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SHORT COMMUNICATION

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The spiral of plants and soil in the cycle of life

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Abstract

This is not an article, but rather an account of a meeting that took place between two naturalists who had not seen each other for a few years and who freely exchanged their doubts and matured lines of thought. It is a provocative dialogue between the author of this article and Sandro Pignatti on natural evolution, considering the soil as a living matrix in which recycling of organic matter (including DNA) takes place. We can also interpret it as an attempt to merge the points of view of vegetation and soil ecologists, in order to revive the discussion on natural evolution. We think we understand it, but we don't. We discussed the following topics: 1) the relationship between phytosociology and plant ecology; 2) the soil as an individual or as an ecosystem's digestive machinery; 3) the hypothesis of a complemental geological (long-term) flow of DNA fragments in relation to the recycling process that takes place in the soil. Past and recent research in the fields of biology and evolution highlights a functional and primordial collaboration between living beings in the exploitation of natural resources. In this process that ultimately is life, soil plays a crucial role because it is cyclically and progressively renewed and enriches the sources of structural building blocks. The purpose of this story is to encourage us to reflect on the meaning of life, considering the functional contribution of death, which we perhaps mistakenly call "biodegradation".

Keywords

biodegradation, biodiversity, Castelporziano, DNA, natural evolution, humus, soil

He found me kneeling in front of a soil profile, 'How are you Zanella? What are you looking for… in a hole?'

I turned to see a jovial man; his eyes bright in the shadow of the visor of an American cap. December 6, 2010 was a sunny day in the Presidential Estate of Castelporziano (Rome).

'Sandro Pignatti', he then pronounced, noticing the uncertainty in my gaze.

Beige waterproof jacket, a little shorter than Lieutenant Colombo's, suede boots, and blue cotton trousers with creases along the legs. I felt a surge of innate sympathy for him: my mother had never been able to understand that to iron blue jeans was not necessary.

Standing up and shaking his hand I said 'We met in 1991, at the Phytosociological Congress organized by Jean-Marie Géhu on forest dynamics, in Bailleul, France (Géhu 1993), do you remember?' Then, pointing to the soil profile I said: 'In the succession of horizons, this soil profile is a disaster'.

He nodded.

I was holding two soil samples (Fig. 1), an organic aggregate called the zoOH horizon (litter transformed into humus by soil animals; zo = zoogenic), and a glomerular handful of organo-mineral soil called the meA horizon (zoogenic organo-mineral aggregates; me = presence of meso-aggregates (1 < diameter ≤ 4 mm). 'Usually, these horizons are one on top of each other, but wild boars, using their nose like a plow, messed everything up; we will have to invent something to classify these strange cases...'.

He smiled as he touched the two samples, and added: 'It is always like this. You arrive on the field with clear ideas; then you observe the reality that surrounds you, and you are in the mist. Even worse, but challenging, when it starts to thin out,

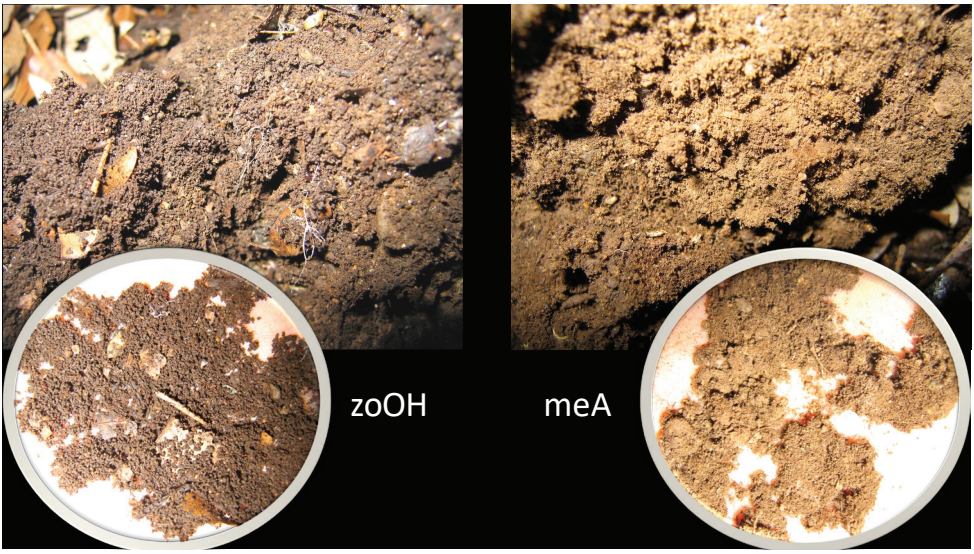

Figure 1. Left: zoOH, zo = zoogenic organic horizon, mainly originating from arthropods. This horizon is located at the soil surface below the more or less decomposed litter horizons and above a more mineral A horizon. Right: meA = organo-mineral A horizon originating from earthworms, whose feces are colonized by arthropods from the overlying horizon zoOH. "me" means horizon which has several stable aggregates with a diameter between 1 and 4 mm (made by earthworms). This meA horizon is typical of calcareous Mediterranean and sub-Mediterranean environments where arthropods and earthworms are called to coexist. The set of superficial horizons forms a humipedon called "Amphi" (Zanella et al. 2022), which means double, due to its double origin from arthropods and earthworms.

the road forks and you don't know which way is the right one. Did you sleep well in the villa?'.

