of native origin.

Despite the awareness of the importance of forest nurseries, in recent years in Italy, there has been a progressive disinterest and abandonment of this activity as part of an ill-advised forestry policy undertaken by regional governments. Urban reforestation, within the actions of the Italian Recovery Fund, is the bet for the future of Italian cities and for the quality of life of the next generations. It will be necessary to overcome the difficulties in finding areas for reforestation in urban areas (lack of political sensitivity, constraints, etc.).

The number of native plants useful for reforestation kept in nursery stocks is still quite limited, partly due to the drastic reduction of regional nurseries and qualified personnel. It is, therefore, necessary to know the current stock of existing nurseries and implement the number of native species for more effective actions in the territory.

The analysis of the two forest nurseries in Sicily and Apulia showed that the available species meet the reforestation plan requirements. In fact, the propagated plant material comes entirely from local autochthonous populations, thus guaranteeing the availability of genotypes that are adapted to the environment in which they will be used and able to cope with the predicted climate change (Selvi et al. 2023). However, although qualitatively adequate, the plant material produced is still quantitatively insufficient to respond to the ever-increasing demands that have arisen following the current "green-oriented" policy.

Acknowledgments

This study was carried out under Action IV.6 "Research Contracts on GREEN Themes – Ministerial Decree 1062/2021 and Ministerial Decree August 10, 2021, No. 1061, PON "Research and Innovation" Resources 2014-2020.

References

Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, Astuti G, Bacchetta G, Ballelli S, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Cecchi L, Di Pietro R, Domina G, Fascetti S, Fenu G, Festi F, Foggi B, Gallo L, Gottschlich G, Gubellini L, Iamonico D, Iberite M, Jimenez-Mejias P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Conti F (2018a) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 179–303. https://doi.org/10.1080/11263504.2017.1419996

Bartolucci F, Domina G, Ardenghi NMG, Banfi E, Bernardo L, Bonari G, Buccomino G, Calvia G, Carruggio F, Cavallaro V, Chianese G, Conti F, Facioni L, Del Vico E, Di Gristina E, Falcinelli F, Forte L, Gargano D, Mantino F, Martino M, Mei G, Mereu G, Olivieri N, Passalacqua NG, Pazienza G, Peruzzi L, Roma-Marzio F, Scafidi F, Scoppola A, Stinca A, Nepi C (2018b) Notulae to the Italian native vascular flora: 5. Italian Botanist 5: 71–81. https://doi.org/10.3897/italianbotanist.5.25892

Bartolucci F, Domina G, Ardenghi NMG, Bacchetta G, Bernardo L, Buccomino G, Buono S, Caldararo F, Calvia G, Carruggio F, Cavagna A, D'Amico FS, Di Carlo F, Festi F, Forte L, Galasso G, Gargano D, Gottschlich G, Lazzaro L, Magrini S, Maiorca G, Medagli P, Mei G, Mennini F, Mereu G, Miserocchi D, Olivieri N, Passalacqua NG, Pazienza G, Peruzzi L, Prosser F, Rempicci M, Roma-Marzio F, Ruggero A, Sani A, Saulle D, Steffanini C, Stinca A, Terzi M, Tondi G, Trenchi M, Viciani D, Wagensommer RP, Nepi C (2018c) Notulae to the Italian native vascular flora: 6. Italian Botanist 6: 45–64. https://doi.org/10.3897/italianbotanist.6.30575

Bartolucci F, Domina G, Alessandrini A, Angiolini C, Ardenghi NMG, Bacchetta G, Banfi E, Bolpagni R, Bonari G, Bräuchler C, Calvia G, Cancellieri L, Cannucci S, Carruggio F, Conti F, Cavallaro V, Fanfarillo E, Ferretti G, Festi F, Fiaschi T, Foggi B, Forte L, Fröhner SE, Galasso G, Gestri G, Gottschlich G, Labadessa R, Lastrucci L, Lazzaro L, Mereu G, Morabito A, Mugnai M, Musarella CM, Orsenigo S, Pazienza G, Pennesi R, Peruzzi L, Pierini B, Podda L, Prosser F, Rossi G, Scoppola A, Spampinato G, Stinca A, Tomaselli V, Zangari G, Nepi C (2019a) Notulae to the Italian native vascular flora: 7. Italian Botanist 7: 125–148. https://doi.org/10.3897/italianbotanist.7.36148

Bartolucci F, Domina G, Ardenghi NMG, Bacaro G, Bacchetta G, Ballarin F, Banfi E, Barberis G, Beccarisi L, Bernardo L, Bonari G, Bonini F, Brullo S, Buono S, Buono V, Calbi M, Caldararo F, Calvia G, Cancellieri L, Cannavò S, Dagnino D, Esposito A, Fascetti S, Filibeck G, Fiorini G, Forte L, Galasso G, Gestri G, Gigante D, Gottschlich G, Gubellini L, Hofmann N, Lastrucci L, Lonati M, Lorenz R, Lunardi L, Magrini S, Mainetti A, Maiorca G, Mereu G, Messa Ballarin RT, Minuto L, Mossini S, Musarella CM, Nimis PL, Passalacqua NG, Peccenini S, Petriglia B, Podda L, Potenza G, Ravetto Enri S, Roma-Marzio F, Rosati L, Ruggero A, Spampinato G, Stinca A, Tiburtini M, Tietto C, Tomaselli V, Turcato C, Viciani D, Wagensommer RP, Nepi C (2019b) Notulae to the Italian native vascular flora: 8. Italian Botanist 8: 95–116. https://doi.org/10.3897/italianbotanist.8.48626

Bartolucci F, Domina G, Andreatta S, Angius R, Ardenghi NMG, Bacchetta G, Ballelli S, Banfi E, Barberis D, Barberis G, Bernardo L, Bertolli A, Bonari G, Bovio M, Briozzo I, Buccomino G, Calvia G, Chianese G, Cibei C, Conti F, Copez M, Crisanti A, Dagnino D, Di Filippo A, Esposito A, Fanni S, Festi F, Forte L, Galasso G, Gentili R, Gottschlich G, Lattanzi E, Liguori P, Locci MC, Longo D, Lonati M, Lucchese F, Marchetti D, Mariotti MG, Menini F, Minuto L, Orrù G, Pala ML, Passalacqua NG, Pellegrino M, Pennesi R, Peruzzi L, Pinzani L, Pirastru G, Prosser F, Ravetto Enri S, Roma-Marzio F, Russo G, Scoppola A, Silletti G, Stinca A, Toffolo C, Tomaselli V, Tondi G, Trenchi M, Turcato C, Nepi C (2020a) Notulae to the Italian native vascular flora: 9. Italian Botanist 9: 71–86. https://doi.org/10.3897/italianbotanist.9.53429

Bartolucci F, Domina G, Bagella S, Barberis G, Briozzo I, Calbi M, Caria MC, Cavallaro V, Chianese G, Cibei C, Conti F, Dagnino D, Esposito A, Galasso G, Giacanelli V, Forte L, Gottschlich G, Lattanzi E, Longo D, Mei G, Merli M, Orsenigo S, Pau GB, Pazienza G, Peccenini S, Pisanu S, Rivieccio G, Roma-Marzio F, Scafidi F, Selvi F, Stinca A, Turcato C, Nepi C (2020b) Notulae to the Italian native vascularflora: 10. Italian Botanist 10: 47–55. https://doi.org/10.3897/italianbotanist.10.60743

Bartolucci F, Domina G, Andreatta S, Argenti C, Bacchetta G, Ballelli S, Banfi E, Barberis D, Barberis G, Bedini G, Bolpagni R, Bonali F, Bovio M, Briozzo I, Brusco A, Caldarella O, Campus G, Cancellieri L, Carotenuto L, Cheli E, Dagnino D, Del Guacchio E, Farris E, Ferretti G, Filibeck G, Foggi B, Gabellini A, Galasso G, Gianguzzi L, Gottschlich G, Gubellini L, Hofmann N, Iamonico D, Laface VLA, Lonati M, Lucarini D, Lupoletti J, Marchianò R, Marenzi P, Martignoni M, Mei G, Menini F, Merli M, Musarella CM, Orsenigo S, Peccenini S, Pennesi R, Peruzzi L, Pica A, Pinzani L, Piovesan G, Pittarello M, Podda L, Ravetto Enri S, Roma-Marzio F, Rosati L, Spampinato G, Stinca A, Tonelli S, Trenchi M, Turcato C, Viciani D, Lastrucci L (2021a) Notulae to the Italian native vascular flora: 11. Italian Botanist 11: 77–92. https://doi.org/10.3897/italianbotanist.11.68048

Bartolucci F, Domina G, Argenti C, Bacchetta G, Ballelli S, Banfi E, Barberis D, Barberis G, Bertolli A, Bolpagni R, Bonari G, Bonini F, Briozzo I, Brundu G, Bruschi T, Calbi M, Callegari M, Calvia G, Campoccia D, Cancellieri L, Cangelmi G, Carfagno S, Carruggio F, Casazza G, Cavallaro V, Cherchi S, Ciocia B, Conti F, Crisafulli A, Dagnino D, Dalla Vecchia A, De Fine G, Del Nero V, Di Filippo A, Dunkel FG, Festi F, Filibeck G, Fois M, Forte L, Fratolin F, Galasso G, Gigante D, Gottschlich G, Gubellini L, Hofmann N, Jiménez-Mejías P, Laface VLA, Lonati M, Lozano V, Mainetti A, Mariotti M, Mei G, Minutillo F, Minuto L, Musarella CM, Nota G, Orsenigo S, Pallanza M, Passalacqua NG, Pazienza G, Pinzani L, Pittarello M, Podda L, Prosser F, Ravetto Enri S, Riva G, Santi F, Scoppola A, Selvaggi A, Selvi F, Spampinato G, Stinca A, Tomaselli V, Tomasi G, Tondi G, Turcato C, Wilhalm T, Lastrucci L (2021b) Notulae to the Italian native vascular flora: 12. Italian Botanist 12: 85–103. https://doi.org/10.3897/italianbotanist.12.78038

Bartolucci F, Domina G, Andreatta S, Argenti C, Astuti G, Ballelli S, Ballestrin S, Banfi E, Barberis D, Bernardo L, Bertolli A, Bonali F, Bonini F, Bruschi T, Buccomino G, Caldarella O, Cancellieri L, Caputo P, Conti F, Crisanti A, Del Guacchio E, Falcinelli F, Festi F, Ferri V, Filibeck G, Galasso G, Gestri G, Gigante D, Gubellini L, Gottschlich G, Guarino R, Hofmann N, Király G, Laghi P, Lazzeri V, Lonati M, Luchino F, Lupoletti J, Mei G, Merli M, Pagitz K, Paura B, Pennesi R, Perrino EV, Pica A, Pierini B, Pinzani L, Pittarello M, Praleskouskaya S, Prosser F, Roma-Marzio F, Santi F, Saiani D, Sebellin A, Soldano A, Spilli T, Stinca A, Terzi M, Tiburtini M, Tomasi G, Venanzoni R, Lastrucci L (2022) Notulae to the Italian native vascular flora: 13. Italian Botanist 13: 67–84. https://doi.org/10.3897/italianbotanist.13.86403

Candore M, Girgenti P (2019) Disposizioni sull'organizzazione e funzionamento del Centro Vivaistico Regionale (C.V.R.). Regione Siciliana, Assessorato Regionale dell'Agricoltura, dello Sviluppo Rurale e della Pesca Mediterranea, Allegato "A". D.D.G. n. 248/2019. [In Italian]

Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E, Celesti-Grapow L, Albano A, Alessandrini A, Bacchetta G, Ballelli S, Bandini Mazzanti M, Barberis G, Bernardo L, Blasi C,

Bouvet D, Bovio M, Cecchi L, Del Guacchio E, Domina G, Fascetti S, Gallo L, Gubellini L, Guiggi A, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Podda L, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Bartolucci F (2018a) An updated checklist of the vascular flora alien to Italy. Plant Biosystems 152(3): 556–592. https://doi.org/10.1080/11263504.2018.1441197

Galasso G, Domina G, Adorni M, Ardenghi NMG, Bonari G, Buono S, Cancellieri L, Chianese G, Ferretti G, Fiaschi T, Forte L, Guarino R, Labadessa R, Lastrucci L, Lazzaro L, Magrini S, Minuto L, Mossini S, Olivieri N, Scoppola A, Stinca A, Turcato C, Nepi C (2018b) Notulae to the Italian alien vascular flora: 5. Italian Botanist 5: 45–56. https://doi.org/10.3897/italianbotanist.5.25910

Galasso G, Domina G, Alessandrini A, Ardenghi NMG, Bacchetta G, Ballelli S, Bartolucci F, Brundu G, Buono S, Busnardo G, Calvia G, Capece P, D'Antraccoli M, Di Nuzzo L, Fanfarillo E, Ferretti G, Guarino R, Iamonico D, Iberite M, Latini M, Lazzaro L, Lonati M, Lozano V, Magrini S, Mei G, Mereu G, Moro A, Mugnai M, Nicolella G, Nimis PL, Olivieri H, Pennesi R, Peruzzi L, Podda L, Probo M, Prosser F, Ravetto Enri S, Roma-Marzio F, Ruggero A, Scafidi F, Stinca A, Nepi C (2018c) Notulae to the Italian alien vascular flora: 6. Italian Botanist 6: 65–90. https://doi.org/10.3897/italianbotanist.6.30560

Galasso G, Domina G, Ardenghi NMG, Aristarchi C, Bacchetta G, Bartolucci F, Bonari G, Bouvet D, Brundu G, Buono S, Caldarella O, Calvia G, Cano-Ortiz A, Corti E, D'Amico FS, D'Antraccoli M, Di Turi A, Dutto M, Fanfarillo E, Ferretti G, Fiaschi T, Ganz C, Guarino R, Iberite M, Laface VLA, La Rosa A, Lastrucci L, Latini M, Lazzaro L, Lonati M, Lozano V, Luchino F, Magrini S, Mainetti A, Manca M, Mugnai M, Musarella CM, Nicolella G, Olivieri N, Orrù I, Pazienza G, Peruzzi L, Podda L, Prosser F, Ravetto Enri S, Restivo S, Roma-Marzio F, Ruggero A, Scoppola A, Selvi F, Spampinato G, Stinca A, Terzi M, Tiburtini M, Tornatore E, Vetromile R, Nepi C. (2019a) Notulae to the Italian alien vascular flora: 7. Italian Botanist 7: 157–182. https://doi.org/10.3897/italianbotanist.7.36386

Galasso G, Domina G, Andreatta S, Angiolin, C, Ardenghi NMG, Aristarchi C, Arnoul M, Azzella MM, Bacchetta G, Bartolucci F, Bodino S, Bommartini G, Bonari G, Buono S, Buono V, Caldarella O, Calvia G, Corti E, D'Antraccoli M, De Luca R, De Mattia F, Di Natale S, Di Turi A, Esposito A, Ferretti G, Fiaschi T, Fogu MC, Forte L, Frigerio J, Gubellini L, Guzzetti L, Hofmann N, Laface VLA, Laghetti G, Lallai A, La Rosa A, Lazzaro L, Lodetti S, Lonati M, Luchino F, Magrini S, Mainetti A, Marignani M, Maruca G, Medagli P, Mei G, Menini F, Mezzasalma V, Misuri A, Mossini S, Mugnai M, Musarella CM, Nota G, Olivieri N, Padula A, Pascale M, Pasquini F, Peruzzi L, Picella G, Pinzani L, Pirani S, Pittarello M, Podda L, Ravetto Enri S, Rifici CD, Roma-Marzio F, Romano R, Rosati L, Scafidi F, Scarici E, Scarici M, Spampinato G, Stinca A, Wagensommer RP, Zanoni G, Nepi C (2019b) Notulae to the Italian alien vascular flora: 8. Italian Botanist 8: 63–93. https://doi.org/10.3897/italianbotanist.8.48621

Galasso G, Domina G, Adorni M, Angiolini C, Apruzzese M, Ardenghi NMG, Assini S, Aversa M, Bacchetta G, Banfi E, Barberis G, Bartolucci F, Bernardo L, Bertolli A, Bonali F, Bonari

G, Bonini I, Bracco F, Brundu G, Buccomino G, Buono S, Calvia G, Cambria S, Castagnini P, Ceschin S, Dagnino D, Di Gristina E, Di Turi A, Fascetti S, Ferretti G, Fois M, Gentili R, Gheza G, Gubellini L, Hofmann N, Iamonico D, Ilari A, Király A, Király G, Laface VLA, Lallai A, Lazzaro L, Lonati M, Longo D, Lozano V, Lupoletti J, Magrini S, Mainetti A, Manca M, Marchetti D, Mariani F, Mariotti MG, Masin RR, Mei G, Menini F, Merli M, Milani A, Minuto L, Mugnai M, Musarella CM, Olivieri N, Onnis L, Passalacqua NG, Peccenini S, Peruzzi L, Pica A, Pinzani L, Pittarello M, Podda L, Prosser F, Ravetto Enri S, Roma-Marzio F, Rosati L, Sarigu M, Scafidi F, Sciandrello S, Selvaggi A, Spampinato G, Stinca A, Tavilla G, Toffolo C, Tomasi G, Turcato C, Villano C, Nepi C (2020a) Notulae to the Italian alien vascular flora: 9. Italian Botanist 9: 47–70. https://doi.org/10.3897/italianbotanist.9.53401

Galasso G, Domina G, Azzaro D, Bagella S, Barone G, Bartolucci F, Bianco M, Bolzani P, Bonari G, Boscutti F, Buono S, Cibei C, Conti F, Di Gristina E, Fanfarillo E, Franzoni J, Giacanelli V, Gubellini L, Hofmann N, Laface VLA, Latini M, Liccari F, Lonati M, Longo D, Lunesu L, Lupoletti J, Magrini S, Mei G, Mereu G, Miconi F, Musarella CM, Nicolella G, Olivieri N, Peruzzi L, Pica A, Pinzani L, Pittarello M, Prosser F, Ranno V, Ravetto Enri S, Rivieccio G, Roma-Marzio F, Scafidi F, Spampinato G, Stinca A, Tavilla G, Tiburtini M, Villa M, Wellstein C, Zerbe S, Nepi C (2020b) Notulae to the Italian alien vascular flora: 10. Italian Botanist 10: 57–71. https://doi.org/10.3897/italianbotanist.10.60736

Galasso G, Domina G, Andreatta S, Argenti E, Bacchetta G, Bagella S, Banfi E, Barberis D, Bardi S, Barone G, Bartolucci F, Bertolli A, Biscotti N, Bonali F, Bonini F, Bonsanto D, Brundu G, Buono S, Caldarella O, Calvia G, Cambria S, Campus G, Caria MC, Contim F, Coppi A, Dagnino D, Del Guacchio E, Di Gristina E, Farris E, Ferretti G, Festi F, Fois M, Furlani F, Gigante D, Guarino R, Gubellini L, Hofmann N, Iamonico D, Jiménez-Mejías P, La Rosa A, Laface VLA, Lallai A, Lazzaro L, Lonati M, Lozano V, Luchino F, Lupoletti J, Magrini S, Mainetti A, Marchetti D, Marenzi P, Marignani M, Martignoni M, Mei G, Menini F, Merli M, Mugnai M, Musarella CM, Nicolella G, Noor Hussain A, Olivieri N, Orlandini S, Peccenini S, Peruzzi L, Pica A, Pilon N, Pinzani L, Pittarello M, Podda L, Probo M, Prosser F, Raffaelli C, Ravetto Enri S, Rivieccio G, Rosati L, Sarmati S, Scafidi F, Selvi F, Sennikov AN, Sotgiu Cocco G, Spampinato G, Stinca A, Tavilla G, Tomaselli V, Tomasi D, Tomasi G, Trenchi M, Turcato C, Verloove F, Viciani D, Villa M, Wagensommer RP, Lastrucci L (2021a) Notulae to the Italian alien vascular flora: 11. Italian Botanist 11: 93–119. https://doi.org/10.3897/italianbotanist.11.68063

Galasso G, Domina G, Angiolini C, Bacchetta G, Banfi E, Barberis D, Bardi S, Bartolucci F, Bonari G, Bovio M, Briozzo I, Brundu G, Buono S, Calvia G, Celesti-Grapow L, Cozzolino A, Cuena-Lombraña A, Curuzzi M, D'Amico FS, Dagnino D, De Fine G, Fanfarillo E, Federici A, Ferraris P, Fiacchini D, Fiaschi T, Fois M, Gubellini L, Guidotti E, Hofmann N, Kindermann E, Laface VLA, Lallai A, Lanfredini P, Lazzaro L, Lazzeri V, Lonati M, Loreti M, Lozano V, Magrini S, Mainetti A, Marchini M, Marignani M, Martignoni M, Mei G, Minutillo F, Mondino GP, Motti R, Musarella CM, Nota G, Olivieri N, Pallanza M, Passalacqua NG, Patera G, Pilon N, Pinzani L, Pittarello M, Podda L, Probo M, Ravetto Enri S, Rosati L, Salerno P, Selvaggi A, Soldano A, Sotgiu Cocco G, Spampinato G, Stinca A, Terzi M, Tondi G, Turcato C, Wellstein C, Lastrucci L (2021b) Notulae to

the Italian alien vascular flora: 12. Italian Botanist 12: 105–121. https://doi.org/10.3897/italianbotanist.12.78010

Galasso G, Domina G, Angiolini C, Azzaro D, Bacchetta G, Banfi E, Barberis D, Barone G, Bartolucci F, Bertolli A, Bolpagni R, Bonari G, Bracchetti L, Calvia G, Campus G, Cancellieri L, Cavallaro V, Conti F, Cuena-Lombraña A, D'Alessandro E, Dal Corso G, Dalla Vecchia A, De Natale A, Del Guacchio E, Di Gregorio G, Di Gristina E, Di Stefano M, Fanfarillo E, Federici A, Federici G, Ferretti G, Festi F, Fiaschi T, Filibeck G, Fois M, Gariboldi L, Gestri G, Gubellini L, Guiggi A, Hofmann N, Laface VLA, Lallai A, Lazzeri V, Lecis AP, Lonati M, Lucchese F, Lupoletti J, Maestri S, Mainetti A, Mantino F, Mascia F, Masin RR, Mei G, Merli M, Messina A, Konnert M, Fady B, Gömöry D, A'Hara S, Wolter F, Ducci F, Koskela J, Bozzano M, Maaten T, Kowalczyk J (2015) Use and transfer of forest reproductive material in Europe in the context of climate change. European Forest Genetic Resources Programme (EUFORGEN), Bioversity International, Rome, Italy, [xvi and] 75 pp.

Musarella CM, Nota G, Olivieri N, Paura B, Pellegrini R, Pica A, Pittarello M, Podda L, Praleskouskaya S, Prosser F, Ratini G, Ravetto Enri S, Roma-Marzio F, Salerno G, Selvaggi A, Soldano A, Spampinato G, Stinca A, Tardella FM, Tavilla G, Tomaselli V, Tomasi G, Tosetto L, Venanzoni R, Lastrucci L (2022) Notulae to the Italian alien vascular flora: 13. Italian Botanist 13: 27–44. https://doi.org/10.3897/italianbotanist.13.85863

Mariotti B, Maltoni A, Tani A (2014) Produzione vivaistica forestale e potenzialità applicative del "Traget Plant Concept". Proceedings of the Second International Congresso of Silvicolture, Florence, November 26th–29th.

Martini S, Maltoni A, Monteverdi MC, De Dato G, Salbitano F, Marchetti M, Mariotti B (2022) Indagine sulla produzione vivaistica forestale pubblica in Italia. Forest@ 19: 18–30. https://doi.org/10.3832/efor4083-019

Mirabile G, Cirlincione F, Venturella G, Torta L (2023) Seed vitality and fungal contamination in *Abies nebrodensis*. Plant Biosytems 157(1): 112–118. https://doi.org/10.1080/11263504.2022.2089765

Pardi R, Venturella G, Cirlincione F, Mirabile G, Di Gristina E, Gargano ML (2022) Forest ecosystems in the Monti Sicani Park (Sicily). Flora Mediterranea 32: 5–16. https://doi.org/10.7320/FlMedit32.005

Pignatti S (2017) Flora d'Italia (Vols. 1–2). Edagricole, Milano.

Pignatti S (2018) Flora d'Italia (Vol. 3). Edagricole, Milano.

Pignatti S (2019) Flora d'Italia (Vol. 4). Edagricole, Milano.

Raunkiaer C (1934) The life forms of plants and statistical plant geography; being the collected papers of C. Raunkiær. Oxford University Press, Oxford.

Raimondo FM, Schicchi R (2005) Rendiconto Sul Progetto LIFE Natura "Conservazione *In Situ* ed *Ex Situ* di *Abies nebrodensis* (Lojac.) Mattei". https://www.parcodellemadonie.it/webdoc/doc/life.pdf [Accessed on 27 March 2023]

Selvi F, Campetella G, Canullo R, Chelli S, Domina G, Farris E, Gasperini C, Rosati L, Wellstein C, Carrari E (2023) The Italian endemic forest plants: an annotated inventory and synthesis of knowledge. Plant Ecology and Evolution 156(1): 29–45. https://doi.org/10.5091/plecevo.95929

Italian Botanist 15: 65–76 (2023)
doi: 10.3897/italianbotanist.15.98538
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

First record of *Rhizomatophora aegopodioides* (Apiaceae) in Italy

Riccardo Pennesi[1], Emilia Cunto[2], Sandro Ballelli[1]

1 *Herbarium Universitatis Camerinensis (CAME), Unit of Plant Diversity and Ecosystems Management, School of Biosciences and Veterinary Medicine, University of Camerino, Camerino (MC), 62032, Italy* **2** *Via G. Marconi 26, Domicella (AV), 83020, Italy*

Corresponding author: Riccardo Pennesi (riccardo.pennesi@unicam.it)

Academic editor: Fabrizio Bartolucci | Received 7 December 2022 | Accepted 1 May 2023 | Published 4 May 2023

Citation: Pennesi R, Cunto E, Ballelli S (2023) First record of *Rhizomatophora aegopodioides* (Apiaceae) in Italy. Italian Botanist 15: 65–76. https://doi.org/10.3897/italianbotanist.15.98538

Abstract

The occurrence of *Rhizomatophora aegopodioides*, a species distributed in the Balkan Peninsula, Greece, southern Caucasus, Turkey and southern Russia, is reported here for the first time in Italy. It was discovered in Calabria (southern Italy) in the Argentino River Valley and along the Abatemarco River (municipality of Cosenza), localities partly included within the Pollino National Park. Information about taxonomy, nomenclature, habitat, phytosociology and distribution of this species in Italy are provided.

Keywords

Apennine, Calabria, *Peucedanum*, Umbelliferae, vascular flora

Introduction

Apiaceae Lindl. is a cosmopolitan family comprising 466 genera and about 3,820 species, found most widely in temperate Eurasia and North America (Plunkett et al. 2018). The species are not evenly distributed among genera, 41% of which are monotypic and 26% comprise only two or three species each (Pimenov and Leonov 1993). Sixty percent of the total number of species have been assigned to a relatively small number of large genera containing over 20 species each (Spalik et al. 2001). These genera include *Ferula* L. (170 species), *Peucedanum* L. (100–120), *Seseli* L. (100–120), and *Ligusticum* L. (40–50), all of which are considered polyphyletic by Katz-Downie et al. (1999) and Downie et al. (2000).

Copyright *Riccardo Pennesi et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Peucedanum sensu lato, distributed in Eurasia and Africa, is one of the most taxonomically complex groups in the Apiaceae (Pimenov and Leonov 1993). Based on morphological and molecular studies, the genus is now reduced to *P. officinale* L. and a few other species, and several distinct genera are recognized (i.e., Reduron et al. 1997; Spalik et al. 2004; Pimenov et al. 2007; Pimenov and Ostroumova 2012; Lei et al. 2022).

During field surveys in southern Italy (Calabria administrative region) carried out in 2016, we discovered several individuals of an unknown species belonging to the Apiaceae not corresponding to any recorded taxon for the Italian vascular flora (Bartolucci et al. 2018; Galasso et al. 2018; Stinca and Ricciardi 2018). This plant was preliminarily identified as *Rhizomatophora aegopodioides* (Boiss.) Pimenov, through literature and herbarium research, a species distributed in the Balkan Peninsula, Greece, southern Caucasus, Turkey, and southern Russia (POWO 2023).

The purpose of this study was to verify the correct identification of this disjunct population occurring in southern Italy and to distinguish it from related genera occurring in Italy. Furthermore, to increase knowledge on the Italian vascular flora, we provide taxonomic, phytosociological, and distributive data relating to this new finding.

Material and method

Field investigations were carried out in September 2016 in Calabria (southern Italy) along the Abatemarco River (Santa Maria del Cedro, Cosenza; WGS 84: 39°44'25"N, 15°52'04.6"E, Fig. 1) and in the Argentino River Valley (Orsomarso, Cosenza; WGS 84: 39°47'42.6"N, 15°55'18.0"E, Fig. 1). The latter locality falls in the Site of Community Importance "Valle del Fiume Argentino" (IT9310023) within the Pollino National Park. Ten samples were collected and one individual was transplanted in the "Carmela Cortini" Botanical Garden of the University of Camerino for *ex situ* conservation purposes.

Careful surveys of relevant literature to find existing records of the species in Italy were performed (Bartolucci et al. 2018 and Galasso et al. 2018 and subsequent updates reported in the Portal to the Flora of Italy 2023; Stinca and Ricciardi 2018). Floristic and phytosociological studies concerning the studied area (Terracciano 1891, 1896, 1900; Gavioli 1932; Maiorca and Spampinato 1994, 1999; Bernardo 2002; Mercurio et al. 2007; Scarfò et al. 2008), or more generally southern Italy and Calabria (Bernardo et al. 2012; Maiorca and Puntillo 2015; Roma-Marzio et al. 2016; Conti et al. 2019; Rosati et al. 2020; Stinca et al. 2021; Spampinato et al. 2022) were also analysed. Identification of the collected specimens was performed following the morphological descriptions and the analytical keys in Seidel (1889), Vandas (1889), Tutin et al. (1968), Chamberlain (1972), Hartvig (1986), Frey (1989), and Pimevov and Ostroumova (2012). The original description of the species was also studied (Boisser 1872). Furthermore, a phytosociological survey was carried out using the Braun-Blanquet approach (1964). All the collected specimens are kept in Herbarium Universitatis Camerinensis (CAME; herbarium acronym follows Thiers 2023).

Figure 1. Italian localities of *Rhizomatophora aegopodioides* (red dots, Google Earth view): 1, Santa Maria del Cedro; 2, Orsomarso.

Results and discussion

***Rhizomatophora aegopodioides* (Boiss.) Pimenov, Umbelliferae Russia 284 (2012)**

≡ *Physospermum aegopodioides* Boiss., Fl. Orient. [Boissier] 2: 923 (1872).
≡ *Peucedanum aegopodioides* (Boiss.) Vandas, Sitzungsber. Königl. Böhm. Ges. Wiss., Math.-Naturwiss. Cl. 1888: 449 (1889).
≡ *Cervaria aegopodioides* (Boiss.) Pimenov, Vestn. Moskovsk. Gosud. Univ., ser. 16, Biol. 4: 37 (1982).

Ind. Loc. "Hab. supra Brusnik in districtu Bitolia Macedoniae (Orph!)".

Type (see Pimenov and Ostroumova 2012). "Supra Brusnik prope Bitolia Macedoniae. 25 July 1862. *Th.G. Orphanides 376*" (holo: G-BOIS; iso: G, GB).

Species description from the Italian (Calabria) material (Figs 2, 3). Erect perennial plants (70–120 cm), with long horizontal rhizomes; solitary, fistulous, glabrous, striated stems; large leaves, 2–3 ternatisect, non-swollen sheaths, broadly triangular laminae, with oblong lobes, glabrous, petiolate, with a minutely rough margin, as well as in the main veins and apiculate teeth; petioles striated round in section, hollow; umbels with 20–35 unequal, slender, minutely scabrous rays mainly on one side; bracts none, 3 or 6, lesiniform; umbrellas with more than 10 rays and numerous lesiniform bracteoles, always present; petals white, largely ovate, erect apex slightly emarginated, lobes swollen; mericarps glabrous (5 × 6.5–7 mm), broadly elliptical or almost round,

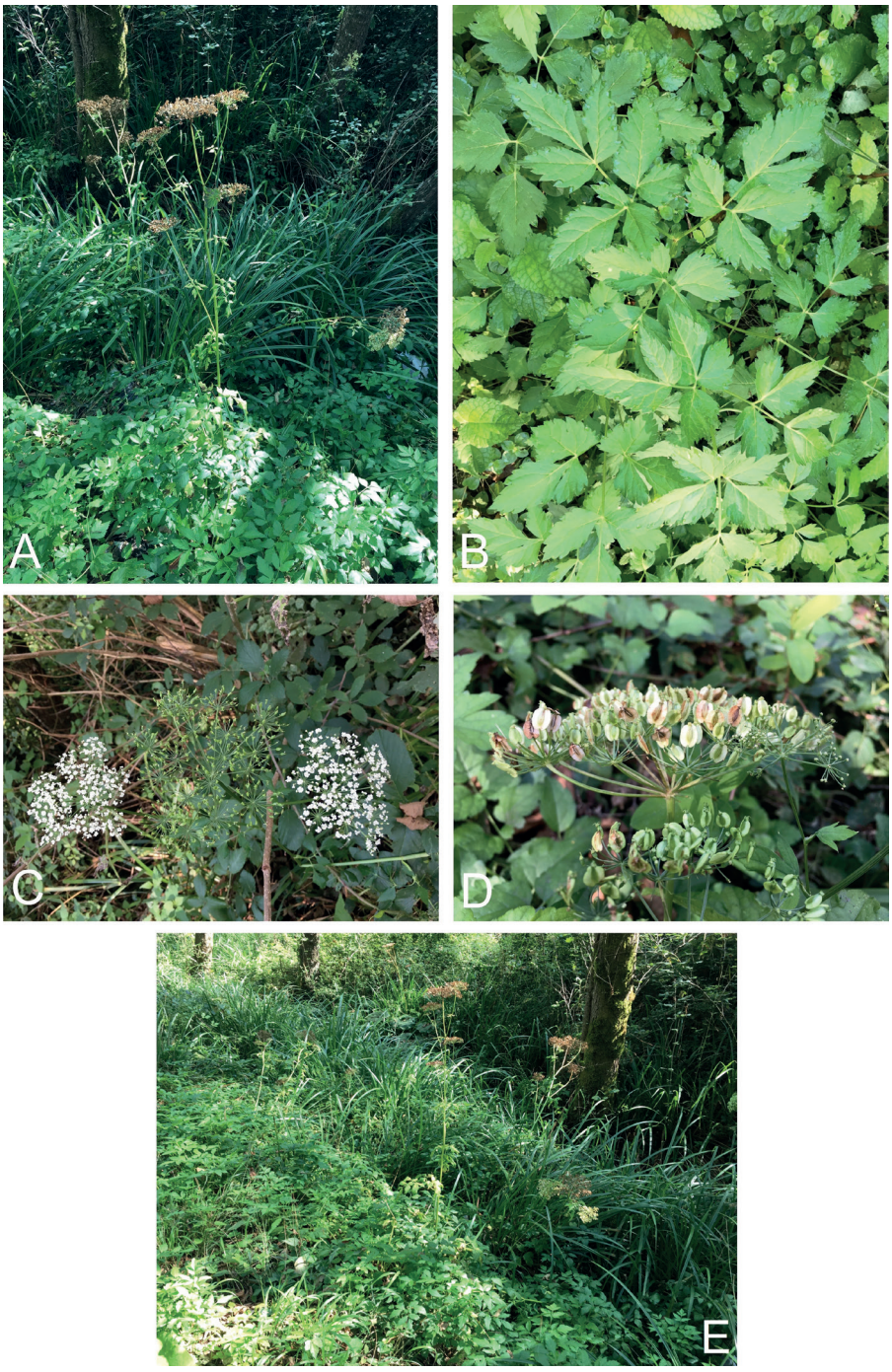

Figure 2. *Rhizomatophora aegopodioides* (Calabria, Santa Maria del Cedro, middle stretch of the Abatemarco River, photo R. Pennesi) **A** whole plant **B** basal leaves **C** flowers **D** fruits **E** habitat.

Figure 3. Herbarium specimen of *Rhizomatophora aegopodioides* kept in CAME.

dorsally compressed, broadly winged (1.5–2 mm), bifid carpophores; flat-conical stylopods, with wavy margin; evident filiform dorsal ribs.

Distribution. *Rhizomatophora aegopodioides* is distributed in the Balkan Peninsula (Albania, Bosnia-Herzegovina, Bulgaria, Montenegro, Croatia, Macedonia, and Serbia), Greece (central-eastern and central-northern; northern and southern Pindus), southern Caucasus (Georgia, Armenia, Azerbaijan), Turkey, southern Russia (POWO 2023), and here reported for southern Italy (Fig. 4). In Calabria, the species is widespread along the banks of the Abatemarco and Argentino rivers and in the adjacent wetlands. Currently, its presence in the Italian peninsula is the westernmost stand of the distribution range. Furthermore, the Calabrian population shows the lowest altitude known for this species. This may be due to the strong thermal inversion in the valley bottoms of the Argentino River Reserve (Maiorca and Spampinato 1999).

Habitat. In Italy, it grows in hygrophilous forests, alder forests, riverbanks, and freshwater habitats at about 100–200 m a.s.l. The results of one relevé carried out in the Santa Maria Del Cedro locality are shown in Table 1.

Phenology. Flowering in August-September, fruiting in September-October.

Chromosome number. 2n = 22 (Kuzmanov et al. 1977 as *Peucedanum aegopodioides*, material from Bulgaria, M. Ljulin; Strid and Franzėn 1983 as *Peucedanum aegopodioides*, material from Greece, M. Olympus)].

Taxonomic remarks. The monotypic genus *Rhizomatophora* Pimenov is characterized by perennial plants, growing in hygrophilous forests, alder forests, riverbanks, wetlands, and freshwater habitats. This genus is morphologically close to *Cervaria* s.str. and *Peucedanum* s.str. In Italy, according to Bartolucci et al. (2018) and subsequent updates summarized in the Portal to the Flora of Italy (2023; see also Martellos et al. 2020) three taxa of *Peucedanum* and one species of *Cervaria* are reported: *P. officinale* L. subsp. *officinale* (native), *P. paniculatum* Loisel. (cryptogenic), *P. coriaceum* Rchb. (native, but not recently confirmed), and *C. rivini* Gaertn. (native). Stinca and Ricciardi (2018) indicate three *Peucedanum* and one *Cervaria* taxa in the second edition of "Flora d'Italia": *P. officinale* subsp. *officinale* (native), *P. paniculatum* (probably casual alien species), *P. coriaceum* (not recently confirmed and probably locally extinct)], and *C. rivini* (native).

Pimenov and Ostroumova (2012) provided the following description for the genus *Rhizomatophora*: leaves 2–3 ternatisect; leaflets petiolulate, broad, ovate to oblong; mar-

Table 1. Relevé on Santa Maria del Cedro, middle stretch of the Abatemarco River, 25/09/2016, 127 m a.s.l. (WGS 84: 39°44'25.6"N, 15°52'04.6"E). The nomenclature of the cited species and subspecies follows Bartolucci et al. (2018).

Alnus glutinosa (L.) Gaertn. (1.1); *Populus nigra* L. subsp. *nigra* (1.1); ***Rhizomatophora aegopodioides*** (Boiss.) Pimenov (3.3); *Carex pendula* Huds. (3.3); *Solanum dulcamara* L. (2.2); *Mentha aquatica* L. subsp. *aquatica* (1.2); *Equisetum telmateia* Ehrh. (1.1); *Brachypodium sylvaticum* (Huds.) P.Beauv. (+.2); *Juncus conglomeratus* L. (+.2); *Tussilago farfara* L. (+.2); *Vinca major* L. subsp. *major* (+.2); *Bidens tripartita* L. subsp. *tripartita* (+); *Cirsium creticum* (Lam.) d'Urv. subsp. *triumfettii* (Lacaita) K.Werner (+); *Clematis vitalba* L. (+); *Convolvulus sepium* L. (+); *Epilobium hirsutum* L. (+); *Epilobium parviflorum* Schreb. (+); *Eupatorium cannabinum* L. subsp. *cannabinum* (+); *Ficus carica* L. (+); *Geranium versicolor* L. (+); *Lamium maculatum* L. (+); *Melissa officinalis* L. subsp. *altissima* (Sm.) Arcang. (+); *Persicaria maculosa* Gray (+); *Pulicaria dysenterica* (L.) Bernh. (+); *Rubia peregrina* L. (+); *Salvia glutinosa* L. (+).

Figure 4. Distribution of *Rhizomatophora aegopodioides* showing the Italian record from Calabria (red dot). Image from POWO (2023, modified).

gins dentate or incised. Bracts absent or 3–6, lanceolate to subulate; rays many, velvety; bracteoles many, subulate; pedicels many, minutely pubescent. Calyx lobes triangulate, membranous at margin; petals white or pinkish; stylopodium plane to conical, wavy at margin. Fruits compressed dorsally, glabrous; dorsal ribs filiform, marginal ribs broadly winged; commissure broad; vittae minute, vallecular 1, commissural 2; rib secretory ducts large, 2 in each rib. Seed face plane. The genus *Rhizomatophora* differs from *Cervaria* s.str. for the long horizontal rhizomes, the petioles and stems fistulous, the largely triangular teeth of the calyx, the obtuse margin of the albumen, the marginal crests of the broadly winged and translucent mericarps, unistrate mesocarps, smooth membranous cells (without an inner layer of tangentially elongated cells), and continuous, rather broad (not isolated, minute) secretory canals. *Rhizomatophora* is also easily recognizable from the related genus *Peucedanum* s.str. by the terminal lobes of the leaves, the long rhizomes, the petioles and stems fistulous, the widely winged mericarps with light striations and continuous secretory canals (Pimenov and Ostroumova 2012). The morphological characters distinguishing *Rhizomatophora* (based on the samples collected in Calabria) from related genera (i.e., *Peucedanum* and *Cervaria*) of the Italian vascular flora are shown in Table 2.

Specimens examined. Italy. Calabria, Orsomarso (Cosenza), initial section of the Argentino River Valley (39°47'42.6"N, 15°55'18.0"E), esp. west, alt. 130–150 m. a.s.l., banks and surrounding wetlands, calcareous substr., 26 September 2016; *S. Ballelli*, *R. Pennesi*, *E. Cunto s.n.* (CAME); Calabria, Santa Maria del Cedro (Cosenza), along the middle section of the Abatemarco River (39°44'25.6"N, 15°52'04.6"E), 120–140 m. a.s.l., banks and surrounding wetlands, calcareous substr., 25 September 2016, *S. Ballelli*, *R. Pennesi*, *E. Cunto s.n.* (CAME); **Greece.** Greece, prope Bitolia Macedoniae, 06 August 1862, *T.G. Orphanides 1017* (JE barcodes JE00000057 [digital photo!], JE00000058 [digital photo!]); prope Vodena Macedoniae, *s.d.*, *T.G. Orphanides 1017* (W No. 1889-

Table 2. Morphological characters distinguishing *Rhizomatophora aegopodioides* (Calabrian population) from related genera of the Italian flora. Morphological features of *Peucedanum* and *Cervaria* follow Stinca and Ricciardi (2018).

Morphological characters	***Rhizomatophora***	***Peucedanum* s.str.**	***Cervaria* s.str.**
Height	70–120 cm	20–200 cm	20–150 cm
Leaves	2–3 ternatisect	2–6 ternate	2–3 pinnatisect
Leaves margin	dentate-apiculate segments	linear segments	dentate-apiculate segments
Umbel rays (primary rays)	20–35, unequal, slender, minutely scabrous mainly on one side	4–50	9–35, pubescent-scabrous on internal side
Bracts	0, 3 or 6, lesiniform	0–6, lesiniform	4–15, linear, reflexed
Bracteoles	erect, numerous, always present	numerous	reflexed, numerous
Petals	white, largely ovate, swollen lobes	white to yellow	white
Petal apex	erect, slightly emarginated	curved towards the center of the flower (inflexed)	curved towards the center of the flower (inflexed)
Mericarps	5 × 6.5–7 mm, glabrous, broadly winged (1.5–2 mm), elliptical or almost round	4–4.5 × 6.5–12 mm, winged (0.5–2 mm), elliptical or oblong	3–4.5 × 4–9 mm, winged (0.5–1.4 mm), elliptical or suborbicular
Dorsal ribs	evident, filiform	evident	inconspicuous

0024958 [digital photo!]; **Serbia.** Jugozapadna: Priboj, Sjeverin (Sutjeska reka-klisura, dornji deo), 43°35.266'N, 19°22.225'E, stene, krecnjak, 400–450 m, 13 August 2008, *Niketic M.*, *Tomovic G. s.n.* (BEOU No. 27989!); Prvriek, dist. Vranja, ad rivulos, *G. Ilić s n.* (BEO No. 16105!); Serbia austr. prope Wranja. *G. Ilić s.n.* (W No. 1895-0000240 [digital photo!]); **Bulgaria.** Bei Lowtsche, 4 July 1898, *Urumoff s.n.* (W No. 1926-0027189 [digital photo!]); **Bosnia and Herzegovina.** In glareosis calcareis faucis Prača, 570 m.; alt. 570 m, 20 July 1920, K. Malý s.n. (W No. 1961-0005131 [digital photo!]).

Conclusion

The discovery of *Rhizomatophora aegopodioides* in Italy is particularly relevant because it provides a contribution to the knowledge on its distribution at the European level. The genus *Rhizomatophora* is new for Italy, which hosts the richest vascular flora in Europe, and is second in the Mediterranean area only to Turkey (Bartolucci et al. 2021, 2022). The discovery of *R. aegopodioides* adds to the recent new acquisitions, for the Italian native vascular flora, of plants with an eastern range (e.g., Bartolucci and Conti 2016; Peruzzi 2016; Peruzzi et al. 2017; Wagensommer et al. 2017; Bartolucci et al. 2022; Conti and Bartolucci 2023), once again underlining the importance of floristic and taxonomic research from a conservationist perspective.

In our opinion, further field surveys are indispensable to define the effective distribution area and ecology of *R. aegopodioides* in Italy, and to understand the origin of these disjointed populations. Furthermore, it would be desirable to monitor the species in order to assess the conservation status of the population described here.

Acknowledgements

We would like to thank Dmitar Lakušić and his staff at the Herbarium of Belgrade University (BEOU) and Marjan Niketić at the Herbarium of Belgrade Natural History Museum (BEO) for providing the herbarium specimens.

References

Bartolucci F, Conti F (2016) *Alyssum desertorum* Stapf (Brassicaceae), new for the Italian flora. Acta Botanica Croatica 75(1): 149–152. https://doi.org/10.1515/botcro-2016-0006

Bartolucci F, De Santis E, Conti F (2022) Nomenclatural synopsis, revised distribution and conservation status of *Ranunculus gracilis* (Ranunculaceae) in Italy. Plants 11(22): e3094. https://doi.org/10.3390/plants11223094

Bartolucci F, Galasso G, Peruzzi L, Conti F (2021) Report 2020 on plant biodiversity in Italy: native and alien vascular flora. Natural History Sciences 8(1): 41–54. https://doi.org/10.4081/nhs.2021.520

Bartolucci F, Galasso G, Peruzzi L, Conti F (2022) Report 2021 on plant biodiversity in Italy: native and alien vascular flora. Natural History Sciences 10(1): 41–50. https://doi.org/10.4081/nhs.2022.623

Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, Astuti G, Bacchetta G, Ballelli S, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Cecchi L, Di Pietro R, Domina G, Fascetti S, Fenu G, Festi F, Foggi B, Gallo L, Gottschlich G, Gubellini L, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Conti F (2018) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 179–303. https://doi.org/10.1080/11263504.2017.1419996

Bernardo L (2002) Fiori e piante del Parco del Pollino (2nd edn.). Edizioni Prometeo, Castrovillari (Cosenza).

Bernardo L, Bartolucci F, Cancellieri L, Costalonga S, Galasso G, Galesi R, Gargano D, Iberite M, Iocchi M, Lattanzi E, Lavezzo P, Magrini S, Peccenini S, Sciandrello S, Scoppola A, Signorino G, Tilia A, Spampinato G (2012) Contributo alla conoscenza floristica della Calabria: resoconto dell'escursione del Gruppo di Floristica (SBI) nel 2008 nella Presila Catanzarese. Informatore Botanico Italiano 44(1): 125–151.

Boissier E (1872) Flora Orientalis (Vol. 2). (H. Georg), Basel, Genéve.

Braun-Blanquet J (1964) Pflanzensoziologie. Springer Verlag, Wien, New York, 865 pp. https://doi.org/10.1007/978-3-7091-8110-2

Chamberlain DF (1972) *Peucedanum aegopodioides* (Boiss.) Vandas. In: Davis PH (Ed.) Flora of Turkey and the East Aegean Islands (Vol. 4). Edinburgh University Press, Edinburgh, 480 pp.

Conti F, Bartolucci F (2023) Taxonomy and distribution of *Spiraea hypericifolia* in Italy and typification of the name *S. flabellata* (Rosaceae). Plants 12: e536. https://doi.org/10.3390/plants12030536

Conti F, Falcinelli F, Giacanelli V, Paolucci M, Pirone G, Proietti E, Stinca A, Bartolucci F (2019) New floristic data of vascular plants from central and southern Italy. Flora Mediterranea 29: 215–222. https://doi.org/10.7320/FlMedit29.215

Downie SR, Watson MF, Spalik K, Katz-Downie DS (2000) Molecular systematics of Old World Apioideae (Apiaceae): relationships among some members of tribe Peucedaneae *sensu lato*, the placement of several island endemics, and resolution within the apioid superclade. Canadian Journal of Botany 78(4): 506–528. https://doi.org/10.1139/b00-02

Frey R (1989) Taxonomische Revision der Gattung *Peucedanum*: Sektion *Peucedanum* und Sektion *Palimbioidea* (*Umbelliferae*). Candollea 44: 257–327.

Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E, Celesti-Grapow L, Albano A, Alessandrini A, Bacchetta G, Ballelli S, Bandini Mazzanti M, Barberis G, Bernardo L, Blasi C, Bouvet D, Bovio M, Cecchi L, Del Guacchio E, Domina G, Fascetti S, Gallo L, Gubellini L, Guiggi A, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Podda L, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Bartolucci F (2018) An updated checklist of the vascular flora alien to Italy. Plant Biosystems 152(3): 556–592. https://doi.org/10.1080/11263504.2018.1441197

Gavioli O (1932) Contributo allo studio della Flora del M. Pollino (Appennino Calabro-Lucano). Archivio Botanico e Biogeografico Italiano 8: 46–80.

Hartvig P (1986) *Peucedanum* L. In: Strid A (Ed.) Mountain flora of Greece (Vol. 1). Cambridge University Press, Cambridge, 714–722.

Katz-Downie DS, Valiejo-Roman CM, Terentieva EI, Troitsky AV, Pimenov MG, Lee BY, Downie SR (1999) Towards a molecular phylogeny of Apiaceae subfamily Apioideae: additional information from nuclear ribosomal DNA ITS sequences. Plant Systematics and Evolution 216(3–4): 167–195. https://doi.org/10.1007/BF01084397

Kuzmanov BA, Andreev N, Georgieva S (1977) In: Löve Á (1977) IOPB chromosome number reports LVII. Taxon 26: 443–452. https://doi.org/10.1002/j.1996-8175.1977.tb04204.x

Lei J-Q, Liu C-K, Cai J, Price M, Zhou S-D, He X-J (2022) Evidence from phylogenomics and morphology provide insights into the phylogeny, plastome evolution, and taxonomy of *Kitagawia*. Plants 11(23): e3275. https://doi.org/10.3390/plants11233275

Maiorca G, Puntillo D (2015) Contributi alla conoscenza floristica della Catena Costiera (Calabria). 1. La forra della Fiumara dei Bagni. Informatore Botanico Italiano 47(2): 187–204.

Maiorca G, Spampinato G (1994) The vascular flora of Argentino River valley, a nature reserve in NW Calabria (Italy). Flora Mediterranea 4: 49–100.

Maiorca G, Spampinato G (1999) La vegetazione della riserva naturale orientata "Valle del fiume Argentino"(Calabria nord-occidentale). Fitosociologia 36(2): 15–60.

Martellos S, Bartolucci F, Conti F, Galasso G, Moro A, Pennesi R, Peruzzi L, Pittao E, Nimis PL (2020) FlorItaly – the portal to the Flora of Italy. PhytoKeys 156: 55–71. https://doi.org/10.3897/phytokeys.156.54023

Mercurio R, Bagnato S, Scarfò F, Spampinato G (2007) I tipi forestali del versante occidentale del Parco Nazionale del Pollino. Edizioni Laruffa, Reggio Calabria.

Peruzzi L (2016) *Crocus heuffelianus* (Iridaceae), a new record for the Italian flora. Phytotaxa 261(3): 291–294. https://doi.org/10.11646/phytotaxa.261.3.10

Peruzzi L, Innangi M, Tatino F, Santangelo A (2017) *Fritillaria messanensis* subsp. *gracilis* (Liliaceae), a new record for the Italian flora (S Italy). Phytotaxa 307(2): 167–170. https://doi.org/10.11646/phytotaxa.307.2.11

Pimenov MG, Kljuykov EV, Ostroumova TA (2007) Critical taxonomic analysis of *Dichoropetalum*, *Johrenia*, *Zeravschania* and related genera of Umbelliferae-Apioideae-Peucedaneae. Willdenowia 37(2): 465–502. https://doi.org/10.3372/wi.37.37208

Pimenov MG, Leonov MV (1993) The Genera of the Umbelliferae. A Nomenclator. Royal Botanical Gardens, Kew & Botanical Garden of Moscow University.

Pimenov MG, Ostroumova TA (2012) Zontichnye (Umbelliferae) Rossii [Umbelliferae of Russia]. KMK Scientific Press, Moscow. [In Russian]

Plunkett GM, Pimenov MG, Reduron JP, Kljuykov EV, van Wyk BE, Ostroumova TA, Henwood MJ, Tilney PM, Spalik K, Watson MF, Lee BY, Pu FD, Webb CJ, Hart JM, Mitchell AD, Muckensturm B (2018) Genera of Apiaceae. In: Kadereit JW, Bittrich V, Kubitzki K (Eds) The Families and Genera of Vascular Plants (Vol. XV). Flowering plants. Eudicots: Apiales, Gentianales (except Rubiaceae). Cham: Springer International Publishing, 9–206. https://doi.org/10.1007/978-3-319-93605-5_2

Portal to the Flora of Italy (2023) Portale della Flora d'Italia/Portal to the Flora of Italy. 2022.1. https://dryades.units.it/floritaly/ [Accessed 18.04.2023]

POWO (2023) Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet. http://www.plantsoftheworldonline.org/ [Accessed 14.04.2023]

Reduron JP, Charpin A, Pimenov MG (1997) Contribution a la nomenclature generique des Apiaceae (Ombelliferes). Le Journal de Botanique de la Société de botanique de France 1: 91–104. https://doi.org/10.3406/jobot.1997.1657

Roma-Marzo F, Bernardo L, Liguori P, Peruzzi L (2016) Vascular flora of Monte Sparviere (Southern Italy, Pollino Massif). Atti della Societa Toscana di Scienze Naturali 122: 79–94. https://doi.org/10.2424/ASTSN.M.2015.08

Rosati L, Fascetti S, Romano VA, Potenza G, Lapenna MR, Capano A, Nicoletti P, Farris E, De Lange PJ, Del Vico E, Facioni L, Fanfarillo E, Lattanzi E, Cano-Ortiz A, Marignani M, Fogu MC, Bazzato E, Lallai E, Laface VLA, Musarella CM, Spampinato G, Mei G, Misano G, Salerno G, Esposito A, Stinca A (2020) New chorological data for the Italian vascular flora. Diversity 12(1): 22. https://doi.org/10.3390/d12010022

Scarfò F, Mercurio R, Bagnato S (2008) I tipi forestali della Riserva Naturale Orientata Valle del Fiume Argentino (Orsomarso, CS). Forest@ 5(4): 233–252. https://doi.org/10.3832/efor0536-0050233

Seidel CF (1889) VIII. *Peucedanum aegopodioides*. Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis in Dresden 1888: 86–92.

Spalik K, Reduron JP, Downie SR (2004) The phylogenetic position of *Peucedanum* sensu lato and allied genera and their placement in tribe Selineae (Apiaceae, subfamily Apioideae). Plant Systematics and Evolution 243(3–4): 189–210. https://doi.org/10.1007/s00606-003-0066-2

Spalik K, Wojewódzka A, Downie SR (2001) The delimitation of genera in Apiaceae with examples from Scandiceae subtribe Scandicinae. Edinburgh Journal of Botany 58(2): 331–346. https://doi.org/10.1017/S096042860100066X

Spampinato G, Laface VLA, Posillipo G, Ortiz AC, Canas RQ, Musarella CM (2022) Alien flora in Calabria (Southern Italy): an updated checklist. Biological Invasions 24: 2323–2334. https://doi.org/10.1007/s10530-022-02800-y

Stinca A, Musarella CM, Rosati L, Laface VLA, Licht W, Fanfarillo E, Wagensommer RP, Galasso G, Fascetti S, Esposito A, Fiaschi T, Nicolella G, Chianese G, Ciaschetti G, Salerno G, Fortini P, Di Pietro R, Perrino EV, Angiolini C, De Simone L, Mei G (2021) Italian Vascular Flora: New Findings, Updates and Exploration of Floristic Similarities between Regions. Diversity 13: e600. https://doi.org/10.3390/d13110600

Stinca A, Ricciardi M (2018) Fam. 176. Apiaceae (=Umbelliferae nom. conserv.). In: Pignatti S, Guarino R, La Rosa M (2018) Flora d'Italia 3. Edagricole di New Business Media (2nd edn.). Milano, Italy, 524–633.

Strid A, Franzén R (1983) Apiaceae: *Peucedanum aegopodioides* (Boiss.) Vandas. In: Löve A (Ed.) IOPB chromosome number reports LXXVIII. Taxon 32(1): 138–140. https://doi.org/10.1002/j.1996-8175.1983.tb02410.x

Terracciano N (1891) Synopsis Plantarum vascularium Montis Pollini. Annuario del Reale Istituto Botanico di Roma 4: 1–191. https://doi.org/10.5962/bhl.title.10001

Terracciano N (1896) Intorno alla flora del monte Pollino e delle terre adiacenti. Atti dell'Accademia delle Scienze Fisiche e Matematiche, ser. 2, 8(9): 1–18.

Terracciano N (1900) Addenda ad synopsis plantarum vascularium Montis Pollini. Annuario del Reale Istituto Botanico di Roma 9: 23–88.

Thiers B (2023) Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/science/ih [Accessed 18.04.2023]

Tutin TG (1968) *Peucedanum aegopodioides* (Boiss.) Vandas. In: Tutin TG, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM, Webb DA (Eds) Flora Europaea. Cambridge University Press, Cambridge 2: e362.

Vandas K (1889) Beiträge zur Kenntnis der Flora Bulgariens. Sitzungsberichte der königlichen Böhmischen Gesellschaft der Wissenschaften 1888(38): 430–453. https://doi.org/10.1007/BF01638757

Wagensommer RP, Bartolucci F, Fiorentino M, Wolfgang L, Peccenini S, Perrino EV, Venanzoni R (2017) First record for the flora of Italy and lectotypification of the name *Linum elegans* (Linaceae). Phytotaxa 296(2): 161–170. https://doi.org/10.11646/phytotaxa.296.2.5

Italian Botanist 15: 77–89 (2023)
doi: 10.3897/italianbotanist.15.105794
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

Notulae to the Italian alien vascular flora: 15

Gabriele Galasso[1], Gianniantonio Domina[2], Carlo Argenti[3], Enrico Bajona[4], Enrico Banfi[1], Davide Barberis[5], Giulio Barone[2], Fabrizio Bartolucci[6], Nello Biscotti[7], Fabrizio Bonali[8], Chiara Bonifazio[9], Daniele Bonsanto[7], Fabrizio Buldrini[10], Silvia Cannucci[11], Alessia Cozzolino[12], Antonino De Natale[13], Emanuele Del Guacchio[14], Emilio Di Gristina[2], Tiberio Fiaschi[11], Andrea Lallai[15], Michele Lonati[5], Fernando Lucchese[16], Jacopo Lupoletti[17], Niccolò Marchi[18], Riccardo Motti[12], Ginevra Nota[5], Antonio Pica[19], Marco Pittarello[20], Giovanna Potenza[21], Giuseppe Ratini[22], Franco Rota[23], Francesco Santi[10], Claudio Santini[24], Marco Sarigu[15], Alberto Selvaggi[25], Marco Simonazzi[26], Federico M. Tardella[27], Silvia Tripi[9], Roberto Vetromile[28], Lorenzo Lastrucci[29]

1 *Sezione di Botanica, Museo di Storia Naturale di Milano, Corso Venezia 55, 20121 Milano, Italy* **2** *Dipartimento di Scienze Agrarie, Alimentari e Forestali (SAAF), Università di Palermo, Viale delle Scienze, edificio 4, 90128 Palermo, Italy* **3** *Via E. Pietriboni 7, 32100 Belluno, Italy* **4** *PLANTA/Center for Research, Documentation and Training, Via Serraglio Vecchio 28, 90123 Palermo, Italy* **5** *Dipartimento di Scienze Agrarie, Forestali e Alimentari (DISAFA), Università di Torino, Largo P. Braccini 2, 10095 Grugliasco (Torino), Italy* **6** *Centro Ricerche Floristiche dell'Appennino (Università di Camerino - Parco Nazionale del Gran Sasso e Monti della Laga), San Colombo, 67021 Barisciano (L'Aquila), Italy* **7** *Dipartimento di Scienze Agrarie, Alimentari ed Ambientali (D3A), Università Politecnica delle Marche, Via Brecce Bianche 10, 60131 Ancona, Italy* **8** *Via G. Carnevali 2, 26100 Cremona, Italy* **9** *Dipartimento di Scienze della Terra, dell'Ambiente e della Vita (DISTAV), Università di Genova, Corso Europa 26, 16132 Genova, Italy* **10** *Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Alma Mater Studiorum Università di Bologna, Via Irnerio 42, 40126 Bologna, Italy* **11** *Dipartimento di Scienze della Vita, Università di Siena, Via P.A. Mattioli 4, 53100 Siena, Italy* **12** *Dipartimento di Agraria, Università di Napoli Federico II, Via Università 100, 80055 Portici (Napoli), Italy* **13** *Dipartimento di Biologia, Università di Napoli Federico II, Via Vicinale Cupa Cintia 21, 80126 Napoli, Italy* **14** *Dipartimento di Biologia, Università di Napoli Federico II, c/o Orto Botanico, Via Foria 223, 80139 Napoli, Italy* **15** *Centro Conservazione Biodiversità (CCB), Dipartimento di Scienze della Vita e dell'Ambiente (DISVA), Università di Cagliari, Viale Sant'Ignazio da Laconi 13, 09123 Cagliari, Italy* **16** *Dipartimento di Scienze, Università di Roma Tre, Viale G. Marconi 446, 00146 Roma, Italy* **17** *Vico del Sacco 22, 64032 Atri (Teramo), Italy* **18** *Via P. Micca 23, 35129 Padova, Italy* **19** *Via Strada Storta 11, 66100 Chieti, Italy* **20** *Dipartimento di Scienze Veterinarie, Università di Torino, Largo P. Braccini 2, 10095 Grugliasco (Torino), Italy* **21** *Scuola di Scienze Agrarie, Forestali, Alimentari e Ambientali, Università della Basilicata, Via dell'Ateneo Lucano 10, 85100 Potenza, Italy* **22** *Via della Lepre 11, 05100 Terni, Italy* **23** *Strada Gariglio 14, 12042 Bra (Cuneo), Italy* **24** *Via Sant'Orsola 7, 41121 Modena, Italy* **25** *Istituto per le Piante da Legno e l'Ambiente (IPLA), Corso Casale 476, 10132 Torino, Italy* **26** *Via G. Bianchi 10, 46020 Pegognaga (Mantova), Italy* **27** *Herbarium Universitatis Camerinensis, Scuola di Bioscienze e Medicina Veterinaria, Università di Camerino, Via Pontoni 5, 62032 Camerino, Italy* **28** *Via G. Boccaccio 5, 80048 Sant'Anastasia (Napoli), Italy* **29** *Sistema Museale di Ateneo, Università di Firenze, Via G. La Pira 4, 50121 Firenze, Italy*

Copyright *Gabriele Galasso et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Corresponding author: Gabriele Galasso (gabriele.galasso@comune.milano.it)

Academic editor: Lorenzo Peruzzi | Received 2 May 2023 | Accepted 12 May 2023 | Published 22 May 2023

Citation: Galasso G, Domina G, Argenti C, Bajona E, Banfi E, Barberis D, Barone G, Bartolucci F, Biscotti N, Bonali F, Bonifazio C, Bonsanto D, Buldrini F, Cannucci S, Cozzolino A, De Natale A, Del Guacchio E, Di Gristina E, Fiaschi T, Lallai A, Lonati M, Lucchese F, Lupoletti J, Marchi N, Motti R, Nota G, Pica A, Pittarello M, Potenza G, Ratini G, Rota F, Santi F, Santini C, Sarigu M, Selvaggi A, Simonazzi M, Tardella FM, Tripi S, Vetromile R, Lastrucci L (2023) Notulae to the Italian alien vascular flora: 15. Italian Botanist 15: 77–89. https://doi.org/10.3897/italianbotanist.15.105794

Abstract

In this contribution, new data concerning the distribution of vascular flora alien to Italy are presented. It includes new records, confirmations, exclusions for Italy or for Italian administrative regions. Nomenclatural and distribution updates, published elsewhere, and corrections are provided as Suppl. material 1.

Keywords

Alien species, floristic data, Italy, nomenclature

How to contribute

The text for the new records, exclusions, and confirmations should be submitted electronically to Lorenzo Lastrucci (lorenzo.lastrucci@unifi.it). The corresponding specimen along with its scan or photograph has to be sent to FI Herbarium: Museo di Storia Naturale (Botanica), Sistema Museale di Ateneo, Via G. La Pira 4, 50121 Firenze (Italy). Those texts concerning nomenclatural novelties and typifications (only for accepted names) should be submitted electronically to Gabriele Galasso (gabriele.galasso@comune.milano.it). Each text should be within 1,000 characters (spaces included).

Floristic records

Acer buergerianum Miq. subsp. *buergerianum* (Sapindaceae)

+ (CAS) TAA: Lavis (Trento), loc. Stazione di Lavis (WGS84: 46.147654°N, 11.099471°E), in una aiuola, 212 m, 14 August 2021, *M. Simonazzi* (FI, ROV). – Casual alien species new for the flora of Trentino-Alto Adige.

A few young individuals (height below 50 cm) were found in an urban flowerbed.

M. Simonazzi

***Acer palmatum* Thunb. (Sapindaceae)**

+ (CAS) TAA: Tenna (Trento), loc. Visintainer, Biotopo "Pizè", sponda del Torrente Vignola (WGS84: 46.0322870°N, 11.2620333°E), sponda torrentizia, 480 m, 25 April 2022, leg. *N. Marchi*, det. *N. Marchi*, *M. Simonazzi* (FI). – Casual alien species new for the flora of Trentino-Alto Adige.

An individual was found in the wild along the banks of the Vignola creek.

N. Marchi, M. Simonazzi

***Acer tataricum* L. subsp. *ginnala* (Maxim.) Wesm. (Sapindaceae)**

+ (CAS) TAA: Levico Terme (Trento), loc. Someari, Biotopo "Le inghiaie", sponda della roggia "La vena" (WGS84: 46.0006175°N, 11.3176637°E), sponda di roggia al margine del bosco, 436 m, 7 June 2021, leg. *N. Marchi*, det. *M. Simonazzi*, *N. Marchi* (FI, ROV). – Casual alien subspecies new for the flora of Trentino-Alto Adige.

A few individuals were found along the banks of the Vena creek.

N. Marchi, M. Simonazzi

***Aesculus hippocastanum* L. (Sapindaceae)**

+ (CAS) PUG: Vico del Gargano (Foggia), loc. Mastrocianni (WGS84: 41.887860°N, 15.953290°E), margine stradale, 420 m, 29 August 2022, *N. Biscotti*, *D. Bonsanto* (FI). – Casual alien species new for the flora of Puglia.

N. Biscotti, D. Bonsanto

***Aloë perfoliata* L. (Asphodelaceae)**

+ (CAS) SIC: Petrosino (Trapani), Torre Sibiliana (WGS84: 37.723575°N, 12.473320°E), arid garrigue, 2 m, 11 May 2022, *G. Domina* (FI, PAL). – Casual alien species new for the flora of Sicilia.

Some flowering individuals were observed.

E. Di Gristina, G. Barone

***Bambusa vulgaris* Schrad. ex J.C.Wendl. (Poaceae)**

– **ITALIA** (**SAR**). – Alien species to be excluded from the flora of Italy (Sardegna).

Based on a review of the available literature, all the naturalized bamboo populations of Sardegna previously attributed to this species (Martinoli 1951; Camarda et al. 2016; Galasso et al. 2018; Calvia and Ruggero 2020) are to be attributed to *Phyllostachys aurea* Carrière ex Revière & C.Revière. *Bambusa vulgaris* 'Vittata' is cultivated in some gardens as ornamental.

A. Lallai, M. Sarigu

***Bidens sulphurea* (Cav.) Sch.Bip. (Asteraceae)**

+ (CAS) BAS: Potenza (Potenza), Discesa San Gerardo (WGS84: 40.641315°N, 15.805873°E), bordo strada, 790 m, 15 September 2021, *L. Rosati*, *G. Potenza* (FI). – Casual alien species new for the flora of Basilicata.

We observed some flowering individuals.

G. Potenza

***Calocedrus decurrens* (Torr.) Florin (Cupressaceae)**

+ (CAS) EMR: Modena (Modena), Cimitero di San Cataldo, tombe antiche sul lato S presso l'ingresso lato Piazza F. Setti (WGS84: 44.658293°N, 10.909558°E), angolo di terreno incolto coperto d'edera presso il muro di cinta, 35 m, 19 November 2022, *F. Buldrini*, *C. Santini* (FI). – Casual alien species new for the flora of Emilia-Romagna.

One individual, probably 3–5 years old (23-cm tall), grows in a shady place at about 40 m from the putative parent plants (four adult ornamental trees in a row).

F. Buldrini, C. Santini

***Catalpa bignonioides* Walter (Bignoniaceae)**

+ (CAS) TOS: Siena (Siena), fiume canalizzato vicino all'area industriale (WGS84: 43.310626°N, 11.359643°E), 213 m, 29 July 2022, leg. *T. Fiaschi*, *R. Fedeli*, det. *T. Fiaschi*, *S. Cannucci* (FI, SIENA). – Casual alien species new for the flora of Toscana.

This species is similar to *Catalpa ovata* G.Don and *C. speciosa* Teas. According to Olsen and Kirkbride (2017), it differs from *C. ovata* by the leaf morphology (trilobate leaf blade in *C. ovata vs* entire in *C. bignonioides*). The differences between *C. bignonioides* and *C. speciosa* concern seed body dimensions and morphological aspects, i.e., 4.5–5.5×30–42 mm, with sides drawn out to an acute apex in *C. bignonioides vs* 5.5–7.5×26–31 mm, with sides drawn out to an obtuse apex in *C. speciosa*. Some young individuals and some fruiting ones were found.

T. Fiaschi, S. Cannucci

***Cedrus atlantica* (Endl.) G.Manetti ex Carrière (Pinaceae)**

+ (CAS) LIG: Pornassio (Imperia), Colle di Nava, lungo la strada che dalla strada SS28 Nord porta al Forte Centrale (WGS84: 44.083667°N, 7.873605°E), muretto a secco che costeggia la strada, 943 m, 19 September 2022, *M. Lonati*, *G. Nota* (FI). – Casual alien species new for the flora of Liguria.

A young individual was found on dry-stone walls along a paved road near the Forte Centrale. Other individuals, about 30–40-cm tall, also grew on the walls of the Forte. These individuals were generated by adult *Cedrus atlantica* trees cultivated in the surroundings.

M. Lonati, G. Nota

***Datura innoxia* Mill. (Solanaceae)**

– PIE. – Alien species to be excluded from the flora of Piemonte.

This species was reported for Piemonte by Abbà (1977, 1986), Correggia (2002), Rota and Cavallo (2005), and Lonati (2006). The specimens from Alba (Cuneo) and Baldissero d'Alba (Cuneo), cited by Abbà (1977, 1986) and preserved in ALBA (Pistarino et al. 1999), should be referred to *Datura wrightii* Regel (revision by A. Selvaggi, F. Rota, 25 November 2022). The specimens from Pocapaglia (Cuneo), cited by Rota and Cavallo (2005) and preserved in CBRA and ALBA, and the plant collected in 1879 by F. Craveri in Bra (Cuneo) and conserved in CBRA (Rota and Cavallo 2005) should be referred to *D. wrightii* (revision by F. Rota, 25 November 2022). The specimen from Viverone (Biella), cited by Lonati (2006) and preserved in TO, should also be referred to *D. wrightii* (revision by A. Selvaggi, 3 November 2022). The record by Correggia (2002) from Mondonio, in the municipality of Castelnuovo Don Bosco (Asti), has no linked specimens that can be verified and the epheremal populations recorded in 2002 are at present not confirmed. Moreover, the photo of the plant seen in this place seems to refer to *D. wrightii*. Consequently, *Datura innoxia* is excluded from the flora of Piemonte.

A. Selvaggi, F. Rota

***Datura wrightii* Regel (Solanaceae)**

+ (CAS) VDA: Chambave (Aosta), ambienti ruderali a W della ex stazione ferroviaria (WGS84: 45.74418°N, 7.55635°E), ambiente ruderale, 468 m, 15 August 2022, *A. Selvaggi* (FI, AO). – Casual alien species new for the flora of Valle d'Aosta.

A. Selvaggi

***Digitaria violascens* Link (Poaceae)**

+ (CAS) LIG: Santo Stefano di Magra (La Spezia), tra Falcinello (fraz. di Sarzana) e Ponzano Superiore (WGS84: 44.159202°N, 9.954352°E), bordo strada, 300 m, 21 September 2019, leg. *S. Argenti*, *C. Argenti*, det. *C. Argenti*, conf. *F. Verloove* (FI, *Herb. C. Argenti*). – Casual alien species new for the flora of Liguria.

Several individuals were found.

C. Argenti

***Ehrharta erecta* Lam. (Poaceae)**

+ (CAS) LIG: Santo Stefano al Mare (Imperia), sulla costa (WGS84: 43.837915°N, 7.893002°E), spiaggia, 0 m, 21 March 2022, *C. Bonifazio*, *S. Tripi* (FI); Taggia (Imperia), Arma di Taggia, sulla costa (WGS84: 43.830717°N, 7.852751°E), spiaggia, 0 m, 8 April 2022, *C. Bonifazio*, *S. Tripi* (FI). – Casual alien species new for the flora of Liguria.

S. Tripi, C. Bonifazio

***Eragrostis mexicana* (Hornem.) Link subsp. *virescens* (J.Presl) S.D.Koch & Sánchez Vega (Poaceae)**

+ (CAS) BAS: Viggiano (Potenza), Via Valloni 2^ Traversa (WGS84: 40.312842°N, 15.920795°E), a lato strada, 584 m, 20 September 2022, leg. et det. *F. Santi*, conf. *E. Banfi* (FI). – Casual alien subspecies new for the flora of Basilicata.

F. Santi

***Gazania linearis* (Thunb.) Druce (Asteraceae)**

+ (CAS) CAM: Centola (Salerno), spiaggia a S di Torre dei Caprioli (WGS84: ca. 40.051801°N, 15.282958°E), spiaggia, 0 m, 17 March 1994, *A. De Natale* (*Herb. A. De Natale* No. 2904). – Casual alien species new for the flora of Campania.

According to the key published by Laguna Lumbreraras and Ferrer Gallego (2013), the specimens cited as *Gazania rigens* (L.) Gaertn. for Cilento by De Natale and Strumia (2007) are to be attributed to *G. linearis*.

E. Del Guacchio, A. De Natale

***Impatiens parviflora* DC. (Balsaminaceae)**

+ (NAT) MAR: Arquata del Tronto (Ascoli Piceno), Pescara del Tronto, Parco Nazionale del Gran Sasso e Monti della Laga, lungo la sponda destra del Fiume Tronto (WGS84: 42.74840636°N, 13.27191404°E), megaforbieto ripariale, 660 m, 8 September 2022, *F.M. Tardella*, *R. Pennesi*, *R. Vetromile* (FI, CAME). – Naturalized alien species new for the flora of Marche.

The species can be found sporadically along the banks of the Tronto river.

F.M. Tardella, R. Vetromile

***Jasminum nudiflorum* Lindl. (Oleaceae)**

+ (CAS) PUG: Vico del Gargano (Foggia), centro storico (WGS84: 41.919412°N, 15.920386°E), in sacche di terra su roccia, 442 m, 21 February 2022, *D. Bonsanto*, *N. Biscotti* (FI). – Casual alien species new for the flora of Puglia.

D. Bonsanto, N. Biscotti

***Oenothera speciosa* Nutt. (Onagraceae)**

+ (CAS) ABR: Chieti (Chieti), quartiere Chieti Scalo, Via Pescasseroli (WGS84: 42.362654°N, 14.144006°E), incolto al margine della strada, ambiente urbano con vegetazione sinantropica, 38 m, 5 May 2022, *A. Pica*, *J. Lupoletti* (FI). – Casual alien species new for the flora of Abruzzo.

The species covered about 30 m^2.

A. Pica, J. Lupoletti

***Opuntia microdasys* (Lehm.) Pfeiff. (Cactaceae)**

+ (NAT) UMB: Arrone (Terni), fraz. Casteldilago, rupe inaccessibile sotto il paese (WGS84: 42.578190°N, 12.759101°E), rupe, 235 m, 30 October 2021, *F. Lucchese* (photo in FI). – Naturalized alien species new for the flora of Umbria.

F. Lucchese, G. Ratini

***Opuntia monacantha* Haw. (Cactaceae)**

+ (CAS) UMB: Arrone (Terni), fraz. Casteldilago, rupe inaccessibile sotto il paese (WGS84: 42.578090°N, 12.759189°E), rupe, 252 m, 30 October 2021, leg. *F. Lucchese*, det. *A. Guiggi* (photo in FI). – Casual alien species confirmed for the flora of Umbria.

Opuntia monacantha was previously reported as doubtfully occurring in Umbria (Galasso et al. 2018), but this record turned out to be never published. The plants are mixed with many individuals of *O. humifusa* (Raf.) Raf.

F. Lucchese, G. Ratini

***Opuntia stricta* (Haw.) Haw. (Cactaceae)**

+ (INV) UMB: Terni (Terni), loc. Le Pisciarelle (WGS84: 42.604104°N, 12.611363°E), pendio pietroso in radura boschiva con leccio e *Pinus halepensis*, 400 m, 17 October 2022, leg. *P. Ratini*, det. *A. Guiggi* (FI). – Invasive alien species new for the flora of Umbria.

Opuntia stricta was observed also in other localities in the province of Terni: Arrone, fraz. Casteldilago (WGS84: 42.578090°N, 12.759189°E); Amelia, fraz. Fornole (WGS84: 42.539353°N, 12.459980°E, and 42.541411°N, 12.465183°E); Amelia, fraz. Sambucetole (WGS84: 42.596905°N, 12.435835°E). This species invades terraces of former olive groves, holm oak clearings, natural cliffs, and artificial escarpments. In the locality upstream of Fornole, about 31 ha are covered by it. In the locality of Le Pisciarelle, it may have hybridized with *O. humifusa* (Raf.) Raf. with which it shares the same habitat.

F. Lucchese, G. Ratini

***Paspalum denticulatum* Trin. (Poaceae)**

+ (NAT) ITALIA (LOM): Milano (Milano), Largo Cairoli, aiuola attorno al monumento in centro alla piazza (WGS84: 45.468240°N, 9.182434°E), tappeto erboso, 124 m, no exp., 5 July 2021, leg. *G. Galasso*, det. *E. Banfi* (MSNM No. 51237 sub *P. dilatatum*); *ibidem*, 21 September 2021, leg. *G. Galasso*, det. *E. Banfi* (MSNM No. 51238 sub *P. dilatatum*); *ibidem*, Via Monte Cimone, spartitraffico alberato (WGS84: 45.450573°N, 9.226346°E), tappeto erboso, 109 m, no exp., 20 November 2022, *E. Banfi* (FI, MSNM barcode MSNM52201). – Naturalized alien species new for the flora of Italy (Lombardia).

This species is native to central-southern America, and shows a high diversity; it belongs to a group of four taxa, treated as synonyms by Zuloaga and Morrone (2005) and by Denham et al. (2010), the best known of which is *Paspalum lividum* Trin. ex Schltdl. The latter name was adopted by Allen and Hall (2003) in the treatment of Flora of North America. In any case, even keeping the two species separate, our find fits better with *P. denticulatum* on morphological grounds, especially regarding the width of the leaf blade (up to 9 mm).

E. Banfi, G. Galasso

***Perilla frutescens* (L.) Britton (Lamiaceae)**

+ (CAS) CAM: Napoli (Napoli), Via M. Pietravalle (WGS84: 40.868711°N, 14.226402°E), bordo strada, 251 m, 21 June 2020, leg. *R. Motti*, det. *A. Cozzolino*, *R. Motti* (FI, PORUN). – Casual alien species new for the flora of Campania.

R. Motti, A. Cozzolino

***Petunia axillaris* (Lam.) Britton, Sterns & Poggenb. (Solanaceae)**

+ (CAS) SIC: Palermo (Palermo), Via Imera (WGS84: 38.117153°N, 13.348883°E), negli interstizi dei marciapiedi, 30 m, 16 July 2021, leg. *E. Di Gristina*, det. *E. Di Gristina*, *G. Domina* (FI). – Casual alien species new for the flora of Sicilia.

Petunia axillaris is an annual herbaceous plant native to temperate southern America, caracterized by a hypocraterimorph white corolla, with a sub-terete tube (Flora e Funga do Brasil 2023 [onwards]). Some mature individuals have been found.

E. Di Gristina, G. Barone

***Physalis philadelphica* Lam. (Solanaceae)**

+ (CAS) ABR: Scafa (Pescara), loc. Decontra (WGS84: 42.239886°N, 14.025695°E), margine stradale nei pressi di una cava di gesso caratterizzato da vegetazione ruderale, 216 m, 16 October 2021, *J. Lupoletti*, *A. Pica* (FI). – Casual alien species new for the flora of Abruzzo.

A single specimen was observed.

J. Lupoletti, A. Pica

***Ruellia simplex* C.Wright (Acanthaceae)**

+ (CAS) SIC: Palermo (Palermo), lungo Corso Tukory (WGS84: 38.108403°N, 13.357091°E), aiuola e bordo strada, 30 m, 6 July 2022, *E. Bajona* (FI, PAL). – Casual alien species new for the flora of Sicilia.

In Sicilia, *Ruellia simplex* spreads spontaneously also in the Botanical Garden of Palermo, where it grows in some pots and flowerbeds, near the cultivated specimen.

E. Bajona

***Saxifraga stolonifera* Curtis (Saxifragaceae)**

+ (CAS) PIE: Mergozzo (Verbano-Cusio-Ossola), nei pressi di Via Nostrani Celso (WGS84: 45.959391°N, 8.448122°E), terrazzamento incolto e muretti a secco adiacenti alla strada, 218 m, 6 September 2021, *M. Pittarello*, *D. Barberis* (FI). – Casual alien species new for the flora of Piemonte.

The species has colonized an area of a few square meters.

M. Pittarello, D. Barberis

***Solanum nitidibaccatum* Bitter (Solanaceae)**

+ (NAT) LOM: Acquanegra Cremonese (Cremona), Via Crotta D'Adda (WGS84: 45.163122°N, 9.887033°E), campo con stoppie di mais, 42 m, no exp, 31 October 2022, *F. Bonali* (FI, *Herb. F. Bonali*). – Naturalized alien species new for the flora of Lombardia.

Numerous individuals are present in three contiguous fields.

F. Bonali

***Tulbaghia violacea* Harv. (Amaryllidaceae)**

+ (CAS) LIG: Pietra Ligure (Savona), scogli di retrospiaggia presso il confine con Loano (WGS84: 44.139524°N, 8.269283°E), rupi costiere con accumulo di sabbia, 5 m, no exp., 30 August 2022, *G. Galasso* (FI, MSNM barcode MSNM52197). – Casual alien species new for the flora of Liguria.

A single small tuft was observed.

G. Galasso, E. Banfi

Nomenclatural and distribution updates from other literature sources

Nomenclatural, status, and distribution updates according to Abbà (1977), Applequist (2023), Bonali (2023), Brusa (2022), Cambria et al. (2023), Carrega and Silla (1999), Conti and Bartolucci (2023), Conti and Giacanelli (2023), Conti et al. (2023), Denham et al. (2010), Di Pietro et al. (2022), Galasso (2009, 2023), Ganz (2022), Ganz et al. (2022a, 2022b), Gariboldi (2022), Iamonico and Bovio (2023), IPNI (2022 [onwards]), Manzi and Truzzi (2023), Martínez-González et al. (2022), Peruzzi (2023), POWO (2022 [onwards], 2023 [onwards]), Prosser et al. (2022), Sennikov et al. (2023), Simonazzi and Truzzi (2023), Tropicos (2022 [onwards]), Viegi and Cela Renzoni (1981), Villa et al. (2022), and Wilson (2022), and corrections to Galasso et al. (2018) and subsequent updates summarised in the Portal to the Flora of Italy (2023) are provided in Suppl. material 1.

G. Galasso, F. Bartolucci

Acknowledgements

We gratefully acknowledge Pablo P. Ferrer-Gallego who confirmed the identification of *Gazania linearis*, Alessandro Guiggi who identified the specimens of *Opuntia monacantha* and *O. stricta*, Laura Guglielmone and Gianni Repetto for the help in consulting herbariums TO and ALBA respectively, and Maurizio Bovio, Franco Correggia, Daniela Longo and Lorenzo Peruzzi who provided informations on distribution.

References

Abbà G (1977) La flora del territorio alla sinistra del Tanaro. Tra Bra ed Asti e tra Alba e Pralormo. Allionia 22: 221–227.

Abbà G (1986) La flora delle Langhe. Alba Pompeia 7(1): 35–52.

Allen CM, Hall DW (2003) *Paspalum* L. In: Flora of North America Editorial Committee (Ed.) Flora of North America North of Mexico, Vol. 25. Oxford University Press, New York, Oxford, 566–599.

Applequist WL (2023) Report of the Nomenclature Committee for Vascular Plants: 73. Taxon 72(1): 179–204. https://doi.org/10.1002/tax.12871

Bonali F (2023) Notulae 591–601. In: Galasso G, Banfi E (Eds) Notulae ad plantas advenas Longobardiae spectantes: 10 (567–673). Pagine Botaniche 44–45 [2021–2022]: 178–184.

Brusa G (2022) Contributo all'incremento delle conoscenze floristiche in Valle d'Aosta. Revue Valdôtaine d'Histoire Naturelle 76: 55–68.

Calvia G, Ruggero A (2020) The vascular flora of Mount Limbara (northern Sardinia): from a troubled past towards an uncertain future. Flora Mediterranea 30: 293–313. https://doi.org/10.7320/FlMedit30.293

Camarda I, Cossu TA, Carta L, Brunu A, Brundu G (2016) An updated inventory of the non-native flora of Sardinia (Italy). Plant Biosystems 150(5): 1106–1118. https://doi.org/10.1080/11263504.2015.1115438

Cambria S, Azzaro D, Caldarella O, Aleo M, Bazan G, Guarino R, Torre G, Cristaudo AE, Ilardi V, La Rosa A, Laface VLA, Luchino F, Mascia F, Minissale P, Sciandrello S, Tosetto L, Tavilla G (2023) New data on native and alien vascular flora of Sicily (Italy): new findings and updates. Plants 12(9): 1743. https://doi.org/10.3390/plants12091743

Carrega M, Silla D (1999) Ricerche floristiche nel Novese e nel Tortonese (Povincia di Alessandria, Piemonte sud orientale) (Aggiornamento anni 1994–1997). Rivista Piemontese di Storia Naturale 20: 3–18.

Conti F, Bartolucci F (2023) Taxonomy and distribution of *Spiraea hypericifolia* in Italy and typification of the name *S. flabellata* (Rosaceae). Plants 12(3): 536. https://doi.org/10.3390/plants12030536

Conti F, Falcinelli F, Giacanelli V, Santucci B, Miglio M, Manzi A, Bartolucci F (2023) New floristic data of vascular plants from central Italy. Natural History Sciences 10(1): 51–56. https://doi.org/10.4081/nhs.2023.636

Conti F, Giacanelli V (2023) Contribution to the vascular flora of Ventotene and Santo Stefano islands (Isole Ponziane, Lazio, Italy) with two taxa new to Lazio. Natural History Sciences 10(1): 83–86. https://doi.org/10.4081/nhs.2023.637

Correggia F (2002) Flora vascolare del settore nord-occidentale della provincia di Asti (Piemonte, Italia NW). Rivista Piemontese di Storia Naturale 23: 3–92.

De Natale A, Strumia S (2007) La flora della costa sabbiosa del Parco Nazionale del Cilento e Vallo di Diano (Salerno). Webbia 62(1): 53–75. https://doi.org/10.1080/00837792.2007.10670816

Denham SS, Morrone O, Zuloaga FO (2010) Estudios en el género *Paspalum* (Poaceae, Panicoideae, Paniceae): *Paspalum denticulatum* y especies afines. Annals of the Missouri Botanical Garden 97(1): 11–33. https://doi.org/10.3417/2008092

Di Pietro R, Giardini M, Iamonico D, Tondi G, Angeloni D, Carli E, Aleffi M, Azzella MM, Di Pietro F, Proietti E, Ravera S, Fortini P (2022) Floristic and coenological data from the travertine substrates of the SAC "Travertini Acque Albule (Bagni di Tivoli)" (Lazio Region – Central Italy). Plant Sociology 59(2): 51–70. https://doi.org/10.3897/pls2022592/05

Flora e Funga do Brasil (2023 [onwards]) *Petunia*. In: Flora e Funga do Brasil. Jardim Botânico do Rio de Janeiro. https://floradobrasil.jbrj.gov.br/FB14687 [Accessed 28.03. 2023]

Galasso G (2009) Notulae 5–6. In: Nepi C, Peccenini S, Peruzzi L (Eds) Notulae alla flora esotica d'Italia: 1 (1–21). Informatore Botanico Italiano 41(2): 359–360.

Galasso G (2023) Notulae 567–571. In: Galasso G, Banfi E (Eds) Notulae ad plantas advenas Longobardiae spectantes: 10 (567–673). Pagine Botaniche 44–45[2021–2022]: 157–160.

Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E, Celesti-Grapow L, Albano A, Alessandrini A, Bacchetta G, Ballelli S, Bandini Mazzanti M, Barberis G, Bernardo L, Blasi C, Bouvet D, Bovio M, Cecchi L, Del Guacchio E, Domina G, Fascetti S, Gallo L, Gubellini L, Guiggi A, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Podda L, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Bartolucci F (2018) An updated checklist of the vascular flora alien to Italy. Plant Biosystems 152(3): 556–592. https://doi.org/10.1080/11263504.2018.1441197

Ganz C (2022) Nota 275. *Dysphania ambrosioides* (L.) Mosyakin & Clemants (Chenopodiaceae). In: Bovio M (Ed.) Note di aggiornamento al volume Flora vascolare della Valle d'Aosta – 8. Revue Valdôtaine d'Histoire Naturelle 76: 91.

Ganz C, Bovio M, Broglio M (2022a) Nota 278. *Calendula officinalis* L. (Asteraceae). In: Bovio M (Ed.) Note di aggiornamento al volume Flora vascolare della Valle d'Aosta – 8. Revue Valdôtaine d'Histoire Naturelle 76: 92.

Ganz C, Bovio M, Broglio M (2022b) Nota 276. *Syringa vulgaris* L. (Oleaceae). In: Bovio M (Ed.) Note di aggiornamento al volume Flora vascolare della Valle d'Aosta – 8. Revue Valdôtaine d'Histoire Naturelle 76: 91.

Gariboldi L (2022) Note floristiche interessanti per la Lombardia, e non solo. Secondo contributo. Pianura 41: 26–40.

Iamonico D, Bovio M (2023) Studies on the genus *Atriplex* (Chenopodiaceae) in Italy. VII. *Atriplex micrantha* and *A. oblongifolia*. Hacquetia 22(1): 97–105. https://doi.org/10.2478/hacq-2022-0010

IPNI (2022[onwards]) *Aesculus carnea* Zeyher. In: International Plant Names Index. The Royal Botanic Gardens, Kew, Harvard University Herbaria & Libraries and Australian National Botanic Gardens. https://www.ipni.org/n/927643-1 [Accessed 21.12.2022]

Laguna Lumbreras E, Ferrer Gallego PP (2013) *Gazania* Gaertn. (Asteraceae): táxones escapados de cultivo en la Comunidad Valenciana (España). Bouteloua 13: 3–10.

Lonati M (2006) Nota n. 33. *Datura innoxia* Miller (Solanaceae). In: Selvaggi A, Soldano A, Pascale M (Eds) Note floristiche piemontesi n. 13–47. Rivista Piemontese di Storia Naturale 27: 435.

Manzi G, Truzzi A (2023) Notulae 581–583. In: Galasso G, Banfi E (Eds) Notulae ad plantas advenas Longobardiae spectantes: 10 (567–673). Pagine Botaniche 44–45 [2021–2022]: 171–174.

Martínez-González CR, Gallegos-Vázquez C, Mascorro-Gallardo JO, Barrientos-Priego AF (2022) Molecular and morphological notes on *Opuntia* ser. *Streptacanthae* (Cactaceae). Phytotaxa 576(1): 1–28. https://doi.org/10.11646/phytotaxa.576.1.1

Martinoli G (1951) Index seminum 1951. Hortus Calaritanus, Cagliari.

Olsen RT, Kirkbride JH (2017) Taxonomic revision of the genus *Catalpa* (Bignoniaceae). Brittonia 69(3): 387–421. https://doi.org/10.1007/s12228-017-9471-7

Peruzzi L (2023) The vascular flora of Empoli (Tuscany, central Italy). Italian Botanist 15: 21–33. https://doi.org/10.3897/italianbotanist.15.101748

Pistarino A, Forneris G, Fossa V (1999) Le collezioni di Giacinto Abbà. Catalogo e note critiche delle raccolte botaniche in Piemonte (1965–1998), Vols 1–2. Museo Regionale di Scienze Naturali di Torino, Torino.

Portal to the Flora of Italy (2023) Portale della Flora d'Italia/Portal to the Flora of Italy. 2022.2. https://dryades.units.it/floritaly/ [Accessed 30.04.2023]

POWO (2022[onwards]) *Aesculus* ×*carnea* Zeyh. In: Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:927643-1 [Accessed 21.12.2022]

POWO (2023[onwards]) *Gazania* ×*splendens* Hend. & A.A.Hend. In: Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:208729-1 [Accessed 04.04.2023]

Prosser F, Bertolli A, Festi F, Tomasi G (2022) Segnalazioni floristiche veronesi. II. Annali del Museo Civico di Rovereto. Sezione: Archeologia, Storia, Scienze Naturali 38: 39–58. https://doi.org/10.53135/ANNMUSCIVROV20223804

Rota F, Cavallo O (2005) Nuovi dati sulla flora del territorio alla sinistra del Tanaro fra Alto Monferrato e Roero. Alba Pompeia 26: 5–55.

Sennikov A, Khassanov F, Ortikov E, Kurbonaliyeva M, Tojibaev KS (2023) The genus *Iris* L. s.l. (Iridaceae) in the mountains of central Asia biodiversity hotspot. Plant Diversity of Central Asia 2(1): 1–104. https://doi.org/10.54981/PDCA/vol2_iss1/a1

Simonazzi M, Truzzi A (2023) Notulae 578–580. In: Galasso G, Banfi E (Eds) Notulae ad plantas advenas Longobardiae spectantes: 10 (567–673). Pagine Botaniche 44–45[2021–2022]: 168–171.

Tropicos (2022[onwards]) *Aesculus* ×*carnea* J. Zeyh. In: Tropicos v3.3.2. Tropicos.org. Missouri Botanical Garden. https://www.tropicos.org/name/100489228 [Accessed 21.12.2022]

Viegi L, Cela Renzoni G (1981) Flora esotica d'Italia: le specie presenti in Toscana. Consiglio Nazionale delle Ricerche, Collana del Programma finalizzato "Promozione della qualità dell'ambiente" AQ/1/132, Pavia.

Villa M, Banfi E, Galasso G (2022) Flora vascolare del Parco regionale di Montevecchia e della Valle del Curone (Lombardia, Italia settentrionale). Natura 112(2): 1–64.

Wilson KL (2022) Report of the General Committee: 24. Taxon 71(6): 1315–1318. https://doi.org/10.1002/tax.12862

Zuloaga FO, Morrone O (2005) Revisión de las especies de *Paspalum* para América del sur austral (Argentina, Bolivia, Sur del Brasil, Chile, Paraguay y Uruguay). Missouri Botanical Garden Press, St. Louis.

Supplementary material 1

Categories concerning the occurrence status of taxa

Authors: Gabriele Galasso, Fabrizio Bartolucci

Data type: species data

Explanation note: 1. Nomenclatural updates; 2. Note updates; 3. Distribution updates; 4. Synonyms, misapplied or included names.