'Not so well. There was a buxom lady in the room, who seemed to stare at me insistently. I pretended to turn off the light to sleep, and then immediately turned it on again to try to catch her moving… Nothing, still fixed on the painting, sly like a still too much alive Gioconda ghost. I also saw stars after bumping my bare foot against a heavy vase protruding from under the bed'.

'You were lucky! They gave you the royal room and you certainly kicked Vittorio Emanuele the Second's ceramic chamber pot', he said, accompanying this with a smile of cordial compassion… 'Let's go and see a forest area where the distribution of vegetation strictly depends on the characteristics of the soil; I want your opinion, follow me'.

We crossed a holm oak forest dotted with circular pools filled with shallow stagnant water, while carrying on an animated discussion about natural evolution. We started from the following empirical personal observations:

1) Mapping the phytosociological units of a plant landscape without using many unclassifiable gray areas is almost impossible. To draw the boundaries between phytosociological units in the field, characteristic plant species are used. However, by definition, these species have a narrow ecological range and are often absent along a line of demarcation between two units.

2) Due to the direct or indirect action of man, recent evolution has not been natural for at least a century. Theoretically, ecosystems should continue to evolve as if living beings and the environment forced these "volumes of nature" [trying to circumscribe Tansley's ecosystem concept (Tansley 1935)] to grow continuously into the future… In the final analysis, to realize this is "to live". For Tansley and many of us after him, the "indivisibility" of the ecosystem is of fundamental importance, although organisms may claim our primary interest. When we try to understand the essence of ecological functioning, we cannot separate living beings from each other, nor each living being from its own environment. If the future biological complexity and evolution remain unknown to us, we can nevertheless foresee them and confine them temporarily over a few decades.

3) Even if partially contradicting what we have just said about the cohesion of an ecosystem and considering plants separately (just as a thought), even if poorly defined on the territory, phytosociological units should exist. Evolving and changing, but composed of plants that "talk" to each other and co-evolve thanks to a common language. We can imagine this set of plants as located in a kind of black hole, influenced by ecological attractors (Mayr 1942) which change, because themselves dependent on the rest, in the space-time of a whirlwind of light, moving and indeterminate.

'I'm not a phytosociologist', he said, 'only an expert in vegetation ecology'.

'Even Lucio Susmel', I continued, 'wrote a well-documented essay against phytosociology (Susmel 1959). In the field, however, we are forced to imitate phytosociologists to recognize units within a landscape, using the colors and structure of the vegetation

as discriminating elements. In "I Boschi d'Italia" (Bartoli et al. 1998) you wrote that one must select those plant units that occupy an area "delimited by ecological factors". This principle was firmly emphasized by Jean-Marie Géhu, the spiritual heir of Josias Braun-Blanquet. On one hand, Jean-Marie feared the destruction of phytosociological classification by an excessive fragmentation of its branches; on the other, he was very fond of upward complexification, and developed the notion of functional unit of the landscape, very useful in cartographic operations (Bioret et al. 2021). We can't deny that vegetational units may be organized both in an ascending and descending way, while always exhibiting blurred outlines.

'I know', he went on, 'with Jean-Marie we discussed this aspect several times: when we (humans) do not understand a process, or when we face a new object, it is easier to coin a new word than to connect such a novelty to previous knowledge…'.

A few steps of silent reflection, and then '…when I could, I also took my family with me on excursions', he said this as if he were talking to himself, in a slightly lower tone of voice and closing his eyes with a sigh... 'However', with more impetus, 'I am absolutely convinced that plants communicate with each other, and also with animals. Simply to survive'.

'I learned that everything dies and ends up becoming humus', I added, 'cyclically. Pedofauna and microorganisms transform all this necromass into building blocks that can be used by new generations of living beings. We have two kinds of soil: a well-known one under plants, and a less visible one in the bellies of animals (even in our human belly), because animals also need to digest the collected food. I don't know to what extent DNA (along with everything else) is disassembled in a decomposition process that takes place in the soil under plants or inside animals, but...'.

'Interesting this double soil concept', he underlined. 'I have always thought that small pieces of DNA could reach new generations of living beings indirectly, outside of the reproductive pathway that we know. DNA exists outside cells, in the environment or stored in organic matter, like the words of a vocabulary of several successive generations; potentially, such a process could explain the observed co-evolution (Lovelock and Margulis 1974; Khakhina 1992; Sapp 1994), the non-coding DNA, and DNA that belongs to organisms other than the one that houses it (Ang 2021)'.

'How exciting!', I thought to myself. 'Not the sexually transmitted DNA, but also the one of a co-inhabiting community of living organisms, the whole ecosystem interacting with DNA, even the one flowing through the soil, in digestive and confined processes of death and recycling - at the ecosystem and individual scale (are the ones we call "mitosis" or "meiosis" original, miniature recycling processes?), a DNA that evolves and combines with the one sexually transmitted, and branches out within the limits imposed by the environment (and today more than ever by man), fluid, dynamic and unpredictable (Fig. 2)'.

Silence, and the rustle of boots in the forest litter.

'It is scientifically unusual to associate biodegradation and reproduction - I continued with less certainty in my words. However, when gametes fuse in a single $2n$ cell, they partially die. The question is: can reproduction be the result of a process of cell death? For example, a cell which swallows another, and which thus forms a new cell with $2n$ chromosomes. Afterwards, a $2n$ cell can give gametes, since functioning with n

chromosomes is already in its power. Decomposition and reproduction could then be linked, which, let's face it, is a bit like the process of death in the soil, which is necessary to provide the building materials for new life. Imagine a soil that perpetuates itself at a lower scale in what we call cellular metabolism and reproduction. When Miller and Urey (1959) tried to understand where life came from, they started from a soup that could also be interpreted as a primordial soil, or even a primordial cell'.

He stopped abruptly, turned to me and said: 'Yes, there is a thread that connects all living beings, and that still eludes us. A transmitted language that is made up of fragments of DNA. When the beaks of Darwin's finches come to mind, we don't give due importance to the joint evolution of plant seeds and insectivorous animals. But Darwin was so sure of the results of his observations that he put them in the title of his book: On the Origin of Species by Means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life. In a formula, Natural Selection = Favoured races + Struggle of life. And just think that he found it without knowing anything about DNA'.

I added: 'Let's say that species evolve with a finality acquired on a higher scale, which is that of the ecosystem that contains them, and within a hierarchy of systems contained one in the other, from the cell to the universe. Of course, this "finality" remains in the future: when you get there, it changes. **It is not the species that evolve, but the ecosystems that contain them, with them**. Species alone don't go anywhere; they must co-exist, die and be recycled (Figure 2)'.

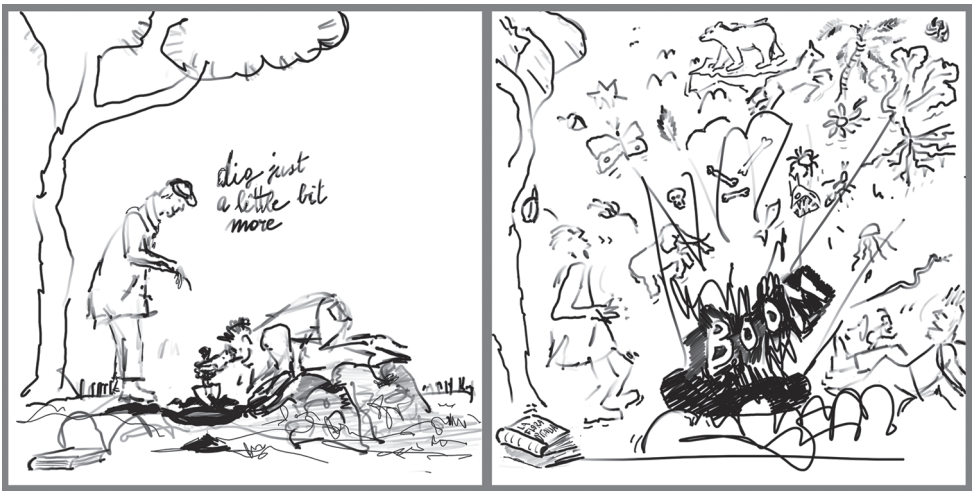

Figure 2. Evolution takes place in a kind of soil. Life and death belong to this same cyclical process which we call evolution; the first (production of new functional structures) needs the second (decomposition of old machinery, to recycle dead branches no longer adapted to the new present time and environment). The two phases must be able to occur at different scales, cyclically and continuously. At the beginning the building blocks were small systems (lumps of particles, then quarks); more recently the units of such material structures became complex, labile and malleable; this made them easier to use in "cells" of even more complex new systems. New systems grew to higher-scale and cyclically collapsed (major mass crises). All this still happens today. On Planet Earth, this process is more visible in the soil (or in soil-like processes), where life and death pass the baton.