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/italianbotanist.15.105794.suppl1

Italian Botanist 15: 91–109 (2023)
doi: 10.3897/italianbotanist.15.105796
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

Notulae to the Italian native vascular flora: 15

Fabrizio Bartolucci[1], Gianniantonio Domina[2], Michele Adorni[3], Gianluigi Bacchetta[4], Enrico Bajona[5], Enrico Banfi[6], Franco Barbadoro[7], Nello Biscotti[8], Daniele Bonsanto[8], Fabio Conti[1], Michele Da Pozzo[9], Davide Dagnino[10], Giuseppe De Fine[11], Emanuele Del Guacchio[12], Luigi Forte[13], Emilio Di Gristina[2], Gabriele Galasso[6], Luigi Ghillani[14], Günther Gottschlich[15], Leonardo Gubellini[16], Valentina Lucia Astrid Laface[17], Cesare Lasen[18], Michele Lonati[19], Andrea Mainetti[20], Francesco Mascia[4], Giuliana Mazzacuva[17], Carmelo Maria Musarella[17], Simone Orsenigo[21], Nicodemo G. Passalacqua[22], Gaetano Pazienza[13], Lorenzo Pinzani[23], Elia Stefano Rodi[24], Francesco Santi[25], Llorenç Sáez[26], Alberto Selvaggi[27], Valeria Tomaselli[14], Luigi Torino[28], Christian Zidorn[29], Lorenzo Lastrucci[30]

1 *Centro Ricerche Floristiche dell'Appennino, Università di Camerino – Parco Nazionale del Gran Sasso e Monti della Laga, Via Prov.le km 4,2 – San Colombo, 67021, Barisciano (L'Aquila), Camerino, Italy* **2** *Dipartimento di Scienze Agrarie, Alimentari e Forestali (SAAF), Università di Palermo, Viale delle Scienze, edificio 4, 90128, Palermo, Italy* **3** *Via degli Alpini 7, 43037 Lesignano de' Bagni, Parma, Italy* **4** *Centro Conservazione Biodiversità (CCB), Dipartimento di Scienze della Vita e dell'Ambiente, Università degli Studi di Cagliari, viale Sant'Ignazio da Laconi 11-13, 09123, Cagliari, Italy* **5** *PLANTA/Center for Research, Documentation and Training, Via Serraglio Vecchio 28, 90123, Palermo, Italy* **6** *Sezione di Botanica, Museo di Storia Naturale di Milano, Corso Venezia 55, 20121, Milano, Italy* **7** *Via della Resistenza 1/3, 40033, Casalecchio di Reno, Bologna, Italy* **8** *Dipartimento di Scienze Agrarie, Alimentari ed Ambientali, Università Politecnica delle Marche, 60131, Ancona, Italy* **9** *Parco Naturale delle Dolomiti d'Ampezzo, Via Rev. Frenademetz, 1 – 32043, Cortina d'Ampezzo, Belluno, Italy* **10** *Centro Studi Bionaturalistici s.r.l., Via San Vincenzo 2, 20° piano, 16121, Genova, Italy* **11** *Istituto Professionale Statale per l'Industria e l'Artigianato "Anna Maria Barlacchi", Via Carducci, 88900, Crotone, Italy* **12** *Dipartimento di Biologia, Università di Napoli Federico II, c/o Orto Botanico, Via Foria 223, 80139, Napoli, Italy* **13** *Dipartimento di Bioscienze, Biotecnologie e Ambiente (DBBA), Campus Universitario "Ernesto Quagliariello", Università degli Studi di Bari "Aldo Moro", Via Orabona 4, 70125, Bari, Italy* **14** *Via Carlo Casalegno 6, 43123, Parma, Italy* **15** *Hermann-Kurz-Straβe 35, 72074, Tübingen, Germany* **16** *Centro Ricerche Floristiche Marche, Provincia di Pesaro e Urbino, Via Barsanti 18, 61122, Pesaro, Italy* **17** *Dipartimento di Agraria, Università "Mediterranea" di Reggio Calabria, Feo di Vito snc, 89122, Reggio Calabria, Italy* **18** *Via Mutten 27, 32032 Arson di Feltre, Belluno, Italy* **19** *Dipartimento di Scienze Agrarie, Forestali e Alimentari, Università degli Studi di Torino, Largo Paolo Braccini 2, 10095, Grugliasco, Torino, Italy* **20** *Servizio Biodiversità e ricerca scientifica,*

Copyright *Fabrizio Bartolucci et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Parco Nazionale Gran Paradiso, fraz. Valnontey 44, 11012, Cogne, Aosta, Italy **21** *Dipartimento di Scienze della Terra e dell'Ambiente, Università degli studi di Pavia, Via Sant'Epifanio, 14 27100, Pavia, Italy* **22** *Museo di Storia Naturale della Calabria ed Orto Botanico, Università della Calabria, Via Savinio, 87036, Arcavacata di Rende, Cosenza, Italy* **23** *Dipartimento di Scienze, Università Roma Tre, Viale G. Marconi 446, 00146, Roma, Italy* **24** *Corso Italia 175, 18034 Ceriana, Imperia, Italy* **25** *BIOME Lab, Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Alma Mater Studiorum, Università di Bologna, Via Irnerio 42, 40126, Bologna, Italy* **26** *Department BABVE, Faculty of Biosciences, Autonomous University of Barcelona, ES-08193, Bellaterra, Barcelona, Spain* **27** *Istituto per le Piante da Legno e l'Ambiente, C.so Casale 476, 10132, Torino, Italy* **28** *Via Sbarre Centrali 366, 89132, Reggio Calabria, Italy* **29** *Pharmazeutisches Institut, Universität zu Kiel, Gutenbergstr. 76, D-24118, Kiel, Germany* **30** *Sistema Museale di Ateneo, Università di Firenze, Via G. La Pira 4, 50121, Firenze, Italy*

Corresponding author: Fabrizio Bartolucci (fabrizio.bartolucci@gmail.com)

Academic editor: Lorenzo Peruzzi | Received 2 May 2023 | Accepted 12 May 2023 | Published 22 May 2023

Citation: Bartolucci F, Domina G, Adorni M, Bacchetta G, Bajona E, Banfi E, Barbadoro F, Biscotti N, Bonsanto D, Conti F, Da Pozzo M, Dagnino D, De Fine G, Del Guacchio E, Forte L, Di Gristina E, Galasso G, Ghillani L, Gottschlich G, Gubellini L, Laface VLA, Lasen C, Lonati M, Mainetti A, Mascia F, Mazzacuva G, Musarella CM, Orsenigo S, Passalacqua NG, Pazienza G, Pinzani L, Rodi ES, Santi F, Sáez L, Selvaggi A, Tomaselli V, Torino L, Zidorn C, Lastrucci L (2023) Notulae to the Italian native vascular flora: 15. Italian Botanist 15: 91–109. https://doi.org/10.3897/italianbotanist.15.105796

Abstract

In this contribution, new data concerning the distribution of native vascular flora in Italy are presented. It includes new records, confirmations, and exclusions to the Italian administrative regions. New combinations in the genera *Pilosella* and *Roemeria* are proposed. Furthermore, the name *Papaver siculum* is lectotypified. Nomenclatural and distribution updates, published elsewhere, and corrigenda are provided as Suppl. material 1.

Keywords

Endemic taxa, Floristic data, Italy, Typification

How to contribute

The text for the new records, exclusions, and confirmations should be submitted electronically to Lorenzo Lastrucci (lorenzo.lastrucci@unifi.it). The corresponding specimen along with its scan or photograph have to be sent to FI Herbarium: Sezione di Botanica "Filippo Parlatore" del Museo di Storia Naturale, Via G. La Pira 4, 50121 Firenze (Italy). Those texts concerning nomenclatural novelties and typifications (only for accepted names) should be submitted electronically to: Fabrizio Bartolucci (fabrizio.bartolucci@gmail.com). Each text should be within 1,000 characters (spaces included).

Floristic records of native taxa

***Alchemilla opaca* Buser (Rosaceae)**

+ **EMR**: Albareto (Parma), tra Passo dei due Santi e M. Colombo (WGS84: 44.39074°N, 9.75444°E), radura di faggeta, 1450 m, 19 July 2017, leg. *M. Adorni*, *L. Ghillani*, det. *F. Festi* (FI). – Species new for the flora of Emilia-Romagna.

M. Adorni, L. Ghillani

***Anacamptis longicornu* (Poir.) R.M.Bateman, Pridgeon & M.W.Chase (Orchidaceae)**

+ **CAL**: Motta San Giovanni (Reggio Calabria), Località Pitea, (WGS84: 38.008450°N, 15.735237°E), a bordo del sentiero in prossimità di impianti di *Pinus* sp.pl. con presenza di formazioni rocciose, 838 m, 3 May 2022, leg. *L. Torino*, det. *V.L.A. Laface*, *G. Mazzacuva, C.M. Musarella, L. Torino, G. Spampinato* (REGGIO); Reggio Calabria (Reggio Calabria), Strada Redentore-Gambarie, Località Bosurgi (WGS84: 38.136818°N, 15.775778°E), pineta di *Pinus halepensis* Mill., 1053 m, 16 May 2018, leg. *V.L.A. Laface,* det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); Motta San Giovanni (Reggio Calabria), Contrada Russa, (WGS84: 38.018911°N, 15.717538°E), pineta di *Pinus halepensis* Mill., 735 m, 13 April 2017, *V.L.A. Laface* (REGGIO). – Species confirmed for the flora of Calabria.

The species was reported by Conti et al. (2005) and Pignatti et al. (2017) exclusively for Sicilia and Sardegna. In Calabria, it was reported as doubtfully occurring by Bartolucci et al. (2018). Few individuals were observed (< 10).

V.L.A. Laface, L. Torino

***Aristolochia clematitis* L. (Aristolochiaceae)**

+ **PUG**: Rodi Garganico (Foggia), lungomare Andrea Pazienza (WGS84: 41.929347°N, 15.891825°E), terreno sabbioso, 1 m, 9 May 2022, *N. Biscotti, D. Bonsanto* (FI). – Species confirmed for the flora of Puglia.

Aristolochia clematitis was historically reported for Puglia by Tenore (1820). This species was so far regarded as doubtfully occurring in this administrative region (Bartolucci et al. 2018).

N. Biscotti, D. Bonsanto

***Carduus cephalanthus* Viv. (Asteraceae)**

+ **CAL**: Reggio Calabria (Reggio Calabria), presso Monte S. Demetrio, in prossimità della strada Santa Venere-Embrisi (WGS84: 38.064516°N, 15.741831°E), impianto incendiato di *Pinus halepensis* Mill., 883 m, NE, 4 January 2023, leg. *G. Mazzacuva*, det. *G. Mazzacuva, V.L.A. Laface, C.M. Musarella* (REGGIO). – Species confirmed for the flora of Calabria.

Carduus cephalanthus was historically reported for southern Calabria by Fiori (1927 as *Carduus cephalanthus* Viv. β *congestus* Guss.) and by Pignatti (1982). This species was so far regarded as doubtfully occurring in this administrative region (Bartolucci et al. 2018; Pignatti et al. 2018). More than 100 individuals were found at the edge of a path on a burnt slope in the Metropolitan City of Reggio Calabria.

G. Mazzacuva, C. M. Musarella

***Carex frigida* All. (Cyperaceae)**

+ **LIG**: Triora (Imperia), Foresta di Gerbonte (WGS84: 44.01840°N, 7.67066°E), sorgente pietrificante del *Cratoneurion* (Habitat Natura 2000 cod.7220*), 1628 m, 7 August 2021, *E.S. Rodi* (GDOR No. 60592). – Species confirmed for the flora of Liguria.

This species was found during an extensive survey of the Natura 2000 Habitat code 7220 in Liguria. According to Ottone Penzig's handwritten notes found on a copy of De Notaris (1844) stored in the library of the University of Genoa and the specimens housed in the GDOR herbarium, this species was also present in several localities of the Ligurian Alps.

D. Dagnino, E. S. Rodi

***Centaurea jacea* L. subsp. *angustifolia* (DC.) Gremli (Asteraceae)**

+ **PUG**: Gravina in Puglia (Bari), area protetta naturale "Bosco Difesa Grande", nei pressi di Lago Splendore, (WGS84: 40.764213°N, 16.382721°E), ai margini di un bosco a *Quercus cerris*, 462 m s.l.m., 4 January 2023, leg. *G. Pazienza*, det. *V. Tomaselli, G. Pazienza,* (FI, BI Nos 57545, 57552). – Subspecies new for the flora of Puglia.

G. Pazienza, V. Tomaselli

Eragrostis minor* Host (Poaceae) subsp. *minor

+ **BAS**: Tramutola (Potenza), centro cittadino (WGS84: 40.312842°N, 15.920795°E), fra i masselli di una pavimentazione esterna, 680 m, 27 September 2022, *F. Santi*, conf. *G. Faggi* (FI). – Species new for the flora of Basilicata.

This species was also observed in Castelsaraceno (Potenza) in the city square (WGS84: 40.162963°N, 15.991274°E), 940 m, on 21 September 2022.

F. Santi

***Glebionis discolor* (d'Urv.) E.Cano, Musarella, Cano-Ortiz, Piñar Fuentes, Spamp. & Pinto Gomes (Asteraceae)**

+ **SAR**: Assemini (Cagliari), 10 May 1973, *A. Scrugli* (CAG sub *Chrysanthemum coronarium* L. var. *discolor*); Porto Torres (Sassari), loc. Cala Reale, Isola Asinara, 18 May 1984, *E. Bocchieri* (CAG sub *C. coronarium* L. var. *discolor*); Strada Villamar-Las Plassas (Cagliari), 19 April 2001, *A. Scrugli* (CAG *sub C. coronarium* L. var. *discolor*);

Capoterra (Cagliari), loc. Tanca di Nissa, margini di colture cerealicole (WGS84: 39.165885°N, 9.010176°E), 1 m s.l.m., 28 February 2020, *F. Mascia* (CAG); Collinas (Sud Sardegna), loc. S'Argiola de sa Sennora, incolti e margini di sentieri (WGS84: 39.636350°N, 8.837509°E), 267 m s.l.m., 10 April 2022, *F. Mascia, G. Tuveri* (CAG). – Species confirmed for the flora of Sardegna.

The first records for Sardegna can be found in Scrugli (1972, 1973) from Cagliari and Assemini, subsequently confirmed by a few authors (e.g., Bacchetta 2006). The doubtful taxonomic value of the varietal ranks led to no longer considering the presence of this taxon in Sardegna (e.g., Arrigoni 2015; Bartolucci et al. 2018). This taxon was recently re-evaluated at species rank and, not reported for the island (Cano et al. 2017).

G. Bacchetta, F. Mascia

***Helictotrichon convolutum* (C.Presl) Henrard (Poaceae)**

– **ABR.** – Species to be excluded from the flora of Abruzzo.

Conti and Di Pietro (2004) indicate that the species has been reported in the past for the Velino by Tenore (1830 sub *Avena fallax*) and for Pietracamela along the Rio Arno and at the Giunghiera by Zodda (1953 sub *Avena sempervirens* var. *filifolia*). They also claim that these localities need to be confirmed. We revised the specimens collected by Zodda preserved in BI [in pascuis: Pietracamela alla Giunghiera, July 1948, Zodda (BI No. 15025); in rupestribus: Pietracamela lungo rio Arno, July 1951, Zodda (BI No. 21999)] and we attributed them to *Trisetum bertolonii* Jonsell. On the other hand, later Tenore (1831) cited *Avena fallax* only for Calabria and Lucania, and according to Montelucci (1958) the record for Velino should be referred to *Helictochloa praetutiana* (Parl. ex Arcang.) Bartolucci, F.Conti, Peruzzi & Banfi.

L. Forte, G. Pazienza

***Helleborus niger* L. (Ranunculaceae)**

– **BAS**. Species to be excluded from the flora of Basilicata.
– **CAM**. Species to be excluded from the flora of Campania.
– **LAZ**. Species to be excluded from the flora of Lazio.

According to the Portal to the Flora of Italy (2023), the presence of this taxon for Campania is doubtful, and it is not at all cited for Lazio. It was reported by Pignatti (1982) for the central Apennines, who also included Campania in the map. The latter author likely relied on Fiori (1898, 1924), who cited in turn Nicola Terracciano. This author recorded the species for Cassino and Campoli Appennino (Terracciano 1890), two localities nowadays in Lazio, where this species was never later reported (Anzalone et al. 2010; Portal to the Flora of Italy 2023). No specimen has been traced at NAP. The indications of *H. niger* for Basilicata by Terracciano (1890, 1901) should be regarded as erroneous (see also Gavioli 1947).

E. Del Guacchio

***Hieracium bifidum* Kit. ex Hornem. subsp. *psammogenes* (Zahn) Zahn (Asteraceae)**

+ **LOM**: Bossico (Bergamo), margine della strada (WGS84: 45.827049°N, 10.038236°E), 780 m s.l.m., exp. SW, 19 April 2021, leg. *S. Orsenigo, B. Cera*, rev. *G. Gottschlich* (PAV); Fonteno (Bergamo), Lago d'Iseo, rupi sul lungolago (WGS84: 45.757146°N, 10.037948°E), 200 m s.l.m., exp. E, 19 April 2021, leg. *S. Orsenigo, B. Cera*, rev. *G. Gottschlich* (FI, PAV); tra Riva di Solto e Tavernola (Bergamo), rupi sulla strada (WGS84: 45.743707°N, 10.048593°E), 200 m s.l.m., exp. E, 19 April 2021, leg. *S. Orsenigo, B. Cera*, rev. *G. Gottschlich* (PAV); Borgo di Zorzino (Bergamo), margine della strada (WGS84: 45.782832°N, 10.049381°E), 220 m s.l.m., exp. S, 19 April 2021, leg. *S. Orsenigo, B. Cera*, rev. *G. Gottschlich* (PAV); da Sonvico verso Fraine (Brescia), sotto i castagni (WGS84: 45.819700°N, 10.131957°E), 600 m s.l.m., exp. W, 19 April 2021, leg. *S. Orsenigo, B. Cera*, rev. *G. Gottschlich* (PAV). – Subspecies confirmed for the flora of Lombardia.

This subspecies was historically reported for Valle d'Aosta, Piemonte (Col di Tenda), Veneto, and Lombardia (Bormio, Lecco, Abbadia Lariana and Mandello del Lario) by Zahn (1906) and Zahn (1921), whilst it was recently confirmed only in Trentino-Alto Adige (Gottschlich and Pujatti 2002) and Abruzzo (Gottschlich 2009). According to specimens collected by Pietro Rossi and determined by Zahn stored in PAV (PAV-LOM014724, PAV-LOM014725, PAV-LOM014726, PAV-LOM014727, PAV-LOM014728, PAV-LOM014729), the subspecies was quite widespread in the past in Grigna massif.

S. Orsenigo, G. Gottschlich

***Hieracium caesioides* Arv.-Touv. subsp. *rionii* (Gremli) Zahn (Asteraceae)**

+ **MAR**: Montemonaco (Macerata), Monti Sibillini, versante N del M. Torrone lungo l'alto Fosso della Tagliola (WGS84: 42.858350°N, 13.277194°E), luoghi sassosi, suolo calcareo, humus scarso o subnullo, 1550-1600 m, 1 July 1988, leg. *A. Brilli-Cattarini*, *L. Gubellini*, det. *S. Di Massimo* (sub *Hieracium* cf. *incisum* Hoppe), rev. *G. Gottschlich* (PESA); Bolognola (Macerata), Monti Sibillini, versante NW del M. Rotondo (WGS84: 42.967906°N, 13.197308°E), pascoli sassosi aridi, suolo calcareo, humus scarso o subnullo, 1850–1900 m, 24 July 1989, leg. *A. Brilli-Cattarini*, *L. Gubellini*, det. *S. Di Massimo* (sub *Hieracium* cf. *incisum* aggr.), rev. *G. Gottschlich* (PESA). – Subspecies new for the flora of Marche.

G. Gottschlich, L. Gubellini

***Hieracium chondrillifolium* Fr. subsp. *boissieri* (A.Huet & É.Huet ex Arv.-Touv.) Zahn (Asteraceae)**

+ **MOL**: Campitello Matese, towards M. Miletto, (WGS84: 41.455833°N, 14.3805564°E), calcerous scree 1670 m, 17 June 2022, leg. *C. Zidorn CZ-*

20220617H-1, det. *G. Gottschlich* (KIEL0005014). – Species and subspecies new for the flora of Molise.

C. Zidorn, G. Gottschlich

***Hieracium grovesianum* Arv.-Touv. ex Belli subsp. *luteobarbatum* Gottschl. (Asteraceae)**

+ **CAL**: Camigliatello Silano (Cosenza), Monte Scuro (WGS84: 39.321806°N, 16.396944°E), rocky stony slopes, 1670 m, 23 July 2022, leg. *E. Di Gristina*, det. *G. Gottschlich* (FI). – Subspecies new for the flora of Calabria.

This subspecies is endemic to Italy and recorded so far only for Abruzzo (Gottschlich 2009) and Marche (Bartolucci et al. 2018).

E. Di Gristina, G. Gottschlich

***Hieracium grovesianum* Arv.-Touv. ex Belli subsp. *rigoanum* (Zahn) Zahn (Asteraceae)**

+ **BAS**: Latronico (Potenza), Monte Alpi (WGS84: 40.127222°N, 15.972222°E), rocky stony slopes, 1480 m, 22 July 2022, leg. *E. Di Gristina*, *E. Bajona*, det. *E. Di Gristina* (FI). – Subspecies new for the flora of Basilicata.

E. Di Gristina, E. Bajona

***Hieracium hypochoeroides* S.Gibson subsp. *bifidopsis* (Zahn) Greuter (Asteraceae)**

+ **MAR**: Montemonaco (Macerata), Monti Sibillini, versante E del M. Torrone (WGS84: 42.845014°N, 13.288944°E), luoghi sassosi, suolo calcareo, humus subnullo, 1525–1575 m, 6 July 1987, leg. *A. Brilli-Cattarini*, *L. Gubellini*, det. *S. Di Massimo* (sub *Hieracium* cfr. *incisum* Hoppe), rev. G. Gottschlich (PESA). – Subspecies new for the flora of Marche.

G. Gottschlich, L. Gubellini

***Hieracium pallescens* Waldst. & Kit. (Asteraceae)**

+ **MAR**: Arquata del Tronto (Ascoli Piceno), Monti Sibillini, nel basso versante SE del M. Vettore sopra S. Gemma (WGS84: 42.811531°N, 13.288583°E), radure sassose ombreggiate, suolo calcareo, humus scarso, 1250–1300 m, 29 June 1987, leg. *A. Brilli-Cattarini*, *L. Gubellini*, det. *S. Di Massimo* (sub *Hieracium incisum* Hoppe), rev. *G. Gottschlich* (PESA); Sarnano (Macerata), Monti Sibillini, nella Valle Tre Santi sotto la Bocchetta dei Tre Santi (WGS84: 42.989367°N, 13.257425°E), luoghi sassosi, suolo calcareo, humus scarso o subnullo, 900–950 m, 27 May 1987, leg. *A. Brilli-Cattarini*, *L. Gubellini*, det. *S. Di Massimo* (sub *Hieracium* cfr. *bifidum* Kit.), rev. *G. Gottschlich* (PESA). – Species new for the flora of Marche.

G. Gottschlich, L. Gubellini

***Hieracium picenorum* Gottschl. (Asteraceae)**

+ **MAR**: Cagli (Pesaro e Urbino), gruppo del M. Nerone, nel basso versante S della Montagnola sotto Fondarca (WGS84: 43.538892°N, 12.537881°E), luoghi boschivi (ostrieto sassoso e degradato), suolo calcareo, humus scarso o subnullo, 725–750 m, 3 June 1988, *A. Brilli-Cattarini* (sub *Hieracium murorum* L. *s.l.*), rev. *G. Gottschlich* (PESA); Montemonaco (Macerata), Monti Sibillini, Valle del Canale presso Foce di Montemonaco (WGS84: 42.877000°N, 13.267206°E), luoghi boschivi (bosco misto mesofilo rado), suolo calcareo, humus da subnullo a +/- abbondante, 975–1025 m, 18 July 1990, leg. *A. Brilli-Cattarini, L. Gubellini, M. Rocchi,* det. *S. Di Massimo* (sub *Hieracium* cfr. *incisum* Hoppe), rev. *G. Gottschlich* (PESA). – Species new for the flora of Marche.

G. Gottschlich, L. Gubellini

***Hieracium pseudogrovesianum* Gottschl. subsp. *amictum* Gottschl. (Asteraceae)**

+ **MAR**: Dintorni di Sarnano (Macerata), nell'alta valle del Torrente Salino tra Borghetti e il Crocifisso (WGS84: 43.054842°N, 13.290556°E), luoghi boschivi (carpineto, castagneto, cerreta, querceto misto), suolo arenaceo, humus da subnullo a +/- abbondante, 525–575 m, 25 May 1981, leg. *A. Brilli-Cattarini* e *L. Gubellini*, det. *A. Brilli-Cattarini* (sub *Hieracium murorum* L.), rev. *G. Gottschlich* (PESA); Carpegna (Pesaro e Urbino), Monti di Carpegna presso il M. Simoncello (WGS84: 43.770278°N, 12.289903°E), boschi, c. 1075 m, 29 May 1961, *A. Brilli-Cattarini* (sub *Hieracium murorum* L. *s.l.*), rev.*G. Gottschlich* (PESA). – Subspecies new for the flora of Marche.

G. Gottschlich, L. Gubellini

***Nasturtium microphyllum* (Boenn.) Rchb. (Brassicaceae)**

+ **TOS**: Grassina (Bagno a Ripoli, Firenze), pescaia del torrente Ema (WGS84: 43.720375°N, 11.296864°E), ambiente ripariale, 87 m, 6 Jul 2022, *L. Pinzani* (FI, *Herb. Pinzani*). – Species new for the flora of Toscana.

L. Pinzani

***Rosa inodora* Fr. (Rosaceae)**

+ **MAR**: Frontone (Pesaro e Urbino), Gruppo del M. Catria, versante N del M. Schioppettino (WGS84: 43.495859°N, 12.704987°E), boschi mesofili, suolo calcareo, 785 m, 16 September 2022, *leg. F. Barbadoro* e *L. Gubellini*, *det. L. Gubellini* (PESA, FI). – Species new for the flora of Marche.

F. Barbadoro, L. Gubellini

***Squilla numidica* Jord. & Fourr. (Asparagaceae)**

+ **CAL**: Cirò (Crotone), località Favaro, 500 m a nord-ovest della Centrale elettrica del Parco Eolico (WGS84: 39.382996°N, 17.036654°E), boscaglia mediterranea, argilloso, 225 m s.l.m, 27 June 2022, leg. *G. De Fine*, det. *N.G. Passalacqua* (FI); *ibidem*, 20 August 2022 (CLU). – Species new for the flora of Calabria.

The numerous reports for Calabria of *Squilla maritima* (L.) Steinh. (sub *Urginea maritima*) were considered incorrect as they refer to *S. pancration* Steinh. (Bernardo et al. 2011). However, following Martinez-Azorìn et al. (2022), our samples can be referred to *S. numidica* by the brownish-red bulb tunics and the greenish tepal midrib.

N. G. Passalacqua, G. De Fine

***Trifolium saxatile* All. (Fabaceae)**

+ **PIE**: Bardonecchia (Torino), tra la Croce Chabrière e la Punta Melmise e su quest'ultima (WGS84: 45.104605°N, 6.717561°E), ghiaioni di calcescisti, 2190–2300 m s.l.m., 26 July 2022, *A. Mainetti, M. Lonati* (FI). – Species confirmed for the flora of Piemonte

This species is endemic to the Alps and listed in Annex II of the Habitats Directive 92/43/EEC. In Italy, it was so far confirmed for Valle d'Aosta and Trentino-Alto Adige, while it was considered possibly extinct in Piemonte (Bartolucci et al. 2018). In the latter region, it had been collected in Valle Orco (Ceresole Reale, Torino) at least until 1910 (Vaccari 1910), and in Val di Susa (Bardonecchia, Torino), on the slopes of "Croce di Chabrière", between 1800 and 2200 m a.s.l. (Sappa 1950). At least 100 individuals were sparsely distributed over an area of at least 200 m^2. Given the abundance of scree of the same bedrock in the area, even at higher elevation, it could be relevant to look for it further.

A. Mainetti, M. Lonati

***Veronica scutellata* L. (Plantaginaceae)**

+ **VEN**: Gosaldo (Belluno), pianoro torboso a SW di Forcella Aurine (WGS84: 46.231111°N, 11.972083°E), 1380 m, 19 August 2022, *M. Da Pozzo, C. Lasen* (FI). – Species confirmed for the flora of Veneto.

In the Veneto Red List (Buffa et al. 2016) it was reported as RE (Regionally Extinct).

M. Da Pozzo, C. Lasen

***Vicia melanops* Sm. (Fabaceae)**

− **ABR.** − Species to be excluded from the flora of Abruzzo.

Vicia melanops was reported near Vigliano (L'Aquila) based on a herbarium specimen (No. 60006) kept in APP (Conti et al. 2017). The recent discovery of *Vicia laeta* Ces. in the National Park of Abruzzo, Lazio and Molise (Conti et al. 2022) allowed us to attribute to this species also the herbarium specimen cited above.

F. Conti, F. Bartolucci

Floristic records of regional alien taxa

***Juglans regia* L. (Juglandaceae)**

+ (NAT) **PUG**: Vico del Gargano (Foggia), loc. Chianche Lisce (WGS84: 41.904593°N, 15.940482°E), margine stradale, 461 m, 17 August 2020, *N. Biscotti, D. Bonsanto* (FI); Vico del Gargano (Foggia), loc. Mastrocianni (WGS84: 41.885610°N, 15.950786°E), incolto, 114 m, 11 August 2020, *N. Biscotti, D. Bonsanto* (*Herb. Biscotti*, *Herb. Bonsanto*); Vico del Gargano (Foggia), loc. Fucito (WGS84: 41.919412°N, 15.920386°E), margine stradale, 564 m, 2 September 2020, *N. Biscotti, D. Bonsanto* (*Herb. Biscotti*, *Herb. Bonsanto*); Rodi Garganico (Foggia), loc. Canneto (WGS84: 41.919412°N, 15.920386°E), 30 m, 11 August 2020, *N. Biscotti, D. Bonsanto* (*Herb. Biscotti*, *Herb. Bonsanto*); Vico del Gargano (Foggia), loc. Monte Nero (WGS84: 41.919412°N, 15.920386°E), 64 m, 24 May 2021, *D. Bonsanto* (*Herb. Bonsanto*); Carpino (Foggia), margine stradale in direzione Bosco Quarto (WGS84: 41.919412°N, 15.920386°E), 148 m, 20 August 2021, *D. Bonsanto* (*Herb. Bonsanto*). – Naturalized regional alien species new for the flora of Puglia.

N. Biscotti, D. Bonsanto

***Paliurus spina-christi* Mill. (Rhamnaceae)**

0 **VDA**. – Regional alien species not confirmed for the flora of Valle d'Aosta.

The presence of *Paliurus spina-christi* in Valle d'Aosta was reported for the first time in *Flora pedemontana* (Allioni 1785 sub *Rhamnus paliurus* L.): "*nascitur circa Augustam Praetoriam*".A manuscript and an exsiccata in TO by L. Bellardi and a plate of "*Iconographia taurinensis*" painted by F. Peyroleri (Forneris et al. 2011) correspond to this indication. The presence of the species was later recorded as *Paliurus australis* Gaertn. at "îles de la Doire, à Chevrot" by J.-M. Henry (Vaccari 1904–1911). A more recent presence is attested by the sample in CAT No. 01074 (http://www.hortusbotanicuscatinensis.it/herbarium/foto/07/001074.jpg), collected by Giuseppe Zodda, who reported on the label "siepi: Aosta, 600 m, agosto 1953". Therefore, the presence of the species must be considered as established, albeit not confirmed for over 70 years, and non-native, certainly introduced a long time ago, probably already by the Romans.

A. Selvaggi

***Pinus nigra* J.F.Arnold subsp. *nigra* (Pinaceae)**

+ (CAS) **PUG**: Monte Sant'Angelo (Foggia), ingresso del paese (WGS84: 41.919412°N, 15.920386°E), in vicinanza di zone ad imboschimento su rupe, 442 m, 21 September 2021, *N. Biscotti, D. Bonsanto* (FI). – Casual regional alien species new for the flora of Puglia.

N. Biscotti, D. Bonsanto

Nomenclatural novelties

***Pilosella pseudopilosella* (Ten.) Soják subsp. *nigrocomosa* (Zahn) Gottschl., comb. nov.**
urn:lsid:ipni.org:names:77319916-1

≡ *Hieracium pseudopilosella* Ten. subsp. *nigrocomosum* Zahn, Hierac. Alp. Mar.: 17 (1916).

Pilosella pseudopilosella is a species with very disjunct occurrences (Northern Africa, Iberian Peninsula, Southern Italy, Balkan Peninsula, and Western Turkey). The subspecies *nigrocomosa* was described from the Ligurian Alps and is endemic to this region.

G. Gottschlich

***Roemeria sicula* (Guss.) Galasso, Banfi, L.Sáez & Bartolucci, comb. nov.**
urn:lsid:ipni.org:names:77319917-1

≡ *Papaver siculum* Guss., Fl. Sicul. Syn. 2(1): 6 (1843–1844) ≡ *Papaver hybridum* subsp. *siculum* (Guss.) Arcang., Comp. Fl. Ital. [Arcangeli]: 24 (1882) ≡ *Papaver hybridum* var. *siculum* (Guss.) Raimondo & Spadaro, Bocconea 20: 12 (2007).
Ind. Loc.: "Inter segetes; *nel fiume fra S. Giuseppe e Castellammare (Gasparrini); Palermo*".
Type (lectotype, designated here): [Italy, Sicily]. Nel fiume da S. Giuseppe a Castellammare, s.d., *Gasparrini s.n.* (NAP barcode NAP0001798 [digital photo!]).
= *Papaver hybridum* L., Sp. Pl. 1: 506 (1753), non *Roemeria hybrida* (L.) DC., Syst. Nat. 2: 92 (1821)
Type (lectotype designated by Aghababyan and Raimondo 2011: 1475): Herb. Burser IX: 56 (UPS).
= *Papaver hispidum* Lam., Fl. Franç. (Lamarck) 3: 174 (1779), nom. illeg. ≡ *Roemeria hispida* Stace, New J. Bot. 7(1): 9 (2017)

According to recent molecular phylogenetic studies, the species belonging to *Papaver* sect. *Argemonidium* Spach have been transferred to the genus *Roemeria* Medik. (Banfi

et al. 2022). The name *Roemeria hispida* proposed by Stace (2017) should be treated as a replacement name (Art. 58.1 of the *ICN*, Turland et al. 2018) and not as a new combination, because it is based on *P. hispidum* Lam., an illegitimate superfluous name for *P. hybridum* L. (Arts. 52.1 and 52.2 of the *ICN*). The final epithet "*hybrida*" is already taken in *Roemeria*, so the next earliest legitimate name at species rank is *P. siculum* Guss., on which the new combination here proposed is based. The name *P. siculum* is also lectotypified here based on a specimen kept in NAP, where Gussone's main collection is housed. The lectotype morphologically matches the description by Gussone (1844) and agrees with the current application of the name *P. hybridum*.

F. Bartolucci, G. Galasso, E. Banfi, L. Sáez

Nomenclatural and distribution updates from other literature sources, and corrigenda

Nomenclatural and distribution updates, and corrigenda to Bartolucci et al. (2018) and subsequent updates summarised in the Portal to the Flora of Italy (2023) according to Vaccari (1909), Ehrendorfer (1962), Barbero and Bono (1970), Milia and Mossa (1977), Baldini (1995), Künkele and Lorenz (1995), Vogel et al. (1998), Poldini et al. (2001), Brullo et al. (2001, 2022a, 2022b, 2023), Ballelli et al. (2005), Garbari et al. (2005), Arrigoni et al. (2007), Aedo (2013), Rottensteiner (2014), Tison and de Foucault (2014), Bartolucci et al. (2016), GIROS (2016), Pignatti et al. (2017), Argenti et al. (2019), Peruzzi et al. (2019), Prosser et al. (2019), Scafidi et al. (2019), Geltman (2020), Arrigoni (2021), Griebl and Presser (2021), Reich et al. (2021), Barbadoro and Marchetti (2022), Bernardello et al. (2022), Boltenkov and Del Guacchio (2022), Cambria et al. (2022, 2023), Di Pietro et al. (2022), Domina et al. (2022), Gallo (2022), Gariboldi (2022), Jiménez-López et al. (2022), Leoni (2022), Španiel et al. (2022), Sutorý (2022), Tomasi et al. (2022), Villa et al. (2022), Calevo et al. (2023), Cambria (2023), Conti and Bartolucci (2023), Conti et al. (2023a, 2023b), Conti and Giacanelli (2023); Dakskobler (2023), Ferrer-Gallego and Talavera (2023), Hassler (2023), Heimer and Frajman (2023), Pennesi et al. (2023), POWO (2023), Štěpánek and Kirschner J (2023), Verlaque et al. (2023), are provided in Suppl. material 1.

F. Bartolucci, G. Galasso

Acknowledgements

We gratefully acknowledge the following colleagues who provided distribution, nomenclatural, and taxonomic advice: Acta Plantarum staff, Sandro Ballelli, Federica Bonini, Giorgio Faggi, Lorenzo Gallo, Daniela Gigante, Rizzieri R. Masin, Lorenzo Peruzzi. We wish to thank Paolo Caputo and Roberta Vallariello (NAP, *Herbarium Neapolitanum*, University of Naples Federico II) for their help with searching for the original material of the name *Papaver siculum*.

References

Aedo C (2013) *Allium* L. In: Rico E, Crespo MB, Quintanar A, Herrero A, Aedo C (Eds) Flora Iberica (Vol. 20). Real Jardin Botanico, CSIC, Madrid, 220–273.

Aghababyan M, Raimondo FM (2011) Typification of the name *Papaver hybridum* L. (Papaveraceae). Taxon 60(5): 1475–1476. https://doi.org/10.1002/tax.605023

Allioni C (1785) Flora Pedemontana sive enumeratio methodica stirpium indigenarum Pedemontii. I. M. Briolus, Torino.

Anzalone B, Iberite M, Lattanzi L (2010) Flora vascolare del Lazio. Informatore Botanico Italiano 42(1): 187–317.

Argenti C, Masin R, Pellegrini B, Perazza G, Prosser F, Scortegagna S, Tasinazzo S (2019) Flora del Veneto dalle Dolomiti alla laguna veneziana (Vols 1–2). Cierre edizioni, Sommacampagna, Verona.

Arrigoni PV (2015) Flora dell'Isola di Sardegna (Vol. V). Carlo Delfino Editore, Sassari.

Arrigoni PV (2021) Flora analitica della Toscana (Vol. 8(1)). Edizioni Polistampa, Firenze.

Arrigoni PV, Ferretti G, Padula M (2007) La flora della riserva di luoghi naturali di "Orrido di Botri" (Bagni di Lucca, Toscana). Parlatorea 9: 7–39.

Bacchetta G (2006) La flora vascolare del Sulcis (Sardegna sud-occidentale, Italia). Guineana 12: 1–369.

Baldini RM (1995) Flora vascolare del Monte Argentario (Arcipelago Toscano). Webbia 50(1): 67–191. https://doi.org/10.1080/00837792.1995.10670598

Ballelli S, Lucarini D, Pedrotti F (2005) Catalogo dell'erbario dei Monti Sibillini di Vittorio Marchesoni. Braun-Blanquetia 38: 193–194.

Banfi E, Bartolucci F, Tison J-M, Galasso G (2022) A new genus for *Papaver* sect. *Meconella* and new combinations in *Roemeria* (Papaveraceae) in Europe and the Mediterranean area. Natural History Sciences 9(1): 67–72. https://doi.org/10.4081/nhs.2022.556

Barbadoro F, Marchetti D (2022) *Asplenium trichomanes* L. subsp. *pachyrachis* (Christ) Lovis et Reichst. (Aspleniaceae, Pteridophyta) nel gruppo del M. Catria (PU, PG), conferma per le Marche e novità per l'Umbria. Annali del Museo Civico di Rovereto 38: 77–80.

Barbero M, Bono G (1970) La végétatation sylvatique thermophile de l'étage collinéen des Alpes Apuanes e de l'Apennin ligure. Lavori della Società Italiana di Biogeografia, n.s. 1: 148–182. https://doi.org/10.21426/B61110522

Bartolucci F, Domina G, Adorni M, Alessandrini A, Angiulli F, Ardenghi NMG, Banfi E, Barberis G, Bedini G, Bonari G, Calbi M, Fenaroli F, Galasso G, Gestri G, Ghillani L, Gottschlich G, Iberite M, Latini M, Lazzeri V, Nicolella G, Olivieri N, Perrino EV, Peruzzi L, Pisani G, Roma-Marzio F, Russo G, Scutellà F, Silletti GN, Stinca A, Wagensommer RP, Nepi C (2016) Notulae to the Italian native vascular flora: 1. Italian Botanist 1: 5–15. https://doi.org/10.3897/italianbotanist.1.8780

Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, Astuti G, Bacchetta G, Ballelli S, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Cecchi L, Di Pietro R, Domina G, Fascetti S, Fenu G, Festi F, Foggi B, Gallo L, Gottschlich G, Gubellini L, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Poldini L,

Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Conti F (2018) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 179–303. https://doi.org/10.1080/11263504.2017.1419996

Bernardello R, Girani A, Marchetti D (2022) *Asplenium trichomanes* L. subsp. *pachyrachis* (Christ) Lovis et Reichst. (Aspleniaceae, Pteridophyta) a Entracque (CN), prima segnalazione sicura per il Piemonte. Annali del Museo Civico di Rovereto 38: 73–75.

Bernardo L, Peruzzi L, Passalacqua N [Eds] (2011) Flora vascolare della Calabria. Prodromo (Vol. 1). Informatore Botanico Italiano 43(2): 185–332.

Boltenkov EV, Del Guacchio E (2022) Taxonomic notes on *Xiphion collinum* (Iridaceae). Phytotaxa 576(1): 113–122. https://doi.org/10.11646/phytotaxa.576.1.7

Brullo S, Brullo C, Cambria S, Ilardi V, Siracusa G, Minissale P, Giusso del Galdo G (2022b) *Ephedra strongylensis* (Ephedraceae), a new species from Aeolian islands (Sicily). Phytotaxa 576(3): 250–264. https://doi.org/10.11646/phytotaxa.576.3.2

Brullo S, Brullo C, Cambria S, Minissale P, Sciandrello S, Tavilla G, Siracusa G, Tomaselli V, Giusso del Galdo G (2023) Taxonomical remarks on *Solenopsis laurentia* (Campanulaceae) in Italy. Phytotaxa 584(2): 59–88. https://doi.org/10.11646/phytotaxa.584.2.1

Brullo S, Brullo C, Tavilla G, Siracusa G, Cambria S (2022a) *Solenopsis bacchettae* (Campanulaceae, Lobelioideae), a new species from Sardinia. Nordic Journal of Botany: e03773. https://doi.org/10.1111/njb.03773

Brullo S, Scelsi F, Spampinato G (2001) La vegetazione dell'Aspromonte. Studio fitosociologico. Laruffa Editore, Reggio Calabria.

Buffa G, Carpenè B, Casarotto N, Da Pozzo M, Filesi L, Lasen C, Marcucci R, Masin R, Prosser F, Tasinazzo S, Villani M, Zanatta K (2016) Lista rossa regionale delle piante vascolari. Regione del Veneto, Europrint S.r.l., Quinto di Treviso.

Cambria S, Azzaro D, Caldarella O, Aleo M, Bazan G, Guarino R, Torre G, Cristaudo AE, Ilardi V, La Rosa A, Laface VLA, Luchino F, Mascia F, Minissale P, Sciandrello S, Tosetto L, Tavilla G (2023) New data on native and alien vascular flora of Sicily (Italy): new findings and updates. Plants 12: e1743. https://doi.org/10.3390/plants12091743

Cambria S, Brullo S, Brullo C, Ilardi V, Siracusa G, Giusso del Galdo G (2022) Sulla presenza in Sicilia di *Elatine campylosperma* (Elatinaceae), specie critica della flora Mediterranea. Notiziario Società Botanica Italiana 6(2): 113–114.

Calevo J, Christenhusz MJM, Fay MF (2023) A taxonomic overview of *Orchis* sect. *Robustocalcare* (Orchidaceae). Phytotaxa 592(2): 157–162. https://doi.org/10.11646/phytotaxa.592.2.10

Cano E, Musarella CM, Cano-Ortiz A, Piñar Fuentes JC, Spampinato G, Pinto Gomes CJ (2017) Morphometric analysis and bioclimatic distribution of *Glebionis coronaria* s.l. (Asteraceae) in the Mediterranean area. PhytoKeys 81: 103–126. https://doi.org/10.3897/phytokeys.81.11995

Conti F, Abbate G, Alessandrini A, Blasi C [Eds] (2005) An annotated checklist of the Italian vascular flora. Palombi & Partner, Roma.

Conti F, Bartolucci F (2023) Taxonomy and distribution of *Spiraea hypericifolia* in Italy and typification of the name *S. flabellata* (Rosaceae). Plants 12(3): e536. https://doi.org/10.3390/plants12030536

Conti F, Cancellieri L, Cangelmi G, Filibeck G, Rosati L, Bartolucci F (2022) New records of native and alien vascular plants from Abruzzo, Lazio and Molise National Park (Italy), and additions to the flora of Abruzzo and Molise administrative regions. Annali di Botanica (Roma) 12: 23–34.

Conti F, Di Pietro R (2004) Note floristiche per l'Italia meridionale. Informatore Botanico Italiano 36(1): 35–39.

Conti F, Falcinelli F, Giacanelli V, Santucci B, Miglio M, Manzi A, Bartolucci F (2023a) New floristic data of vascular plants from central Italy. Natural History Sciences 10(1): 51–56. https://doi.org/10.4081/nhs.2023.636

Conti F, Giacanelli V (2023) Contribution to the vascular flora of Ventotene and Santo Stefano islands (Isole Ponziane, Lazio, Italy) with two taxa new to Lazio. Natural History Sciences 10(1): 83–86. https://doi.org/10.4081/nhs.2023.637

Conti F, Oberprieler C, Dorfner M, Schabel E, Nicoară R, Bartolucci F (2023b) *Adonis fucensis* (*A.* sect. *Adonanthe*, Ranunculaceae), a new species from the Central Apennines (Italy). Biology 12(1): e118. https://doi.org/10.3390/biology12010118

Conti F, Paolucci M, Bartolucci F, Di Carlo F, Manzi A, Paris P, Santucci B (2017) Aggiunte alla flora vascolare d'Abruzzo e aree limitrofe. IV contributo. Natural History Sciences 4 (1): 97–104. https://doi.org/10.4081/nhs.2017.330

Dakskobler I (2023) *Spiraea decumbens* Koch subsp. *tomentosa* (Poech) Dostál (*Spiraea hacquetii* Fenzl & K. Koch), novelty for the flora of Slovenia and the Dinaric Alps. Hacquetia 22(1): 107–116. https://doi.org/10.2478/hacq-2022-0003

De Notaris G (1844) Repertorium Florae Ligustica I-II. Reg. Typogr. Taurini.

Di Pietro R, Giardini M, Iamonico D, Tondi G, Angeloni D, Carli E, Aleffi M, Azzella MM, Di Pietro F, Proietti E, Ravera S, Fortini P (2022) Floristic and coenological data from the travertine substrates of the SAC "Travertini Acque Albule (Bagni di Tivoli)" (Lazio Region – Central Italy). Plant Sociology 59(2): 51–70. https://doi.org/10.3897/pls2022592/05

Domina F, Uhlich H, Barone G (2022) *Orobanche australis* Moris ex Bertol. the correct name for *O. thapsoides* Lojac. (Orobanchaceae). Phytotaxa 531(2): 91–96. https://doi.org/10.11646/phytotaxa.531.2.1

Ehrendorfer F (1962) Beitraege zur Phylogenie der Gattung *Knautia* (Dipsacaceae), I. Cytologische Grundlagen und allgemeine Hinweise. Oesterreichische Botanische Zeitschrift 109(3): 276–343. https://doi.org/10.1007/BF01289204

Ferrer-Gallego PP, Talavera M (2023) *Rhagadiolus edulis* (Cichorieae, Compositae), a replacement name for *Lapsana rhagadiolus* L. or a name of a new taxon? Phytotaxa 589(1): 91–96. https://doi.org/10.11646/phytotaxa.589.1.9

Fiori A (1898) *Helleborus* (Tourn.) L. In: Fiori A, Paoletti G (Eds) Flora Analitica d'Italia (Vol. 1(2)), Tipografia del Seminario, Padova, 517–519.

Fiori A (1924) Nuova Flora Analitica d'Italia (Vol. 1(5)). Tipografia di M. Ricci, Firenze, 641–800.

Fiori A (1927) Nuova Flora Analitica d'Italia (Vol. II(5)). Tipografia M. Ricci, Firenze.

Forneris G, Pistarino A, Pandolfo G, Bovio M (2011) Il "diario" del viaggio compiuto nel 1764 dalla Valle d'Aosta alla Savoia dai botanici Ludovico Bellardi e Francesco Peyrolery. Revue Valdôtaine d'Histoire Naturelle 65: 5–82.

Gallo L (2022) Endemic Crassulaceae in the Euro-Mediterranean biogeographical region needing protection. A preliminary checklist for conservation purposes. Bradleya 2022(sp40): 83–104. https://doi.org/10.25223/brad.sp40.2022.a9

Garbari F, Borzatti von Loewenstern A (2005) Flora pisana: elenco annotato delle piante vascolari della Provincia di Pisa. Atti Società Toscana di Scienze naturali, Memorie, Serie B, 112: 1–125.

Gariboldi L (2022) Note floristiche interessanti per la Lombardia, e non solo. Secondo contributo. Pianura 41: 26–40.

Geltman DV (2020) A synopsis of *Euphorbia* (Euphorbiaceae) for the Caucasus. Novitates Systematicae Plantarum Vascularium 51: 43–78. https://doi.org/10.31111/novitates/2020.51.43

GIROS (2016) Orchidee d'Italia. Guida alle orchidee spontanee (2° Ed.). Il Castello Editore, Milano.

Gottschlich G (2009) Die Gattung *Hieracium* L. (Compositae) in der Region Abruzzen (Italien). Stapfia 89: 1–328.

Gottschlich G, Pujatti D (2002) Il Genere *Hieracium* (Compositae) in Provincia di Trento (Nord Italia): chiave di determinazione, descrizione morfologica e distribuzione locale delle specie. Annali del Museo Civico di Rovereto 16: 273–351.