Silently, we started walking through the woods again. Thinking.

There are published works demonstrating the action of parts of DNA in the soil, with important repercussions on biological evolution (Mazzoleni et al. 2015; Kooch et al. 2022; Zheng et al. 2022). Soil microorganisms of natural environments may have a lower biodiversity index, and be biologically and physiologically more connected to each other than those found in equivalent more anthropized environments (Mo et al. 2022, 2023). In a recent article, Klaes et al. (2023) show an organo-mineral aggregate of the A horizon of an Andosol magnified to the micrometric scale and explain its functioning with graphs that speak for themselves: the flows of minerals and organic matter are interdependent and connected to the biological activity which varies with the rainy periods. Each aggregate is a miniature soil. Presented in preprint (Martins et al. 2023), the microbial biodiversity outside and inside the soil would be functionally connected; nitrogen fertilization significantly reduced soil bacterial diversity (–2.3%), and this effect was more significant in cropland than grassland and forest (Wang et al. 2023). Polyspecific meadows make better use of environmental resources than monospecific ones (Moeneclaey et al. 2022). An exogenous species can generate a new ecosystem (Gentili et al. 2022). The process can also be purposely designed to build up what needs to be destroyed, leaving behind only what is needed to continue in the right direction (Ameisen 1999). Like other species, *Homo sapiens* may be just a link in the chain.

Living beings are organized into functional groups, they are not randomly aggregated, but each of them must serve as a cog in a clock system (Ette et al. 2023; Fan et al. 2023; Liu et al. 2023; Lopezosa et al. 2023; Martins et al. 2023; Zhang et al. 2023; Zhu et al. 2023). Thus, they constitute members of a functionally biodiverse species, which interact and together "give transformed resources to others in order to also receive modified resources from others". Bringing different species together without them being functionally connected increases biodiversity and automatically generates a new system. This, however, if allowed to evolve, tends to return to a status with functionally connected biodiversity. When we destroy a natural ecosystem, we eliminate with it this historical set of biological, physical-chemical interdependences that is unknown and for this reason difficult to reconstruct. These aspects certainly recall the very important pioneering works of Lovelock and Margulis (1974), Lovelock (1990), Margulis (1998).

Three attempts to graphically summarize all these thoughts, also with the help of Artificial Intelligence, are shown in Fig. 3.

We arrived at the site of the Castelporziano estate where the forest changed from ash wood with laurel (*Laurus nobilis* L.) on fresh soil, to oak wood with Turkey (*Quercus cerris* L.) and Frainetto (*Quercus frainetto* Ten.) oaks on drier and filtering soil. The passage materialized along a band that meandered between the two types of forest. We dug holes: the ash wood grew on a Mull (without OH horizon) resting on an impermeable clay layer (Bt horizon), while in the oak wood we found

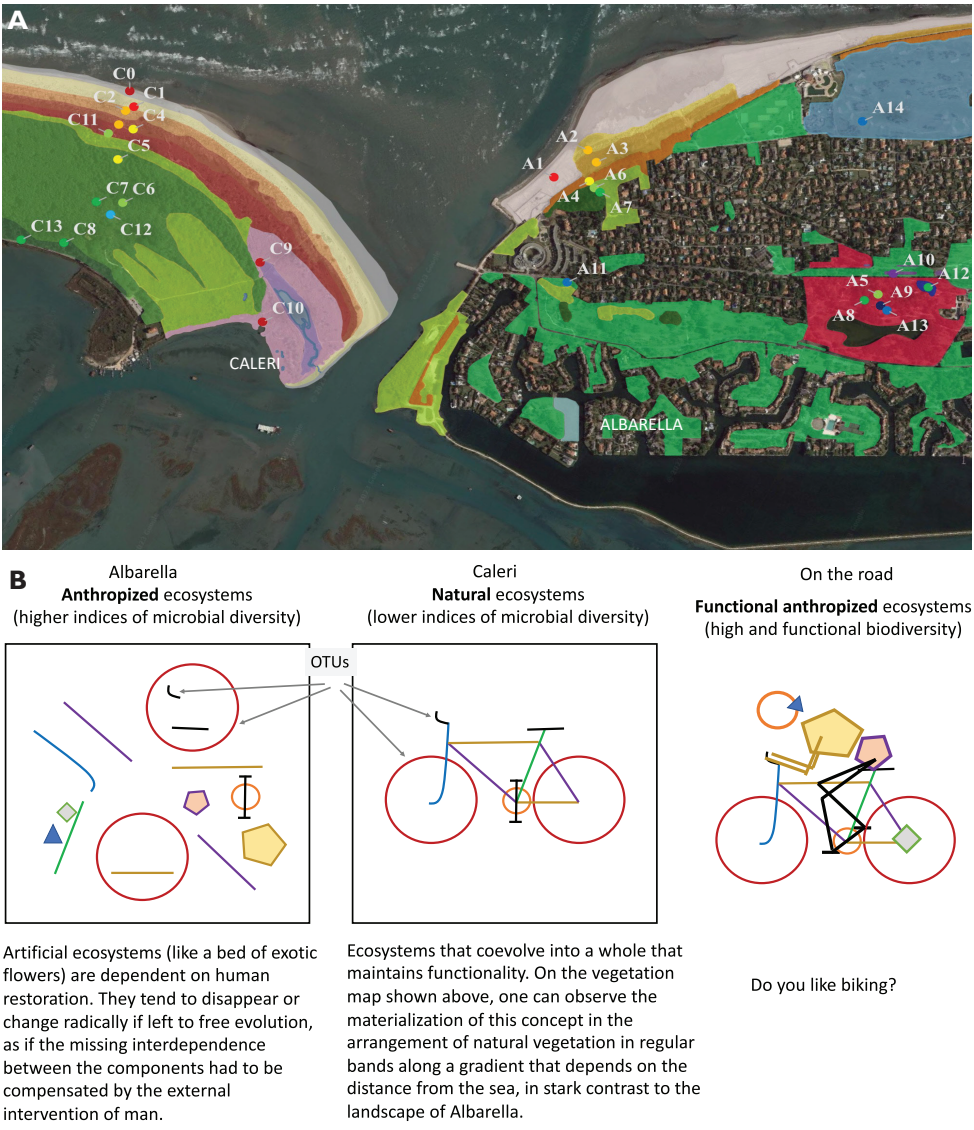

Figure 3. Scrutinizing evolution **A** comparison of vegetation maps; on the left the vegetation bands of the protected coastal area of Porto Caleri; on the right the relict or transformed patches of the same vegetation in the inhabited area of Albarella. The codes on the maps correspond to survey points. When vegetation grows freely, it is arranged along natural gradients which indicate the dependence of living organisms on the environment in which they grow **B** high biodiversity is not synonymous with high functionality. In Porto Caleri, a natural area, there were fewer taxonomic units among soil microorganisms than in the equivalent neighbouring anthropized ecosystem of Albarella. When humans change the environment decisively, they trigger a new evolutionary dynamic. The problem is that we don't know where this new dynamic will lead (with a thought to the ongoing global warming).

Figure 3. Continued. **C** The two figures are produced in a few seconds by an online A.I. software (https://www.bing.com/images/create), using as prompt the words written under the pictures.

an Amphi (with OH horizon above an A horizon), in contact with a sandy and filtering horizon (BC). The ecosystem changed altogether, in just a few meters.

While we were eating a sandwich at the end of the excursion, I also asked him 'How did you manage to put together the Flora of Italy (Pignatti et al. 2017b, 2017a, 2018, 2019)?'.

'My house was full of lists of plants', he answered frankly. 'In small notebooks scattered on the bedside table, along the stairs, on each bookshelf, everywhere. Census years. And a network of passionate and hard-working collaborators. Indeed, it amused me, it has been my life. I can't tell you what a struggle it was to put everything in order. A monstrous effort, and we're not done yet'.

Smiling, like a hero.

Author Contributions

The author only added references to the dialogue he remembers, to simulate the style of a scientific communication.

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RESEARCH ARTICLE

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Notulae to the Italian native vascular flora: 17

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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 for taxa in the genera *Anacyclus*, *Anthyllis*, *Bolboschoenus*, *Catapodium*, *Festuca*, *Hordeum*, *Lavandula*, *Ophrys*, *Pseudopodospermum*, *Rosa*, *Sorbus* and *Spergula*. Nomenclatural and distribution updates, published elsewhere, and corrigenda are provided as Suppl. material 1.

Keywords

Endemic taxa, Floristic data, Italy

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

***Anacyclus clavatus* (Desf.) Pers. (Asteraceae)**

+ **LIG**: Arma di Taggia (Imperia), parcheggio Piazzale Sant'Erasmo, lungo la ciclabile Imperia-San Remo (WGS84: 43.832754°N, 7.856074°E), aiuole incolte sul margine del parcheggio, 7 m, 1 June 2023, *M. Lonati, G. Nota* (FI). – Species new for the flora of Liguria.

This species forms a well-established population on an uncultivated area of over one ha, with several hundreds of individuals in the flowering stage.