Griebl N, Presser H (2021) Orchideen Europas. Kosmos, Naturfuhrer.

Gussone G (1843–1844) Florae Siculae Synopsis (Vol. 2(1)). Ex Typis Tramater, Neapoli. https://doi.org/10.5962/bhl.title.50455

Hassler M (2023) World Ferns. Synonymic checklist and distribution of Ferns and Lycophytes of the World. Version 15.2. www.worldplants.de/ferns/ [Accessed 23.03.2023]

Heimer V, Frajman B (2023) Polyploidization was not involved in the origin of five endemic species from southern Europe but is otherwise frequent in *Euphorbia* section *Esula* (Euphorbiaceae). Botanical Journal of the Linnean Society: boac040. https://doi.org/10.1093/botlinnean/boac040

Jiménez-López FJ, Viruel J, Arista M, Ortiz PL, Talavera M (2022) Molecular approaches reveal speciation between red and blue flowered plants in the Mediterranean *Lysimachia arvensis* and *Lysimachia monelli* (Primulaceae). Botanical Journal of the Linnean Society 199(2): 557–577. https://doi.org/10.1093/botlinnean/boab081

Künkele S, Lorenz R (1995) Zum Stand der Orchideenkartierung in Sizilien. Jahresberichte des Naturwissenschaftlichen Vereins in Wuppertal 48: 21–115.

Martínez-Azorín M, Crespo MB, Alonso-Vargas MÁ (2022) Reinstatement of *Squilla* Steinh., a priority name against the illegitimate *Charybdis* Speta (Hyacinthaceae, Urgineoideae) Mediterranean Botany 43: e78272. https://doi.org/10.5209/mbot.78272

Montelucci G (1958) Appunti sulla vegetazione del Monte Velino (Appennino Abruzzese). Nuovo Giornale Botanico Italiano, n.s., 65 (1–2): 237–334.

Milia G, Mossa L (1977) Ricerche floristiche e vegetazionali nell'Isola di S. Antioco (Sardegna meridionale): la flora. Bollettino della Societa Sarda di Scienze Naturali 16(1976): 167–213.

Leoni G (2022) *Biarum tenuifolium* (L.) Schott una nuova specie per la bergamasca e l'Italia settentrionale. Notiziario Floristico del Gruppo Flora Alpina Bergamasca 62: 15–16.

Pennesi R, Cunto E, Ballelli S (2023) First record of *Rhizomatophora aegopodioides* (Apiaceae) in Italy. Italian Botanist 15: 65–76. https://doi.org/10.3897/italianbotanist.15.98538

Peruzzi L, Viciani D, Angiolini C, Astuti G, Banfi E, Brandani S, Bonari G, Cambria S, Cannucci S, Castagnini P, D'Antraccoli M, De Giorgi P, Di Natale S, Ferretti G, Fiaschi T, Gonnelli V, Gottschlich G, Lastrucci L, Lazzaro L, Misuri A, Mugnai M, Pierini B, Pinzani L, Roma-Marzio F, Sani A, Selvi F, Spinelli A, Bedini G (2019) Contributi per una flora vascolare di Toscana. XI (664–738). Atti della Società Toscana di Scienze Naturali, Memorie, Serie B 126(2019): 35–46.

Pignatti S (1982) Flora d'Italia, 1–3. Edagricole, Bologna.

Pignatti S, Guarino R, La Rosa M (2017) Flora d'Italia 1 (2nd Ed.). Edagricole di New Business Media,Milano, Italy.

Pignatti S, Guarino R, La Rosa M (2018) Flora d'Italia 3 (2nd Ed.). Edagricole di New Business Media, Milano, Italy.

Portal to the Flora of Italy (2023) Portale della Flora d'Italia/Portal to the Flora of Italy. 2022.2. https://dryades.units.it/floritaly/ [Accessed 1.05.2023]

POWO (2023) Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. http://www.plantsoftheworldonline.org/ [Accessed 14.04.2023]

Prosser F, Bertolli A, Festi F, Perazza G (2019) Flora del Trentino. Osiride-Fondazione Museo Civico, Rovereto, 1211 pp.

Reich D, Gutermann W, Prehsler D, Greimler J (2021) Typification of Kerner names in *Gentiana* sect. *Endotricha* Froel. (currently classified as *Gentianella* Moench, Gentianaceae). Phytotaxa 482(1): 1–13. https://doi.org/10.11646/phytotaxa.482.1.1

Rottensteiner WK [Ed.] (2014) Exkursionsflora für Istrien. Verlag des Naturwissenschaftlichen Vereins für Kärnten, Klagenfurt.

Sappa F (1950) La stazione di *Trifolium saxatile* All. in val di Susa (val Dora Riparia). Nuovo Giornale Botanico Italiano 56: 731–733. https://doi.org/10.1080/11263505009431497

Scafidi F, Raimondo FM (2019) Contribution to the vascular flora of the archaeological park of Selinunte and Cave of Cusa (South-Western Sicily, Italy): preliminary results. Bocconea 28: 371–390. https://doi.org/10.7320/Bocc28.371

Scrugli A (1972) Numeri cromosomici per la flora italiana: 124–125. Informatore Botanico Italiano 4(2): e129.

Scrugli A (1973) Numeri cromosomici per la flora italiana: 162–166. Informatore Botanico Italiano 5(3): 264–270.

Soldano A, Badino A (1989) Flora del Monte Fenera (Bassa Val Sesia) Rivista Piemontese di Storia Naturale 10: 93–112.

Španiel S, Juillerat P, Kaplan K, Bovio M, Bäumler B, Perret M, Mártonfiová L, Zozomová-Lihová L (2022) Out of the Balkans and Anatolia to the Western Alps? Surprising phylogenetic implications for two endemic *Alyssum* (Brassicaceae) species: *A. cognense* sp. nov. and *A. rossetii*. Botanical Journal of the Linnean Society 201(3): 286–308. https://doi.org/10.1093/botlinnean/boac041

Stace CA (2017) New combinations in six genera of the British flora. New Journal of Botany 7(1): 9–10. https://doi.org/10.1080/20423489.2017.1344044

Štěpánek J, Kirschner J (2023) A distinctive group of species allied to *Taraxacum danubium* (*T.* sect. *Erythrosperma*, Compositae-Crepidinae): a taxonomic revision. Folia Geobotanica. https://doi.org/10.1007/s12224-023-09425-6

Sutorý K (2022) Two omitted *Cynoglossum species* (Boraginaceae) from the Mediterranean area. Acta Musei Moraviae, Scientiae Biologicae 107(1–2): 37–47.

Tenore M (1820) Flora Napolitana 2. Stamperia francese, Napoli.

Tenore M (1830) Succinta relazione del viaggio fatto in Abruzzo ed in alcune parti dello Stato Pontificio dal Cavalier Tenore nell'Està del 1829. Stamperia della Società Filomatica: [1]–90 [91].

Tenore M (1831) Sylloge Plantarum Vascularium Florae Neapolitanae Hucusque Detectarum. Tipografia del Fibreno, Neapoli [Naples], 580 pp.

Terracciano N (1890) Intorno ad alcune piante della Terra di Lavoro. Atti della Reale Accademia delle Scienze fisiche e matematiche di Napoli, ser. 2, 4, app. 2, 10 pp. [reprint]

Tison J-M, de Foucault B (2014) Flora Gallica. Flore de France. Biotope Éditons, Mèze.

Tomasi G, Prosser F, Bertolli A (2022) Aggiornamento alla "Flora del Trentino", 3: *Utricularia breemii* Heer ex Koell. Annali del Museo Civico di Rovereto 38: 31–38.

Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Kusber W-H, Li D-Z, Marhold K, May TW, McNeill J, Monro AM, Prado J, Price MJ, Smith GF [Eds] (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile 159: 1–254. https://doi.org/10.12705/Code.2018

Vaccari L (1904–1911) Catalogue raisonné des plantes vasculaires de la Vallée d'Aoste. Volume I – Thalamiflores et Calyciflores. Imprimerie Catholique, Aoste. Ristampa anastatica + indici. Ed. S.G.S., Torino. https://doi.org/10.1002/fedr.19100082011

Vaccari L (1909) Plantae italicae criticae. Fasciculus I. Annali di Botanica (Roma) VII(3): 291–320.

Vaccari L (1910) 1507. *Trifolium saxatile* All. In: Béguinot A, Fiori A (Eds) Flora Italica Exsiccata. Series II. Giornale Botanico Italiano, nuova serie, 18: e461.

Verlaque R, Hardion L, Lambertini C, Canavan K, Verlaque M, Vila B (2023) New highlights on Old World giant *Phragmites* (Poaceae) using leaf and floral bract microscopic characters. Aquatic Botany 184: e103591. https://doi.org/10.1016/j.aquabot.2022.103591

Villa M, Banfi E, Galasso G (2022) Flora vascolare del Parco regionale di Montevecchia e della Valle del Curone (Lombardia, Italia settentrionale). Natura 112(2): 1–64.

Vogel JC, Rumsey FJ, Schneller JJ, Jacob J (1998) The origin, status and distribution of *Asplenium presolanense* spec. nov. (Aspleniaceae, Pteridophyta). Botanica Helvetica 108: 269–288.

Zahn KH (1906) Die Hieracien der Schweiz. Neue Denkschriften der Allg(emeinen) Schweizerischen Gesellschaft für die gesammten Naturwissenschaften 40(4): 163–728.

Zahn KH (1921) *Hieracium*. In: Engler A (Ed.) Das Pflanzenreich 76 (IV.280). Engelmann, Leipzig, 289–576.

Zodda G (1953) La Flora Teramana. Webbia 10: 1–317. https://doi.org/10.1080/00837792.1954.10669624

Supplementary material 1

Supplementary data

Authors: Fabrizio Bartolucci, Gabriele Galasso

Data type: species data

Explanation note: 1. Nomenclatural updates; 2. Note updates; 3. Distribution updates; 4. Synonyms, misapplied or included names.

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/italianbotanist.15.105796.supp1

Italian Botanist 15: 111–136 (2023)
doi: 10.3897/italianbotanist.15.102589
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

Spontaneous vascular flora of the historical monumental cemetery of Modena (N-Italy)

Fabrizio Buldrini[1,2], Ilaria Gianaroli[3], Giovanna Bosi[3,4], Alessandro Alessandrini[5], Claudio Santini[6]

1 *Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Università di Bologna, Via Irnerio 42, 40126, Bologna, Italy* **2** *Sistema Museale di Ateneo, Università di Bologna, Via Irnerio 42, 40126, Bologna, Italy* **3** *Laboratorio di Palinologia e Paleobotanica, Dipartimento di Scienze della Vita, Università di Modena e Reggio Emilia, Via G. Campi 287, 41125, Modena, Italy* **4** *NBFC, National Biodiversity Future Center, 90133, Palermo, Italy* **5** *San Pietro in Casale, Bologna, Italy* **6** *Gruppo Flora Modenese, Modena, Italy*

Corresponding author: Fabrizio Buldrini (fabrizio.buldrini@unibo.it)

Academic editor: Fabrizio Bartolucci | Received 16 March 2023 | Accepted 27 May 2023 | Published 12 July 2023

Citation: Buldrini F, Gianaroli I, Bosi G, Alessandrini A, Santini C (2023) Spontaneous vascular flora of the historical monumental cemetery of Modena (N-Italy). Italian Botanist 15: 111–136. https://doi.org/10.3897/italianbotanist.15.102589

Abstract

The first floristic study of the historical monumental cemetery of San Cataldo in Modena (N-Italy) is presented. The research was performed in the period 2019–2022, considering only spontaneous individuals growing within the historical area (4.8 ha). A total of 266 taxa (species and subspecies) was found, of which 1 new for the flora of Italy (*Malus* ×*robusta* 'John Downie'), 2 new for the administrative region of Emilia-Romagna (*Calocedrus decurrens* and *Salvia haematodes*) and 1 new for the province of Modena (*Epilobium ciliatum*). Therophytes prevail (37.6%), followed by hemicryptophytes (31.6%), phanerophytes (16.2%) and geophytes (11.7%). The chorological spectrum is dominated by Eurasian species (32.0%), followed by Mediterranean (26.3%), Cosmopolitan (24.8%), Boreal (6%) and N-American (4.5%) ones. Allochthonous species are 16.5% of the list, with neophytes always prevailing over archaeophytes (28 *vs.* 9 species). Invasive species are 67.8% of the neophytes; on a regional scale they are 1.5% of the list. Protected species are 2.6% of the total; 3 of them are internationally protected and 2 are included in the red list of Italian flora. This study confirms the great biological richness of urban environments and the potential of historical cemeteries as a refugium for the conservation of species that have become rare, endangered or infrequent at a regional or national level, because of the heavy human impact on the territory.

Keywords

Allochthonous species, historical cemetery, plant biodiversity, protected species, ruderal species, urban ecosystem

Copyright *Fabrizio Buldrini et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

In Europe, monumental cemeteries are intended as those with «a planned and grandiose layout […] articulated by a web of axial avenues and punctuated by major buildings, such as chapels, gateways and porticoes»: in other words, they are cemeteries where «architecture must prevail over the landscape», in contrast to the so-called garden (or picturesque) cemeteries (Malone 2017). In Italy, they are defined as burial grounds characterised by remarkable monuments of historical-artistic relevance and historical-cultural value as sites of collective memory, linked to important historical episodes or specific religious ambits. These cemeteries are ascribable to the category of the so-called «cultural landscapes», also thanks to given landscape features (Regione Emilia-Romagna 2022). They are typical of Mediterranean Europe, in countries of Latin culture, and are often inspired by the architectonic structure of the medieval cloister, by the Italian garden and by the Roman monumental tradition (Bontempi 2011; Malone 2017). They often have a high artistic value, since tombs are adorned with elaborate sculptures (at times paintings, too) that can be the work of famous artists. Certain monumental cemeteries, such as the Cimitero della Certosa of Bologna, the Cimitero Monumentale di Milano or the Cimitero Monumentale di Staglieno in Genoa, are true open-air museums, visited, in the past, by writers and poets like Chateaubriand, Byron, Stendhal, Mommsen and Dickens in the course of their Grand Tour (Felicori 2006; Felicori and Zanotti 2006). Most of these cemeteries were conceived and built after the Décret Impérial sur les Sépultures, promulgated by Napoleon on June 12th, 1804, to solve the hygiene problems related to the custom of inhuming the dead within the city walls, that for centuries had been the practice in the entire continent (Malone 2017). Therefore, these sites are generally 150–200 years old (Barban 1928; Felicori 2006; Marino 2014; Malone 2017). In Italy, the first one was built in Naples (Poggioreale, 1813–1840), followed by those of Brescia (1815–1856), Cagliari (1827–1829), Turin (1828–1830), Verona (1828–1844), Cremona (1828–1860s) and Genoa (1844–1860s). Nevertheless, some monumental cemeteries pre-date the Napoleonic decree: for example, that of Pisa (Campo Santo), founded in 1278 and described as the first monumental cemetery in Italy (Rovani 1854), will be the model for numerous subsequent cemeteries in Italy and Europe; the ones of Bologna (Certosa, founded in 1801) and Ferrara (1811) both reused pre-existing structures dating from 1334 and 1452, respectively (Malone 2017).

Today, historical cemeteries are of remarkable interest also from an ecological viewpoint, because they can act as a refuge for numerous animal, plant and lichen species (Trzaskowska and Karczmarz 2013; Kowarik et al. 2016; Löki et al. 2019) that elsewhere are rare or extinct owing to the profound human impact on the territory. The floristic diversity of cemeteries derives from geographical, historical, cultural and social factors (Czarna et al. 2007), whereas species richness depends on management type of the various areas; to zones differing by age of foundation correspond diverse biotic communities, well characterised by a peculiar species composition (Kowarik et al. 2016). The partial or nearly total abandonment to which some portions of a cemetery are often

subjected permits the formation of particular habitats, where it is not infrequent to discover rare species that have found a refuge because of the low human disturbance (Czarna and Piskorz 2005; Latini 2007; Sigiel-Dopierała and Jagodziński 2011; Trzaskowska and Karczmarz 2013; Buchholz et al. 2016). Age of the cemetery and religious confession do not seem to have a particular influence on species diversity (Rutkovska et al. 2011). In the long run, the inveterate use of adorning graves with cut flowers or living plants, often exotic, kept in a pot or in the ground, allows them first to naturalise within the cemetery, then spread out and start colonising the territory (Hügin and Hügin 1999; Pyšek et al. 2004; Lazzeri et al. 2013; Bellone et al. 2015). In fact, a strong positive correlation exists between the area occupied by the cemetery and the number of allochthonous species recorded therein (Rutkovska et al. 2011); moreover, some species introduced by Man over time become naturalized and well established in cemeteries, so that they are known as «permanent cemetery species» (*sensu* Czarna 2001 and Czarna et al. 2011, defined as «old» vascular plants, cultivated since many years).

Historical cemeteries can host a great number of autochthonous and exotic vascular plant species, including many that are infrequent in rural zones (McBarron et al. 1988). Nonetheless, studies on the flora and vegetation of cemeteries are still scarce (Šilc 2009) and mostly limited to simple lists of woody species, whereas herbaceous ones are nearly never considered (Stypiński 1978; Dorda 1995; Antkowiak and Heine 2005). In addition, although the potential of cemeteries in the spreading of allochthonous species is not negligible, the first research efforts in this sense are recent and still confined to very few countries (e.g., Bowdler et al. 2002, 2007; Gudžinskas 2005).

In general, interest for the study of cemetery flora can be explained as follows:

- it is a flora that normally develops in mostly anthropogenic habitats, which are, however, similar to natural habitats with moderate disturbance;
- it is possible to thoroughly investigate the presence of exotic species, for whom the cemetery might act as a spreading centre for the surrounding territory;
- it is possible to compare the spontaneous flora of the cemetery with that of the historical centre of the same city, since both are stable environments from an urban viewpoint, albeit very different in terms of quality and intensity of human disturbance;
- it offers an opportunity to increase our knowledge of the auto-ecology of various species and the effects of human influence on other living organisms.

Even though the notable botanical interest of historical cemeteries has been recognized since the 1920s (Rojecka 1934), studies exclusively dedicated to cemeteries built in the XIX century are still very few and often referred to central-eastern Europe or to the Baltic Republics; to our knowledge, no information on monumental cemeteries is available so far. The aim of this work was to perform the first systematic research on the spontaneous flora of one of the most ancient monumental cemeteries in Italy, the Cimitero di San Cataldo in Modena (Avramidou and Maio 2006). The cemetery is renowned because it hosts the tombs of some famous people (such as Enzo Ferrari, founder of the well-known car factory). To date, the entire area has been the object of

simple sporadic observations, which were mostly made during a floristic analysis of the whole province (Alessandrini et al. 2010; Santini et al. 2019). The results will be compared to those obtained in a recent study of the urban flora of the historical city centre (Buldrini et al. 2020), as an ideal continuation and completion of the research on the spontaneous flora of the most ancient part of the city of Modena. A comparison will also be made with studies on other cemeteries in Europe; these are very different, both from a climatic-environmental and physiognomical standpoint, so the comparison will be necessarily made only at a general level.

Materials and methods

Study area: geographical, pedological, and urban context

Modena (44°10.683'N, 10°55.533'E, 35 m a.s.l.) is situated in northern Italy (Emilia-Romagna administrative region, Fig. 1), in a flat territory bordered by the River Secchia westward and the River Panaro eastward. Inhabitants are 185719 (Comune di Modena – Servizio Statistica 2022).

Soils are principally clayey with a small amount of silt, very calcareous and moderately alkaline. From a geographical standpoint, they are part of a plain with alluvial cover and are situated on transition deposits joining valleys and natural embankments. These soils are very deep, with good oxygen supply for plant roots; their texture is moderately fine at the surface and they do not present any constraints for plant growth. According to the Soil Taxonomy, they are classified as Fluventic Ustochrepts fine-silty, mixed, mesic (Guermandi and Preti 1993).

The study site is the Cimitero di San Cataldo, a historical monumental cemetery in the northwestern outskirts of the city (Fig. 1A, B), whose name derives from the ancient church and convent of San Cataldo, adjacent to the cemetery; it is situated *ca*. 2 km northwest of the ancient city walls (Avramidou and Maio 2006).

Study area: climate

Modena is about 100 km from the Adriatic Sea and has a typically continental climate, with rigid winters, warm summers, often very high atmospheric humidity and absence of wind. Especially during winter, and particularly in suburban areas, the formation and persistence of fog is frequent, normally associated to anticyclonic periods. Summer is generally humid, hot and muggy, with stormy precipitation (Lombroso and Quattrocchi 2008; Alessandrini et al. 2010).

During the climate reference period 1991–2020, average monthly temperatures showed a minimum in January (4.3 °C) and a maximum in July (26.1 °C); during summer it is frequent to exceed 30 °C, not rarely for many consecutive days, with peaks close to 40 °C (Lombroso and Teggi 2017, 2018; Lombroso et al. 2019). Average annual temperature is 15.1 °C; average minimum temperature is 11.6 °C and

average maximum temperature is 18.6 °C (Lombroso et al. 2022). In the surrounding suburban areas, the urban heat island raises average monthly temperatures by 1.4 °C in the daytime and by over 6 °C at night, in particular during peaks of heat and cold (Magli et al. 2015). On average, the days with minimum temperature lower than 0 °C are 16.9 per year and those with maximum temperature lower than 0 °C are 1.2 per year. The average relative humidity is 61.7%, variable from 45.4% in July and 79.5% in November–December. Annual precipitation is 691.4 mm, with 114 rainy days per year; spring and autumn are the wettest seasons. Snow precipitation, on average, is 29.5 cm per year (Lombroso et al. 2022; Lombroso and Despini unpubl. data). In the years 2019–2022, when the floristic research was performed, significant differences were recorded with respect to the above-mentioned average climatic conditions (Lombroso et al. 2020, 2021, 2022): anomalous rainfall values (+37.8% in 2019, -47.0% in 2021, -23.8% in 2022) and higher average annual temperatures (+1.1 °C in 2019, +1.7 °C in 2022); snowfall never exceeded 16 cm per year.

Floristic research: the zones considered

To investigate the flora of all historic and monumental parts of the Cimitero di San Cataldo, we explored 4 zones differing in surface area, age of foundation, and frequency of visits (Fig. 1A): in the Catholic cemetery, we considered the monumental part (zone 1a – Fig. 1D), the ancient tombs disposed all along the southern perimeter wall of the cemetery (zone 1b), and the grasslands of the ancient ossuary (zone 1c – Fig. 1E); in the Jewish cemetery, we took into account the entire area (zone 2 – Fig. 1F). All of the green areas within the cemetery complex are mowed on average 7–8 times per year, depending on the season's weather trend; even in case of exceptionally snowy winters or rainy summers, mowing frequency never exceeds 10 times per year (Bartolamasi *in verbis*).

The Catholic cemetery

The first construction of a burial site in the area of San Cataldo, outside the city walls, dates back to 1773: it is one of the very first extraurban cemeteries of Italy and Europe (Bertuzzi 1990; Avramidou and Maio 2006; Malone 2017). The project realisation, attributed to Giovanni Francesco Zanini, was very complex due to the characteristics of the area, namely the fact that the ground did not permit adequate degradation of organic matter and effective drainage of rainwater. The first cemetery was built with a rectangular base (86×61 m) and was surrounded by an embankment *ca*. 3.5 m high. Its style, inspired by the Enlightenment criteria of that age, was quite anonymous and impersonal, without a particular architecture or any ornament to the memory of the dead (monuments and chapels were added from 1778 onwards – Malone 2017). This site remained in operation for decades, until in 1850 the Municipal Council of Modena decided to refurbish it; the project was developed by the architect Cesare Costa. When the cemetery was reopened, albeit partially, in 1864, it was 51000 m² wide and its construction was still incomplete.

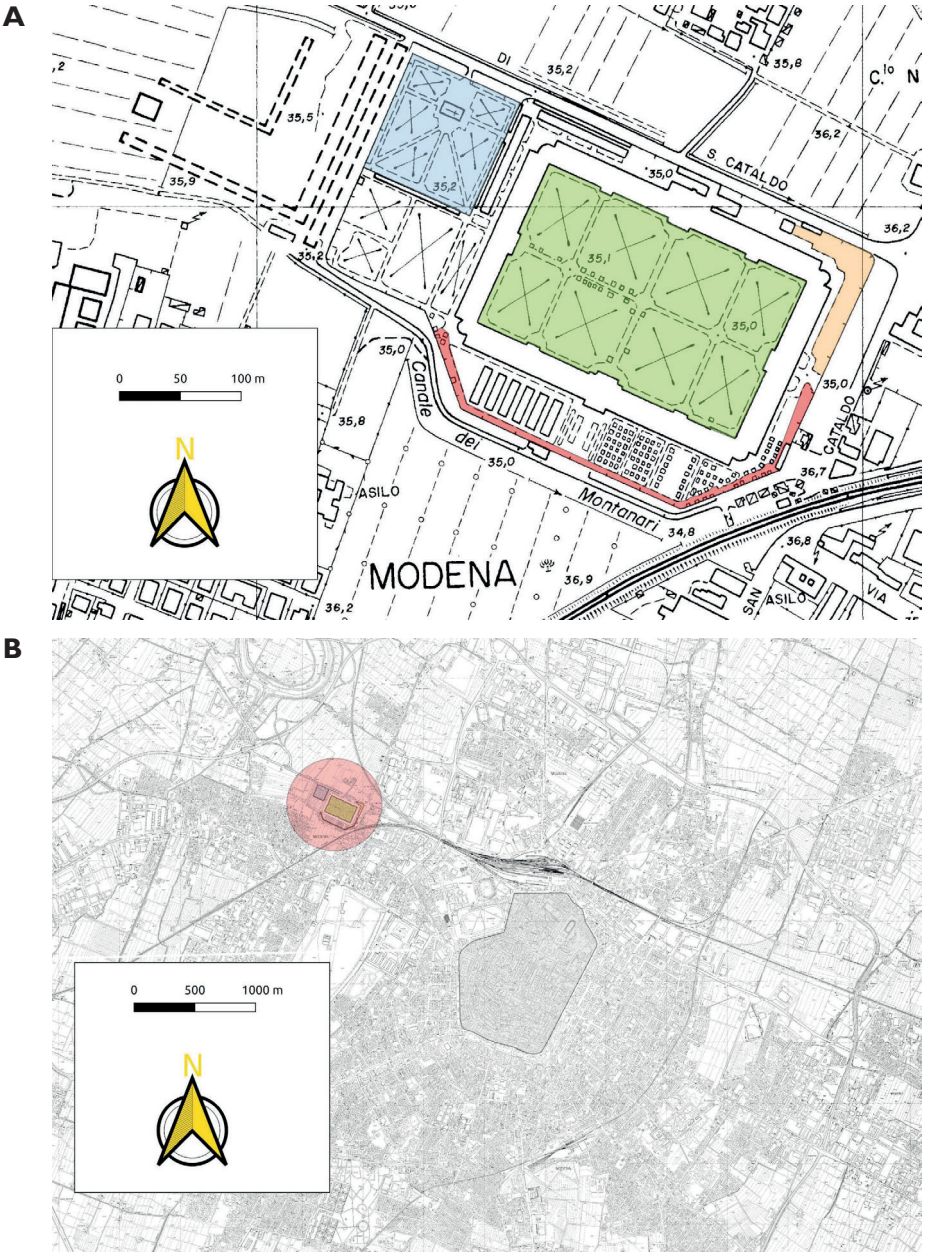

Figure 1. The cemetery area of Modena **A** position of the areas investigated (green: Catholic cemetery, monumental part – zone 1a in the text; red: Catholic cemetery, ancient tombs disposed all along the southern perimeter wall of the cemetery complex – zone 1b in the text; orange: Catholic cemetery, grasslands of the ancient ossuary – zone 1c in the text; blue: Jewish cemetery – zone 2 in the text) **B** position of the cemetery area with regard to the historical city centre (in gray) **C** position of Modena (black dot) within Italy **D** view of the Catholic cemetery in the monumental part **E** view of the grassland of the ancient ossuary in the Catholic cemetery **F** view of the Jewish cemetery. The cartographic base of parts **A** and **B** derives from the Carta Tecnica Regionale dell'Emilia-Romagna (scale 1:5000), with modifications.

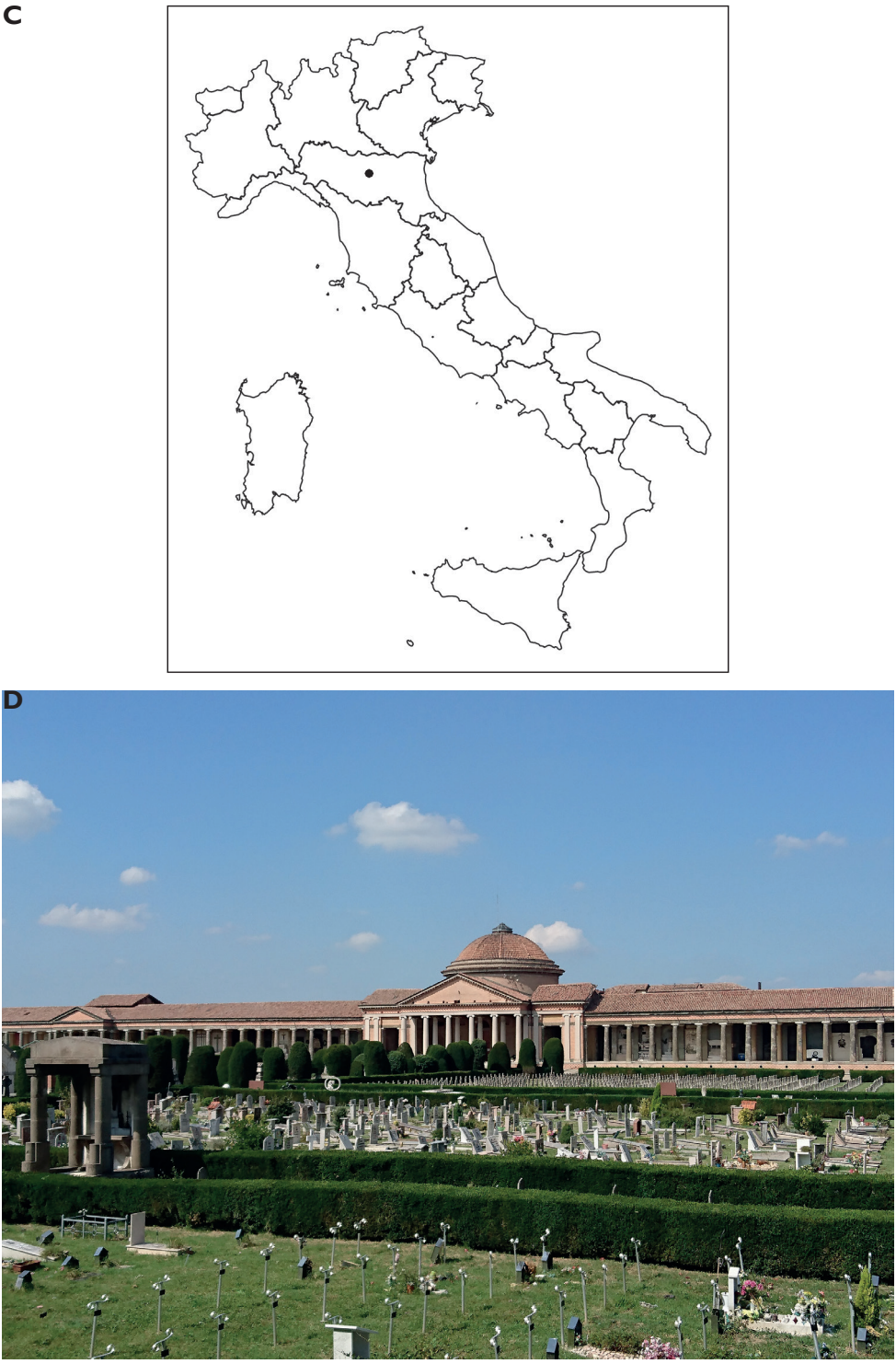

Figure 1. Continued.

E

F

Figure 1. Continued.

During the 1930s, other works on the columns of the portico were carried out, then others in 1948 and again in the 1960s and 1970s, with the construction of new external galleries in the northern and eastern sides and a refurbishment of the southern access. Finally, the cemetery acquired the monumental aspects of funerary architecture, that should assure the survival of the dead in the collective memory. In fact, it is rich in statues and artworks adorning tombs, that make it a true open-air museum (Felicori and Zanotti 2006).

Three areas were investigated in the Catholic cemetery:

- zone 1a (33000 m²) – the area is delimited by the portico and is subdivided into eight rectangular sectors disposed in two rows, intermixed with gravel driveways. Many of these sectors are currently in use, therefore subjected to quite frequent works; the remnant, not occupied by tombs or dedicated to the soldiers who died in the First World War, are maintained as lawns;
- zone 1b (2500 m²) – this area is occupied by the tombs disposed all along the southern perimeter wall of the entire cemetery complex, outside the monumental part described above; they often are quite old (late XIX-early XX century), with a certain show of monumentality and, in many cases, abandoned;
- zone 1c (2560 m²) – this area comprises the grasslands of the ancient ossuary, scarcely visited and dating back to the late XVIII century, i.e. at the foundation of the entire cemetery complex (Avramidou and Maio 2006).

The Jewish cemetery

The present Jewish cemetery of Modena (zone 2) substitutes the original one, dating back to the XVII century, which was situated a few hundred meters outside the city walls, in a zone that is now densely urbanised. In 1900, the Municipal Council approved the project of the new cemetery, in an area adjacent to the Catholic one; the cemetery itself, built and paid by the local Jewish community, was opened in 1903. Bodies and tombstones were then transferred here and the old cemetery was closed and subsequently dismantled (Avramidou and Maio 2006).

In this cemetery, little or nothing has changed since its opening. It does not have the monumental character of the Catholic one, consists of a square-shaped area of 10000 m², surrounded by a perimeter wall and divided into six parts (two rectangular ones practically without tombs, and four larger ones, one of them nearly devoid of tombs), intermixed with narrow gravel driveways. Many other tombs are situated all along the perimeter walls. In an off-centre position there is a small building in neoclassical style, used for funeral rites, designed by the engineer Eugenio Guastalla. All six parts of the cemetery are maintained as lawns (Avramidou and Maio 2006).

Study method

The floristic surveys were carried out in the period 2019–2022, spread over nine months of observation per year (during the vegetative season from February to October); two surveys per month were generally performed (Gianaroli 2020 and unpubl. data).

Data from occasional observations performed in past years (from April 1998 to April 2015) and data from herbarium samples preserved in the Erbario dell'Orto Botanico di Modena (MOD), which were already published by Alessandrini et al. (2010), were also considered.

Only spontaneous vascular plant species were taken into account. Individuals growing in the grasslands, under or within the hedgerows or other ornamental plants, among or over the tombstones, on the gravel driveways, in the cracks of sidewalks or walls up to a height of 1 m above ground level were considered (further details are reported in Table 1). Species introduced by Man for ornamental purposes were taken into account only if they had spread spontaneously, since they can be regarded as exotic cultivated and naturalized species (*sensu* Viegi et al. 1974). All areas subjected to works during the study period (addition of new tombs, refurbishment of existing ones etc.) were excluded from our analyses, to record only the species with a more or less stable presence within the historical part of the cemetery.

Whenever possible, plant species were identified directly in the field; otherwise, a sample was collected and examined under a stereomicroscope (Nikon C-PS SMZ645). Identifications were performed following Zangheri (1976), Rothmaler (2000), Eggenberg and Möhl (2015), Pignatti et al. (2017–2019), Lepší et al. (2019). In particular, *Malus* ×*robusta*

Table 1. Growth environments considered in this study, with a description of their characteristics and plant cover.

Growth environment	Explanation and kind of plant cover
Grasslands	grasslands and lawns, regularly mowed, with or without tombs (plant cover: continuous and dense)
Fissures	fissures and cracks between the stone slabs composing the monumental tombs, or in the sidewalks (plant cover: isolated, sporadical individuals, in general)
Sand	sandy sediment at the base of the brick walls, due to the degradation of the mortar and the bricks themselves (plant cover: isolated individuals)
Under the hedgerows	under the hedgerows, or under the crown of other woody plants cultivated for ornament (plant cover: at places continuous, at places discontinuous)
Within the hedgerows	within the hedgerows, or within the crown of other woody plants cultivated for ornament (plant cover: single individuals emerging from the crown of the hedgerow or ornamental woody plant, but whose roots are at the foot of the hedgerow/ornamental woody plant itself)
Soil from the flowerbeds on the grave closing slabs	soil (not rarely old) from the flowerbeds on the slabs closing the graves, both in monumental tombs and in graves on the ground (plant cover: continuous, sometimes nearly dense)
Clay between adjacent tombs	clay between two adjacent tombs, not or rarely mowed (plant cover: nearly continuous, but not necessarily dense)
Gravel driveways	in the gravel driveways, or at their margins (but not on the slope of the grasslands or lawns, which is formed by the rise of the ground in the burial areas) (plant cover: discontinuous, but sometimes relatively dense)
Backfill	backfill, sometimes mixed with old soil, of the large flowerbeds where hedgerows and ornamental trees are grown (plant cover: discontinuous, at places sparse)
Clay	clay in the driveways or at the margins of grasslands and lawns (on the slopes) (plant cover: sparse)

was identified according to Stace (1997), Johnson and More (2006), Sterry (2007), Brickell (2012) and Wöhner et al. (2014). Life forms and chorotypes were attributed according to Pignatti et al. (2017–2019); in view of the analyses, chorotypes were subsequently grouped into macro-chorotypes *sensu* Poldini (1991), Tomaselli and Gualmini (2000) and Alessandrini et al. (2010). Nomenclature, taxonomy, distribution and status (native, archaeophyte, neophyte, cryptogenic) of the species follow Bartolucci et al. (2018) and Galasso et al. (2018) and their updates periodically appearing in the Portal to the Flora of Italy (2022; see also Martellos et al. 2020). Protection level at a national and regional scale was attributed according to Rossi et al. (2013, 2020) and Regione Emilia-Romagna (2018).

To better characterize the single zones examined, we calculated the number of growth environments detected in each one, Pearson's correlation coefficient between species number and number of growth environments for each area and Jaccard's similarity index for all the areas.

Results

The taxa (species and subspecies) recorded in the entire area examined were 266 (see Suppl. material 1), of which 129 were found in zone 1a, 100 in zone 1b, 61 in zone 1c and 180 in zone 2. The taxa found in the three areas belonging to the Catholic cemetery summed up to 205; 118 out of 205 taxa (57.6%) were also present in the Jewish cemetery. Of the 266 taxa, 176 (66.2%) were already included in the flora of the historical centre of Modena.

These 266 taxa belong to 66 families and 175 genera. The most represented families are Asteraceae (37 taxa), Poaceae (35), Brassicaceae (16), Fabaceae (14), Rosaceae (13), Caryophyllaceae (12) and Lamiaceae (11); the others include up to 10 taxa each. The most represented genera are *Crepis*, *Galium*, *Ranunculus* and *Trifolium* (each one with 5 taxa), *Erigeron*, *Geranium*, *Lepidium*, *Poa* and *Veronica* (4 taxa), *Allium*, *Anisantha*, *Cerastium*, *Convolvulus*, *Epilobium*, *Equisetum*, *Euphorbia*, *Lactuca*, *Oxalis*, *Quercus*, *Salvia* and *Setaria* (3 taxa).

Of the total number of taxa recorded, 1 is new for the flora of Italy (*Malus* ×*robusta* (Carrière) Rehder 'John Downie', casual alien), 2 are new for the flora of Emilia-Romagna (*Calocedrus decurrens* (Torr.) Florin, casual alien, and *Salvia haematodes* L., native to Italy) and 1 is new for the flora of the province of Modena (*Epilobium ciliatum* Raf., naturalized alien on a national and regional scale). They were found in zone 1a (*E. ciliatum*), zone 1b (*C. decurrens*), zone 1c (*M.* ×*robusta* 'John Downie') and in all areas (*S. haematodes*), respectively.

Draba verna L. subsp. *verna* is the only taxon collected in the cemetery that is also present in the Erbario dell'Orto Botanico di Modena (*Leg*. A. Vaccari, April 1883, «Muri del cimitero di S. Cataldo presso Modena», in MOD), later confirmed during field surveys. On the contrary, the following species, recorded in past years, were not confirmed during this research: *Allium pallens* L., *Ranunculus sardous* Crantz, *Salvia virgata* Jacq. (all three in the Catholic cemetery) and *Ranunculus acris* L. subsp. *acris* (Jewish cemetery), whose findings date back to the period 1999–2014.

Concerning the growth environments (Table 1), most taxa were found in grasslands and gravel driveways (158 and 108, respectively), followed by fissures and cracks (73), soil from the flowerbeds on the grave closing slabs (55), and backfill (54); the other habitats hosted no more than 30 taxa each. The highest environmental variety was found in zone 1a, the lowest in zone 1c (Table 2). The correlation value between number of taxa recorded in each zone and number of growth environments is 0.709.

The life form spectrum (Fig. 2) is always dominated by annual species (therophytes), forming up to 40.0% of the total list (entire study area 37.6%), followed by hemicryptophytes, variable between 30.0 and 32.7% (entire study area 31.6%), phanerophytes, variable between 11.7 and 20.0% (entire study area 16.2%) and geophytes, variable between 10.6 and 13.3% (entire study area 11.7%). Chamaephytes and helophytes are a very marginal presence (entire study area 2.6% and 0.4%, respectively), not observed in all of the sectors. The vast majority of the flora is, therefore, composed

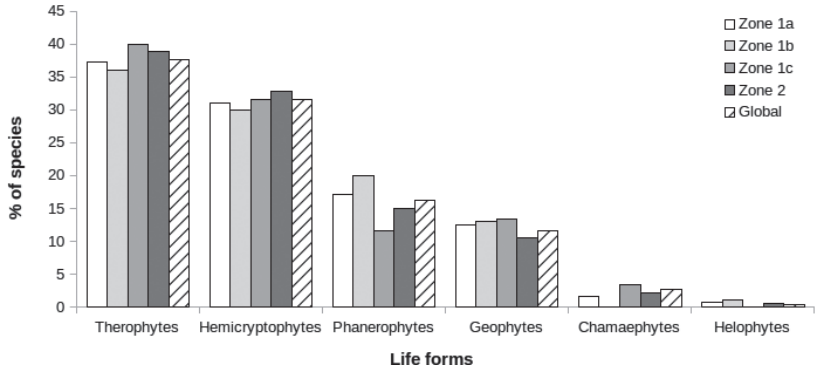

Figure 2. Life form spectrum of the study area. Zone 1a: Catholic cemetery, monumental part; zone 1b: Catholic cemetery, ancient tombs disposed all along the southern perimeter wall of the cemetery complex; zone 1c: Catholic cemetery, grasslands of the ancient ossuary; zone 2: Jewish cemetery.

Table 2. Growth environments in each of the cemetery sectors analysed during this study. Zone 1a: Catholic cemetery, monumental part; zone 1b: Catholic cemetery, ancient tombs disposed all along the southern perimeter wall of the cemetery complex; zone 1c: Catholic cemetery, grasslands of the ancient ossuary; zone 2: Jewish cemetery.

Growth environment	Zone 1a	Zone 1b	Zone 1c	Zone 2
Grasslands	x		x	x
Fissures	x	x	x	x
Sand	x			
Under the hedgerows	x		x	x
Within the hedgerows	x	x		x
Soil from the flowerbeds on the grave closing slabs	x	x		x
Clay between adjacent tombs	x	x		x
Gravel driveways	x	x		x
Backfill	x	x		
Clay	x	x	x	x
Total number	**10**	**7**	**4**	**8**

by herbaceous species, with values comprised between 80.0% in zone 1b and 88.3% in zone 1c (entire study area 83.8%).

The chorological spectrum (Fig. 3) is always dominated by widely distributed types. The prevailing species are Eurasian, Mediterranean and cosmopolitan, with values ranging between 31.0 and 35.0% (entire study area 32.0%), 19.0 and 30.0% (entire study area 26.3%) and 21.7 and 36.2% (entire study area 24.8%), respectively.

Allochthonous species occurred in all sectors analysed, with values comprised between 9.8% in zone 1c and 22.0% in zone 1b; in the entire study area they were 16.9% of the list (Table 3). Neophytes were always dominant, with values comprised between 47.4 and 100% of the total number of exotic species (in zones 1a and 1c, respectively); in the entire study area they composed 62.2% of the exotic species list. Among neophytes, invasive species made up 67.8% of the total, but the species with an invasive behaviour also on a regional scale were limited to 4 out of 28, i.e., *Ailanthus altissima* (Mill.) Swingle, *Erigeron canadensis* L., *Lonicera japonica* Thunb. and *Vitis* ×*koberi* Ardenghi, Galasso, Banfi & Lastrucci. Archaeophytes were few (9 species, i.e. 3.4% of the total floristic list); most of

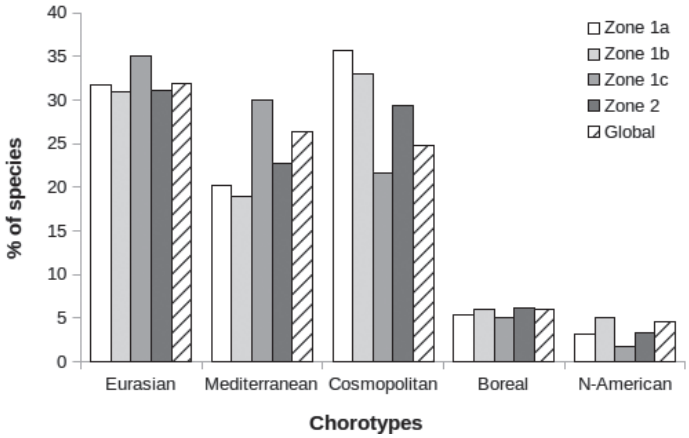

Figure 3. Chorological spectrum of the study area. Chorotypes with less than 3% of species are omitted. Zone 1a: Catholic cemetery, monumental part; zone 1b: Catholic cemetery, ancient tombs disposed all along the southern perimeter wall of the cemetery complex; zone 1c: Catholic cemetery, grasslands of the ancient ossuary; zone 2: Jewish cemetery.

Table 3. Number of allochthonous species recorded in this study, subdivided by area and category. Zone 1a: Catholic cemetery, monumental part; zone 1b: Catholic cemetery, ancient tombs disposed all along the southern perimeter wall of the cemetery complex; zone 1c: Catholic cemetery, grasslands of the ancient ossuary; zone 2: Jewish cemetery.

Species category	Zone 1a	Zone 1b	Zone 1c	Zone 2	Global
Archaeophytes	5	3	0	8	9
Neophytes	9	13	6	16	28
Cryptogenic	5	6	0	6	8
Total number	**19**	**22**	**6**	**30**	**45**

them were casual or naturalized species on a national scale (the only invasive archaeophyte was *Sorghum halepense* (L.) Pers.). Cryptogenic species (8, globally) were never invasive. None of the allochthonous species was frequent or abundant: only *Erigeron sumatrensis* Retz. and *Euphorbia prostrata* Aiton were relatively common, but populations were always composed by a modest number of individuals (5–10 or less) or even isolated plants.

The species classified as endangered at a national level were 2 (*Allium roseum* L. subsp. *roseum* and *Bellevalia romana* (L.) Sweet, both assessed as «LC» – least concern), those protected at a regional level were 5 (*Anacamptis morio* (L.) R.M.Bateman, Pridgeon & M.W.Chase, *Ilex aquifolium* L., *Orchis purpurea* Huds., *Spiranthes spiralis* (L.) Chevall. – Fig. 4 – and *Taxus baccata* L.). It should be pointed out that *A. morio*, *O. purpurea* and *S. spiralis* are also protected at an international level (CITES), since

Figure 4. Flowering individual of *Spiranthes spiralis* (L.) Chevall. in the grasslands of the Jewish cemetery (zone 2). The plant is ca. 15 cm high.

all species ascribed to the Orchidaceae are listed among those for which international trade is forbidden. Globally, the 7 species mentioned above account for 2.6% of the total list. In zone 2, 5 red-listed species were found (*A. roseum* subsp. *roseum*, *A. morio*, *B. romana*, *S. spiralis*, *T. baccata*), in zone 1a 2 (*A. roseum* subsp. *roseum*, *I. aquifolium*) and in zone 1c 1 (*O. purpurea*).

The similarity *sensu* Jaccard of the zones considered is as follows: 1a–1b: $J = 0.316$; 1a–1c: $J = 0.132$; 1a–2: $J = 0.373$; 1b–1c: $J = 0.135$; 1b–2: $J = 0.353$; 1c–2: $J = 0.137$.

Discussion

This study examines, for the first time, the spontaneous vascular flora of a European historical monumental cemetery. In Europe, in fact, the few surveys conducted so far on cemetery flora concern «normal» burial grounds, without monumental features or with any particular visual or aesthetic impact. The sole European country where cemeteries are quite well studied from a botanical viewpoint is Poland (Löki et al. 2019; Moysiyenko et al. 2021).

In our study, species number in the single areas was lower than that recorded in other urban cemeteries (e.g. from 171 to 218 species in four cemeteries of the area of Poznań, but the areas covered generally were 6–8 ha and only in one case 0.25 ha; cfr. Czarna et al. 2011); it is, however, proportionally much higher if we consider the entire study area: 266 species on a 4.8 ha surface. Nonetheless, the comparison makes sense only if differences in climate, environmental variety, richness of the national flora and kind of plant are taken into account. In more general terms, it is noteworthy that the average plant species number recorded so far in European cemeteries is only 86 (Otves et al. 2016).