M. Lonati, G. Nota

***Anthyllis apennina* F.Conti & Bartolucci (Fabaceae)**

+ **MAR**: Conca S. Lorenzo, costone rupestre, 1360 m, 14 July 1960, *V. Marchesoni* (FI, CAME); Pendici meridionali orientali del M. Cetrognola, pascoli xerici, substrato calcareo, 1300–1400 m, 30 June 1986, *S. Ballelli* (CAME); M. Gioco del Pallone, vers. E-NE, pascoli pingui e seslerieti, 1100–1200 m, 13 July 1995, *S. Ballelli* (CAME); *ibidem*, pascoli xerici di vetta, 1180 m, 13 July 1995, *S. Ballelli* (CAME); *ibidem*, rupi e pascoli a *Sesleria apennina*, 1110 m, 13 July 1995, *S. Ballelli* (CAME); M. Gioco del Pallone, vers. W, pascoli rocciosi e bosco sottostante, 1100–1200 m, 13 July 2001, *S. Ballelli* (CAME); Pendici SE del M. Vettoretto, Pié Vettore, cespuglieti a *Juniperus* e *Arctostaphylos*, substr. calcareo, 1400–1450 m, 29 July 1992, *S. Ballelli* (CAME);

ibidem, seslerieti e arctostafileti, substr. calcareo, 1500–1800 m, 29 July 1992, *S. Ballelli* (CAME); M. Costa, pendici nord (a nord di Monte Spina di Gualdo), esp. NE, bosco di faggio e pascoli sovrastanti, substr. calcareo, 9 June 2001, *S. Ballelli* (CAME); Castelsantangelo sul Nera (Macerata), Spina di Gualdo, presso la Forca, pascoli, substr. calcareo, 1320 m ca., 19 June 2003, *S. Ballelli* (CAME); Valle dell'Infernaccio lungo il sentiero nella valle, prati e pascoli aridi, substr. calcareo, 4 June 1995, *S. Ballelli* (CAME). − Species new for the flora of Marche.
+ **UMB**: M. Castellaccio, Pian Grande, xerogramineti a *Stipa*, 1350–1450 m, 20 July 1962, *V. Marchesoni* (FI, CAME); M. Castello (sopra inghiottitoio di Pian Grande), esp. E, boschi e pascoli, substr. calcareo, 13 June 1997, *S. Ballelli* (CAME); *ibidem*, pascoli a *Sesleria*, 1 July 2003, *S. Ballelli* (CAME); Colle delle Cupaie (M. Ventosola), esp. SE, pascoli rupestri, substr. calcareo, 1250–1350 m, 4 June 2002, *S. Ballelli* (CAME); sotto Costa Precino (M. Ventosola), esp. E, pascoli sassoso-rupestri, substr. calcareo, 19 June 2020, *S. Ballelli* (CAME). − Species new for the flora of Umbria.

Anthyllis apennina was so far recorded for Abruzzo and Lazio (Conti and Bartolucci 2022).

F. Conti, S. Ballelli

***Bolboschoenus planiculmis* (F.Schmidt) T.V.Egorova (Cyperaceae)**

+ **TOS**: Pelago (Firenze), Il Fossato (WGS84: 43.781428°N, 11.447483°E), sponda fluviale, 90 m, 4 September 2023, leg. *L. Pinzani*, det. *L. Lastrucci*, *L. Pinzani* (FI, *Herb. Pinzani*). – Species confirmed for the flora of Toscana.

According to Di Natale et al. (2020), this species is documented in Toscana only by a single ancient specimen (Padule di Massaciuccoli, Feb 1864, *O. Beccari*, FI058805 sub *Scirpus maritimus*; rev. L. Pignotti 09/1998, sub *Scirpus maritimus*). At the site of discovery, this species forms a small population in a temporarily wet depression along the Sieve River.

L. Pinzani, L. Lastrucci

***Catapodium pauciflorum* (Merino) Brullo, Giusso, Miniss. & Spamp. (Poaceae)**

+ **MAR**: Marina Palmense (Fermo), Habitat: Prateria subsalsa. Area di Volo di Marina Palmense, nei pressi del Camping "Spinnaker" (WGS84: 43.1557288°N, 13.81091827°E), 8 May 2023, *M. Tiburtini, R. Tiburtini* (FI). – Species new for the flora of Marche.

Along the Adriatic coast, this species shows a patchy distribution (Bartolucci et al. 2024), and this may due to identification problems with similar species (Brullo et al. 2003).

M. Tiburtini, R. Tiburtini

***Festuca circummediterranea* Patzke (Poaceae)**

+ **TAA**: Brentonico (Trento), M. Baldo, ca. 100 m a N di Malga Postemon (WGS84: 45.773300°N, 10.9199990°E), pascolo su calcare, 1390 m, 12 June 2007, *F. Prosser,*

A. Bertolli, det. *F. Prosser*, rev. *T. Wilhalm*, conf. *B. Foggi* (FI). – Species new for the flora of Trentino-Alto Adige.
+ **VEN**: Malcesine (Verona), M. Baldo, versante W del M. Altissimo al Dosso dei Roveri (WGS84: 45.814932°N, 10.868885°E), zona erbosa su calcare, 1060 m, 3 August 2005, *F. Prosser*, rev. *T. Wilhalm*, conf. *B. Foggi* (FI, ROV 48119). – Species confirmed for the flora of Veneto.