The taxa new for the Italian or regional flora are either young individuals born by natural dissemination from adult plants cultivated *in loco* for ornamental purposes (*Malus* ×*robusta* 'John Downie' and *Calocedrus decurrens* – Buldrini and Santini 2023), or adult individuals of species naturally growing in the cemetery area (*Epilobium ciliatum* and *Salvia haematodes*). This is proof of the continuous need for a floristic exploration of the territory, even of zones that apparently are the best known on a national scale, such as Emilia-Romagna (Alessandrini and Montanari 2022). It is also a proof of the potential that cemeteries have in introducing and spreading exotic species, since 3 of the 4 new species are allochthonous to the Italian flora (Portal to the Flora of Italy 2022). It is worth noting that the presence of *S. haematodes* is often underestimated, although it is possibly the dominant species in Italy within the group of *Salvia pratensis* L. (Pignatti et al. 2017–2019, Vol. III: 308, sub *S. pratensis* L. subsp. *haematodes* (L.) Briq.), thus a more careful examination may reveal that it is widespread throughout the national territory.

Concerning *Symphytum bohemicum* F.W.Schmidt, we provisionally accepted this identification, based on the corolla white-yellowish, the stems with few ramifications and the plant colour dark green (see Kobrlová et al. 2022), noting that this would be the first record of the species at the regional level. In fact, it is a simple new attribution

of populations formerly identified as *Symphytum officinale* L. (Pignatti et al. 2017–2019), therefore, further investigations are necessary to ascertain its real distribution in Emilia-Romagna. Similarly, for *Malus* ×*robusta* 'John Downie' given the horticultural origin of the mother plants and the probable hybridization with other species of the same group, at present we maintain the identification proposed (see Stace 1997; Johnson and More 2006; Sterry 2007; Brickell 2012; Wöhner et al. 2014), but there is a need to monitor the persistence and growth of the plantlets detected and further study the parent species, since it is a new taxon for the Italian flora.

The scarce influence on species number due to religion, as previously asserted by Rutkovska et al. (2011), and cemetery dimensions, as demonstrated by Nowińska et al. (2020), is apparently confirmed: 180 taxa in the Jewish cemetery on a surface of 1.0 ha, 205 taxa in the Catholic cemetery on a surface of 3.8 ha. Such a difference may rather be due, overall, to the diverse architectural and environmental characteristics of the areas (Kowarik et al. 2016). It has been demonstrated, in fact, that anthropic disturbance has a notable influence in shaping and selecting the flora of cemetery areas, favouring species with a short life cycle (Nowińska et al. 2020). Not surprisingly, in the Cimitero di San Cataldo annual species account for up to 40% of the total list and, in general, the species recorded are in many cases ruderal and typical of trampled areas (*Parietaria judaica* L., *Portulaca oleracea* L., *Polygonum rurivagum* Jord. ex Boreau, *Stellaria media* (L.) Vill. subsp. *media* etc.), or have a broad ecology, are common in many zones of continental Europe or are cosmopolitan (such as *Arabidopsis thaliana* (L.) Heynh., *Convolvulus sepium* L., *Cichorium intybus* L., *Trifolium repens* L.), or at least eurimediterranean (e.g. *Anisantha madritensis* (L.) Nevski subsp. *madritensis*, *Chondrilla juncea* L., *Leucanthemum vulgare* (Vaill.) Lam., *Malva setigera* K.F.Schimp. & Spenn.). Several of these species are quite frequent or even common also in the historical city centre of Modena, linked to disturbed places, uncultivated flowerbeds, backfill etc. (Danin et al. 2014, 2016; Buldrini et al. 2020). Other species, instead, testify to particular micro-ecological conditions: for example, *Allium pallens* L., *Carex caryophyllea* Latourr., *Convolvulus cantabrica* L. and *Spiranthes spiralis* (L.) Chevall. are typical of arid grasslands on draining or even rocky substrates (Pignatti et al. 2017–2019), while *Carex hirta* L. and *Mentha spicata* L. are indicators of a certain amount of soil moisture (Pignatti et al. 2005). It is probable that cracks and fissures in the tombstones mimic, in some respects, the fissures that can be observed in rocks and cliffs, whose vegetation is obviously selected by the very low presence of substrate and the strong heat, especially when these fissures are small and superficial and exposed to full sunlight. In such conditions, the species we observed are generally Mediterranean (e.g. *Allium roseum* L. subsp. *roseum*, *Asparagus officinalis* L. subsp. *officinalis*, *Ficus carica* L.), or at least short-lived therophytes (*Anisantha sterilis* (L.) Nevski). On the other hand, especially in zones 1c and 2, the grasslands, growing on a draining substrate for obvious sanitary reasons (Avramidou and Maio 2006), have a clearly arid character, with species like *Muscari comosum* (L.) Mill., *Ononis spinosa* L. subsp. *spinosa*, *Salvia verbenaca* L., *Scorpiurus subvillosus* L., *Thymus pulegioides* L. The essentially xeric conditions of the study area are also testified by the presence of some succulent species

(*Sedum* spp., *Petrosedum* spp.) among the chamaephytes and only one helophyte in the entire cemetery (*Phragmites australis* (Cav.) Trin. ex Steud. subsp. *australis*, that has a certain ecological amplitude – Pignatti et al. 2005, 2017–2019).

All the zones investigated in the Cimitero di San Cataldo are, to some extent, similar although they are very different in terms of history and number of visitors. Floristic richness varies among the single areas, probably depending on the number of environments that are present in each one (a strong correlation exists between these two parameters), as it is logical to expect and as already observed in the flora of the historical city centre of Modena (Buldrini et al. 2020). Such a similarity (at least ecological) is corroborated by the substantial constancy of the biological spectrum (Fig. 2): the diverse sectors analysed nearly always show analogous values for every life form, very close to those of the whole area (the only significant difference is a major presence of phanerophytes in zone 1b and a corresponding minor presence in zone 1c). Instead, differences are detectable in the chorological spectrum (Fig. 3), that shows a certain Mediterranean and thermophilous character in the flora of zone 1c and, to a lesser extent, of zone 2 (also characterised by wide grasslands), and a prevailing generalist character, with a tendency to floristic pollution, in zones 1a and 1b. The diversity analysis by Jaccard's index equally confirms the existence of considerable floristic differences, because the maximum similarity value is 0.373 (zones 1a–2), indicating that the two areas share only 37.3% of the species. These differences can be quite easily explained if we remember the diverse architectonic and physiognomic characters of the single zones: grasslands, monumental tombs, gravel driveways, hedgerows, and some ornamental trees in zone 1a, monumental tombs and gravel driveways in zone 1b, a wide grassland closed by a brick wall and a hedgerow with various large stones closing the small wells where the bones of ancient corpses are buried in zone 1c, grasslands, gravel driveways, and a few hedgerows in zone 2.

The number of exotic species (16.9% of the list) seems lower than in the cemeteries of central Europe: in Poland, for example, a study on 78 cemetery areas in the southeast of the country revealed the presence of 19–36% of allochthonous species (Czarna and Nowińska 2011; Nowińska et al. 2020). In some Poznań cemeteries, allochthonous taxa accounted for more than 50% of the list (Czarna et al. 2011; Czarna 2016a, b) although, in some cases, they were only 12–15% of the list (Celka and Żywika 2004; Sigiel-Dopierała and Jagodziński 2011). It is worth noting that the percentage of exotic species of zones 1a and 2 is very similar (14.7% *versus* 16.7%, respectively), whereas zone 1c is the least floristically polluted (9.8% of exotic species) and zone 1b the most polluted one (22.0%). For zone 2, the result is not surprising, since in the Jewish culture the use of adorning tombs with flowers or ornamental cultivated species does not exist (Palacz 1996), therefore exotic species always constitute a small fraction of the list even in other European countries (e.g., Czarna and Nowińska 2010). For zone 1c, the low value is probably due to the age of this sector, dating back to the foundation of the entire cemetery complex; indeed, the grassland is nearly 250 years old and reflects a prolonged stability. It seems clear, anyway, that the historical cemetery of Modena has, in some respects, a conservative behaviour from a floristic viewpoint,

exactly as observed in the historical city centre (Buldrini et al. 2020); this fact could be due to the never invasive nor intense human presence, the moderate disturbance imposed by lawn mowing, and the substantial stability of burial areas (Avramidou and Maio 2006). The different results obtained in Poland may be the effect of a colder continental climate (Kowarik 1995; Pyšek 1998; Lososová et al. 2012), with consequent absence of the autochthonous Mediterranean and thermophilous floristic components (cfr. Mirek et al. 2002) that could, at least partially, prevent the establishment of some allochthonous species, particularly those typical of warm climates.

The number of red-listed species in the monumental cemetery of Modena is very low (2.6% of the total), but comparable to 2.8–3.6% of protected species found in the cemeteries of the urban area of Poznań (Czarna 2016a, b). In other European countries, protected species can account for higher proportions of the floristic list, e.g. 5.6–5.7% in southern Ukraine (Moysiyenko et al. 2021; Skobel et al. 2023) and in the Ostrów Wielkopolski area (central south-western Poland; Celka and Żywika 2004). In Hungary, they represented an average of 0.12 ± 1.47% (calculated on a global list of 991 cemeteries) and the number of protected species in the single cemeteries varied from 1 to 13 (Löki et al. 2020). It should be pointed out, however, that in the above-mentioned countries protected species are often planted for their ornamental value, therefore, the cemetery would be a secondary station of anthropogenic origin (Sigiel-Dopierała and Jagodziński 2011); only in some cases they spread spontaneously in the burial grounds, coming from adjacent zones (e.g. Nowińska et al. 2020). In the Cimitero di San Cataldo, the only protected species cultivated for ornament are *Ilex aquifolium* and *Taxus baccata* (both native to the Italian territory), which spread naturally in the studied area by ornithochorous dispersal; the others simply arrived by spontaneous colonisation. The persistence of some of them (e.g. *Bellevalia romana* and *Spiranthes spiralis*) may be due to the moderate, periodical disturbance imposed by mowing, that allows regular flowering and dissemination, as already observed for other grassland species typical of initial or intermediate stages of the ecological succession (Buldrini and Dallai 2011; Buldrini et al. 2013). Regarding protected species, the most interesting area is zone 2, where 5 of the 7 protected species were observed, all of them spontaneous. Among them, *S. spiralis* is of particular importance as it is rare in all of northern Italy (Pignatti et al. 2017–2019) and especially in the Po valley (Alessandrini and Bonafede 1996; Tedaldi 2000; Piccoli et al. 2014); it is, by contrast, quite frequent in arid grasslands of the hill belt. More than 50 individuals of this species were found in zone 2. Its presence, together with that of *Anacamptis morio* (ca. 25 individuals) and *B. romana*, is a sure indicator of good naturalness and scarce disturbance of the study site.

Conclusions

The flora of ancient monumental cemeteries is of high interest from a biological and ecological viewpoint. The variety of habitats and substrates and the moderate disturbance permit the development of a rich flora, where allochthonous and protected

species can grow together within a restricted area (a few dozen meters) and the invasive ones do not behave as such, at least in the present case. The environmental and ecological conditions of a monumental cemetery can show some similarities to those of ancient city centres, whose conservative value from a floristic standpoint has already been verified. It is, therefore, desirable that other monumental cemeteries be investigated, both in Italy and in other European countries, to better understand their role in preserving the native flora and in spreading the exotic one.

Acknowledgements

We are deeply grateful to Elena Giusti (Servizi Demografici del Comune di Modena – PO Polizia Mortuaria e Stato Civile) and Cristina Bartolamasi (Dugoni Scrl), who provided the mowing dates of the green areas, permitting us to organize our field activities; they also allowed us to preserve from mowing part of the Jewish cemetery to observe the undisturbed plant growth for all the vegetative season of 2019. We thank Luca Lombroso and Francesca Despini (Osservatorio Geofisico, Università degli Studi di Modena e Reggio Emilia) for providing the meteorological data for 2022 and other climatic data for the period 1991–2020. We thank for their precious help in species identification Davide Donati (formerly Università di Bologna – *Sedum* spp., *Petrosedum* spp.), Nicola M.G. Ardenghi (Herbarium Universitatis Ticinensis – Università degli Studi di Pavia – *Vitis* spp.) and Morgan Santini (International Dendrology Society – *Calocedrus decurrens*, *Malus* ×*robusta*). Filiberto Fiandri (Gruppo Flora Modenese, Modena) kindly provided floristic data on the historical part of the cemetery. We are also grateful to Claudio Fangarezzi and Enrico Selmi (LIPU onlus – Modena) for their surveys and surveillance of *Anacamptis morio* and *Spiranthes spiralis* in the Jewish cemetery. Financial support by Fondazione per la Flora Italiana for the publication fee is also gratefully acknowledged.

References

Alessandrini A, Bonafede F (1996) Atlante della Flora Protetta della Regione Emilia-Romagna. Regione Emilia-Romagna, Bologna, 365 pp.

Alessandrini A, Delfini L, Ferrari P, Fiandri F, Gualmini M, Lodesani U, Santini C (2010) Flora del Modenese. Censimento, Analisi, Tutela. Provincia di Modena, Istituto per i Beni Culturali della Regione Emilia-Romagna, 415 pp.

Alessandrini A, Montanari S (2022) Aggiunte alla Flora dell'Emilia-Romagna apparse in Acta Plantarum. Ulteriore contributo. Acta Plantarum Notes 8: 143–160.

Antkowiak W, Heine A (2005) Dendroflora and current state of historic cemeteries of the Koło District in Central Poland. Roczniki Akademii Rolniczej w Poznaniu 373, Botanika-Steciana 9: 3–12.

Avramidou N, Maio B (2006) Guida Storica di San Cataldo dal Settecento al Novecento. Aracne editrice, Roma, 101 pp.

Barban B (1928) Il Cimitero Monumentale di Verona: 1828–1928. Tipografia G. Liziero, Verona, 195 pp.

Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, Astuti G, Bacchetta G, Ballelli S, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Cecchi L, Di Pietro R, Domina G, Fascetti S, Fenu G, Festi F, Foggi B, Gallo L, Gottschlich G, Gubellini L, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Conti F (2018) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 199–303. https://doi.org/10.1080/11263504.2017.1419996

Bellone G, Ardenghi NMG, Banfi E, Longo D (2015) Noterella 0152. *Eragrostis frankii* C.A. Mey. ex Steud. Acta Plantarum Notes 3: 91.

Bertuzzi G (1990) Modena Scomparsa. L'abbattimento delle Mura. Aedes Muratoriana, Modena, 157 pp.

Bontempi D (2011) Paesaggi della Memoria. Botanica funeraria nel Cimitero della Villetta a Parma. PhD Thesis, Università degli Studi di Parma, Italy.

Bowdler R, Hanna S, White J, Knight D (2007) Paradise preserved. An introduction to the assessment, evaluation, conservation and management of historical cemeteries. English Heritage, Peterborough. https://thegardenstrust.org/wp-content/uploads/2016/11/EH-Paradise-Preserved-2007-1.pdf

Bowdler R, Martin B, Rutherford S, White J, Frith M (2002) Paradise Preserved. An Introduction to the Assessment, Evaluation, Conservation and Management of Historical Cemeteries. English Heritage and English Nature, Peterborough.

Brickell C (2012) A-Z L'Enciclopedia delle piante da giardino. Seconda Edizione Italiana (Vol. 2). The Royal Horticultural Society, London, 668–672.

Buchholz S, Blick T, Hannig K, Kowarik I, Lemke A, Otte V, Scharon J, Schönhofer A, Teige T, von der Lippe M, Seitz B (2016) Biological richness of a large urban cemetery in Berlin. Results of a multi-taxon approach. Biodiversity Data Journal 4: e7057. https://doi.org/10.3897/BDJ.4.e7057

Buldrini F, Dallai D (2011) Schede per una Lista Rossa della flora vascolare e crittogamica italiana: *Viola pumila* Chaix. Informatore Botanico Italiano 43(2): 435–438.

Buldrini F, Dallai D, Adorni M, Bona E, Bonali F, Castello M, Costalonga S, Pellegrino G, Picco F, Polani F, Romani E, Santini C, Selvaggi A, Tasinazzo S, Vidali M, Zanotti E (2013) Schede per una Lista Rossa della flora vascolare e crittogamica italiana: *Viola elatior* Fries. Informatore Botanico Italiano 45(1): 181–186.

Buldrini F, Gentilini M, Bruni C, Santini C, Alessandrini A, Bosi G (2020) Flora vascolare urbana della città di Modena: analisi del centro storico. Natural History Sciences 7(1): 3–56. https://doi.org/10.4081/nhs.2020.443

Buldrini F, Santini C (2023) *Calocedrus decurrens* (Torr.) Florin (Cupressaceae). In: Galasso G, Bartolucci F (Eds) Notulae to the Italian alien vascular flora: 15. Italian Botanist 15: 80. https://doi.org/10.3897/italianbotanist.15.105794

Celka Z, Żywika J (2004) Flora naczyniowa wybranych cmentarzy Ostrowa Wielkopolskiego i okolicy. Roczniki Akademii Rolniczej w Poznaniu 363, Botanika 7: 11–31.

Comune di Modena – Servizio Statistica (2022) Servizio Statistica del Comune di Modena. https://www.comune.modena.it/servizio-statistica [Accessed 15.01.2022]

Czarna A (2001) Flora naczyniowa cmentarzy ewangelickich w Koźminie i Koźmińcu (Nizina Wielkopolska). Roczniki Akademii Rolniczej w Poznaniu 334, series Botanica 4: 27–37.

Czarna A (2016a) Vascular plants in the Cemetery of the Meritorious in Poznań (Poland). Annales Universitatis Mariae Curie-Skłodowska. Sectio C, Biologia 71(2): 59–73. https://doi.org/10.17951/c.2016.71.2.59

Czarna A (2016b) Vascular plant flora in the Cytadela cemeteries in Poznań (Poland). Acta Agrobotanica 69(4): e1695. https://doi.org/10.5586/aa.1695

Czarna A, Nowińska R (2010) Vascular plants of certain old Jewish cemeteries in Western Carpathians. Roczniki Akademii Rolniczej w Poznaniu 389, Botanika-Steciana 14: 45–52.

Czarna A, Nowińska R (2011) Vascular flora in cemeteries of the Roztocze region and surrounding areas (south-east Poland). Acta Agrobotanica 64(2): 77–92. https://doi.org/10.5586/aa.2011.020

Czarna A, Nowińska R, Wysakowska I (2007) Vascular flora of the municipal cemetery in Ustrzyki Dolne (Bieszczady Mts., Poland). Roczniki Akademii Rolniczej w Poznaniu 386, Botanika-Steciana 11: 29–33.

Czarna A, Piskorz R (2005) Vascular flora of cemeteries in the town of Zakopane in the Tatra Mountains. Roczniki Akademii Rolniczej w Poznaniu 373, Botanika-Steciana 9: 47–58.

Czarna A, Woźnicka A, Maj M, Morozowska M (2011) Flora of vascular plants of selected Poznań cemeteries. Acta Agrobotanica 64(4): 123–140. https://doi.org/10.5586/aa.2011.054

Danin A, Buldrini F, Bandini Mazzanti M, Bosi G (2014) The history of the *Portulaca oleracea* aggregate in the Emilia Romagna Po plain (Northern Italy) from the Roman age to the present. Plant Biosystems 148(4): 622–634. https://doi.org/10.1080/11263504.2013.788098

Danin A, Buldrini F, Bandini Mazzanti M, Bosi G, Caria MC, Dandria D, Lanfranco E, Mifsud S, Bagella S (2016) Diversification of *Portulaca oleracea* L. complex in the Italian peninsula and adjacent islands. Botany Letters 163(3): 261–272. https://doi.org/10.1080/23818107.2016.1200482

Dorda A (1995) Ciekawostki dendrologiczne na cmentarzu żydowskim w Cieszynie. Wszechświat 86(12): 320–321.

Eggenberg S, Möhl A (2015) Flora Vegetativa. Un guide pour déterminer les plantes de Suisse à l'état végétatif. 2e édition, entièrement remaniée et augmentée. Rossolis, Bussigny, 726 pp.

Felicori M (2006) Gestione e valorizzazione dei cimiteri storici: il caso della Certosa di Bologna. Economia della Cultura 16(2): 237–246.

Felicori M, Zanotti A (2006) Cimiteri d'Europa. Touring Club Italiano, Milano, 228 pp.

Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E, Celesti-Grapow L, Albano A, Alessandrini A, Bacchetta G, Ballelli S, Bandini Mazzanti M, Barberis G, Bernardo L, Blasi C, Bouvet D, Bovio M, Cecchi L, Del Guacchio E, Di Pietro R, Domina G, Fascetti S, Gallo L, Gubellini L, Guiggi A, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E,

Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Podda L, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Bartolucci F (2018) An updated checklist of the vascular flora alien to Italy. Plant Biosystems 152(3): 556–592. https://doi.org/10.1080/11263504.2018.1441197

Gianaroli I (2020) La flora nel cimitero storico di San Cataldo. Three years degree thesis, Università degli Studi di Modena e Reggio Emilia, Italy.

Gudžinskas Z (2005) Case studies on the alien flora of the vicinity of cemeteries in Lithuania. Latvijas Universitātes Raksti 685: 21–37.

Guermandi M, Preti D (1993) I suoli della pianura modenese. Regione Emilia-Romagna, Provincia di Modena, 123 pp.

Hügin G, Hügin H (1999) Segnalazioni Floristiche Italiane: 904. In: Brilli Cattarini AJB, Scoppola A (Eds) Informatore Botanico Italiano 30(1–3) [1998]: 61.

IPNI (2023) International Plant Names Index. The Royal Botanic Gardens, Kew, Harvard University Herbaria & Libraries and Australian National Herbarium. http://www.ipni.org [Accessed 23.02.2023]

Johnson O, More D (2006) Collins Tree Guide – The most complete field guide to the trees of Britain and Europe. Harper Collins Publishers Ltd., London, 464 pp.

Kobrlová L, Duchoslav M, Hroneš M (2022) Morphological, ecological and geographic differences between diploids and tetraploids of *Symphytum officinale* (Boraginaceae) justify both cytotypes as separate species. Annals of Botany Plants 14: 1–17. https://doi.org/10.1093/aobpla/plac028

Kowarik I (1995) On the role of exotic species in urban flora and vegetation. In: Pyšek P, Prach K, Rejmánek M, Wade M (Eds) Plant Invasions: General Aspects and Special Problems. SPB Academic Publishing, Amsterdam, 85–103.

Kowarik I, Buchholz S, der Lippe M, Seitz B (2016) Biodiversity functions of urban cemeteries: evidence from one of the largest Jewish cemeteries in Europe. Urban Forestry and Urban Greening 19: 68–78. https://doi.org/10.1016/j.ufug.2016.06.023

Latini L (2007) Luoghi della memoria. Disegno e cultura del paesaggio nei cimiteri e nei memoriali italiani. In: Tongiorgi Tomasi L, Zangheri L (Eds) Bibliografia del Giardino e del Paesaggio Italiano, 1980–2005. L.S. Olschki, Firenze, 95–103.

Lazzeri V, Mascia F, Sammartino F, Campus G, Caredda A, Carlesi V, Fois M, Gestri G, Mannocci M, Mazzoncini V, Cuena Lombraña A, Santinelli M (2013) Novità floristiche per le regioni Sardegna e Toscana. Acta Plantarum Notes 2: 42–60.

Lepší M, Lepší P, Koutecký P, Lučanová M, Koutecká E, Kaplan Z (2019) *Stellaria ruderalis*, a new species in the *Stellaria media* group from central Europe. Preslia 91: 391–420. https://doi.org/10.23855/preslia.2019.391

Löki V, Deák B, Lukács AB, Molnár A (2019) Biodiversity potential of burial places e a review on the flora and fauna of cemeteries and churchyards. Global Ecology and Biogeography 18: e00614. https://doi.org/10.1016/j.gecco.2019.e00614

Löki V, Schmotzer A, Takács A, Süveges K, Lovas-Kiss A, Lukács BA, Tökölyi J, Molnár A (2020) The protected flora of long-established cemeteries in Hungary: using historical

maps in biodiversity conservation. Ecology and Evolution 10(14): 7497–7508. https://doi.org/10.1002/ece3.6476

Lombroso L, Costanzini S, Despini F, Teggi S (2020) Annuario 2019 dell'Osservatorio Geofisico di Modena. Atti della Società dei Naturalisti e Matematici di Modena 151: 5–32.

Lombroso L, Costanzini S, Despini F, Teggi S (2021) Annuario 2020 dell'Osservatorio Geofisico di Modena: le osservazioni continuano e l'Osservatorio è nominato Centennial Observing Station WMO. Atti della Società dei Naturalisti e Matematici di Modena 152: 5–35.

Lombroso L, Costanzini S, Despini F, Teggi S (2022) Annuario 2021 dell'Osservatorio Geofisico di Modena. Atti della Società dei Naturalisti e Matematici di Modena 153: 5–32.

Lombroso L, Quattrocchi S (2008) L'Osservatorio di Modena: 180 anni di misure meteoclimatiche. Edizioni Società Meteorologica Subalpina, Bussoleno (Torino), 501 pp.

Lombroso L, Teggi S (2017) Annuario delle osservazioni meteoclimatiche dell'anno 2016 all'Osservatorio Geofisico di Modena. Atti della Società dei Naturalisti e Matematici di Modena 148: 5–30.

Lombroso L, Teggi S (2018) Annuario 2017 dell'Osservatorio Geofisico di Modena: osservazioni a Modena, Reggio Emilia e nella Riserva naturale Karen Mogensen (Costa Rica). Atti della Società dei Naturalisti e Matematici di Modena 149: 5–36.

Lombroso L, Teggi S, Despini F, Costanzini S (2019) Annuario delle osservazioni meteoclimatiche dell'anno 2018 dell'Osservatorio Geofisico di Modena: l'Osservatorio restaurato. Atti della Società dei Naturalisti e Matematici di Modena 150: 5–34.

Lososová Z, Chytrý M, Tichý L, Danihelka J, Fajmon K, Hájek O, Kintrová K, Kühn I, Láníková D, Otýpková Z, Řehořek V (2012) Native and alien floras in urban habitats: a comparison across 32 cities of central Europe. Global Ecology and Biogeography 21(5): 545–555. https://doi.org/10.1111/j.1466-8238.2011.00704.x

Magli S, Lodi C, Lombroso L, Muscio A, Teggi S (2015) Analysis of the urban heat island effects on building energy consumption. International Journal of Energy and Environmental Engineering 6(1): 91–98. https://doi.org/10.1007/s40095-014-0154-9

Malone H (2017) Architecture, death and nationhood: monumental cemeteries of nineteenth-century Italy. Routledge, London, 262 pp. https://doi.org/10.4324/9781315597485

Marino F (2014) Edilizia funeraria. Progettazione, normativa, esempi. Maggioli Editore, Santarcangelo di Romagna (Rimini), 234 pp.

Martellos S, Bartolucci F, Conti F, Galasso G, Moro A, Pennesi R, Peruzzi L, Pittao E, Nimis PL (2020) FlorItaly – the portal to the Flora of Italy. Phytokeys 156: 55–71. https://doi.org/10.3897/phytokeys.156.54023

McBarron EJ, Benson DH, Doherty MD (1988) The botany of old cemeteries. Cunninghamia 2(1): 97–105.

Mirek Z, Piękoś-Mirkowa H, Zając A, Zając M (2002) Flowering plants and pteridophytes of Poland. A checklist. Krytyczna lista roślin naczyniowych Polski. Biodiversity of Poland (Vol. 1). W. Szafer Institute of Botany, Polish Academy of Science, Kraków, 441 pp.

Moysiyenko II, Skobel NO, Sudnik-Wójcikowska B, Dembicz I, Zachwatowicz M, Zakharova MYa, Dzerkal VM (2021) Old cemeteries as refuge of the steppe flora in Southern Ukraine. Chornomors'kij botanichnij zhurnal 17(3): 194–217. https://doi.org/10.32999/ksu1990-553X/2021-17-3-1

Nowińska R, Czarna A, Kozłowska M (2020) Cemetery types and the biodiversity of vascular plants – A case study from south-eastern Poland. Urban Forestry & Urban Greening 49: e126599. https://doi.org/10.1016/j.ufug.2020.126599

Otves C, Arsene G-G, Neacşu A (2016) Species diversity of the plants found in the Roman-Catholic and Orthodox cemeteries (from the Mehala Neighbourhood) and the heroes cemetery from Timisoara. Research Journal of Agricultural Science 48(2): 82–92.

Palacz T (1996) Cmentarze żydowskie w Wielkopolsce. In: Matyaszczyk D (Ed.) Miejsca i Obiekty Kultu w Wielkopolsce, Prahistoryczne, Chrześcijańskie i Judaistyczne. Wielkopolski Ośrodek Studiów i Ochrony Środowiska Kulturowego w Poznaniu, Poznań, 131–173.

Piccoli F, Pellizzari M, Alessandrini A (2014) Flora del Ferrarese. Longo Editore, Ravenna, 314 pp.

Pignatti S, Guarino R, La Rosa M (2017–2019) Flora d'Italia (2nd edn., Vols 1–4). Edagricole di New Business Media, Milano.

Pignatti S, Menegoni P, Pietrosanti V (2005) Bioindicazione attraverso le piante vascolari. Valori di indicazione secondo Ellenberg (Zeigerwerte) per le specie della Flora d'Italia. Braun-Blanquetia 39: 1–97.

Poldini L (1991) Atlante corologico delle piante vascolari del Friuli-Venezia Giulia. Arti Grafiche Friulane, Udine, 900 pp.

Portal to the Flora of Italy (2022) Portale della Flora d'Italia/Portal to the Flora of Italy 2022.1. https://dryades.units.it/floritaly/ [Accessed 23.11.2022]

Pyšek P (1998) Alien and native species in Central European urban floras: a quantitative comparison. Journal of Biogeography 25: 155–163. https://doi.org/10.1046/j.1365-2699.1998.251177.x

Pyšek P, Richardson DM, Rejmánek M, Webster GL, Williamson M, Kirschner J (2004) Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. Taxon 53(1): 131–143. https://doi.org/10.2307/4135498

Regione Emilia-Romagna (2018) Flora protetta. Misure Generali di Conservazione di Rete Natura 2000, Protezione della Flora spontanea. https://ambiente.regione.emilia-romagna.it/it/parchi-natura2000/consultazione/dati/download/flora-protetta-ER/@@download/file/FLORAprotetta2018.pdf [Accessed 20.11.2022]

Regione Emilia-Romagna (2022) Legge Regionale n. 21 del 15-12-2022 "Riconoscimento e valorizzazione dei cimiteri monumentali e storici della Regione Emilia-Romagna. Modifiche alla legge regionale 24 marzo 2000, n. 18 (Norme in materia di biblioteche, archivi storici, musei e beni culturali)". Bollettino Ufficiale della Regione Emilia-Romagna – Parte Prima 369: 1–8.

Rojecka N (1934) Flora starego cmentarza karaimskiego w Trokach. Prace Towarzystwa Przyj. Nauk w Wilnie 8: 381–391.

Rossi G, Montagnani C, Gargano D, Peruzzi L, Abeli T, Ravera S, Cogoni A, Fenu G, Magrini S, Gennai M, Foggi B, Wagensommer RP, Venturella G, Blasi C, Raimondo FM, Orsenigo S (2013) Lista Rossa della Flora Italiana. 1. Policy Species e altre specie minacciate. Comitato Italiano IUCN e Ministero dell'Ambiente e della Tutela del Territorio e del Mare.

Rossi G, Orsenigo S, Gargano D, Montagnani C, Peruzzi L, Fenu G, Abeli T, Alessandrini A, Astuti G, Bacchetta G, Bartolucci F, Bernardo L, Bovio M, Brullo S, Carta A, Castello

M, Cogoni D, Conti F, Domina G, Foggi B, Gennai M, Gigante D, Iberite M, Lasen C, Magrini S, Nicolella G, Pinna MS, Poggio L, Prosser F, Santangelo A, Selvaggi A, Stinca A, Tartaglini N, Troia A, Villani MC, Wagensommer RP, Wilhalm T, Blasi C (2020) Lista Rossa della Flora Italiana. 2. Endemiti e altre specie minacciate. Ministero dell'Ambiente e della Tutela del Territorio e del Mare.

Rothmaler W (2000) Exkursionflora von Deutschland. Band 3. Gefäßpflanzen: Atlasband. Spektrum Akademischer Verlag, Heidelberg-Berlin, 753 pp.

Rovani G (1854) Il Cimitero di Milano. Giornale dell'Ingegnere, Architetto e Agronomo 1(16): 357.

Rutkovska S, Pučka I, Novicka I (2011) Analysis of invasive flora in cemetery territories of the city of Daugavpils. In: Ansone V (Ed.) Proceedings 8th International Scientific and Practical Conference on Environment, Technology, Resources; 20–22 June, Rēzekne (LT). Rēzeknes Augstskola, Rēzekne, RA Izdevniecība, Vol. II: 344–351.

Santini C, Fiandri F, Gualmini M, Buldrini F, Lodesani U (2019) Aggiornamento della Flora del Modenese, prime considerazioni sui dati raccolti e conservazione del patrimonio floristico. Atti della Società dei Naturalisti e Matematici di Modena 150: 121–144.

Sigiel-Dopierała A, Jagodziński AM (2011) Materials to the vascular flora of the neglected Evangelical cemeteries of the western part of the Drawsko Landscape Park (Poland). Roczniki Akademii Rolniczej w Poznaniu 390, Botanika-Steciana 15: 57–64.

Šilc U (2009) Vegetation of the Žale cemetery (Ljubljana). Hacquetia 8(1): 41–47. https://doi.org/10.2478/v10028-009-0003-1

Skobel N, Moysiyenko I, Sudnik-Wójcikowska B, Dembicz I, Zachwatowicz M, Zakharova M, Marushchak O, Dzerkal V (2023) Vascular plants of old cemeteries in the Lower Dnipro region (Southern Ukraine). Biodiversity Data Journal 11: e99004. https://doi.org/10.3897/BDJ.11.e99004

Stace C (1997) New Flora of the British Isles (2nd edn.). Cambridge University Press, Cambridge (UK), 368–369.

Sterry P (2007) Collins complete guide to British trees. A photographic guide to every common species. Harper Collins Publishers Ltd., London, 210–214.

Stypiński P (1978) Drzewa i krzewy cmentarzy Olsztyna. Roczniki Dendrologiczne 31: 153–161.

Tedaldi G (2000) *Spiranthes spiralis*. Quaderno di Studi e Notizie di Storia Naturale della Romagna 13: 71.

Tomaselli M, Gualmini M (2000) Gli elementi corologici nella flora di altitudine dell'Appennino Tosco Emiliano. Annali del Museo Civico di Rovereto 14(suppl.): 95–112.

Trzaskowska E, Karczmarz K (2013) Spontaneous vascular flora of selected cemeteries in Lublin and the surrounding area. Acta Agrobotanica 66(2): 107–122. https://doi.org/10.5586/aa.2013.028

Viegi L, Cela Renzoni G, Garbari F (1974) Flora esotica d'Italia. Lavori della Società Italiana di Biogeografia 4: 125–220.

Wöhner T, Ali ME, Peil A (2014) Wildspecies Apple: *Malus ×robusta*. JKI data sheets – Fruit varieties 2014(1): 1–17. https://doi.org/10.5073/jkidfv.2014.001

Zangheri P (1976) Flora Italica. CEDAM, Padova.

Supplementary material 1

Floristic list of the study area

Authors: Fabrizio Buldrini, Ilaria Gianaroli, Giovanna Bosi, Alessandro Alessandrini, Claudio Santini

Data type: PDF file

Explanation note: List of taxa found in the areas investigated. Zone 1a: Catholic cemetery, monumental part; zone 1b: Catholic cemetery, ancient tombs disposed all along the southern perimeter wall of the cemetery complex; zone 1c: Catholic cemetery, grasslands of the ancient ossuary; zone 2: Jewish cemetery.

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/italianbotanist.15.102589.suppl1

Italian Botanist 15: 137–163 (2023)
doi: 10.3897/italianbotanist.15.103217
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

The Fucales (Ochrophyta, Phaeophyceae) of the Island of Pantelleria (Sicily Channel, Mediterranean Sea): a new contribution

Giuliana Marletta[1], Andrea Lombardo[2]

1 *Department of Life and Environmental Sciences, Polytechnic University of Marche, Via Brecce Bianche 60131 Ancona, Italy* **2** *Department of Biological, Geological and Environmental Sciences, University of Catania, 95124 Catania, Italy*

Corresponding author: Giuliana Marletta (giulianamarletta93@gmail.com)

Academic editor: Cecilia Maria Totti | Received 8 March 2023 | Accepted 5 June 2023 | Published 15 June 2023

Citation: Marletta G, Lombardo A (2023) The Fucales (Ochrophyta, Phaeophyceae) of the Island of Pantelleria (Sicily Channel, Mediterranean Sea): a new contribution. Italian Botanist 15: 137–163. https://doi.org/10.3897/italianbotanist.15.103217

Abstract

In the past, only a few studies were carried out on the marine vegetation of the Island of Pantelleria, reporting a high level of biodiversity in this island. However, the most recent study, performed about 20 years ago, documented a total loss of Fucales below ca. 12 m of depth and their substitution with morphologically simpler species. In the present study, the current presence and distribution of *Cystoseira* s.l. and *Sargassum* around the Island of Pantelleria were assessed, comparing the current data with the previous studies on the marine vegetation of this island. Through monitoring activities (both snorkelling and scuba diving), 19 taxa were recorded: seven belonging to *Cystoseira*, six to *Ericaria*, four to *Gongolaria*, and two to *Sargassum*. Comparing these data with the previous studies, it was highlighted that most of the species previously reported are still present on the island. Moreover, approximately 20 years after their documented disappearance, deep-water species such as *C. foeniculacea* f. *latiramosa*, *G. elegans*, *G. montagnei*, *G. montagnei* v. *compressa* and *Sargassum* cf. *acinarium* were recorded during this study, suggesting a natural recovery for these Fucales. We recommend that, in order to guarantee a long-term conservation of these fucalean populations, it would be useful to establish a marine protected area in the Island of Pantelleria.

Keywords

Biodiversity, brown algae, *Cystoseira*, *Ericaria*, *Gongolaria*, marine vegetation, *Sargassum*

Copyright *Giuliana Marletta & Andrea Lombardo.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

The Island of Pantelleria is located in the Sicily Strait, 55 nautical miles (approx. 88.5 km) from Cape Granitola (Italy) and 39 miles (approx. 62.8 km) from Cape Bon (Tunisia), with a surface area of 83 km² and a morphology derived mainly from ancient volcanic activities (Bianchi and Acri 2003). The island is located in the Pantelleria Rift, the deepest part of the Strait of Sicily, and has an irregular elliptical shape with the longest axis NW–SE (Paladino et al. 1935). This island can be subdivided into two geomorphologically distinct areas: the SE area is elevated above the sea surface, while the NW area is lowland and hilly (Paladino et al. 1935). The SE rocky shore consists of high, jagged cliffs, steeply sloping to depths of 30–40 m, into a bottom with large boulders interspersed with coarse sand or gravel (Alongi et al. 2004).

The current knowledge of the marine biology of the Island of Pantelleria is based on a few studies, focusing mostly on marine botany (Giaccone et al. 1972; Barone et al. 1978; Calvo and Sortino 1979), which revealed a high level of biodiversity of the marine biota (Bianchi and Acri 2003). The most recent study on the marine vegetation of this island was performed by Alongi et al. (2004), who documented a total disappearance of *Cystoseira* s.l. species and their replacement with morphologically simpler seaweeds, such as *Dictyopteris polypodioides* (De Candolle) J. V. Lamouroux, *Halopteris scoparia* (Linnaeus) Sauvageau and *Womersleyella setacea* (Hollenberg) R. E. Norris, at depths below ca. 12. Alongi et al. (2004) suggested that the reasons of this loss could be an increase in seawater temperature and changes in deep circulation pattern.

Despite the high value and vulnerability of *Cystoseira sensu lato* (i.e., genera *Cystoseira* C. Agardh, *Ericaria* Stackhouse and *Gongolaria* Boehmer) and *Sargassum* C. Agardh species, data on the distribution and conservation status of these Fucales are surprisingly limited and ecological analyses for many areas are still rare (Mancuso et al. 2018). Due to the massive decline of these taxa in many Mediterranean areas (Cormaci and Furnari 1999; Thibaut et al. 2005; Serio et al. 2006; Tsiamis et al. 2013; Thibaut et al. 2015; Catra et al. 2019), there is an urgent need to assess in detail the current species distributions and the stressors threatening them (Mulas et al. 2020), particularly in islands where there is typically a high level of endemism. This is the case, for example, for *Ericaria sedoides* Neiva & Serrão, an endemic species of the African coasts of Algeria and Tunisia and the Island of Pantelleria (Colombo et al. 1982; Bouafif et al. 2014). The Sicilian Channel represents the eastern limit of its range (Colombo et al. 1982; Boudouresque et al. 1996) thus representing a geographical limit. Its relatively restricted range and rarity make it a vulnerable species justifying measures for its protection (UNEP-MAP-RAC/SPA 2012).

In consideration of this, the aims of this study were to assess the current occurrence and distribution of *Cystoseira* s.l. and *Sargassum* species around the Island of Pantelleria, approximately 20 years after the latest study on the macrophytobenthos of the island, comparing the current data with those of previous studies.

Methods

During the first week of July 2022, a monitoring activity was carried out around the Island of Pantelleria. In particular, eleven sites were examined, covering all sides of the island: Bue Marino, Kattibuale, Punta Spadillo, Gadir, Cala Tramontana, Cala Levante, Martingana, Scauri, Grotte Sataria, Kuddie Rosse and Arenella (Fig. 1). In the sites of Punta Spadillo, Cala Tramontana and Cala Levante, a total of four scuba dives (each of an average duration of one hour) was performed. The other sites were visually inspected by snorkelling (see Table 1). Unfortunately, it was not possible to carry out further scuba dives, due to adverse marine conditions.

Fucalean species were identified *in situ* and photographed using two underwater cameras Olympus TG-6 and TG-4. When species examination was impossible to obtain in the field, a few fragments of thalli (subsequently stored in the private collection of G.M.) were collected and identified in the laboratory according to Gómez-Garreta et al. (2001), Cormaci et al. (2012), Rodríguez-Prieto et al. (2013) and Blanfuné et al. (2022).

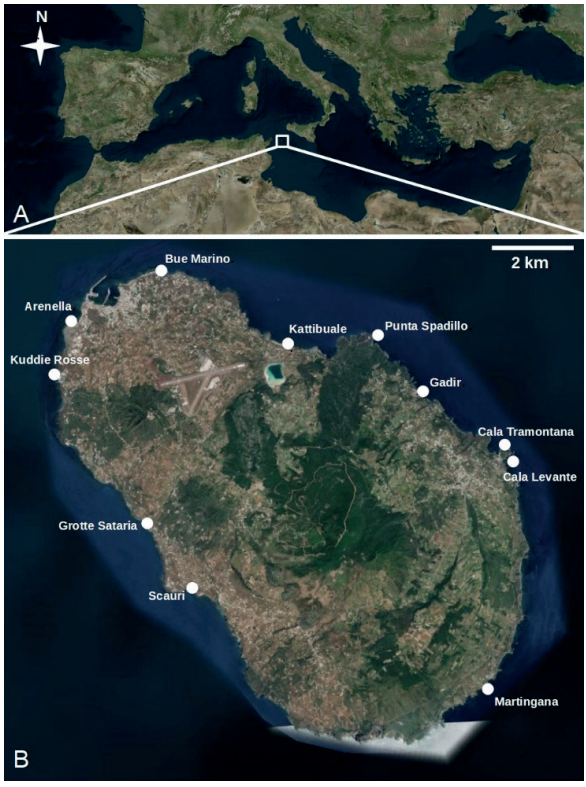

Figure 1. Island of Pantelleria **A** location of the island in the Mediterranean Sea **B** sites of the island investigated during this study.

Table 1. Detail of study sites, including GPS coordinates, dates and survey activities conducted during this study.

Site	Coordinates	Activity	Date
Bue Marino	36°50.5'N, 11°57.55'E	snorkelling	3rd July
Kattibuale	36°49.356'N, 11°59.436'E	snorkelling	4th July
Punta Spadillo	36°49.473'N, 12°0.843'E	scuba diving	4th July–5th July
Gadir	36°49.133'N, 12°1.9'E	snorkelling	5th July
Cala Tramontana	36°48.015'N, 12°2.943'E	scuba diving	4th July
Cala Levante	36°47.931'N, 12°3.163'E	scuba diving	5th July
Martingana	36°44.838'N, 12°2.676'E	snorkelling	8th July
Scauri	36°46.5'N, 11°57.15'E	snorkelling	9th July
Grotte Sataria	36°46.133'N, 11°57.25'E	snorkelling	7th July
Kuddie Rosse	36°48.908'N, 11°55.581'E	snorkelling	6th July
Arenella	36°49.77'N, 11°55.97'E	snorkelling	7th July

Results

During the monitoring activities, a total of 19 taxa was found: seven belonging to *Cystoseira*, six to *Ericaria*, four to *Gongolaria*, and finally two to *Sargassum*. The species and the sites where they were found are reported in Table 2.

Comparing our data with those previously reported by Giaccone et al. (1972), it is possible to note that 10 of the 18 fucalean species reported by these authors were also found during our monitoring activities (Table 3). On the contrary, the following taxa have not been observed: *Cystoseira platyclada* Sauvageau, *Ericaria zosteroides* (C. Agardh) Molinari & Guiry, *Cystoseira jabukae* Ercegovic, *Cystoseira humilis* Schousboe ex Kützing, *Gongolaria sauvageauana* (Hamel) Molinari & Guiry, *Cystoseira crinitophylla* Ercegovic, *Sargassum trichocarpum* J. Agardh and *Sargassum hornschuchii* C. Agardh.

Compared to the study by Alongi et al. (2004), only *C. humilis* was not recorded, while the other seven species identified by these authors were also found by us (Table 3).

For each species found during this study, we report below relevant information, including taxonomic and nomenclatural information (Basionym, Synonyms, Description, Habitat, Distribution, Remarks). The validity of the species names was checked by consulting Algaebase (Guiry and Guiry 2023).

Cystoseira compressa (Esper) Gerloff & Nizamuddin

Fig. 2A, B

Fucus compressus Esper, 1799. Basionym.

Cystoseira filicina Bory, *Cystoseira abrotanifolia* f. *fimbriata* Sauvageau, *Fucus fimbriatus* Desfontaines, 1799, *Cystoseira fimbriata* Bory, 1832. Synonyms.

Morphology of specimens from Pantelleria. This species is caespitose, attached to the substrate by a small discoid holdfast, from which several axes, both flattened and cylindrical, are issued, all devoid of spiniform appendages. The apices are tiny, smooth

Table 2. List of the species with their sampling depth found during the monitoring activity in the study sites: BM = Bue Marino; Kat = Kattibuale; PSpad = Punta Spadillo; Ga = Gadir; CTram = Cala Tramontana; CLev = Cala Levante; Mar = Martingana; Sca = Scauri; GSat = Grotte Sataria; KR = Kuddie Rosse; Ar = Arenella.

Taxa	BM	Kat	PSpad	Ga	CTram	CLev	Mar	Sca	GSat	KR	Ar
Range of depth	0–1 m	0–1 m	0–48 m	0–1 m	0–30 m	0–35 m	0–3 m	0–1 m	0–1 m	0–1 m	0–3 m
Cystoseira compressa	0–1 m	0–1 m	0–6 m	0–1 m	0–3 m	0–5 m	0–1 m	0–1 m	0–1 m	0–1 m	0–1 m
Cystoseira compressa f. *plana*	0.2–1 m						0.5–1 m				
Cystoseira compressa f. *rosetta*		0–0.5 m		0–1 m	0–0.5 m		0–1 m		0–0.5 m	0–0.5 m	0–1 m
Cystoseira pustulata			1–12 m		1–7 m	1–6 m	1–2 m			1 m	
Cystoseira foeniculacea						0.5–1 m				0.5–1 m	
Cystoseira foeniculacea f. *latiramosa*			20–30 m		18–22 m						
Cystoseira foeniculacea f. *tenuiramosa*						8–10 m					
Ericaria amentacea	0–0.2 m		0–0.2 m	0–0.2 m	0–0.2 m		0–0.2 m	0–0.2 m	0–0.2 m	0–0.2 m	0–0.2 m
Ericaria barbatula	0.5–1 m	0.5–1 m					0.5–2 m	0.5–1 m		0.5–1 m	0.5–3 m
Ericaria balearica	0.5–1 m		0.5–25 m		0.5–22 m	0.5–28 m		0.5–1 m	0.5–1 m	0.5–1 m	
Ericaria cf. *dubia*			40 m			35 m					
Ericaria crinita							1–3 m				0.5–2 m
Ericaria sedoides	0–1 m									0–1 m	0–1 m
Gongolaria barbata										0.5–1 m	1–2 m
Gongolaria elegans		1 m	1–15 m	1 m	1–8 m	1–12 m	1–3 m			1 m	1–3 m
Gongolaria montagnei			12–20 m		8–15 m	17–22 m					
Gongolaria montagnei var. *compressa*			28–35 m		26–30 m	33–35 m					
Sargassum cf. *acinarium*			30–45 m		28–30 m	32–35 m					
Sargassum vulgare	1 m	1 m	1–25 m	1 m	1–16 m	1–18 m	1–3 m	1 m	1 m	1 m	1–3 m

Table 3. Comparison of records of fucalean taxa obtained in this study with previous studies. x indicates that the species was reported previously; – indicates that the species was not reported; ? means that that the authors only indicated the genus.

Taxa	Giaccone et al. 1972	Alongi et al. 2004
Cystoseira compressa	x	x
Cystoseira compressa f. *plana*	–	–
Cystoseira compressa f. *rosetta*	–	–
Cystoseira pustulata	–	–
Cystoseira foeniculacea	–	–
Cystoseira foeniculacea f. *latiramosa*	x	–
Cystoseira foeniculacea f. *tenuiramosa*	x	x
Ericaria amentacea	x	x
Ericaria barbatula	–	x
Ericaria balearica	–	x
Ericaria cf. *dubia*	–	–
Ericaria crinita	x	–
Ericaria sedoides	x	x
Gongolaria barbata	–	–
Gongolaria elegans	x	–
Gongolaria montagnei	x	–
Gongolaria montagnei var. *compressa*	–	x
Sargassum cf. *acinarium*	x	?
Sargassum vulgare	x	?

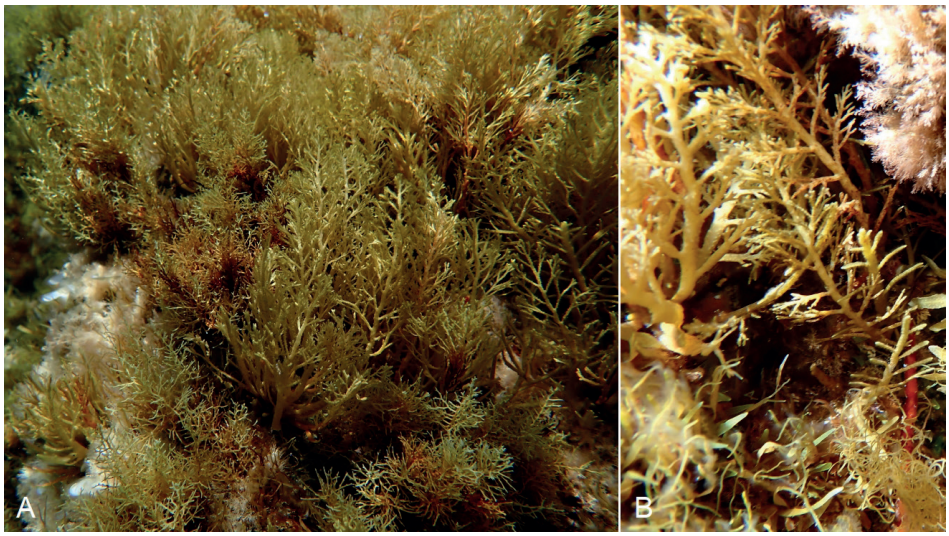

Figure 2. *Cystoseira compressa* **A** habit **B** detail of flattened branches with distichous-alternate disposal.

and not sharply protruding. Primary branches are generally flattened at the base, whereas they tend to be cylindrical at the apical parts. They are arranged distichously and alternating. Higher order branches can be flattened or cylindrical. In very sheltered environments this species shows numerous large isolate or grouped aerocysts. During the monitoring activities, this species was found fertile. Tiny lanceolate-fusiform receptacles are occurred in the terminal parts of branches. They were simple or branched and were located at the top of an aerocyst, to which they were connected by a small pedicel.

Habitat. *C. compressa* was found in all the inspected sites of the Island of Pantelleria, both during scuba dives and snorkelling activities. It was observed in the upper and middle infralittoral (from 0 to 6 m depth).

Distribution. This species is distributed in both the Atlantic Ocean (Nord-West Atlantic, Bermuda Islands and Nord-East Atlantic, from the Azores to Cape Verde) and Mediterranean Sea (Blanfuné et al. 2022).

Remarks. This species is quite common along the coasts of the island, where it is usually vicariant of *E. amentacea*.

***Cystoseira compressa* f. *plana* (Ercegovic) Cormaci, G. Furnari, Giaccone, Scammacca & D. Serio**
Fig. 3A, B

Cystoseira abrotanifolia subsp. *plana* Ercegovic. Basionym.

Morphology of specimens from Pantelleria. This form is caespitose with a pyramidal shape, attached to the substrate by a discoid holdfast. The apices are smooth and not

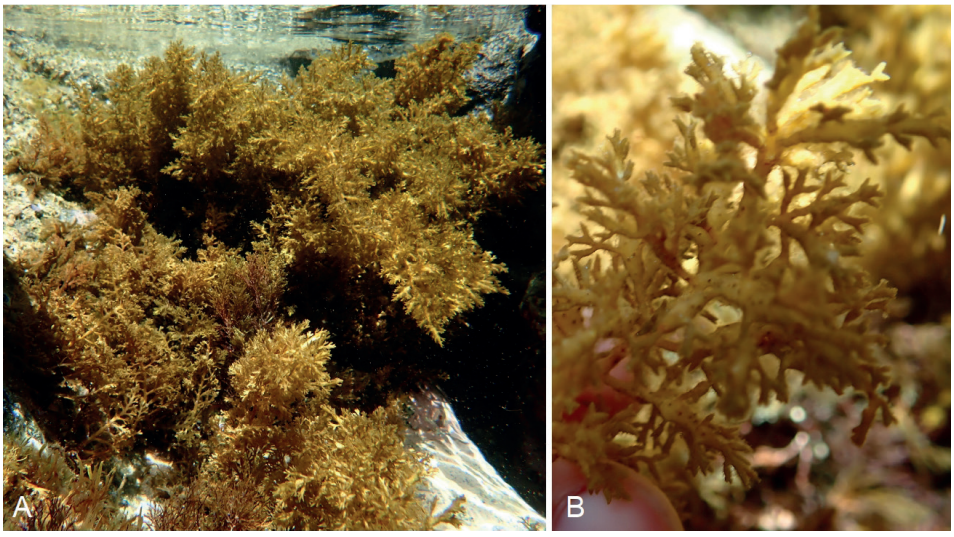

Figure 3. *Cystoseira compressa* f. *plana* **A** habit **B** detail of receptacles.

very protruding. All branches are flattened and arranged in a single plane with a distichous and pinnate disposal. They are crossed by a slightly protruding midrib, which is bordered by cryptostomata. During the monitoring activities, the thalli of this form were found reproductive. The receptacles are carried on terminal branches and are branched in a single plane.

Habitat. *C. compressa* f. *plana* was observed at Bue Marino and Martingana in shallow (0.2–1 m) and sheltered waters.

Distribution. This form has been recorded for Sicily, Adriatic Sea, Cyprus, Spain, Greece, Tunisia and Turkey (Blanfuné et al. 2022).

***Cystoseira compressa* f. *rosetta* (Ercegovic) Cormaci, G. Furnari, Giaccone, B. Scammacca & Serio**

Fig. 4A, B

Cystoseira compressa subsp. *rosetta* Ercegovic. Basionym.
Cystoseira compressa subsp. *rosetta* Ercegovic. Synonym.

Morphology of specimens from Pantelleria. This form is cespitose, with flattened habit, forming a rosette. It is attached to the substate by a small discoid holdfast. The apices are smooth. Primary branches are short (1–4 cm), strongly flattened and foliaceous. They are usually crossed by brownish transversal stripes. The branches are arranged with a distichous and alternating disposal. The cryptostomata are not very prominent and are disposed on longitudinal series. During the monitoring activity, we did not find fertile thalli of this form.

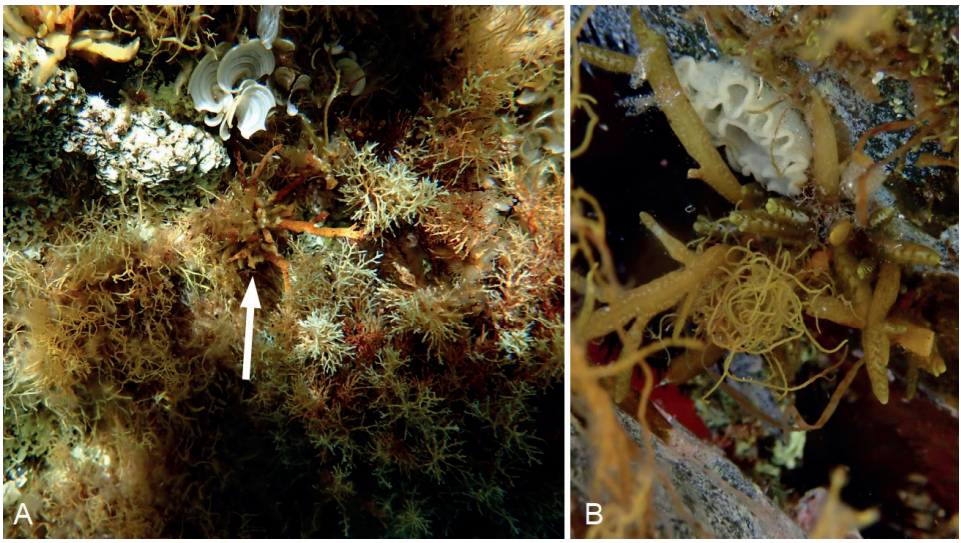

Figure 4. *Cystoseira compressa* f. *rosetta* **A** habit (the arrow indicates the thallus) **B** detail of primary branches with brownish transverse bands and cryptostomata disposed in longitudinal series.

Habitat. *C. compressa* f. *rosetta* occurred on wave-exposed coasts at Kattibuale, Gadir, Cala Tramontana, Martingana, Grotte Sataria, Kuddie Rosse and Arenella, in the upper infralittoral (0–1 m).

Distribution. It is distributed in the whole Mediterranean Sea and along the North-West Atlantic, Bermudas Islands and East Atlantic, from Azores to Cape Verde (Blanfuné et al. 2022).

Remarks. During the monitoring, thalli of this form were found isolated in shaded habitats, such as in small crevices between rocks.

Cystoseira pustulata **(Ercegovic) Neiva & Serrão**

Fig. 5A–C

Cystoseira abrotanifolia subsp. *pustulata* Ercegovic. Basionym.
Cystoseira compressa subsp. *pustulata* (Ercegovic) Verlaque. Synonym.

Morphology of specimens from Pantelleria. *C. pustulata* is a caespitose species, attached to the substrate with a small discoid holdfast. It has smooth apices, and cylindrical, thin and short axes. Primary branches are compressed, almost at the base, while higher order branches are cylindrical and always slender. This species bears protruding cryptostomata, which give it a pustulate habit. During the monitoring, this species was found fertile. The receptacles were borne in the terminal portions of the branches, fusiform in shape, isolated or rarely bifurcated.

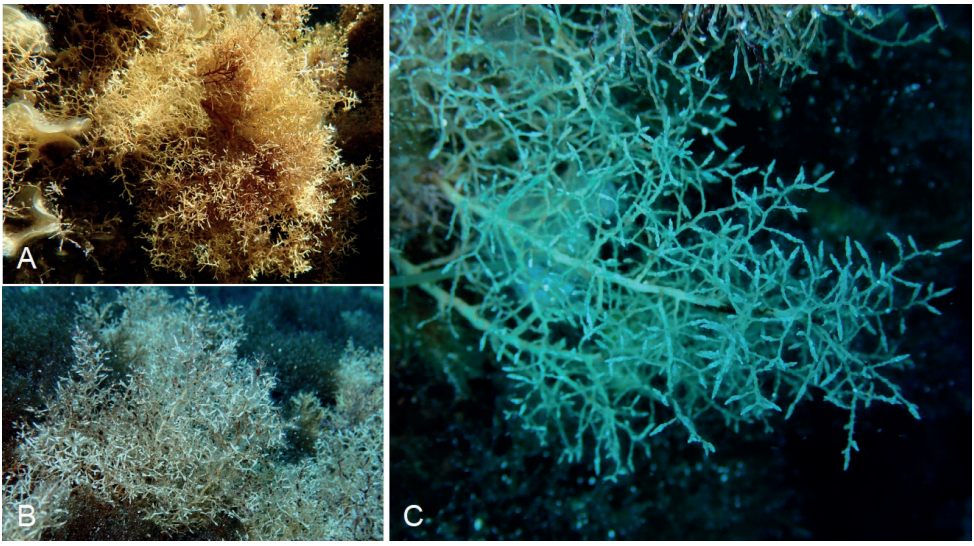

Figure 5. *Cystoseira pustulata* **A, B** habit **C** detail of receptacles.

Habitat. This species was found at Punta Spadillo, Cala Tramontana, Cala Levante, Martingana and Kuddie Rosse. It was detected during both snorkelling surveys and scuba dives, from the upper to the middle infralittoral (from 1 to 12 m depth).

Distribution. According to Neiva et al. (2022), who recently elevated it to species rank, *C. pustulata* is distributed in the Azores, Canary Islands, Spain, Italy, Malta and Greece.

Remarks. Some authors previously considered this species conspecific with *C. humilis* Schousboe ex Kützing. However, Neiva et al. (2022) demonstrated that *C. pustulata* is an independent species and reported it for Pantelleria. Therefore, we believe that the past records of *C. humilis* by Giaccone et al. (1972) and Alongi et al. (2004) might actually refer to this new taxon.

Cystoseira foeniculacea (Linnaeus) Greville

Fig. 6A–D

Fucus foeniculaceus Linnaeus. Basionym.

Cystoseira abrotanifolia (Linnaeus) C. Agardh, *C. concatenata* (Linnaeus) C. Agardh, *C. discors* (Linnaeus) C. Agardh, *C. ercegovicii* Giaccone, *Fucus abrotanifolius* Linnaeus, *F. barbatus* Linnaeus, *F. concatenatus* Linnaeus, *F. discors* Linnaeus, *Phyllacantha concatenata* (Linnaeus) Kützing. Synonyms.

Morphology of specimens from Pantelleria. *C. foeniculacea* is a caespitose species, with numerous axes that originate from an irregular discoid holdfast. The axes bear numerous small protuberances that give them a knotty habit. The apices are spinose

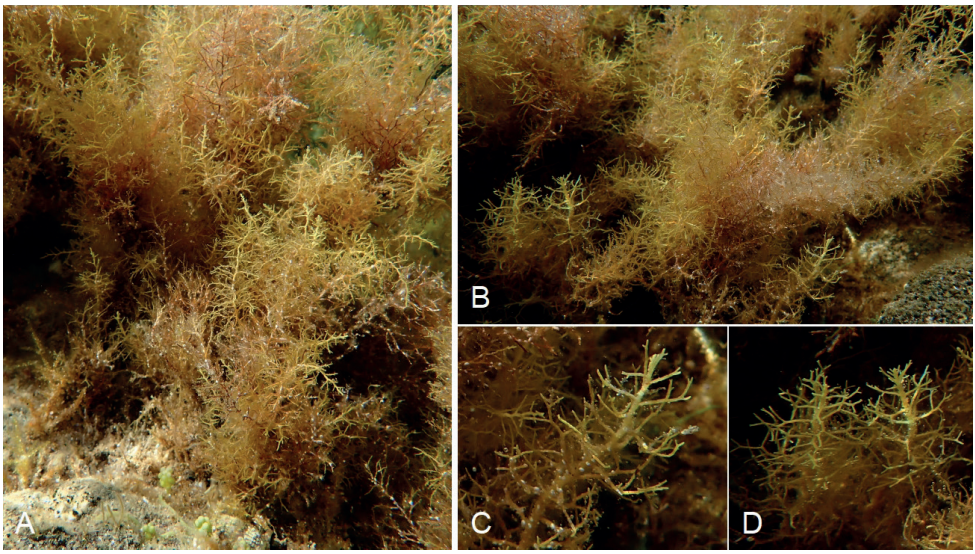

Figure 6. *Cystoseira foeniculacea* **A, B** habit **C, D** detail of axes with distichous branching.

and not sharply protruding. Axes can be flattened and branched distichously. Secondary branches can be flattened or cylindrical. Higher order branches are filiform, divaricate, alternating in several planes. During the monitoring activity, this species was not reproductive.

Habitat. This species was found in shallow (0.5–1 m) and sheltered habitats (as rock pools) partially covered by coarse gravel and cobbles at Kuddie Rosse and Cala Levante.

Distribution. The species is widely distributed in the Mediterranean Sea and occurs also in the Atlantic Ocean, from Scotland to Cape Verde (Blanfuné et al. 2022).

Cystoseira foeniculacea f. *latiramosa* (Ercegovic) A. Gómez Garreta, M. C. Barceló, M. A. Ribera & J. R. Lluch

Fig. 7A, B

Cystoseira discors subsp. *latiramosa* Ercegovic. Basionym.
Cystoseira ercegovicii f. *latiramosa* (Ercegovic) Giaccone, *Cystoseira schiffneri* f. *latiramosa* (Ercegovic) Giaccone. Synonyms.

Morphology of specimens from Pantelleria. This form is caespitose, attached to the substrate by an irregular discoid holdfast, from which cylindrical and knotty axes originate. The apices of axes are spinose. All branches are flattened, with a central midrib and toothed margins. Branching is sparse and distichous-alternate. During the monitoring activities, this species was found fertile. The receptacles are apical, lanceolate-fusiform, briefly pedicellate, isolated or branched.

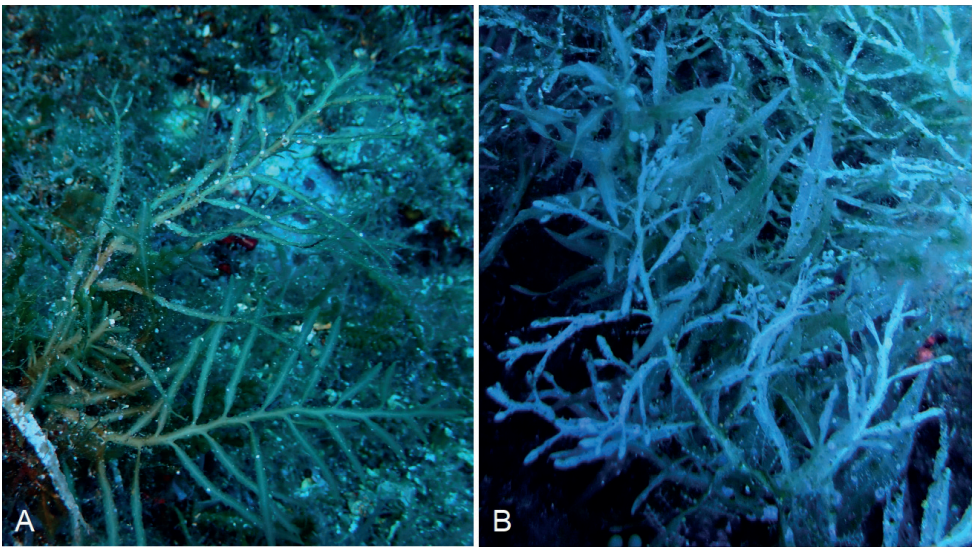

Figure 7. *Cystoseira foeniculacea* f. *latiramosa* **A, B** habit with knotty axes and flattened and distichous-alternate branching.

Habitat. *C. foeniculacea* f. *latiramosa* was observed during scuba dives at Punta Spadillo and Cala Tramontana, in deep waters (from 18 to ca. 30 m of depth).

Distribution. This form has been reported from Spain, Corsica, Tunisia, Malta, Italy, Adriatic, Greece, Cyprus and Turkey (Blanfuné et al. 2022).

Remarks. *C. foeniculacea* f. *latiramosa* is considered a rare seaweed in phase of regression (Rodríguez-Prieto et al. 2013), due to its distribution in deep environments, which are nowadays particularly subjected to trawling, pollution, deposition of marine litter, over-sedimentation, and competition with invasive alien species. Therefore, the record of this species in the waters of the Island of Pantelleria is particularly interesting and should receive special attention.

***Cystoseira foeniculacea* f. *tenuiramosa* (Ercegovic) A. Gómez Garreta, M. C. Barceló, M. A. Ribera & J. Rull Lluch**
Fig. 8A, B

Cystoseira discors f. *tenuiramosa* Ercegovic. Basionym.
Cystoseira ercegovicii f. *tenuiramosa* (Ercegović) Giaccone, *Cystoseira schiffneri* f. *tenuiramosa* (Ercegović) Giaccone. Synonyms.

Morphology of specimens from Pantelleria. *C. foeniculacea* f. *tenuiramosa* is caespitose, fixed to the substrate by a discoid holdfast from which several cylindrical axes originate. The apices are prominent and spinose. Primary branches are cylindrical,

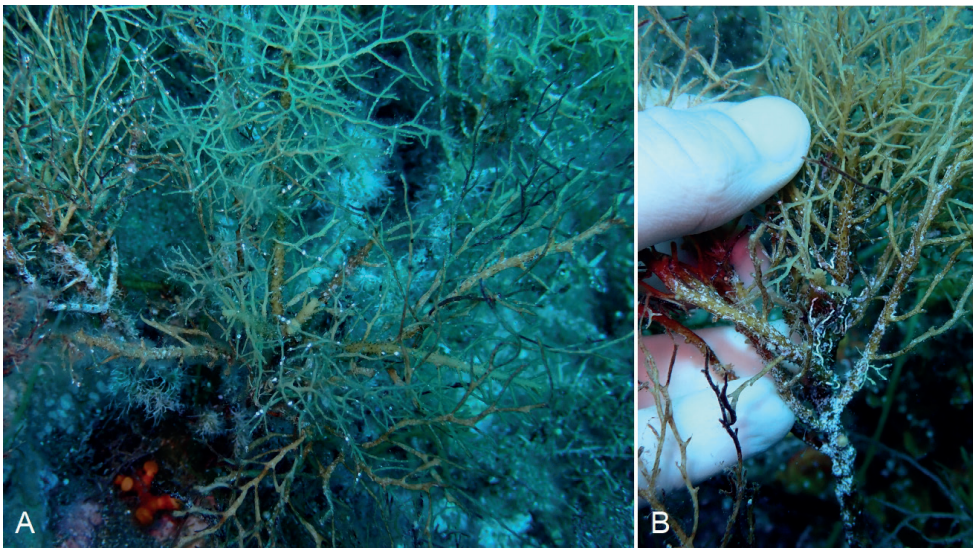

Figure 8. *Cystoseira foeniculacea* f. *tenuiramosa* **A** habit **B** detail of a prominent and spinose apex.

sometimes compressed, and knotty. Higher order branches are filiform, cylindrical and without spinose appendages.

Habitat. During the monitoring activities, this form was only observed at Cala Levante at 8–10 m depth.

Distribution. This form is distributed both in the Atlantic Ocean (Canary Islands) and in the Mediterranean Sea (Adriatic, Balearic Islands, Cyprus, Spain, France, Greece, Italy, Tunisia and Turkey) (Blanfuné et al. 2022).

Ericaria amentacea (C. Agardh) Molinari & Guiry

Fig. 9A–C

Cystoseira ericoides var. *amentacea* C. Agardh. Basionym.
Cystoseira stricta var. *amentacea* (Bory) Giaccone, *Halerica amentacea* (C. Agardh) Kützing, *Carpodesmia amentacea* (C. Agardh) Orellana & Sansón. Synonyms.

Morphology of specimens from Pantelleria. *E. amentacea* is a caespitose species, fixed to the substrate by a robust crustose holdfast. *In situ* it shows a blue-violet iridescence, especially near the apices and young branchlets. The apices are spinose and not very prominent. The axes are cylindrical and short. All branches are covered by simple or bifid spinose appendages. During the monitoring activities, this species was found fertile. Receptacles are compact, terminal and spinose, with conceptacles present at the base of each spinose appendage.

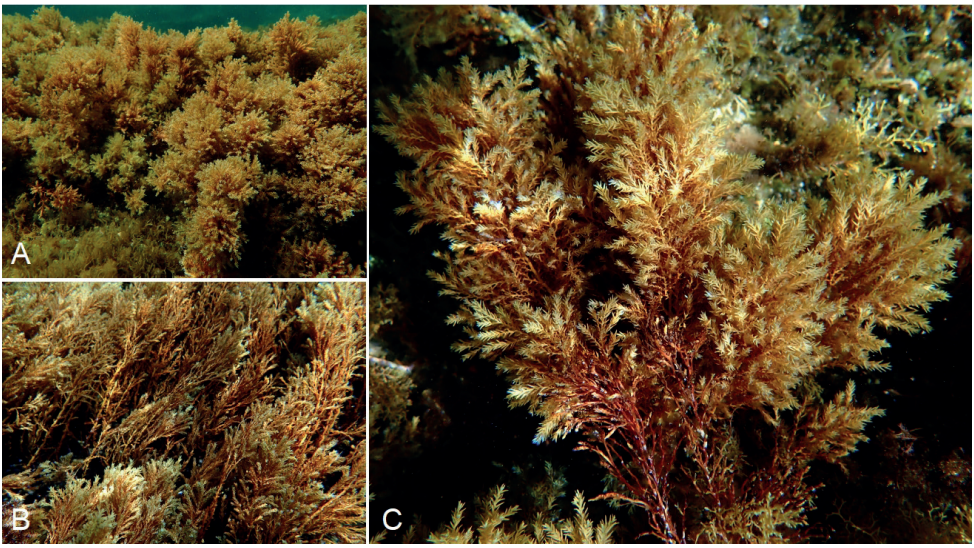

Figure 9. *Ericaria amentacea* **A, B** habit **C** branches with fertile receptacles.

Habitat. During the monitoring, this species was observed forming a continuous belt in the infralittoral fringe along exposed and semi-exposed coasts at Bue Marino, Punta Spadillo, Gadir, Cala Tramontana, Martingana, Scauri, Grotte Sataria, Kuddie Rosse and Arenella.

Distribution. According to Neiva et al. (2022), this entity falls within the *Ericaria selaginoides* complex haplogroup A, which is distributed in the Atlantic, south-eastern Iberian Peninsula, Balearic Islands and the Island of Pantelleria.

Remarks. Comparing the distribution reported by Alongi et al. (2004) with our data, the distribution of this species appears to have remained almost stable at the investigated sites.

***Ericaria barbatula* (Kützing) Molinari & Guiry**
Fig. 10A, B, C, D

Cystoseira barbatula Kützing. Basionym.
Cystoseira graeca Schiffner ex Gerloff & Nizamuddin, *Carpodesmia barbatula* (Kützing) Orellana & Sansón. Synonyms.

Morphology of specimens from Pantelleria. *E. barbatula* is caespitose, attached to the substrate by an irregular basal disc, from which several cylindrical, thin and blackish axes take origin. The axes are tuberculate for the presence of basal stumps of the fallen primary branches. The apices are strongly prominent and smooth. Primary and

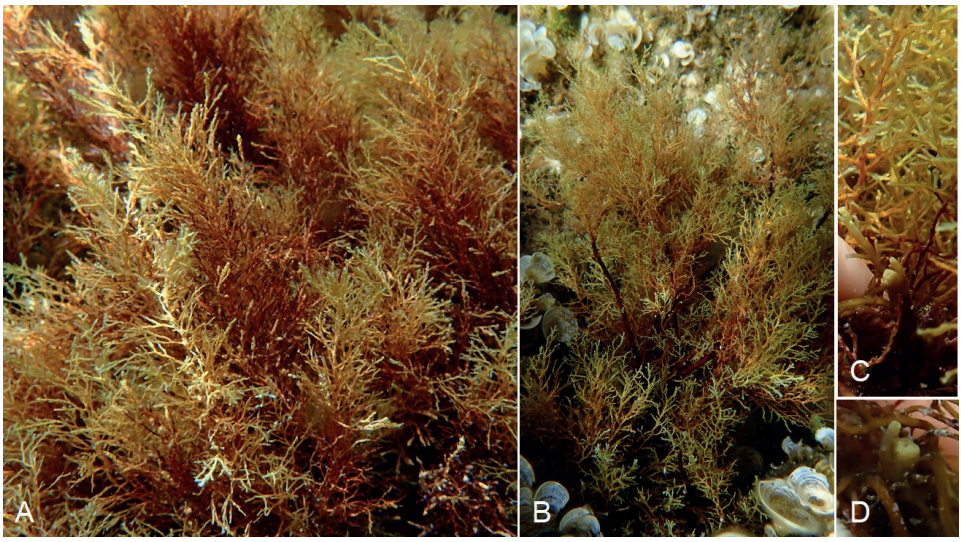

Figure 10. *Ericaria barbatula* **A** branches with fertile receptacles) **B** habit **C, D** prominent and smooth apex.

higher order branches are cylindrical. During the monitoring activities, this species was found fertile. The receptacles are borne on the apical parts of branchlets and are compact, tuberculate; they can bear 1–2 spinose appendages.

Habitat. *E. barbatula* was observed during snorkelling in shallow environments (from 0.5 to 3 m of depth) along sheltered and moderately exposed coasts at Bue Marino, Kattibuale, Martingana, Scauri, Kuddie Rosse and Arenella.

Distribution. Cyprus, Greece, Libya, Malta, Italy and Tunisia (Blanfuné et al. 2022).

Remarks. Comparing our data with the study by Alongi et al. (2004), this species appears to have expanded its distribution along the island since then. According to Neiva et al. (2022), this entity falls in the *Ericaria crinita* complex, which includes samples identified as *E. crinita*, *E. barbatula* and *E. giacconei* D. Serio & G. Furnari.

Ericaria balearica (Sauvageau) Neiva, Ballesteros & Serrão

Fig. 11A–D

Cystoseira balearica Sauvageau. Basionym.
Cystoseira brachycarpa var. *balearica* (Sauvageau) Giaccone. Synonyms.

Morphology of specimens from Pantelleria. This species is caespitose, with an irregular, spreading holdfast, from which several axes are issued. The axes are cylindrical and knotty due to the presence of basal stumps of the fallen branches. This species shows a dark blue-green iridescence *in situ*, especially in the apical parts of branchlets. The apices are not prominent and bear spinose appendages. Primary branches are cylindrical and are spinose only in the basal parts. Higher order branches are cylindrical

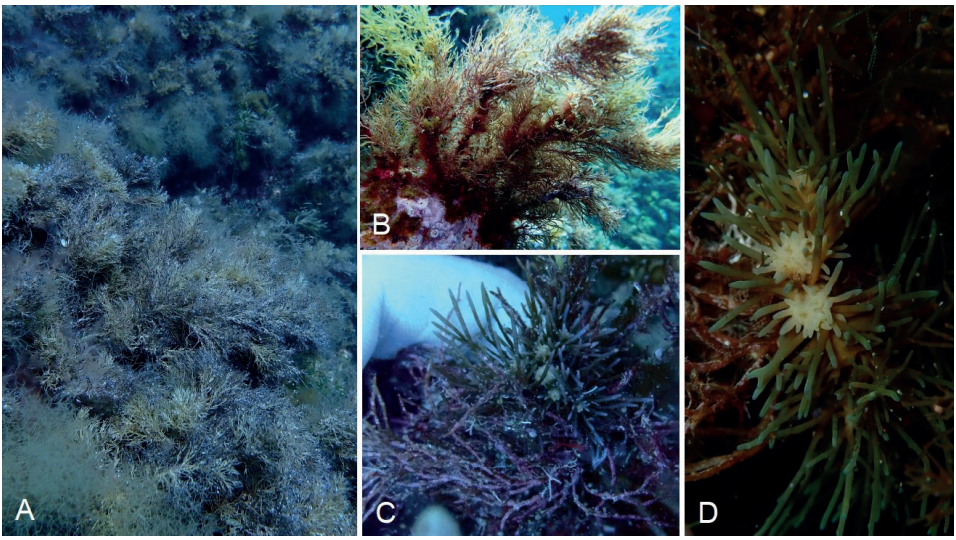

Figure 11. *Ericaria balearica* **A, B** habit **C, D** detail of not prominent apices with spinose appendages.

as well, but they are not spinose. During the monitoring activities, this species was not reproductive.

Habitat. *E. balearica* was observed during both scuba dives and snorkelling activities at Bue Marino, Punta Spadillo, Cala Tramontana, Cala Levante, Scauri, Grotte Sataria, Kuddie Rosse. In the Island of Pantelleria it is widely distributed from the upper to the lower infralittoral (from 0.5 to 28 m of depth).

Distribution. According to Neiva et al. (2022), this species is distributed in the Balearic Sea and the Island of Pantelleria.

Remarks. This species was reported from the island by Alongi et al. (2004) as *Cystoseira brachycarpa* J. Agardh. Recently, Neiva et al. (2022) concluded that *E. brachycarpa* (J. Agardh) Molinari & Guiry and *E. balearica* are two cryptic species with different biogeographical distribution.

Ericaria cf. *dubia* (Valiante) Neiva & Serrão

Fig. 12A–C

Cystoseira dubia Valiante. Basionym.

Morphology of specimens from Pantelleria. In the examined specimens, the holdfast could not be observed in detail because it was sunken in coarse gravel. The axes are creeping on the substrate and issue on the upper side erect primary branches in which two portions can be recognized: a cylindrical basal one and a flattened and ribbon-like upper one. Primary branches are distichous, without spinose appendages, with an entire margin and an evident midrib. During the monitoring this species was not found reproductive.

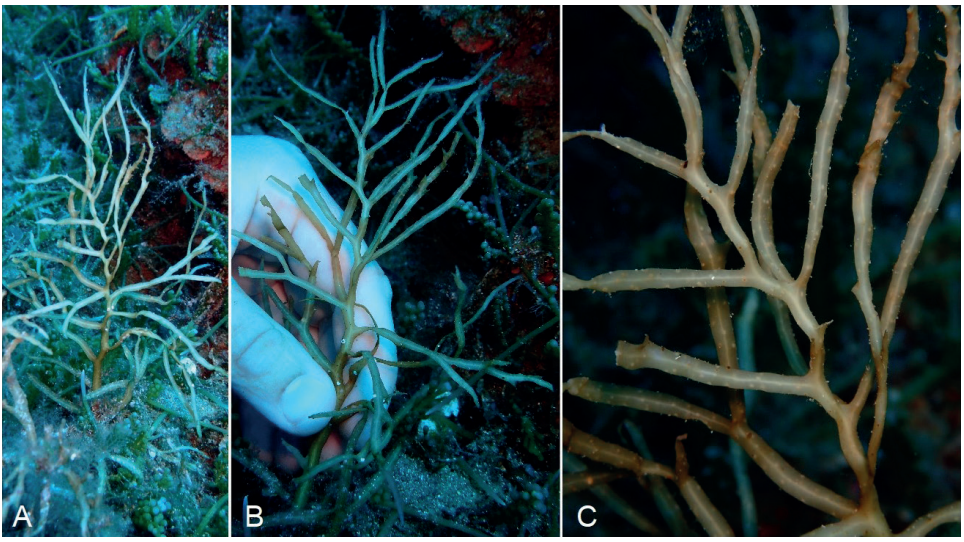

Figure 12. *Ericaria* cf. *dubia* **A, B** habit **C** detail of flattened branches with distichous disposal and an evident midrib.

Habitat. *Ericaria* cf. *dubia* was observed during scuba dives at Punta Spadillo and Cala Levante, at 40 and 35 m depth, respectively.

Distribution. This species is distributed in the Adriatic Sea, Greece, Italy, Syria, Tunisia, Turkey and Middle East (Blanfuné et al. 2022).

Remarks. The identification at species level was not certain because we did not manage to observe the holdfast, apex and receptacles of this entity.

Ericaria crinita (Duby) Molinari & Guiry

Fig. 13A–C

Cystoseira crinita Duby. Basionym.

Cystoseira granulata Schousboe, *Fucus crinitus* Desfontaines, *Carpodesmia crinita* (Duby) Orellana & Sansón. Synonyms.

Morphology of specimens from Pantelleria. *E. crinita* is a caespitose species, adhering to the substrate by an irregular discoid holdfast, from which several cylindrical and knotted axes are issued. The apices are protruding and covered by spinose appendages. Primary branches are cylindrical, with a pyramidal habit. Higher order branches are cylindrical, thin, more or less twisted and usually devoid of spines. During the monitoring activities, this species was found fertile. Receptacles are borne on terminal branchlets; they are compact, cylindrical, swollen, single or once branched, usually without spiny appendages.

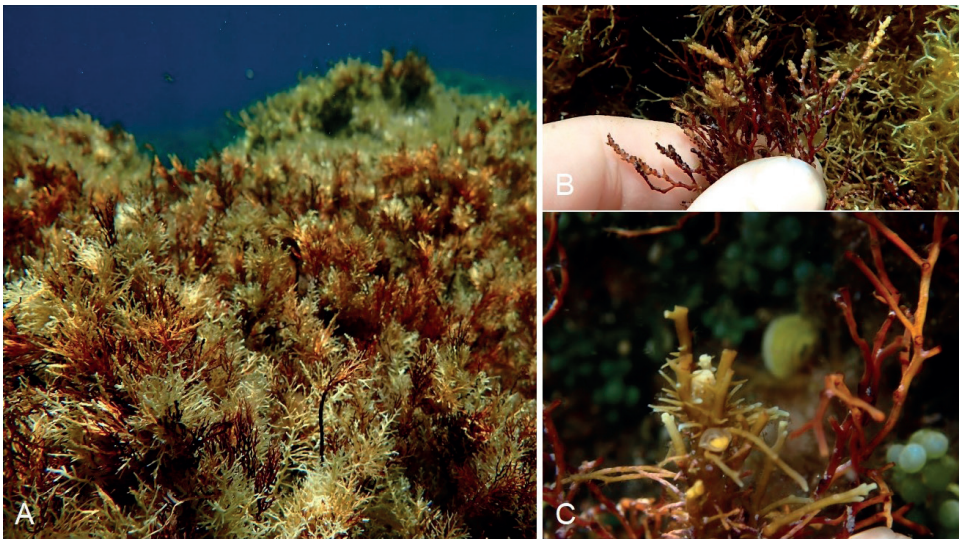

Figure 13. *Ericaria crinita* **A** habit **B** detail of receptacles **C** detail of prominent apex with spinose appendages.

Habitat. This species was observed during snorkelling activities at Martingana and Arenella, in shallow (0.5–3 m) and sheltered habitats.

Distribution. This species is widespread in the Mediterranean Sea and Canary Islands (Blanfuné et al. 2022).

Remarks. This species was found by Giaccone et al. (1972) in several sites of the island. Subsequently, it was not reported by Alongi et al. (2004). Our record seems to suggest that *E. crinita* might be in a phase of recovery and expansion on the island. According to Neiva et al. (2022), this entity is part of the *Ericaria crinita* complex, which includes samples identified as *E. crinita*, *E. barbatula* and *E. giacconei*.

Ericaria sedoides **Neiva & Serrão**

Fig. 14A–C

Fucus sedoides Desfontaines. Basionym.
Fucus ericoides var. *sedoides* Turner, *Cystoseira sedoides* C. Agardh. Synonyms.

Morphology of specimens from Pantelleria. *E. sedoides* is a non-caespitose species, adhering to the substrate by a discoid holdfast from which a single cylindrical, trunk-like axis originates. This species is easily recognized by its typical brush-like habit. The axis is very thick and usually poorly branched. The apex is not very prominent and usually is covered by branches that form a compact terminal rosette. All branches are covered by spinose appendages, which are slender, bifid and uniformly distributed along the branches. Primary branches are short (1–3 cm) and their attachment is perpendicular to the

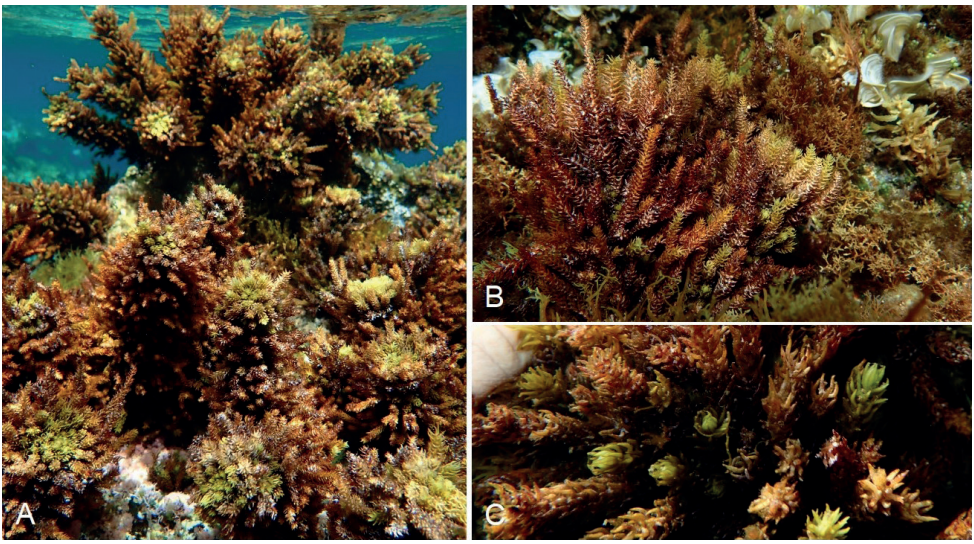

Figure 14. *Ericaria sedoides* **A, B** habit **C** not prominent apex, covered by the branches.

main axis. Secondary branches are usually simple and do not reach the top of primary branches. During the monitoring activities, this species was not found fertile.

Habitat. This species was observed during snorkelling activities in the upper infralittoral (0–1 m) along semi-exposed and exposed coasts at Bue Marino, Kuddie Rosse and Arenella.

Distribution. *E. sedoides* is endemic to Algeria, Tunisia and the Island of Pantelleria (Blanfuné et al. 2022).

Gongolaria barbata **(Stackhouse) Kuntze**

Fig. 15A–D

Abrotanifolia barbata Stackhouse. Basionym.

Cystoseira barbata var. *hoppei* (C. Agardh) J. Agardh, *Cystoseira barbata* f. *hoppei* (C. Agardh) Woronichin, *Cystoseira hoppei* C. Agardh, *Fucus barbatus* Goodenough & Woodward, *Treptacantha barbata* (Stackhouse) Orellana & Sansón. Synonyms.

Morphology of specimens from Pantelleria. *G. barbata* is a non-caespitose species, attached to the substrate by a small discoid holdfast, from which a single trunk-like, cylindrical axis is issued. The apex is smooth and prominent, protruding above the insertion of primary branches. These are cylindrical, while higher order branches are filiform and can bear aerocysts, either isolated or in chains. During the monitoring activities, this species was found fertile. Receptacles are borne on terminal branchlets, are compact, single, cylindrical-lanceolate or spindle-shaped, sometimes with a terminal spine, and pedicellate when they grow over an aerocyst.

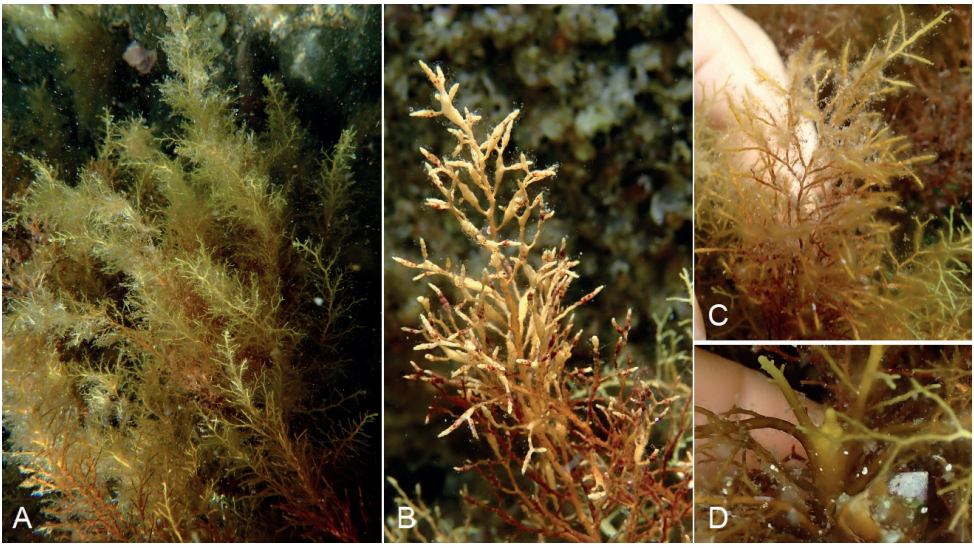

Figure 15. *Gongolaria barbata* **A** habit **B** detail of aerocysts surmounted by receptacles **C** detail of spindle-shaped receptacles **D** Detail of prominent and smooth apex.

Habitat. During the monitoring activities, this species was observed in the upper infralittoral (0.5–2 m) in sheltered habitats (such as rock pools) at Kuddie Rosse and Arenella.

Distribution. *G. barbata* is widely distributed in the Mediterranean Sea, and it also known from the Atlantic Ocean, in the Canary Islands and Savage Islands (Blanfuné et al. 2022).

Remarks. This species had not been reported from the island before.

***Gongolaria elegans* (Sauvageau) Molinari & Guiry**
Fig. 16A–C

Cystoseira elegans Sauvageau. Basionym.
Treptacantha elegans (Sauvageau) Orellana & Sansón. Synonyms.

Morphology of specimens from Pantelleria. *G. elegans* is a non-caespitose species, attached to the substrate by a robust discoid holdfast. The axis is short, trunk-like and cylindrical, not or poorly branched. The apex is spinose and not prominent. With the surrounding tips of primary branches, usually it forms a typical spinose rosette. Primary branches are cylindrical and bare in their basal parts. Higher order branches are cylindrical and covered with bifid spinose appendages. This species bears spinose and ovoid tophules, grouped along the axis. During the monitoring activities, this species was not found fertile.

Habitat. *G. elegans* was observed during both snorkelling activities and scuba dives, from the upper to the middle infralittoral (from 1 to 15 m) in moderately exposed/

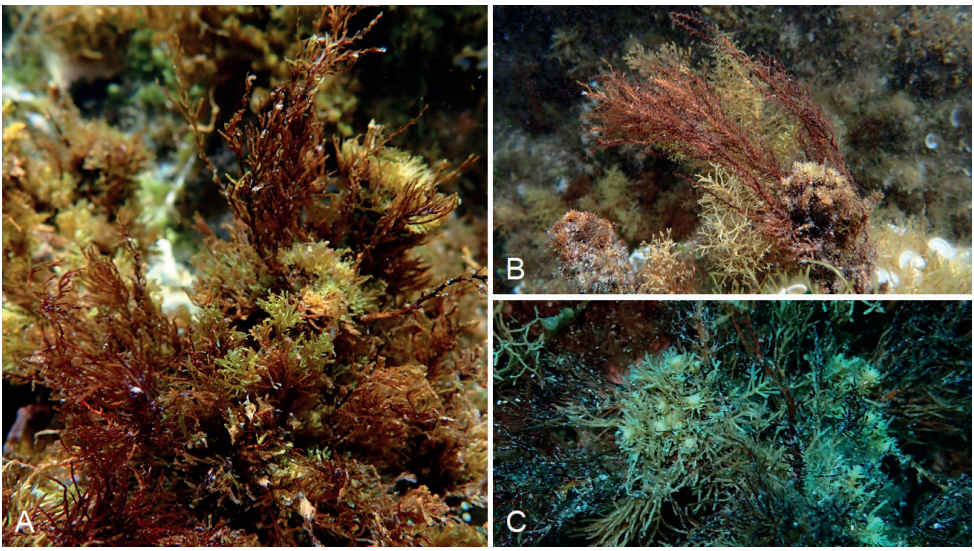

Figure 16. *Gongolaria elegans* **A, B** habit **C** detail of the apex surrounded by the buds of primary branches, which form a wide spinose rosette.

exposed waters at Kattibuale, Punta Spadillo, Gadir, Cala Tramontana, Cala Levante, Martingana, Kuddie Rosse and Arenella.

Distribution. This species is distributed in Spain, France, Morocco, Algeria, Tunisia, Italy, Adriatic, Greece, Cyprus and Turkey (Blanfuné et al. 2022).

Remarks. This species was found by Giaccone et al. (1972), but Alongi et al. (2004) did not record it. Our record suggests that *G. elegans* might be in phase of expansion on the island.

Gongolaria montagnei (J.Agardh) Kuntze

Fig. 17A–C

Cystoseira montagnei J. Agardh. Basionym.

Cystoseira spinosa Sauvageau, *Cystoseira adriatica* Sauvageau, *Phyllacantha montagnei* (J. Agardh) Kützing, *Treptacantha montagnei* (J. Agardh) Orellana & Sansón, *Treptacantha ballesterosii* Orellana & Sansón. Synonyms.

Morphology of specimens from Pantelleria. *G. montagnei* is a non-caespitose species, fixed to the substrate by a robust discoid holdfast. The axis is trunk-like and cylindrical, unbranched or poorly branched. The apex is spinose and not prominent. Primary branches are cylindrical and bear numerous sparse bifid or multifid spinose appendages. Secondary branches are shorter and less branched, with divaricate and bifid spinose appendages. This species has oblong and spinose tophules. During scuba

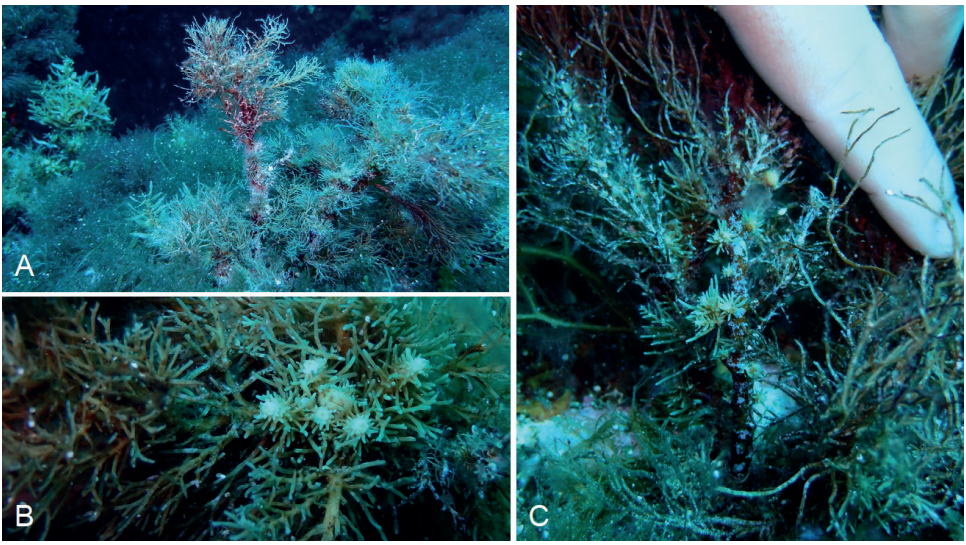

Figure 17. *Gongolaria montagnei* **A** habit **B** detail of not prominent and spinose apex **C** preliminary appearance of new primary branches from tophules.

dives, we observed new primary branches arising from tophules. During the monitoring activities, this species was not found fertile.