The specimens from Monte Baldo were noticed because they resembled an (octoploid) *F. laevigata* Gaudin (Arndt 2005), but leaf section and sheath corresponded to that of (diploid) *F. circummediterranea* (Ardenghi et al. 2016). The stomata length also clearly indicated a diploid plant (approx. 25 µm, Fischer et al. in prep.). The specimen from Trentino-Alto Adige comes from an isolated tussock, that from the Veronese part from a limited individual-rich population in a barely impacted area. The present records extend the range of this Mediterranean species to southern Alps.

F. Prosser, T. Wilhalm

***Hordeum geniculatum* All. (Poaceae)**

+ **MAR**: Staffolo (Ancona), loc. Coste di Staffolo (WGS84: 33T 43.4529256°N, 13.2201362°E), stradello argilloso sopra al calanco, suolo argilloso-limoso, c. 250 m, 17 May 2002, leg. et det. *S. Pesaresi* (sub *Hordeum hystrix* Roth, PESA); Pesaro (Pesaro e Urbino), tra Candelara e Ginestreto, margini di campo lungo la strada della Blilla (WGS84: 43.852420°N, 12.850836°E), suolo argilloso, humus nullo, c. 155 m, 29 May 2012, leg. et det. *L. Gubellini* (PESA, FI). – Species new for the flora of Marche.

L. Gubellini, S. Pesaresi

***Lavandula latifolia* Medik. (Lamiaceae)**

– **CAM.** Species to be excluded from the flora of Campania.

The occurrence of this species in Campania is exclusively based on an indication for Alburni massif (Salerno) by Caputo et al. (1977): "Rupi presso «Il Figliolo» (m 1300)". According to our field surveys and pertinent specimens [*Herb. Del Guacchio* (NAP)], this indication is to be attributed to the recently described *L. austroapennina* N.G.Passal., Tundis & Upson. Accordingly, *L. latifolia* should be excluded from the regional flora (see also Grande 1924).

E. Del Guacchio, E. Di Iorio

***Ophrys fusca* Link subsp. *forestieri* (Rchb.f.) Kreutz (Orchidaceae)**

+ **CAL**: Motta San Giovanni (Reggio Calabria), località Pitea (WGS84: 38.008475°N, 15.734279°E), in prossimità di un impianto di *Pinus* sp. con presenza di formazioni rocciose, 826 m, 11 February 2024, leg. *V.L.A. Laface, G. Mazzacuva*, det. *V.L.A. Laface, G. Mazzacuva, L. Torino* (REGGIO, FI). – Subspecies new for the flora of Calabria.

Many individuals have been observed growing in the pine forest and near the rock formations. This subspecies is easily distinguished by its early flowering, beginning to bloom in January with full flowering in February/March.

V.L.A. Laface, G. Mazzacuva

***Pseudopodospermum hispanicum* (L.) Zaika, Sukhor. & N.Kilian subsp. *neapolitanum* (Grande) Bartolucci, Galasso & F.Conti (Asteraceae)**

+ **TOS**: Roccalbegna (Grosseto), margini di boscaglia lungo la strada fra Usi e Rocconi nella valle dell'Albegna (WGS84: 42.740556°N, 11.472238°E), 530 m ca., suolo argilloso, raro, 12 June 1999, leg. *F. Selvi* 0341, vid. *F. Bartolucci* (FI); Castell'Azzara (Grosseto), scendendo alla Sforzesca, erbosi su calanco argilloso (WGS84: 42.774027°N, 11.703910°E), 600 m ca., raro, 18 May 2007, *F. Selvi 2843* (FI); Usi (Grosseto) radure e margini boschivi lungo la strada verso Murci (WGS84: 42.740556°N, 11.472238°E), suolo argilloso, 500 m ca., 9 May 2009, leg. *F. Selvi 3132*, vid. *F. Bartolucci* (FI). – Subspecies new for the flora of Toscana.

The specimens of *Scorzonera hispanica* L. mentioned in Selvi (2010) belong to this subspecies, endemic to central and southern Italy (Bartolucci et al. 2020). The Tuscan populations mark the northern distribution limit of this taxon.