Habitat. This species was observed during scuba dives at Punta Spadillo, Cala Levante and Cala Tramontana, in the middle-lower infralittoral (from 8 down to a depth of 22 m).

Distribution. *G. montagnei* is widely distributed in the Mediterranean Sea (Blanfuné et al. 2022).

***Gongolaria montagnei* var. *compressa* (Ercegovic) Verlaque, Blanfuné, Boudouresque & Thibaut**

Fig. 18A–C

Cystoseira adriatica subsp. *compressa* Ercegovic. Basionym.

Cystoseira adriatica subsp. *compressa* Ercegovic, *Cystoseira platyramosa* Ercegovic, *Cystoseira adriatica* subsp. *intermedia* Ercegovic, *Cystoseira adriatica* var. *intermedia* (Ercegovic) Giaccone, *Cystoseira spinosa* var. *compressa* (Ercegovic) Cormaci, G. Furnari, Giaccone, Scammacca & D. Serio, *Cystoseira montagnei* var. *compressa* (Ercegovic) M. Verlaque, Blanfuné, Boudouresque, Thibaut & Sellam. Synonyms.

Morphology of specimens from Pantelleria. This form is non-caespitose, adhering to the substrate by a discoid holdfast. The axis is trunk-like, simple, and usually shorter than in the autonymous form. All branches are flattened, with an alternate arrangement. They have serrated edges and a midrib. Spinose appendages can be present in

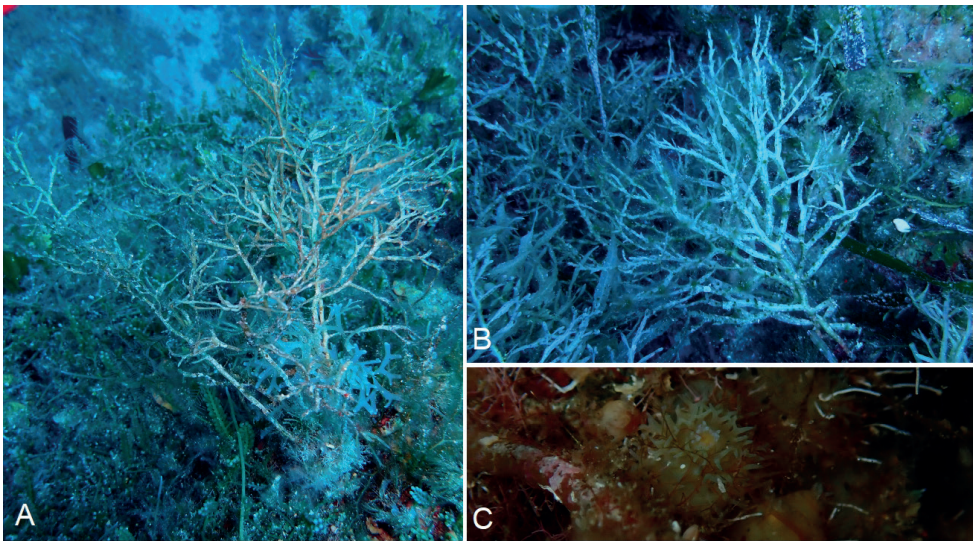

Figure 18. *Gongolaria montagnei* var. *compressa* **A** habit **B** flattened branches with midrib **C** detail of spinose tophules.

the apical parts of secondary branches. The tophules are borne near the base of the axis, oblong and spinose. During the monitoring activities, this form was not found fertile.

Habitat. *G. montagnei* var. *compressa* was observed during scuba dives at Punta Spadillo, Cala Levante and Cala Tramontana. In these sites, it grows in the lower infralittoral/circalittoral (from ca. 26 to 35 m of depth), on bottoms largely covered by detritus and subject to unidirectional currents.

Distribution. *G. montagnei* var. *compressa* is known from Spain, France, Italy, Adriatic, Greece, Libya and Turkey (Blanfuné et al. 2022).

Remarks. This seaweed was reported by Alongi et al. (2004) with a very limited coverage at Cala Levante. Therefore, it might currently be in a phase of increase.

Sargassum cf. *acinarium* (Linnaeus) Setchell

Fig. 19A, B

Fucus acinarius Linnaeus. Basionym.

Fucus acinarius S. G. Gmelin, *Fucus linariifolius* Turner, *Fucus linifolius* Turner, *Sargassum linifolium* C. Agardh, *Sargassum linifolium* f. *gibraltica* Grunow, *Sargassum vulgare* var. *linifolium* (C. Agardh) Zanardini. Synonyms.

Morphology of specimens from Pantelleria. *Sargassum* cf. *acinarium* is attached to the substrate by small discoid holdfast. Primary branches are cylindrical and knotty. Foliaceous branches are narrow (ca. 0.5–1 cm) with an evident midrib, acute apex and denticulate or entire margin. This species has spherical aerocysts with a cylindrical pedicel. During the monitoring, some specimens showed receptacles.

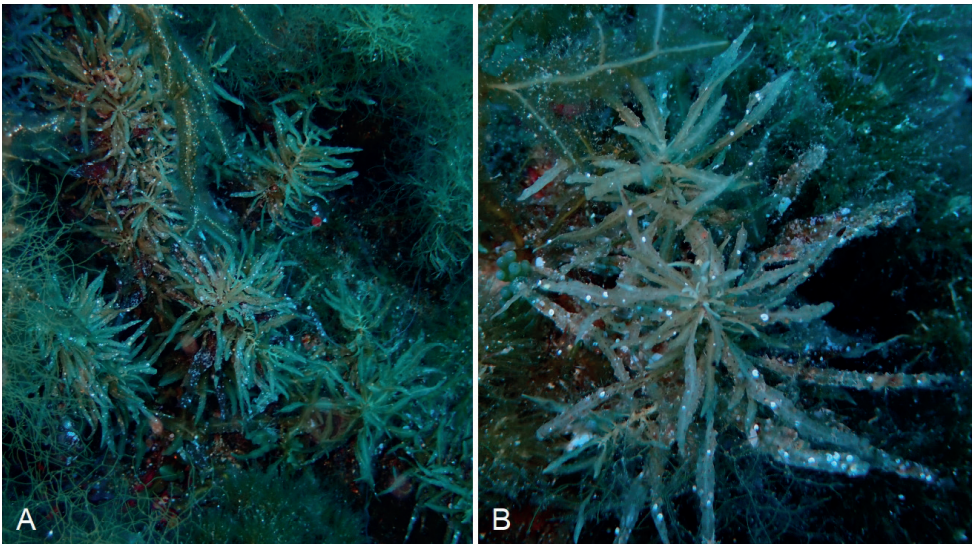

Figure 19. *Sargassum* cf. *acinarium* **A** habit **B** narrow foliaceous branches with an evident midrib.

Habitat. *S.* cf. *acinarium* was observed during scuba dives at Punta Spadillo, Cala Tramontana and Cala Levante, in the lower infralittoral/circalittoral (from 28 to 45 m).

Distribution. This seaweed is distributed in the north-western Atlantic (from Spain to Guinea-Bissau) and in the Mediterranen Sea (Blanfuné et al. 2022).

Remarks. The identification at species level was not certain because it was not possible to collect the receptacles of this entity.

***Sargassum vulgare* C. Agardh**

Fig. 20A–C

Sargassum vulgare C. Agardh, nom. illeg. Basionym.
Fucus salicifolius S. G. Gmelin, *Sargassum megalophyllum* Montagne, *Sargassum coarctatum* Kützing, *Sargassum vulgare* var. *megalophyllum* (Montagne) Vickers. Synonyms.

Morphology of specimens from Pantelleria. *S. vulgare* is attached to the substrate by a small discoid holdfast. The axis is cylindrical and short. Primary branches are cylindrical and smooth or knotty, bearing sparse secondary branches with distichous-alternate arrangement. Foliaceous branches are abundant, lanceolate, with an evident midrib and serrate or wavy margins. The aerocysts are spherical, with a short cylindrical or flattened pedicel. During the monitoring this species was found fertile. The receptacles are fusiform or warty, simple or bifid, borne at the top of a short sterile, cylindrical and branched pedicel.

Habitat. *S. vulgare* was observed both during the snorkelling activities and scuba dives in all examined sites, from the upper infralittoral to the lower infralittoral (from 1 to 25 m) and in both sheltered and wave-exposed habitats.

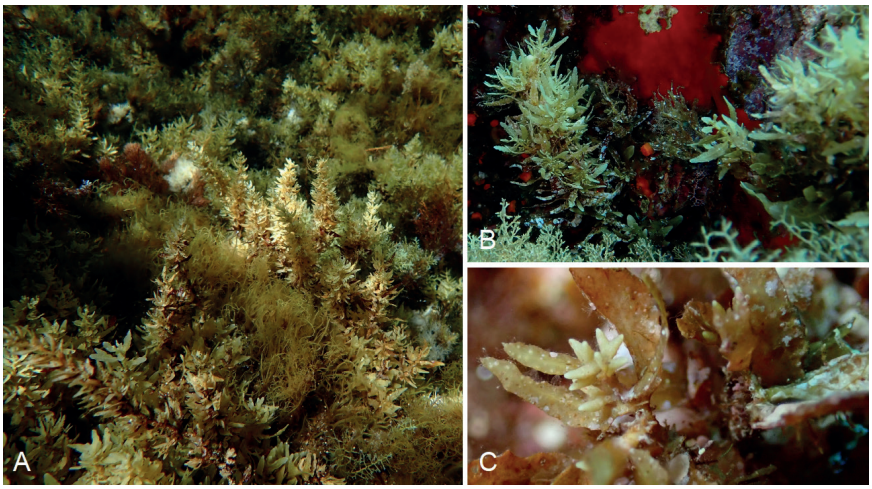

Figure 20. *Sargassum vulgare* **A, B** habit **C** detail of warty receptacles on a short pedicel.

Distribution. *S. vulgare* is widely distributed in the Atlantic Ocean and in the Mediterranean Sea (Blanfuné et al. 2022).

Remarks. Together with *C. compressa* and *E. amentacea*, this species was among the most common fucalean seaweeds along the coasts of the island.

Discussion

The present study allowed to provide an assessment of the current presence and distribution of *Cystoseira* s.l. and *Sargassum* species along the Island of Pantelleria, approximately 20 years after the most recent study on the marine flora of this island. The monitoring activities unraveled the occurrence of 19 taxa: seven belonging to *Cystoseira*, six to *Ericaria*, four to *Gongolaria*, and two to *Sargassum*. Unfortunately, due to the adverse sea conditions it was possible to carry out only a low number of scuba dives, thus this did not enable us to make a more accurate identification of *Sargassum* cf. *acinarium* and *Ericaria* cf. *dubia*. Moreover, the recent taxonomic and biogeographic revision of *Cystoseira* s.l. species demonstrated the necessity to combine morphological studies with genetic analyses, to reveal the possible existence of new entities or cryptic species (Neiva et al. 2022). This is the case of *C. pustulata*, which had previously been identified by some authors as *C. humilis*, but Neiva et al. (2022) highlighted that these are two separate species with well-defined and distinct biogeographical ranges. Neiva et al. (2022) analysed genetically many samples from the island of Pantelleria, but for other taxa additional studies based on molecular analyses should be carried out in the near future.

Comparing these data with the previous studies by Giaccone et al. (1972) and Alongi et al. (2004), we can confirm that most of the species found by these authors are still present on the island. However, we observed an important difference among the species reported by Giaccone et al. (1972) and those found by Alongi et al. (2004).

Indeed, Alongi et al. (2004) did not record some lower infralittoral/circalittoral species documented by Giaccone et al. (1972). In this study, deep-water species such as *C. foeniculacea* f. *latiramosa*, *G. elegans*, *G. montagnei*, *G. montagnei* v. *compressa* and *Sargassum* cf. *acinarium* were detected again about fifty years after the study of Giaccone et al. (1972). Moreover, we noted the presence of *Ericaria* cf. *dubia*, a species previously not documented for Pantelleria. This might indicate a possible natural recovery trend for these Fucales in the island, similar to what was observed at the Medes MPA (Spain) and at Ustica MPA (Italy), where there was a gradual recovery of *Cystoseira* s.l. populations at ca. 10–20 years after their disappearance (Bonaviri et al. 2009; Hereu and Quintana 2012; Sala et al. 2012). As suggested by Gianni et al. (2013), this progressive recolonization can happen thanks to the existence of fragmented reproductive populations in scattered refuge areas, even if at low densities. Therefore, it is likely that over the years it has occurred a gradual expansion of residual populations, survived in refuge sites in the Island of Pantelleria, which could be overlooked in previous surveys.

These deep species could be seriously impacted by the intense fishing activity carried out around the island, which could harm the populations through trawling or anchoring. Therefore, to guarantee a long-term conservation of these fucalean species, it would be helpful to establish a marine protected area in the Island of Pantelleria. Indeed, the marine environment of this island is currently not subjected to any kind of environmental protection, although a proposal to establish a marine protected area was forwarded approximately 20 years ago (Picchetti et al. 2010).

Recently, we (Lombardo and Marletta 2023) also reported a high potential diversity of marine Heterobranchia in the waters of Pantelleria. Therefore, we argue that it would be recommendable to establish a zonation of the island and regulate the anthropic activities, in order to preserve the high biodiversity of the Island of Pantelleria.

Acknowledgements

The authors wish to thank Prof. Fabio Rindi for his interesting and valuable comments and suggestions.

References

Alongi G, Catra M, Cormaci M, Furnari G, Serio D (2004) Spring marine vegetation on rocky substrata of Pantelleria Island (the Straits of Sicily, Italy). Nova Hedwigia 79(3–4): 447–478. https://doi.org/10.1127/0029-5035/2004/0079-0447

Barone R, Calvo S, Sortino M (1978) Contributo alla conoscenza della flora sommersa del Porto di Pantelleria. Giornale Botanico Italiano 112(4): 239–248. https://doi.org/10.1080/11263507809426624

Bianchi F, Acri F (2003) The Island of Pantelleria (Sicily Strait, Italy): towards the establishment of a marine protected area. First oceanographic investigations. Bollettino di Geofisica Teorica ed Applicata 44(1): 3–9.

Blanfuné A, Verlaque M, Boudouresque CF, Rozis E, Thibaut T (2022) Les forêts marines de France et de Méditerranée. Guide de détermination des espèces-ingénieurs. Sargassaceae, Fucales, Phaeophyceae. Presses Universitaries de Provence, 207 pp.

Bonaviri C, Fernández TV, Badalamenti F, Gianguzza P, Di Lorenzo M, Riggio S (2009) Fish versus starfish predation in controlling sea urchin populations in Mediterranean rocky shores. Marine Ecology Progress Series 382: 129–138. https://doi.org/10.3354/meps07976

Bouafif C, Ouerghi A, Langar H (2014) *Cystoseira sedoides* (Desfontaines) C. Agardh des côtes Tunisiennes: état actuel des connaissances. In: Langar H, Bouafif C, Ouerghi A (Eds) Proceeding of the 5th Mediterranean Symposium on Marine Vegetation. UNEP/MAP – RAC/SPA, Portorož, 52–57.

Boudouresque CF, Beaubrun PC, Relini G, Templado J, Van Klaveren MC, Van Klaveren P, Walmsley JG, Zotier R (1996) Critères de sélection et liste révisée des espèces en danger et menacées (marines et saumâtres) en Méditerranée. GIS Posidonie, 73 pp.

Calvo S, Sortino M (1979) Tipologia e distribuzione della vegetazione sommersa del Porto di Pantelleria (Canale di Sicilia). Informatore Botanico Italiano 11: 189–195.

Catra M, Alongi G, Leonardi R, Negri MP, Sanfilippo R, Sciuto F, Serio D, Viola A, Rosso A (2019) Degradation of a photophilic algal community and its associated fauna from eastern Sicily (Mediterranean Sea). Mediterranean Marine Science 20(1): 74–89. https://doi.org/10.12681/mms.17765

Colombo P, Curcio MF, Giaccone G (1982) Biologia dello sviluppo di un endemismo mediterraneo del genere *Cystoseira* (Phaeophyceae, Fucales): *Cystoseira sedoides* C. Agardh. Naturalista Siciliano 6: 81–93.

Cormaci M, Furnari G (1999) Changes of the benthic algal flora of the Tremiti Islands (Southern Adriatic) Italy. In: Kain JM, Brown MT, Lahaye M (Eds) Sixteenth International Seaweed Symposium. Developments in Hydrobiology. Hydrobiologia, Springer, Dordrecht, 398/399: 75–79. https://doi.org/10.1007/978-94-011-4449-0_9

Cormaci M, Furnari G, Catra M, Alongi G, Giaccone G (2012) Flora marina bentonica del Mediterraneo: Phaeophyceae. Bollettino dell'Accademia Gioenia di Scienze Naturali di Catania 45(375): 1–508.

Giaccone G, Scammacca B, Cinelli F, Sartoni G, Furnari G (1972) Studio preliminare sulla tipologia della vegetazione sommersa del Canale di Sicilia e isole vicine. Giornale Botanico Italiano 106(4): 211–229. https://doi.org/10.1080/11263507209426550

Gianni F, Bartolini F, Airoldi L, Ballesteros E, Francour P, Guidetti P, Meinesz A, Thibaut T, Mangialajo L (2013) Conservation and restoration of marine forests in the Mediterranean Sea and the potential role of Marine Protected Areas. Advances in Oceanography and Limnology 4(2): 83–101. https://doi.org/10.1080/19475721.2013.845604

Gómez-Garreta A, Barceló-Martí MC, Ribera-Siguan MA, Rull-Lluch J (2001) *Cystoseira* C. Agardh. In: Gómez-Garreta A (Ed.) Flora Phycologica Iberica (Vol. 1 Fucales, 1st edn.). Universidade de Murcia, Múrcia, 99–166.

Guiry MD, Guiry GM (2023) AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. https://www.algaebase.org [searched on 3 April 2023]

Hereu B, Quintana X (2012) El Fons Marí de les Illes Mesed i el Montgrí, Quatre Dècades de Recerca per a la Conservació. Càtedra d'Ecosistemes Litorals Mediterranis, 193 pp.

Lombardo A, Marletta G (2023) Diversity of the Marine Heterobranchia Fauna at the Island of Pantelleria, Sicily Channel, Mediterranean Sea: First Contribution. Acta Zoologica Bulgarica 75(1): 37–48.

Mancuso FP, Strain EMA, Piccioni E, De Clerck O, Sarà G, Airoldi L (2018) Status of vulnerable *Cystoseira* populations along the Italian infralittoral fringe, and relationships with environmental and anthropogenic variables. Marine Pollution Bulletin 129(2): 762–771. https://doi.org/10.1016/j.marpolbul.2017.10.068

Mulas M, Neiva J, Sadogurska SS, Ballesteros E, Serrão EA, Rilov G, Israel Á (2020) Genetic affinities and biogeography of putative Levantine-endemic seaweed *Treptacantha rayssiae* (Ramon) M.Mulas, J.Neiva & Á.Israel, comb. nov. (Phaeophyceae). Cryptogamie, Algologie 41(10): 91–103. https://doi.org/10.5252/cryptogamie-algologie2020v41a10

Neiva J, Bermejo R, Medrano A, Capdevila P, MillaFigueras D, Afonso P, Ballesteros E, Sabour B, Serio D, Nóbrega E, Soares J, Valdazo J, Tuya F, Mulas M, Israel Á, Sadogurska SS, Guiry MD, Pearson GA, Serrão EA (2022) DNA barcoding reveals cryptic diversity, taxonomic conflicts and novel biogeographical insights in *Cystoseira* s.l. (Phaeophyceae). European Journal of Phycology: 1–25. https://doi.org/10.1080/09670262.2022.2126894

Paladino G, Perez G, Epifanio V, Libertini G (1935) Enciclopedia Italiana. https://www.treccani.it/enciclopedia/pantelleria_%28Enciclopedia-Italiana%29/ [Accessed 21.07.2022]

Picchetti G, Caravello A, Ghelia M, Di Martino V (2010) Proposta per il parco nazionale nello stretto di Sicilia: la A.M.P. di Pantelleria. 41st S.I.B.M. Congress: 82–83.

Rodríguez-Prieto C, Ballesteros E, Boisset F, Afonso Carrilo J (2013) Guía de las Macroalgas y Fanerógamas Marinas del Mediterráneo Occidental. Ediciones Omega, 656 pp.

Sala E, Ballesteros E, Dendrinos P, Di Franco A, Ferretti F, Foley D, Fraschetti S, Friedlander A, Garrabou J, Guclusoy H, Guidetti P, Halpern BS, Hereu B, Karamanlidis AA, Kizilkaya Z, Macpherson E, Mangialajo L, Mariani S, Micheli F, Pais A, Riser K, Rosenberg AA, Sales M, Selkoe KA, Starr R, Tomas F, Zabala M (2012) The structure of Mediterranean rocky reef ecosystems across environmental and human gradients, and conservation implications. PLoS ONE 7(2): e32742. https://doi.org/10.1371/journal.pone.0032742

Serio D, Alongi G, Catra M, Cormaci M, Furnari G (2006) Changes in the benthic algal flora of Linosa Island (Straits of Sicily, Mediterranean Sea). Botanica Marina 49(2): 135–144. https://doi.org/10.1515/BOT.2006.018

Thibaut T, Blanfune A, Boudouresque CF, Verlaque M (2015) Decline and local extinction of Fucales in the French Riviera: the harbinger of future extinctions? Mediterranean Marine Science 16(1): 206–224. https://doi.org/10.12681/mms.1032

Thibaut T, Pinedo S, Torras X, Ballesteros E (2005) Long-term decline of the populations of Fucales (*Cystoseira* spp. and *Sargassum* spp.) in the Albères coast (France, North-western Mediterranean). Marine Pollution Bulletin 50(12): 1472–1489. https://doi.org/10.1016/j.marpolbul.2005.06.014

Tsiamis K, Panayotidis P, Salomidi M, Pavlidou A, Kleinteich J, Balanika K, Küpper FC (2013) Macroalgal community response to re-oligotrophication in Saronikos Gulf. Marine Ecology Progress Series 472: 73–85. https://doi.org/10.3354/meps10060

UNEP-PAM-RAC/SPA (2012) Protocol concerning specially protected areas and biological diversity in the Mediterranean. Annex II. List of endangered or threatened species. Paris, France, 8–10 February 2012, 7–7.

Italian Botanist 15: 165–175 (2023)
doi: 10.3897/italianbotanist.15.105302
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

An updated inventory of the vascular flora of the Cerbaie hills (Tuscany, Italy)

Giovanni Gestri[1], Brunello Pierini[2], Marco D'Antraccoli[3], Andrea Bernardini[4], Lorenzo Peruzzi[3,5]

1 *Via Bonfiglioli 30, 59100 Prato, Italy* **2** *Via Zamenhof 2, 56127 Pisa, Italy* **3** *Orto e Museo Botanico, Sistema Museale di Ateneo, Università di Pisa, Pisa, Italy* **4** *Consorzio Forestale delle Cerbaie, P.zza R. Bertoncini 1, 56022 Castelfranco di Sotto (Pisa), Italy* **5** *PLANTSEED Lab, Dipartimento di Biologia, Università di Pisa, Italy*

Corresponding author: Lorenzo Peruzzi (lorenzo.peruzzi@unipi.it)

Academic editor: Fabrizio Bartolucci | Received 21 April 2023 | Accepted 11 June 2023 | Published 23 June 2023

Citation: Gestri G, Pierini B, D'Antraccoli M, Bernardini A, Peruzzi L (2023) An updated inventory of the vascular flora of the Cerbaie hills (Tuscany, Italy). Italian Botanist 15: 165–175. https://doi.org/10.3897/italianbotanist.15.105302

Abstract

We present an updated list of the vascular flora occurring in the Cerbaie hills (Tuscany), a site of high naturalistic interest. The list is based on a literature survey and on field studies carried out in the years 2010–2022. The Cerbaie hills host a flora of 1,107 specific and subspecific taxa (including 100 naturalized aliens), 32 casual aliens and 10 hybrid taxa. Two taxa are new for Tuscany: *Carex oedipostyla* and *Thalictrum simplex* subsp. *galioides*; 330 taxa are new for the study area. Concerning old records, 344 have been confirmed, while 47 were not confirmed, albeit considered reliable. Moreover, we considered three taxa as locally extinct, 19 as doubtfully occurring, and three as wrongly reported. Despite the low elevation of the study area, life forms and chorotypes show marked Eurosiberian affinities, in agreement with the temperate and continental climate.

Keywords

alien species, biodiversity, endemics, floristic data, phytogeography

Introduction

A flora is a useful source of information for biogeographical, ecological and evolutionary studies (Peruzzi 2018; D'Antraccoli et al. 2022), so that floristic inventories are crucial to provide suitable data for decision-making processes in biodiversity conservation and

Copyright *Giovanni Gestri et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

landscape planning (Carta et al. 2018). One of the most important naturalistic areas in Tuscany (central Italy) are the Cerbaie hills, which also represent a Special Area for Conservation (SAC code IT5170003) according to the European Union's Habitats Directive.

The first floristic records for these hills can be found in Caruel (1860–1864, 1866–1870). Then, Sandri and Fantozzi (1895) provided abundant information, also cited by Baroni (1897–1908). Di Moisè (1959) published a first floristic study of the area. In addition to her own collections and observations, she referred also to herbarium specimens preserved at the Herbarium of Firenze (FI). Later, Arrigoni (1997) carried out a vegetation study, and Tomei (2004) published a survey on the floristic peculiarities of the area. Interesting new floristic data were published by Bacci et al. (2008) and Lastrucci et al. (2008), and the occurrence of several noteworthy species was then published by Bernardini et al. (2013a, 2013b). Further floristic records devoted to single species were published by Fiori (1943), Di Moisè (1951), Del Prete (1978), Tomei and Pistolesi (1980), Tomei et al. (1986, 1991), Tomei and Guazzi (1993), Arrigoni and Menicagli (1999), Corsi and Magrini (2001), Pierini and Peruzzi (2005), La Rosa and Peruzzi (2007), Arrigoni (2018, 2019, 2020, 2021), Astuti et al. (2019), Peruzzi et al. (2017, 2019b, 2019c, 2021, 2022).

The aim of this study is to present a comprehensive analysis of previous literature, using an updated and coherent nomenclature, complemented by field investigations, to compile a floristic inventory of the vascular flora of the Cerbaie hills. It is part of a series of investigations carried out by the PLANTSEED Lab (Department of Biology, University of Pisa) devoted to improving the floristic knowledge of Tuscany (Pierini et al. 2008; Peruzzi et al. 2011; Gestri and Peruzzi 2012, 2013, 2014; Pierini and Peruzzi 2014; Ciccarelli et al. 2015; Gei et al. 2016; Roma-Marzio et al. 2016; Carta et al. 2018; Roma-Marzio et al. 2020; Peruzzi 2021, 2023).

Materials and methods

Study area

The Cerbaie are low hills (maximum elevation, reached in Montefalcone, is 117 m a.s.l.) that cover an area of ca. 114 km^2 in the middle portion of northern Tuscany (Fig. 1). These hills lie between the Bientina plain on the western side, the Fucecchio swamp on the northern and eastern side, and the Arno river on the southern side. The territories of seven municipalities are involved: Fucecchio (Firenze); Bientina, Calcinaia, Castelfranco di Sotto, Santa Croce sull'Arno, and Santa Maria a Monte (Pisa), and Altopascio (Lucca). A peculiarity of the territory is the abundant presence of streams and impluvia (locally called "vallini"), mostly oriented SE-NW.

From a geological perspective, the Cerbaie hills are constituted mainly by Pliocenic and Pleistocenic sedimentary rocks and sediments (AA. VV. 2009). Soils are more or less acid, deriving from siliceous substrates (Arrigoni 1997).

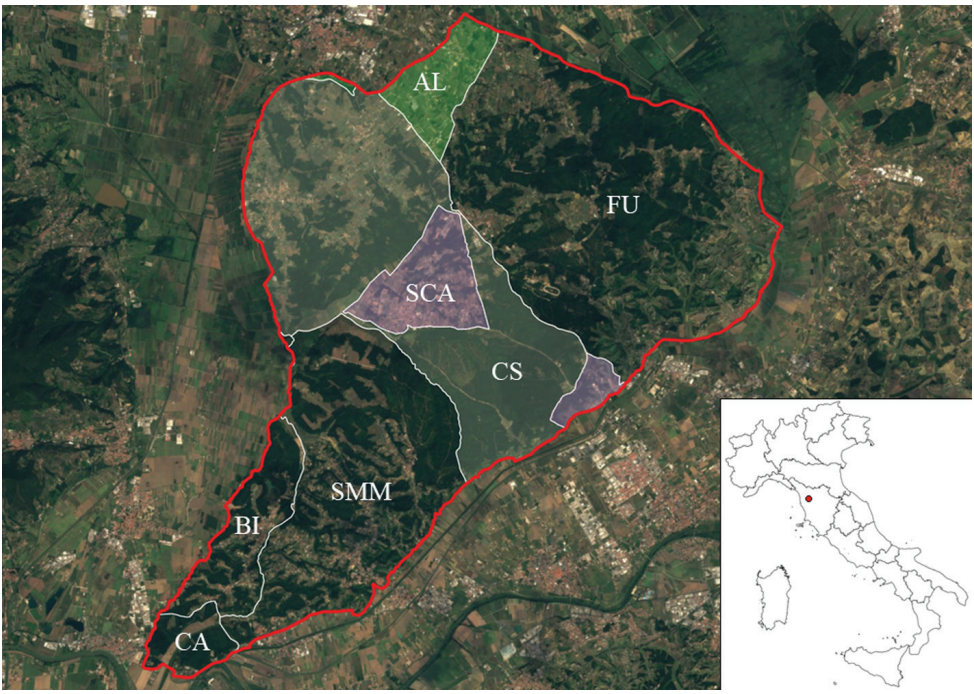

Figure 1. Localisaton of the Cerbaie hills in Italy. The red line circumscribes the study area. The different shades of colours identify disjunct territories belonging to the same municipality. AL = Altopascio (Lucca), CA = Calcinaia (Pisa), BI = Bientina (Pisa), SMM = Santa Maria a Monte (Pisa), SCA = Santa Croce sull'Arno (Pisa), CS = Castelfranco di Sotto (Pisa), FU = Fucecchio (Firenze).

The climate of the Cerbaie hills is temperate, continental and rather homogeneous (AA. VV. 2009), showing some degree of summer aridity, especially in July (Arrigoni 1997) and precipitation peaks in autumn and spring (mean annual precipitation 950–1100 mm; AA. VV. 2009).

Concerning vegetation and land use, the southern portions of the Cerbaie hills are dominated by olive orchards and cultivated fields; the rest of the territory is mostly covered by woods, which cover about 40% of the surface, where *Pinus pinaster* Aiton subsp. *pinaster* and the alien *Robinia pseudoacacia* L. are becoming particularly widespread in recent times (Piussi and Stiavelli 1995). Often mesophilous, meso-hygrophilous, and thermophilous species can be found growing very close to each other (Arrigoni 1997).

Most of the hills belong to the preapenninic acidophilous durmast oak vegetation series of plain areas from Tuscany and Umbria (*Hieracio racemosi-Querco petraeae sigmetum*), while surrounding areas belong to the peninsular hygrophilous *geosigmetum* of riparian vegetation (*Salicion albae*, *Populion albae*, *Alno-Ulmion*) (De Dominicis et al. 2010a, 2010b). For an in-depth syntaxonomic treatment of durmast oak woods, see Viciani et al. (2016, 2018) and Viciani (2023).

Floristic inventory

To obtain a 'working hypothesis' concerning the number of taxa expected in the study area, we used the approach followed by D'Antraccoli et al. (2019), which relied on species-area relationships (SARs) adjusted by environmental modeling. We searched all published papers dealing with plants of the Cerbaie hills and extracted occurrence records for all those species reported for the area. These data were complemented by field observations available in the portal Wikiplantbase #Toscana (Peruzzi and Bedini 2013 onwards) and our own field expeditions carried out from 2010 to 2022. The taxa reported by Sandri and Fantozzi (1895) were considered only when clearly referring to the Cerbaie hills. We did not consider the floristic list published by Guarino and Bernardini (2002), which also concerns the Cerbaie hills, because it was impossible to distinguish taxa occurring within the study area from those occurring in neighbouring areas.

Nomenclature and circumscription of the taxa follows Bartolucci et al. (2018), Galasso et al. (2018) and their updates periodically appearing in the Portal to the Flora of Italy (https://dryades.units.it/floritaly/index.php; Martellos et al. 2020). Angiosperm families are arranged according to APG IV (2016). Life forms and chorotypes were attributed according to Pignatti (2017a, 2017b, 2018), not considering casual aliens and cultivated species. Information about Italian endemics was derived from Peruzzi et al. (2014, 2015), and Bartolucci et al. (2018). We also highlighted those taxa included in the Italian Red List (Rossi et al. 2013, 2020). The OGUs were identified based on the different municipalities (Fig. 1). The complete dataset assembled for the present study is available in Suppl. material 1.

Results

Floristic inventory

The expected number of species/subspecies and alien taxa was 1,021 and 86, respectively.

A total of 1,107 specific and subspecific taxa currently occur in the study area, including 100 naturalized aliens, representing about 9% of the established flora, not considering casual aliens (32) and hybrid taxa (10); two are new records for Tuscany, and 330 are new for the Cerbaie hills. While 344 taxa have been directly confirmed during field surveys, 47 taxa reliably recorded in the past were not confirmed. We excluded three taxa, while three other taxa were considered as locally extinct and 19 as doubtfully occurring in the area.

Three families alone account for about 30% of the total vascular flora (Asteraceae 126 taxa, Fabaceae 112, and Poaceae 96), although Cyperaceae are also well represented (53). The most represented genera are *Trifolium* (35), *Carex* (20), *Lathyrus* (17), *Juncus*, and *Vicia* (15).

Biological and chorological spectra highlight that hemicryptophytes (35.2%), therophytes (32.2%), and geophytes (15.1%) are the most represented life forms,

followed by phanerophytes (11.7%), hydrophytes (3.1%), and chamaephytes (2.7%). As far as the chorological spectrum is concerned, Eurosiberian (32.5%) and transitional Eurosiberian-Mediterranean (25.5%) are the most frequent chorotypes, followed by wide distribution (16.5%) and Mediterranean (15.4%). Alien taxa represent 9% of the total flora.

Italian endemics are 13: *Cardamine apennina* Lihová & Marhold, *Crocus biflorus* Mill., *Hieracium grovesianum* Arv.-Touv. ex Belli, *Melampyrum italicum* (Beauverd) Soó, *Ornithogalum etruscum* Parl. subsp. *etruscum*, *O. etruscum* Parl. subsp. *umbratile* (Tornadore & Garbari) Peruzzi & Bartolucci, *Ophrys appennina* Romolini & Soca, *O. classica* Devillers-Tersch. & Devillers, *O. maritima* Pacifico & Soca, *Polygala flavescens* DC. subsp. *flavescens*, *P. nicaeensis* W.D.J.Koch subsp. *italiana* (Chodat) Arrigoni, *P. vulgaris* L. subsp. *valdarnensis* (Fiori) Arrigoni, and *Scabiosa uniseta* Savi. In addition, there is also a microspecies, putatively a narrow endemic to the study area, namely *Taraxacum cerbariense* Arrigoni. Three species recorded by previous authors were not found, and could be possibly extinct at the local level, i.e. *Lysimachia tenella* L., *Menyanthes trifoliata* L., and *Potentilla alba* L.

Discussion

With respect to the predicted richness based on SARs, the number of species/subspecies is 8% above the theoretical prediction. This suggests a high floristic richness of the study area, as compared with other areas in Tuscany (D'Antraccoli et al. 2019). However, it is noteworthy that also the number of alien taxa is 53% above the expected value. Accordingly, the number of aliens in the Cerbaie hills is relatively high, although there are floras of surrounding areas showing up to +207% of expected aliens, such as the municipality of Empoli (Peruzzi 2023). Among alien taxa, *Ailanthus altissima* (Mill.) Swingle is listed in European regulation UE 2019/1262.

Many of the taxa occurring in the Cerbaie hills are of high phytogeographical interest. *Drosera rotundifolia* L. is found at the southern margin of its distribution range, while other taxa can be found in Tuscany only in the Cerbaie hills (i.e. the new records *Carex oedipostyla* Duval-Jouve and *Thalictrum simplex* L. subsp. *galioides* (DC.) Korsh.) or still survive only there in Tuscany (*Exaculum pusillum* (Lam.) Caruel and *Gentiana pneumonanthe* L. subsp. *pneumonanthe*) (Peruzzi and Bedini 2013 onwards). There are species which usually grow at higher elevations, such as *Asphodelus macrocarpus* Parl. subsp. *macrocarpus*, *Betula pendula* Roth, and *Veratrum album* L.

Other rare species in Tuscany are: *Cardamine amporitana* Sennen & Pau, *Carex demissa* Hornem. subsp. *demissa*, *C. rostrata* Stokes, *Cicendia filiformis* L., *Cyperus michelianus* (L.) Link, *Dictamnus albus* L., *Hottonia palustris* L., *Hydrocotyle vulgaris* L., *Hypochaeris maculata* L., *Juncus heterophyllus* Dufour, *Lathraea clandestina* L., *Lysimachia minima* (L.) U.Manns & Anderb., *Lythrum tribracteatum* Salzm. ex Spreng., *Melampyrum pratense* L. subsp. *commutatum* (Tausch ex A.Kern.) C.E.Britton, *Nymphoides peltata* (S.G.Gmel.) Kuntze, *Solenopsis laurentia* (L.) C.Presl (also originally

described from this area, see Peruzzi et al. 2019a), *Thysselinum palustre* (L.) Hoffm., *Tripleurospermum inodorum* (L.) Sch.Bip., *Utricularia australis* R.Br., *Veronica scutellata* L., and *Viburnum opulus* L.

The taxa showing some conservation interest (Rossi et al. 2013, 2020) are 44, 27 of which are categorized as Least Concern, three Data Deficient, five Near Threatened (*Carex rostrata*, *Gladiolus palustris* Gaudin, *Osmunda regalis* L., *Utricularia australis*, and *Zannichellia palustris* L.), three Vulnerable (*Leucojum aestivum* L. subsp. *aestivum*, *Ranunculus ophioglossifolius* Vill., and *Thelypteris palustris*), and six Endangered (*Baldellia ranunculoides* (L.) Parl., *Cardamine amporitana*, *Exaculum pusillum*, *Hottonia palustris*, *Hydrocotyle vulgaris*, and *Sagittaria sagittifolia* L.) at national level.

Life forms and chorotypes show marked Eurosiberian affinities, despite the low elevation but in agreement with the temperate and continental climate. Comparing the flora of the Cerbaie hills with those of surrounding areas, in Monte Pisano (Pierini et al. 2009) and Empoli (Peruzzi 2023) the proportion of life forms is similar to the Cerbaie hills, while in Montalbano therophytes dominate and geophytes are more represented (Gestri and Peruzzi 2013). Concerning biogeographical affinities, a more abundant presence of Mediterranean species was recorded in Monte Pisano (Pierini et al. 2009) and in Empoli (Peruzzi 2023), while chorotypes transitional between Mediterranean and Eurosiberian regions dominate in Montalbano (Gestri and Peruzzi 2013).

Thanks to its rich and diversified flora, the Cerbaie hills stand out as one of the sites showing the highest phytogeographical and conservation interest in Tuscany.

Acknowledgements

Financial support by Fondazione per la Flora Italiana for the publication fee is gratefully acknowledged. We are grateful to the curators of the Herbaria of Florence (FI), Pisa (PI), and Siena (SIENA) for providing useful information on localities, literature, and/or digital images of some specimens.

References

AA VV (2009) Relazione illustrativa del quadro conoscitivo. Variante al piano strutturale. Comune di S. Croce sull'Arno. Provincia di Pisa.

APG IV (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society 181(1): 1–20. https://doi.org/10.1111/boj.12385

Arrigoni PV (1997) Documenti per la carta della vegetazione delle Cerbaie (Toscana settentrionale). Parlatorea 2: 39–71.

Arrigoni PV (2018) Flora analitica della Toscana. Vol. 4. Edizioni Polistampa, Firenze.

Arrigoni PV (2019) Flora analitica della Toscana. Vol. 6. Edizioni Polistampa, Firenze.

Arrigoni PV (2020) Flora analitica della Toscana. Vo. 7. Edizioni Polistampa, Firenze.

Arrigoni PV (2021) Flora analitica della Toscana. Vol. 8(1). Edizioni Polistampa, Firenze.

Arrigoni PV, Menicagli E (1999) Carta della vegetazione forestale della Regione Toscana. Ediz. Regione Toscana.

Astuti G, Liu L, Peruzzi L (2019) Chromosome numbers for the Italian flora: 7 Italian Botanist 7: 183–187. https://doi.org/10.3897/italianbotanist.7.36004

Bacci S, Bernardini A, Corsi R, Malfanti F, Petrolo M (2008) Le colline delle Cerbaie e Il Padule di Bientina – stato di conservazione della Natura e gestione sostenibile del paesaggio. Edizioni ETS Pisa.

Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, Astuti G, Bacchetta G, Ballelli S, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Cecchi L, Di Pietro R, Domina G, Fascetti S, Fenu G, Festi F, Foggi B, Gallo L, Gottschlich G, Gubellini L, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Conti F (2018) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 199–303. https://doi.org/10.1080/11263504.2017.1419996

Baroni E (1897–1908) Supplemento generale al "Prodromo della Flora toscana di T. Caruel". Firenze.

Bernardini A, D'Antraccoli M, Gestri G, Peruzzi L, Petrolo M, Pierini B (2013a) Notulae alla checklist della flora vascolare italiana, 16: 2011–2012. Informatore Botanico Italiano 45(2): 304.

Bernardini A, D'Antraccoli M, Gestri G, Peruzzi L, Petrolo M, Pierini B (2013b) Segnalazioni 265–284. In: Peruzzi L, Viciani D, Bedini G (Eds) Contributi per una flora vascolare di Toscana. V (247–319). Atti della Società Toscana di Scienze Naturali, Memorie, Serie B 120: 35–44.

Carta A, Forbicioni L, Frangini G, Pierini B, Peruzzi L (2018) An updated inventory of the vascular flora of Elba island (Tuscan Archipelago, Italy). Italian Botanist 6: 1–22. https://doi.org/10.3897/italianbotanist.6.26568

Caruel T (1860–1864) Prodromo della Flora toscana. Firenze.

Caruel T (1866–1870) Supplemento al Prodromo della Flora toscana. Firenze.

Cecchi L, Selvi F (2015) Synopsis of Boraginaceae subfam. Boraginoideae tribe Boragineae in Italy. Plant Biosystems 149: 630–677. https://doi.org/10.1080/11263504.2015.1057261

Ciccarelli D, Di Bugno C, Peruzzi L (2014) Checklist della flora vascolare psammofila della Toscana. Atti della Società Toscana di Scienze Naturali, Memorie, serie B 121: 37–88.

Corsi R, Magrini A (2001) Segnalazioni Floristiche Italiane: 971. Informatore Botanico Italiano 32(1–3)[2000]: 50–51.

D'Antraccoli M, Bedini G, Peruzzi L (2022) Next Generation Floristics: a workflow to integrate novel methods in traditional floristic research. Plant Biosystems 156(2): 594–597. https://doi.org/10.1080/11263504.2022.2056650

D'Antraccoli M, Roma-Marzio F, Carta A, Landi S, Bedini G, Chiarucci A, Peruzzi L (2019) Drivers of floristic richness in the Mediterranean: a case study from Tuscany. Biodiversity and Conservation 28: 1411–1429. https://doi.org/10.1007/s10531-019-01730-x

De Dominicis V, Angiolini C, Gabellini A (2010a) Le serie di vegetazione della regione Toscana. In: Blasi C (Ed.) La vegetazione d'Italia. Palombi & Partner S.r.l., Roma, 205–230.

De Dominicis V, Angiolini C, Gabellini A (2010b) Carta delle serie di vegetazione della regione Toscana. In: Blasi C (Ed.) La vegetazione d'Italia, Carta delle Serie di Vegetazione, scala 1:500.000. Palombi & Partner S.r.l., Roma.

Del Prete C (1978) Contributi alla conoscenza delle Orchidaceae d'Italia. II. Il genere *Cephalanthera* Richard in Toscana. Atti della Società Toscana di Scienze Naturali, Pisa, Memorie, Serie B 84(1977): 17–34.

Di Moisè B (1951) *Potentilla alba* L. in Toscana. Nuovo Giornale Botanico Italiano, nuova serie 58(3–4): 586–588.

Di Moisè B (1959) Ricerche sulla vegetazione dell'Etruria. XII. Flora e vegetazione delle Cerbaie (Valdarno inferiore). Nuovo Giornale Botanico Italiano, nuova serie 65(4)[1958]: 601–744.

Fiori A (1943) Flora Italica Cryptogama, 5. Pteridophyta. Firenze.

Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E, Celesti-Grapow L, Albano A, Alessandrini A, Bacchetta G, Ballelli S, Bandini Mazzanti M, Barberis G, Bernardo L, Blasi C, Bouvet D, Bovio M, Cecchi L, Del Guacchio E, Di Pietro R, Domina G, Fascetti S, Gallo L, Gubellini L, Guiggi A, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Podda L, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Bartolucci F (2018) An updated checklist of the vascular flora alien to Italy. Plant Biosystems 152(3): 556–592. https://doi.org/10.1080/11263504.2018.1441197

Gei F, Fastelli D, Maetzke FG, Gestri G, Peruzzi L (2016) Calvana e Monte Morello. Due rilievi a confronto. Geografia, geologia, climatologia, rimboschimenti, vegetazione e flora vascolare. Accademia Italiana di Scienze Forestali, Tipografia Linari, Firenze, 233 pp.

Gestri G, Peruzzi L (2012) La flora vascolare del Monte Pelato (Colline Livornesi, Toscana). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 118(2011): 25–38.

Gestri G, Peruzzi L (2013) I fiori di Leonardo. La flora vascolare del Montalbano in Toscana. Aracne editrice, Roma.

Gestri G, Peruzzi L (2014) La flora vascolare di Monte Le Coste e Poggio alle Croci (Prato, Toscana). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 120(2013): 13–34.

Guarino R, Bernardini A (2002) Indagine sulla diversità floro-vegetazionale del comprensorio del cuoio (Toscana centro-settentrionale). Tipografia Bongi, S. Miniato (Pisa).

La Rosa M, Peruzzi L (2007) Notulae alla checklist della flora vascolare italiana, 5: 1440–1443. Informatore Botanico Italiano 40(1): 104–105.

Lastrucci L, Viciani D, Nuccio C, Melillo C (2008) Indagine vegetazionale su alcuni laghi di origine artificiale limitrofi al padule di Fucecchio (Toscana, Italia centrale). Annali del Museo Civico di Rovereto, Sezione: Archeologia, Storia, Scienze Naturali 23(2007): 169–203.

Martellos S, Bartolucci F, Conti F, Galasso G, Moro A, Pennesi R, Peruzzi L, Pittao E, Nimis PL (2020) FlorItaly – the portal to the Flora of Italy. PhytoKeys 156: 55–71. https://doi.org/10.3897/phytokeys.156.54023

Peruzzi L (2018) Floristic inventories and collaborative approaches: a new era for checklists and floras? Plant Biosystems 152(2): 177–178. https://doi.org/10.1080/11263504.2017.1419997

Peruzzi L (2021) Flora Empolese – Elenco della flora vascolare della terra d'Empoli. Edizioni ETS, Pisa.

Peruzzi L (2023) The vascular flora of Empoli (Tuscany, central Italy). Italian Botanist 15: 21–33. https://doi.org/10.3897/italianbotanist.15.101748

Peruzzi L, Barbo M, Bartolucci F, Bovio M, Carta A, Ciccarelli D, Conti F, Costalonga S, Di Pietro R, Galasso G, Gestri G, Lattanzi E, Lavezzo P, Marsili S, Peccenini S, Pierini B, Tardella FM, Terzo V, Turrisi RE, Bedini G (2011) Contributo alla conoscenza floristica delle Colline Pisane: resoconto dell'escursione del Gruppo di Floristica (S.B.I.) nel 2009. Informatore Botanico Italiano 43(1): 3–27.

Peruzzi L, Bedini G [Eds] (2013 [onwards]) Wikiplantbase #Toscana. http://bot.biologia.unipi.it/wpb/toscana/index

Peruzzi L, Conti F, Bartolucci F (2014) An inventory of vascular plants endemic to Italy. Phytotaxa 168(1): 1–75. https://doi.org/10.11646/phytotaxa.168.1.1

Peruzzi L, Domina G, Bartolucci F, Galasso G, Peccenini S, Raimondo FM, Albano A, Alessandrini A, Banfi E, Barberis G, Bernardo L, Bovio M, Brullo S, Brundu G, Brunu A, Camarda I, Carta L, Conti F, Croce A, Iamonico D, Iberite M, Iiriti G, Longo D, Marsili S, Medagli P, Pistarino A, Salmeri C, Santangelo A, Scassellati E, Selvi F, Soldano A, Stinca A, Villani M, Wagensommer RP, Passalacqua NG (2015) An inventory of the names of vascular plants endemic to Italy, their loci classici and types. Phytotaxa 196(1): 1–217. https://doi.org/10.11646/phytotaxa.196.1.1

Peruzzi L, Galasso G, Domina G, Bartolucci F, Santangelo A, Alessandrini A, Astuti G, D'Antraccoli M, Roma-Marzio F, Ardenghi NMG, Barberis G, Conti F, Bernardo L, Peccenini S, Stinca A, Wagensommer RP, Bonari G, Iamonico I, Iberite M, Viciani D, Del Guacchio E, Giusso del Galdo G, Lastrucci L, Villani M, Brunu A, Magrini S, Pistarino A, Brullo S, Salmeri C, Brundu G, Clementi M, Carli E, Vacca G, Marcucci R, Banfi E, Longo D, Di Pietro R, Passalacqua NG (2019a) An inventory of the names of native, non-endemic vascular plants described from Italy, their loci classici and types. Phytotaxa 410: 1–215. https://doi.org/10.11646/phytotaxa.410.1.1

Peruzzi L, Viciani D, Angiolini C, Astuti G, Banfi E, Brandani S, Bonari G, Cambria S, Cannucci S, Castagnini P, D'Antraccoli M, De Giorgi P, Di Natale S, Ferretti G, Fiaschi T, Gonnelli V, Gottschlich G, Lastrucci L, Lazzaro L, Misuri A, Mugnai M, Pierini B, Pinzani L, Roma-Marzio F, Sani A, Selvi F, Spinelli A, Bedini G (2019b) Contributi per una flora vascolare di Toscana. XI (664–738). Atti della Società Toscana di Scienze Naturali, Memorie, Serie B 126: 35–46.

Peruzzi L, Roma-Marzio F, Dolci D, Flamini G, Braca A, De Leo M (2019c) Phytochemical data parallel morpho-colorimetric variation in *Polygala flavescens* DC. Plant Biosystems 153(6): 817–834. https://doi.org/10.1080/11263504.2018.1549615

Peruzzi L, Viciani D, Adami M, Angiolini C, Astuti G, Bonari G, Bonaventuri G, Castagnini P, de Simone L, Domina G, Fanfarillo E, Fedeli R, Ferretti G, Festi F, Fiaschi T, Foggi B, Franzoni J, Gabellini A, Gennai M, Gestri G, Giacò A, Gottschlich G, Maccherini S,

Mugnai M, Pierini B, Pinzani L, Roma-Marzio F, Sarmati S, Vannini A, Zangari G, Bedini G (2021) Contributi per una flora vascolare di Toscana. XIII (813–873). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 128: 85–94.

Peruzzi L, Viciani D, Agostini N, Angiolini C, Ardenghi NMG, Astuti G, Bardaro MR, Bertacchi A, Bonari G, Boni S, Chytrý M, Ciampolini F, D'Antraccoli M, Domina G, Ferretti G, Guiggi A, Iamonico D, Laghi P, Lastrucci L, Lazzaro L, Lazzeri V, Liguori P, Mannocci M, Marsiaj G, Novák P, Nucci A, Pierini B, Roma-Marzio F, Romiti B, Sani A, Zoccola A, Zukal D, Bedini G (2017) Contributi per una flora vascolare di Toscana. VIII (440–506) Atti della Società Toscana di Scienze Naturali, Memorie, Serie B 123(2016): 71–82.

Peruzzi L, Viciani D, Astuti G, Bandinelli A, Bettini D, Carta A, Cutroneo A, Domina G, Fontana D, Franzoni J, Gavazzi C, Gestri G, Giacò A, Mo A, Pierini B, Pinzani L, Roma-Marzio F, Selvi F, Stinca A, Vangelisti R, Bedini G (2022) Contributi per una flora vascolare di toscana. XIV (874–958). Atti della Società Toscana di Scienze Naturali, Memorie, serie B 129: 57–69.

Pierini B, Peruzzi L (2015) Notulae alla Flora esotica d'Italia, 12: 251. Informatore Botanico Italiano 47(1): 79.

Pierini B, Garbari F, Peruzzi L (2009) Flora vascolare del Monte Pisano (Toscana nord–occidentale). Informatore Botanico Italiano 41(2): 147–213.

Pierini B, Peruzzi L (2014) Prodromo della flora vascolare della Provincia di Lucca (Toscana nord–occidentale). Informatore Botanico Italiano 46(1): 3–16 [+ electronic appendix (500 pp.)]

Pignatti S (2017a) Flora d'Italia 1, 2nd edn. New Business Media: Milano, Italy, 1064 pp.

Pignatti S (2017b) Flora d'Italia 2, 2nd edn. New Business Media: Milano, Italy, 1178 pp.

Pignatti S (2018) Flora d'Italia 3, 2nd edn. New Business Media: Milano, Italy, 1286 pp.

Piussi P, Stiavelli S (1995) Storia dei boschi delle Cerbaie. In: Prosperi A (Ed.) Il Padule di Fucecchio. Roma, 123–136.

Roma-Marzio F, Bedini G, Müller, Peruzzi L (2016) A critical checklist of the woody flora of Tuscany. Phytotaxa 287(1): 1–135. https://doi.org/10.11646/phytotaxa.287.1.1

Roma-Marzio F, D'Antraccoli M, Angeloni D, Bartolucci F, Bernardo L, Cancellieri L, Caruso G, Conti F, Dolci D, Gestri G, Gubellini L, Hofmann N, Laface VLA, Lattanzi E, Lavezzo P, Maiorca G, Montepaone G, Musarella CM, Noto D, Perrino EV, Proietti E, Masin RR, Scoppola A, Stinca A, Tiburtini M, Tilia A, Peruzzi L (2020) Contribution to the floristic knowledge of Sillaro, Santerno, and Senio high valleys (Tuscany, Italy). Italian Botanist 10: 101–111. https://doi.org/10.3897/italianbotanist.10.60118

Rossi G, Montagnani C, Gargano D, Peruzzi L, Abeli T, Ravera S, Cogoni A, Fenu G, Magrini S, Gennai M, Foggi B, Wagensommer RP, Venturella G, Blasi C, Raimondo FM, Orsenigo S (2013) Lista Rossa della Flora Italiana. 1. Policy Species e altre specie minacciate. Comitato Italiano IUCN e Ministero dell'Ambiente e della tutela del Territorio e del Mare.

Rossi G, Orsenigo S, Gargano D, Montagnani C, Peruzzi L, Fenu G, Abeli T, Alessandrini A, Astuti G, Bacchetta G, Bartolucci F, Bernardo L, Bovio M, Brullo S, Carta A, Castello M, Cogoni D, Conti F, Domina G, Foggi B, Gennai M, Gigante D, Iberite M, Lasen C, Magrini S, Nicolella G, Pinna MS, Poggio L, Prosser F, Santangelo A, Selvaggi A, Stinca A, Tartaglini N, Troia A, Villani MC, Wagensommer RP, Wilhalm T, Blasi C (2020) Lista

Rossa della Flora Italiana. 2 Endemiti e altre specie minacciate. Ministero dell'Ambiente e della tutela del Territorio e del Mare.

Sandri G, Fantozzi P (1895) Contribuzione alla Flora di Valdinievole. Nuovo Giornale Botanico Italiano, nuova serie 2: 129–180; 289–333.

Tomei PE, Amadei L, Giordani A (1986) Sulla presenza di alcune specie rare ai laghi Acquato e di San Floriano in Toscana. Atti della Società Toscana di Scienze Naturali, Memoria, Serie B 92(1985): 121–132.

Tomei PE, Guazzi E (1993) Le zone umide della Toscana. Lista generale delle entità vegetali. Atti del Museo Civico di Storia Naturale di Grosseto 15: 107–152.

Tomei PE, Longombardo G, Lippi A (1991) Specie vegetali igrofile delle zone dulciacquicole della Toscana planiziale: aspetti floristici e bioecologici. Pacini Editore, Pisa.

Tomei PE, Pistolesi G (1980) Indagini sulle zone umide della Toscana. III. Aspetti floristici e vegetazionali del Padule di Bientina. Nota preliminare. Atti della Società Toscana di Scienze Naturali, Memorie, Serie B 86(1979): 377–406. https://doi.org/10.21426/B66110095

Tomei PE (2004) Le Cerbaie di Fucecchio. La flora: appunti e considerazioni. In: Le Cerbaie, la natura e la storia. Istituto Storico Lucchese, Sezione Valdarno. Banca di Bientina. Pacini Editore, Pisa, 29–36.

Viciani D (2023) Validation of syntaxon names and lectotypifications for some Italian vegetation types. Mediterranean Botany 44(1): e77383. https://doi.org/10.5209/mbot.77383

Viciani D, Gabellini A, Gennai M, Foggi B, Lastrucci L (2018) Woods with *Quercus petraea* (Matt.) Liebl. in Tuscany (Italy): a vegetation classification approach. Mediterranean Botany 39(1): 3–16. https://doi.org/10.5209/MBOT.59040

Viciani D, Gennai M, Lastrucci L, Gabellini A, Armiraglio S, Caccianiga M, Andreis C, Foggi B (2016) The *Quercus petraea*-dominated communities in Italy: floristic, coenological and chorological diversity in an European perspective. Plant Biosystems 150(6): 1376–1394. https://doi.org/10.1080/11263504.2016.1165754

Supplementary material 1

Floristic list and records

Authors: Giovanni Gestri, Brunello Pierini, Marco D'Antraccoli, Andrea Bernardini, Lorenzo Peruzzi

Data type: PDF file

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/italianbotanist.15.105302.suppl1

Italian Botanist 15: 177–191 (2023)
doi: 10.3897/italianbotanist.15.107040
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

Global and Regional IUCN Red List Assessments: 15

Simone Orsenigo[1], Giulia Calderisi[2], Donatella Cogoni[2], Andrea Mondoni[1], Juri Nascimbene[3], Francesco Rota[4,5], Thasajini Sajeevan[1,6], Malaka Wijayasinghe[7], Camilla Wellstein[4], Giuseppe Fenu[2]

1 *Department of Earth and Environmental Sciences, University of Pavia, Via S. Epifanio 14, 27100, Pavia, Italy* **2** *Department of Life and Environmental Sciences, University of Cagliari, Viale S. Ignazio da Laconi 13, 09123, Cagliari, Italy* **3** *BIOME Lab, Department of Biological, Geological and Environmental Sciences, Alma Mater Studiorum, University of Bologna, 40126, Bologna, Italy* **4** *Faculty of Agricultural, Environmental and Food Sciences, Free University of Bozen-Bolzano, 39100, Bolzano, Italy* **5** *Swiss Federal Institute for Forest, Snow and Landscape Research WSL, 8903 Birmensdorf, Switzerland* **6** *Department of Biological Sciences, Faculty of Applied Sciences, South Eastern University of Sri Lanka, Oluvil, Sri Lanka* **7** *Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka*

Corresponding author: Simone Orsenigo (simone.orsenigo@unipv.it)

Academic editor: Lorenzo Peruzzi | Received 26 May 2023 | Accepted 30 June 2023 | Published 7 July 2023

Citation: Orsenigo S, Calderisi G, Cogoni D, Mondoni A, Nascimbene J, Rota F, Sajeevan T, Wijayasinghe M, Wellstein C, Fenu G (2023) Global and Regional IUCN Red List Assessments: 15. Italian Botanist 15: 177–191. https://doi.org/10.3897/italianbotanist.15.107040

Abstract

In this contribution, the conservation status assessment of three vascular plants are presented according to IUCN categories and criteria. It includes the assessment of *Oryza rhizomatis* D.A.Vaughan and *Saxifraga facchinii* W.D.J.Koch at a global level and *Helianthemum caput-felis* Boiss. at a regional level.

Keywords

conservation, extinction risk, IUCN protocol, threats

How to contribute

The text of the global and regional assessments should be submitted electronically to Simone Orsenigo (simone.orsenigo@unipv.it) or to Giuseppe Fenu (gfenu@unica.it); the text, up to 8000 characters in length (spaces included), must include a distribution map and a picture of the assessed species.

Copyright *Simone Orsenigo et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Red List Assessments

Oryza rhizomatis D.A.Vaughan

Global assessment
Taxonomy and nomenclature
Order: Poales *Family*: Poaceae

Oryza rhizomatis D.A.Vaughan, Bot. J. Linn. Soc. 103(2): 160 (1990)

Common name: Uru wee (Singhalese), rhizomatous rice (En).

Geographic distribution range: *Oryza rhizomatis* (Fig. 1) is endemic to Sri Lanka (Vaughan 1990) and it is restricted to the low altitude dry zone of eastern and south-western Sri Lanka (Liyanage et al. 2002). *Oryza rhizomatis* occurs only in six administrative districts: Puttalam, Anuradhapura, Kurunagale, Hambantota, Monaragale and Ampara (Fig. 2).

Distribution: *Countries of occurrence*: Sri Lanka.

Biology: *Plant growth form*: Perennial (hemicryptophyte).

Flowering and fruiting time: The flowering season is from late September to May, with a peak from January to April. Mature panicles have been observed from January to March. However, most of the seeds are dispersed from panicles after March (Liyanage et al. 2002; field observations of authors).

Reproduction: Reproduction occurs by seeds. Seeds of *O. rhizomatis* are capable of dormancy (Timple et al. 2018), but no detailed information on seed germination is available. Underground rhizomes contribute to reproduction through vegetative means.

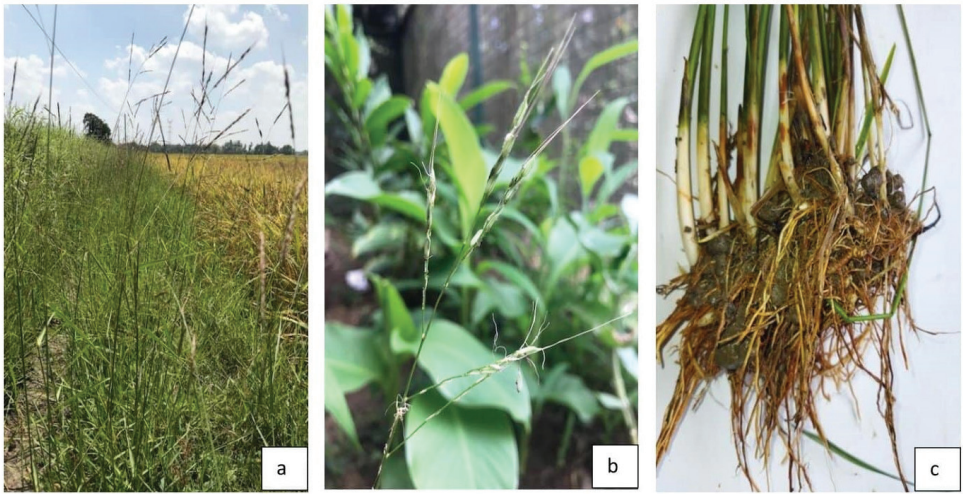

Figure 1. Natural habitat (**a**) panicle (**b**) and rhizome (**c**) of *Oryza rhizomatis* located at Karuwalagaswewa, Sri Lanka (photograph by Thasajini Sajeevan).

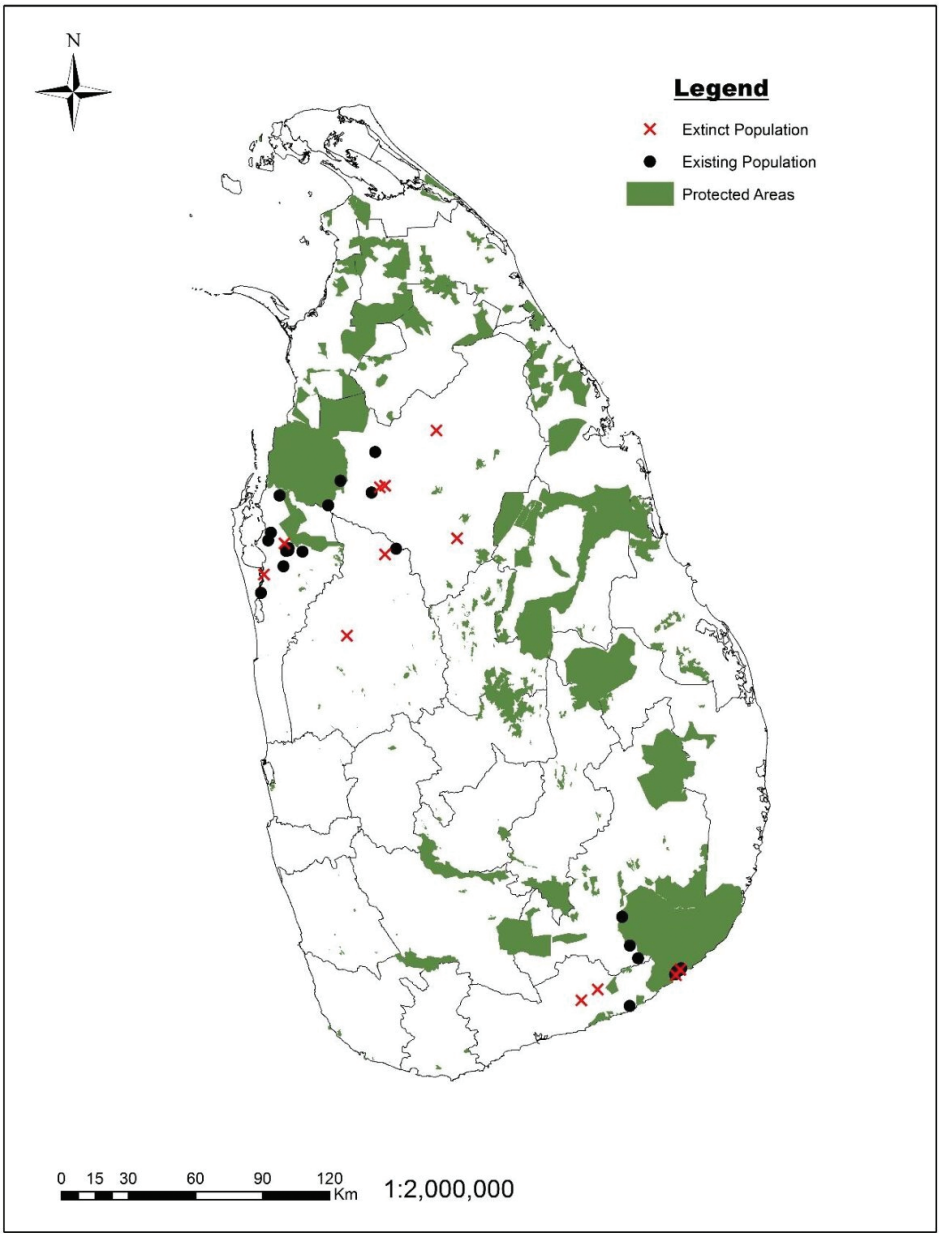

Figure 2. Distribution map of *Oryza rhizomatis* in Sri Lanka showing current (black dot) or extinct (red cross) populations according to recent field surveys.

Habitat and ecology: Field records suggest that *O. rhizomatis* occurs in forests and open, tall scrub with grassy clearings. It occurs in swampy or periodically flooded areas, usually in full sun or partial shade. The dry zone of Sri Lanka where *O. rhizomatis* grows is characterized by an annual rainfall of 850–1900 mm (Vaughan et al. 2003).

Population information: There is no detailed information available on population dynamics. However, field observations show that the habitats of *O. rhizomatis* are becoming degraded due to urbanization and grazing by animals in most localities. Several populations in the districts of Puttalam, Kurunagale, Anuradhapura and Hambantota reported earlier (Liyanage et al. 2002; Ratnayake et al. 2021), could not be found during recent field surveys in 2021 and 2022. This suggests that the number of mature individuals in many populations and, therefore, overall population size may be declining.

Threats: *1.1 Residential and commercial development (Housing and urban areas)*: some populations in the Northwestern province are threatened by urbanization, especially construction of houses and roads.

2.3.1 Livestock farming and ranching (Nomadic grazing): in many sites, populations of *O. rhizomatis* are impacted by grazing of domestic animals, such as cattle and goats. Further, elephant grazing was observed in some populations situated within forests or close to forests.

4.1 Transportation & Service corridors (Roads & Railroads): populations reported in the Northwestern province of Sri Lanka (Liyanage et al. 2002) grow along the roadside. Furthermore, development of roads and roadside cleaning could disturb the natural vegetation.

9.3.3 Agricultural & forestry effluents (Herbicides & Pesticides): three populations in Puttalam district and one locality in Anuradhapura district are near cultivated fields; they could be affected by hazardous herbicides and pesticides, and further expansion of agricultural lands.

10.2 Geological events (Tsunami): The coastal populations in Hambantota district, especially in Kirinda, were affected by widespread destruction around the coastal belts of the country due to the tsunami waves in 2004. A widespread population decline, down to 20 individuals, was caused by this disastrous event.

11.2 Drought: The conservation of *O. rhizomatis* depends on the presence of swampy or periodically flooded areas, therefore drying up of swamps during the wet season due to high temperature and reduced precipitation could affect populations of this species.

CRITERIA APPLIED

Criterion A: There has been a decline in AOO (37%) and EOO (28%) in the last 20 years with destruction and loss of habitat quality. Twelve populations were not confirmed during the field surveys conducted from 2020 to 2022.

(c) A decline in habitat quality, AOO and EOO by 36.66 and 27.75%, respectively was observed.

Criterion B: **EOO:** 14,603 km^2 calculated with GeoCAT (Geospatial Conservation Assessment Tool) software (Bachman et al. 2011).

AOO: 76 km^2 calculated with a 2×2 km cell fixed grid

a) No severe fragmentation and number of locations >10
b) Continuing decline observed in EOO, AOO, extent and quality of habitat, and number of mature individuals.
c) No extreme fluctuations.

Red list category and Criterion

VU	**Vulnerable**	**A2c**

Rationale for the assessment: *Oryza rhizomatis* is endemic to Sri Lanka**.** Recent field surveys have demonstrated that there has been a continuous decrease in population size, which currently continues, a reduction of AOO, and EOO and a loss of suitable habitats. The EOO has declined from 20,213 to 14,603 km^2 (28%). The AOO has decreased from 120 to 76 km^2 (37%) in the last 20 years. Populations are threatened by urban, residential, and industrial developments, roads and agriculture, as well as by grazing domestic and wild animals. The AOO is less than 500 km^2 and it almost qualifies for a threatened listing under criterion B1, no severe fragmentation or extreme fluctuations is observed, and the number of locations is higher than 10. For this reason, this plant is considered as Vulnerable (VU) under criterion A2c at a global level.

Previous assessment: *Oryza rhizomatis* was assessed at global level as Near Threatened (NT) with an urgent need for information on its population trends (Phillips and Yang 2017). According to the national Red List of Sri Lanka (The National Red List 2020) it was categorized as Vulnerable (VU).

Conservation actions: There are 20 *ex situ* accessions stored in the germplasm bank of the International Rice Research Institute and 23 accessions are present in the Plant Genetic Resources Center, Peradeniya, Sri Lanka. The species is present within protected areas of Sri Lanka including the Yala National Park, Luhugala National Park and Wilpattu National Park. The first *in situ* conservation site for wild rice in Vanathavilluwa (Puttalam district) was established under the Northwestern Province Environmental Statute No: 12 of 1990.

Conservation actions needed: Research and monitoring activities are needed to better understand the population trend of this species. Moreover, to implement genetic variability of *ex situ* accessions, new seed collections should be planned.

Notes: *Oryza rhizomatis* is related to other species of the *O. officinalis* Wall. ex Watt complex but differs from it in having a different spikelet and panicle structure. It differs morphologically from *O. eichingeri* Peter (of which it is considered a synonym by some authors, Clayton et al. 2006) and the tetraploid *O. minuta* J.Presl by its larger plant and spikelet size, larger panicle with widely spreading branches, and rhizomes.

Thasajini Sajeevan, Malaka Wijayasinghe, Andrea Mondoni

Saxifraga facchinii W.D.J.Koch

Global assessment
Taxonomy and nomenclature
Order: Saxifragales *Family*: Saxifragaceae

Saxifraga facchinii W.D.J.Koch Flora 25(2): 624 (1842); Syn. Fl. Germ. ed. 2, 445

Common name: Sassifraga di Facchinii (It).

Geographic distribution range: *Saxifraga facchinii* (Fig. 3) is a rare perennial hemicryptophyte that occurs only in the Dolomites (Italy), on several massifs (Catinaccio/Rosengarten, Pale di San Martino, Marmolada, Sella, Sasso Lungo/Langkofel group, Tofane, Conturines, Odle), on calcareous and dolomitic rocks. More than half of the occupied habitat area is in small and isolated patches, thus definitely fulfilling the criteria for considering the species as "severely fragmented" (Fig. 4).

Distribution: *Countries of occurrence*: Italy.

Biology: *Plant growth form*: Perennial (hemicryptophyte).

Flowering time: From late July to September.

Reproduction: The most probable dispersal strategy is barichory (autochory). No information on pollination and seed germination is available.

Figure 3. *Saxifraga facchinii* at Piz Lavarella (Badia, Bozen, Italy), 2850 m a.s.l. (Photograph by Francesco Rota).

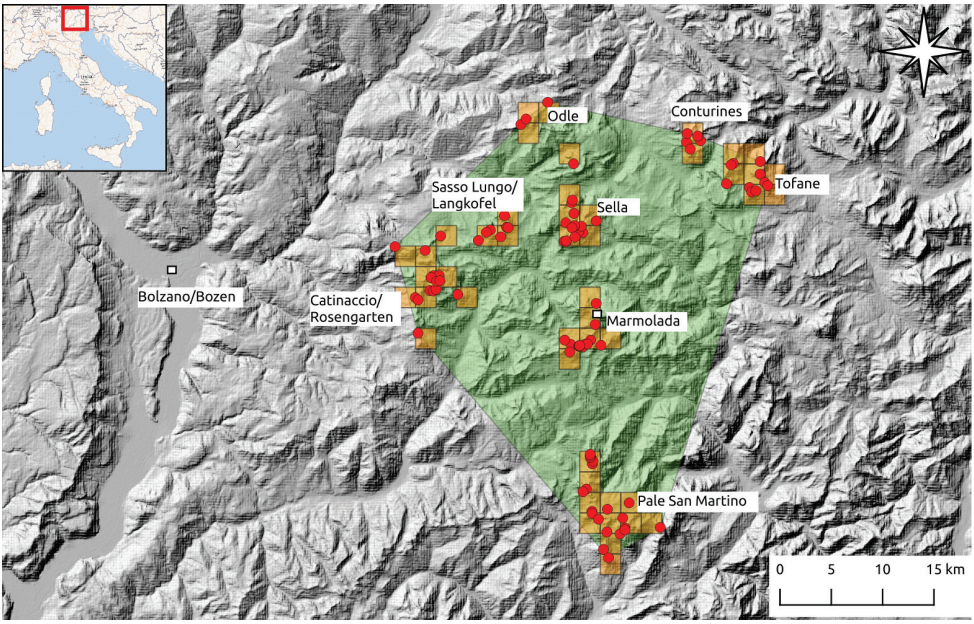

Figure 4. Hillshade map of the Dolomites with the occurrences of *Saxifraga facchinii* showing the EOO (in green), and AOO (in orange) grids (2×2 km) where the species occurs.

Habitat and ecology: *Saxifraga facchinii* grows on carbonate (dolomitic and calcareous) rocks at an elevation of about 2600–3200 m a.s.l., on ridges, crests and rocky habitats. It belongs to high-alpine to nival hemicryptophytic plant communities characterized by the occurrence of some endemic taxa, such as *Draba dolomitica* Buttler.

Population information: There is no detailed information available on population dynamics. Field observations indicate some stable subpopulations (Pale di San Martino/Sella), while all the others show only few scattered individuals. Subpopulations that were recorded at the beginning of the 20th century near the lower elevational limit of the distribution of the species (2500 m) in the Schlern/Sciliar massif (that has a maximum elevation of 2563 m) (see www.florafauna.it), are now missing (personal field observation). They are very likely extinct, since the occurrence areas reported one century ago, have now become arid meadows on calcareous shallow soil with *Sesleria caerulea* (L.) Ard., and the rocky habitats typical of the species have already shrunk, filled by expanding low alpine communities.

Threats: *1.3. Tourism and recreational areas*: some subpopulations could be threatened by projects aimed at developing and connecting skiing areas at high elevations.

5.2.1. Gathering terrestrial plants, intentional use: the plant might be collected by amateurs and rock garden species collectors.

6.1. Recreational activities: some populations have individuals that grow on trails used by hikers and climbers and are, therefore, threatened by human trampling.

11.1. Habitat shifting & alteration: the plant is potentially threatened by natural habitat evolution (growth of grass and shrubs on partially stabilized debris); this process is particularly evident at the lower climatic boundary of the species around 2600 m.

CRITERIA APPLIED

Criterion B: **EOO**: 978 km^2 calculated with QGIS 3.0 software with minimum convex hull

AOO: 196 km^2 calculated with a 2×2 km cell fixed grid

a) Severely fragmented.
b) Continuing decline projected in: (iii) area extent and quality of habitat (Rota et al. 2022), (iv) number of subpopulations or location.

Red List category and Criteria (Global Assessment)

EN	**Endangered**	**B1ab(iii,iv)+B2ab(iii,iv)**

Rationale for the assessment: *Saxifraga facchinii* is a rare plant endemic to the highest peaks of the Dolomites currently occurring only in the Pale di San Martino, Marmolada, Catinaccio/Rosengarten, Sella, Sasso Lungo/Langkoffel, Tofane, Conturines and Odle groups; some populations consist of a relatively higher number of mature plants (Pale di San Martino, Sella), while the northern edge populations are very rare, scattered and with few individuals only (personal observation). *Saxifraga facchinii* could be affected in the near future by the effects of the ongoing climate change with a habitat loss, projected to 2070, in the rcp 4.5 scenario of an average – 75.52% (± 19.86) and in the rcp 8.5 scenario of an average – 87.59% (± 20.06) (Rota et al. 2022). Taking together the previous assessments and the newly gathered data by Rota et al. (2022), this species is upgraded to Endangered (EN) at a global level.

Previous assessment: The taxon was evaluated as NT at the global level in the Red List of Endemic Plants of Italy (Rossi et al. 2020). At a regional level, it was evaluated as EN for the Veneto administrative region (Buffa et al. 2016), VU for the Autonomous Province of Bozen/Bolzano (Wilhalm and Hilpold 2006) and NT for the Autonomous Province of Trento (Prosser et al. 2019).

Conservation actions: *Saxifraga facchinii* is not protected either by international, national or regional laws. At present, there are no conservation measures for this species. Many populations grow in protected areas, within the Natural Parks of Paneveggio-Pale di San Martino Natural Park, Puez Odle, Sciliar-Catinaccio, Fanes Sennes Braies, and Dolomiti d'Ampezzo, while others grow in areas with high rates of human disturbance due to alpine tourism (Sella and Marmolada).

Conservation actions needed: Research activities and a monitoring program are recommended in order to better understand the reproductive biology of the species and the population trend. Moreover, *in situ* and *ex situ* conservation actions should be designed for possible population reinforcement plans and assisted colonizations, aimed at increasing the probability of survival under climate change.

A specific monitoring program would be important to prevent and evaluate the possible future threats (e.g., increasing temperature, increasing human activities such

as expansion of ski resorts at high elevations, or stochastic events), which could change the current conservation status of this plant.

Notes: The present assessment is based on the PhD thesis of F. Rota, funded by the Free-University of Bozen-Bolzano. The idea originated at the COST Action 18201 "Conserve Plants" during the training school on IUCN Red List assessment held in Podgorica (MNE) in spring 2022. We thank Gabriele Casazza (Università di Genova), Michele Da Pozzo (Parco Naturale delle Dolomiti d'Ampezzo), Thomas Wilhalm (Museo di Scienze Naturali dell'Alto Adige), Malin Rivers (Botanic Gardens Conservation International and IUCN/SSC Global Tree Specialist Group) and several participants of the COST training school for their contribution to the discussion on this assessment.

Francesco Rota, Juri Nascimbene, Camilla Wellstein

Helianthemum caput-felis Boiss.

Regional assessment (Italy)
Taxonomy and nomenclature
Order: Malvales *Family*: Cistaceae

Helianthemum caput-felis Boiss. Elench. Pl. Nov.: 16 (1838).

Common name: Rock rose (En), Eliantemo a testa di micio (It), Jarilla de cabeza de gato (Es).

Geographic distribution range: *Helianthemum caput-felis* (Fig. 5), which ranges in height from 35 to 50 cm, is a thermophilous long-lived shrub distributed in several disjunct and fragmented populations throughout the coasts of the western Mediterranean Basin (SE Iberian Peninsula, Balearic Islands, Sardinia, and NW Africa; Sulis et al. 2020). In Sardinia, two main populations are present, but isolated or scattered groups of plants are also present outside these populations, all located in the Sinis Peninsula (Fig. 6).

Distribution: *Countries of occurrence*: Algeria, Italy (Sardinia), Morocco, Spain.

Biology: *Plant growth form*: Half shrub (chamaephyte).

Flowering and fruiting time: The phenological period varies according to the locality; in Sardinia, the flowering period is from March to June, and the fruiting season runs from late April to the beginning of August (Fenu et al. 2015; Sulis et al. 2017). Flowers of *H. caput-felis* are hermaphrodite and have a short lifespan (3–4 days; Rodríguez-Pérez 2005).

Reproduction: It is an entomophilous, mostly self-incompatible, plant species; fruits are capsules that detach at maturation, and seed germination takes place in autumn, at the onset of the rainy season (Rodríguez-Pérez 2005). Seeds exhibit a high germination rate after scarification (Rodríguez-Pérez 2005; Sulis et al. 2017).

Habitat and ecology: *Helianthemum caput-felis* is a thermophilous long-lived half shrub with a growth preference for coastal areas under the direct influence of the sea,

Figure 5. *Helianthemum caput-felis* Boiss. at Capo Mannu (San Vero Milis, Oristano, Sardinia, Italy). (Photograph by Giulia Calderisi).

mostly on calcareous rocky cliffs (0–200 m a.s.l.) with garrigues or scrublands; some populations grow sand dunes in Majorca, fossil dunes in Morocco and rocky slopes bordering inland ravines and, rarely, in open wooded areas (Fenu et al. 2015; Sulis et

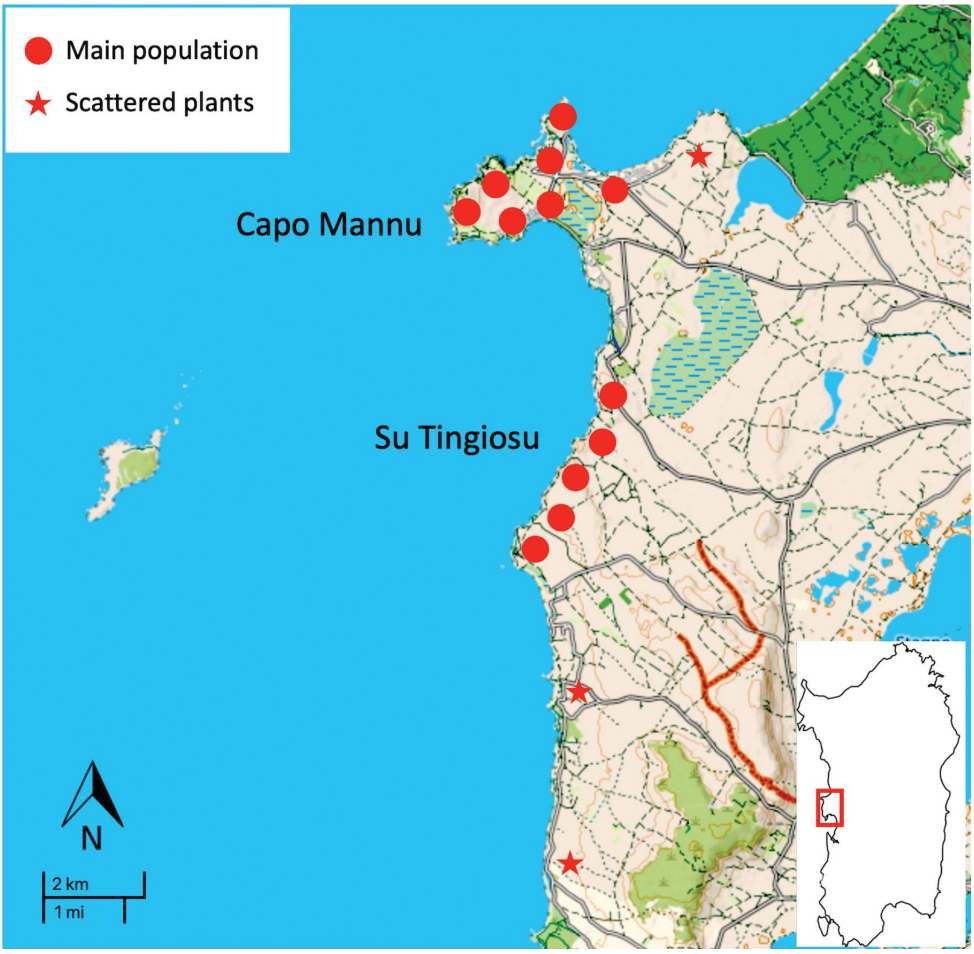

Figure 6. Geographic range and distribution map of *Helianthemum caput-felis* Boiss. in Sardinia (Italy).

al. 2020). In Sardinia, *H. caput-felis* grows on limestone or arenaceous substrates and, sometimes, sandy soils, at altitudes up to 55 m a.s.l.; sporadically, it can be found on evolved soils, in the clearings of the juniper scrublands. The species participates in and characterizes plant communities rich in endemics (*Limonium lausianum* Pignatti, *Polygala sinisica* Arrigoni) and other species of phytogeographic interest (*Viola arborescens* L., *Coris monspeliensis* L., *Erica multiflora* L.).

Population information: Numerous populations, representative of the range of the species, present in Spain and Sardinia are included in a recent study of population dynamics covering a four-year period (Sulis et al. 2018, 2021); the results of this short-term dynamic study indicate that the global *H. caput-felis* population was at equilibrium, although this result seems to disagree with the threats and the human disturbance observed in the field (Sulis et al. 2018). Sardinian populations are those that have greater equilibrium ($\lambda > 1$), probably due to the stable structure of the populations, which are mainly composed of large individuals (Sulis et al. 2021); specifically,

the population of Capo Mannu is in demographic growth, while that of Su Tingiosu is stable (Sulis et al. 2021). The monitoring activities show no signs of continuous decline, if some stochastic events (landslides) that have affected the Su Tingiosu population, and caused a reduction in the number of individuals, are excluded.

Threats: *6.1 Recreational activities*: the growing tourist development of the coasts and of the Capo Mannu area in particular, with the consequent modification of the territory, was considered the main threat to the species; in fact, in these territories there has been an increase in recreational activities, in particular hiking and extreme off-road competitions, which have caused a loss of individuals and a fragmentation of the habitat with the opening of new paths within the population (Fenu et al. 2015). However, the periodic monitoring activities do not detect a continuous decline in the populations.

2.2 Wood & pulp plantations and 2.3 Livestock farming & ranching: in the past, the areas of occurrence of the populations were regularly used for non-indigenous crops and grazing (mainly sheep in Su Tingiosu) and subjected to reforestation (Capo Mannu).

8 Invasive & other problematic species, genes & diseases: if not adequately controlled, the presence of numerous alien species, widely used in tourist villages and in some cultivations, could constitute a potential threat to the species.

10.3 Avalanches/landslides: stochastic events, such as the natural evolution of the rocky cliffs affected in recent decades by landslides and collapses, especially in the Su Tingiosu population, have led to the loss of individuals.

CRITERIA APPLIED

Criterion B: **EOO:** 16 km^2
AOO: 16 km^2 calculated with a 2×2 km cell fixed grid

a) The Sardinian populations are not fragmented.
b) No continuous decline observed in extent of occurrence, area of occupancy, extent and quality of habitat, number of locations and subpopulations, and number of mature individuals.

Red List category and Criteria (Regional Assessment)

NT	**Near Threatened**	

Rationale for the assessment: At a global level *Helianthemum caput-felis* has been categorized as EN under criterion E (Sulis et al. 2020). In Sardinia, although this plant is subjected to some natural and human-related factors, their populations are in expansion and a continuous decline has not been observed. Our results of the population dynamics study support the downgrading of the risk category previously assigned at the regional level. However, considering that the abovementioned threats, especially those related to the natural evolution of the cliffs, could increase in the near future,

and adopting a precautionary approach suggested by the IUCN guidelines, this species could be assessed as NT at the regional level, on the understanding that if the predicted threats affect populations, it would qualify to be classified as EN due to the low AOO, combined with declining habitat surface and number of mature individuals.

Previous assessment: The taxon is evaluated EN at the global level (Sulis et al. 2020). At a regional level, *H. caput-felis* was recorded as EN in Europe (Bilz et al. 2011) and Spain (Agulló et al. 2011), and Critically Endangered in Algeria (Agulló et al. 2017) and Italy (Fenu et al. 2012).

Conservation actions: *Helianthemum caput-felis* is included in Annex I of the Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats 1979, updated in 2002), and, at the European level, in Annex II of the Habitats Directive (92/43/EEC). All Sardinian populations are included in protected areas, such as Natura 2000 sites (ITB030038 – Stagno di Putzu Idu, Salina Manna e Pauli Marigosa and ITB030080 – Isola di Mal di Ventre e Catalano), the MPA "Penisola del Sinis – Isola di Mal di Ventre and the Regional Park of Montiferru-Sinis Peninsula (L.R. 31/89). The Sardinian populations are being monitored since more than 20 years. Seeds of this species are stored *ex situ* in various European germplasm banks.

Conservation actions needed: Continuous monitoring is required of all populations, which is essential for assessing the conservation status and identifying effective local conservation measures when necessary.

Note: *Helianthemum caput-felis* has been subjected to translocation actions in different parts of its distribution range with positive results (Fenu et al. 2023), therefore this *in situ* conservation action could be widely exploited in the case of local extirpations or to reinforce small existing populations.

Giulia Calderisi, Donatella Cogoni, Giuseppe Fenu

References

Agulló JC, Juan A, Alonso MÁ, Crespo MB (2011) *Helianthemum caput-felis* Boiss. In: Bañares Á, Blanca G, Güemes J, Moreno JC, Ortiz S (Eds) Atlas y Libro Rojo de La Flora Vascular Amenazada de España. Addenda 2010. Dirección General de Medio Natural y Política Forestal (Ministerio de Medio Ambiente, y Medio Rural y Marino) – Sociedad Española de Biología de la Conservación de Plantas, Madrid, 76–77.

Agulló JC, Juan A, Crespo MB, Alonso MÁ, Terrones A (2017) An updated report on the distribution and conservation status of the endangered Cat's Head Rockrose *Helianthemum caput-felis* (Magnoliopsida: Violales: Cistaceae) in Algeria. Journal of Threatened Taxa 9: 9885–9891. https://doi.org/10.11609/jott.2592.9.3.9885-9891

Bachman S, Moat J, Hill AW, Torre J de la, Scott B (2011) Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. In: Smith V, Penev L (Eds) E-Infrastructures for data publishing in biodiversity science. ZooKeys 150: 117–126. https://doi.org/10.3897/zookeys.150.2109

Bilz M, Kell SP, Maxted N, Lansdown RV (2011) European Red List of Vascular Plants. Publications Office of the European Union, Luxembourg, Luxembourg.

Buffa G, Carpenè B, Casarotto N, Da Pozzo M, Filesi L, Lasen C, Marcucci R, Masin R, Prosser F, Tasinazzo S, Villani M, Zanatta K (2016) Lista rossa regionale piante vascolari del Veneto. Regione Veneto.

Clayton WD, Harman KT, Williamson H (2006) World Grass Species – Synonymy database The Board of Trustees of the Royal Botanic Gardens, Kew. http://www.kew.org/data/grasses-db.html

Fenu G, Sulis E, Cogoni D, Bacchetta G (2012) Schede per una Lista Rossa della Flora vascolare e crittogamica Italiana: *Helianthemum caput-felis* Boiss. Informatore Botanico Italiano 44(1): 233–236.

Fenu G, Cogoni D, Sulis E, Bacchetta G (2015) Ecological response to human trampling and conservation status of *Helianthemum caput-felis* (Cistaceae) at the eastern periphery of its range. Acta Botanica Gallica 162(3): 191–201. https://doi.org/10.1080/12538078.2015.1060898

Fenu G, Calderisi G, Boršić I, Bou Dagher Kharrat M, García Fernández A, Kahale R, Panitsa M, Cogoni D (2023) Translocations of threatened plants in the Mediterranean Basin: current status and future directions. Plant Ecology, in press. https://doi.org/10.1007/s11258-023-01303-7

Liyanage ASU, Hemachandra PV, Edirisinghe DK, Senevirathna SK (2002) Surveying and mapping of wild rice species of *Oryza* in Sri Lanka. Japanese Journal of Tropical Agriculture (Japan) 14–22. https://doi.org/10.11248/jsta1957.46.14

Phillips J, Yang L (2017) *Oryza rhizomatis*. The IUCN Red List of Threatened Species 2017: e.T112680830A113899786.

Prosser F, Bertolli A, Festi F, Perazza G (2019) Flora del Trentino. Fondazione Museo civico di Rovereto.

Ratnayake SS, Kariyawasam CS, Kumar L, Hunter D, Liyanage ASU (2021) Potential distribution of crop wild relatives under climate change in Sri Lanka: implications for conservation of agricultural biodiversity. Current Research in Environmental Sustainability 3: 100092. https://doi.org/10.1016/j.crsust.2021.100092

Rodríguez-Pérez J (2005) Breeding system, flower visitors and seedling survival of two endangered species of *Helianthemum* (Cistaceae). Annals of Botany 95: 1229–1236. https://doi.org/10.1093/aob/mci137

Rossi G, Orsenigo S, Gargano D, Montagnani C, Peruzzi L, Fenu G, Abeli T, Alessandrini A, Astuti G, Bacchetta G, Bartolucci F, Bernardo L, Bovio M, Brullo S, Carta A, Castello M, Cogoni D, Conti F, Domina G, Foggi B, Gennai M, Gigante D, Iberite M, Lasen C, Magrini S, Nicolella G, Pinna MS, Poggio L, Prosser F, Santangelo A, Selvaggi A, Stinca A, Tartaglini N, Troia A, Villani MC, Wagensommer RP, Wilhalm T, Blasi C (2020) Lista Rossa della Flora Italiana. 2 Endemiti e altre specie minacciate. Ministero dell'Ambiente e della Tutela del Territorio e del Mare.

Rota F, Casazza G, Genova G, Midolo G, Prosser F, Bertolli A, Wilhalm T, Nascimbene J, Wellstein C (2022) Topography of the Dolomites modulates range dynamics of narrow endemic plants under climate change. Scientific Reports 12: 1398. https://doi.org/10.1038/s41598-022-05440-3

Sulis E, Bacchetta G, Cogoni D, Fenu G (2017) Reproductive performance of *Helianthemum caput-felis* along its fragmented distribution in the Mediterranean coasts. Flora 234: 24–33. https://doi.org/10.1016/j.flora.2017.06.013

Sulis E, Bacchetta G, Cogoni D, Fenu G (2018) Short-term population dynamics of *Helianthemum caput-felis*, a perennial Mediterranean coastal plant: a key element for an effective conservation program. Systematics and Biodiversity 16: 774–783. https://doi.org/10.1080/14772000.2018.1492469

Sulis E, Bacchetta G, Cogoni D, Gargano D, Fenu G (2020) Assessing the global conservation status of the rock rose *Helianthemum caput-felis*. Oryx 54: 197–205. https://doi.org/10.1017/S0030605318001424

Sulis E, Bacchetta G, Cogoni D, Fenu G (2021) From global to local scale: where is the best for conservation purpose? Biodiversity and Conservation 30: 183–200. https://doi.org/10.1007/s10531-020-02085-4

The National Red list (2020) Conservation Status of the flora of Sri Lanka. Sri Lanka: Biodiversity Secretariat, Ministry of Environment and the National Herbarium, Department of Botanic Gardens, 254.

Timple SE, Hay FR, Mercado MFO, Borromeo TH, Cruz PC (2018) Response of intact seeds of wild rice (*Oryza*) species to dry heat treatment and dormancy-breaking chemicals. Seed Science and Technology 46: 157–173. https://doi.org/10.15258/sst.2018.46.1.16

Vaughan DA (1990) A new rhizomatous *Oryza* species (Poaceae) from Sri Lanka. Botanical Journal of the Linnean Society 103: 159–163. https://doi.org/10.1111/j.1095-8339.1990.tb00182.x

Vaughan DA, Morishimay H, Kadowaki K (2003) Diversity in the *Oryza* genus. Current Opinion in Plant Biology 6: 139–146. https://doi.org/10.1016/S1369-5266(03)00009-8

Wilhalm T, Hilpold A (2006) Rote Liste der gefährdeten Gefäßpflanzen Südtirols. Naturmuseum Südtirols, Bozen.