F. Selvi

***Rosa nitidula* Besser (Rosaceae)**

+ **UMB**: Gubbio (Perugia), Monte Petria (WGS84: 43.428747°N, 12.661019°E), margini di bosco e arbusteti, suolo calcareo, 875 m, 1 June 2022, leg. *L. Gubellini et N. Hofmann*, det. *L. Gubellini* (PESA, FI). – Species new for the flora of Umbria.

L. Gubellini, N. Hofmann

+ **MOL**: Fragnete (Isernia), Colle Santa Maria (WGS84: 41.98472°N, 14.31583°E, cespuglieto, ca. 460 m, 16 May 2005, leg. *V. Viscosi*, det. *E Lattanzi* (IS); Fornelli (Isernia) (WGS84: 41.61410°N, 14.13828°E), siepe su marna argillosa, ca. 500 m, 25 May 2005, leg. *S. Pietrunti*, det. *S. Pietrunti, E. Lattanzi, A. Tilia* (IS); Colli al Volturno (Isernia), strada provinciale da Colli al Volturno a Fornelli (WGS84: 41.59928°N, 14.10741°E), cespuglieto, ca. 450 m, 18 July 2006, leg. *S. Pietrunti*, det. *S. Pietrunti, E Lattanzi* (FI, IS). – Species new for the flora of Molise.

P. Fortini, L. Quaranta

***Sorbus chamaemespilus* (L.) Crantz (Rosaceae)**

– **CAM**. Species to be excluded from the flora of Campania.

– **PUG**. Species to be excluded from the flora of Puglia.

Tenore (1831–1833: 70, under the name *Pyrus chamaemespylus*, see also Tenore 1831) indicated this species for Montevergine (Avellino, Campania) and Gargano

(Foggia, Apulia), where it has been no longer found. By the expression "Tenore, 1827 (Monte di Mezzo, in subalpinis)", Fenaroli (1970) merely quoted that indication. Bartolucci et al. (2024) does not indicate this species for Campania and report it as doubtful for Puglia (see also Pignatti 1982, Conti and Bartolucci 2015). As Tenore (1831–1833: 278) himself deleted all the localities of southern Italy (not represented at NAP), the reports for Campania and Puglia are considered erroneous.

E. Del Guacchio

***Spergula arvensis* L. (Caryophyllaceae)**

+ **MAR**: Castelsantangelo sul Nera (Macerata), Monti Sibillini, al Piano perduto (WGS84: 42.839953°N, 13.196694°E), luoghi erbosi incolti, suolo calcareo, humus nullo o subnullo, c. 1310 m, 8 October 2023, leg. et det. *L. Gubellini* (PESA, FI) – Species confirmed for the flora of Marche.

This species, recorded at the end of the 19th century for the Pesaro area by Paolucci (1890), was recently found in the southern sector of Marche region at Pian Perduto (Mts. Sibillini), where it forms a population of about a hundred individuals in resting fields.

L. Gubellini, N. Hofmann

Nomenclatural and distribution updates from other literature sources

Nomenclatural and distribution updates, and corrigenda to Bartolucci et al. (2024) according to Klaver and Rossi (2011), Pignatti et al. (2017), Hertel and Presser (2021), Tison et al. (2021), Iamonico et al. (2022), Adamo et al. (2023), Martini et al. (2023), Parolo and Della Ferrera (2023), Uhlemann (2023), Gianguzzi et al. (2024), Gottschlich (2024), Iamonico and Del Guacchio (2024), Kozlowski et al. (2024); Sennikov (2024), Sennikov and Tikhomirov (2024), Španiel et al. (2024), Valle et al. (2024) are provided in Suppl. material 1.

F. Bartolucci, G. Galasso

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Supplementary material 1

Supplementary data

Authors: Fabrizio Bartolucci, Gabriele Galasso

Data type: species data (PDF file)

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

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RESEARCH ARTICLE

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Notulae to the Italian flora of algae, bryophytes, fungi and lichens: 17

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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 genera *Chara* and *Nitella*, the bryophyte genera *Brachythecium*, *Didymodon*, *Fissidens*, *Physcomitrium*, and *Riccia*, the fungal genera *Biatoropsis*, *Cantharellus*, *Coprinellus*, *Dacrymyces*, *Inosperma*, *Nigropuncta*, *Urocystis*, and *Xanthoriicola*, and the lichen genera *Arthonia*, *Bellemerea*, *Circinaria*, *Lecania*, *Lecanora*, *Lecidella*, *Mycobilimbia*, *Naetrocymbe*, *Parmelia*, *Peltigera*, *Porpidia*, *Scytinium*, and *Usnea*.

Keywords

Ascomycota, Basidiomycota, Bryidae, Charophyceae, Ricciaceae

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

***Chara contraria* Kütz (Characeae)**

+ **ABR**: Lago di Campotosto, Parco Nazionale del Gran Sasso e Monti della Laga, Campotosto (L'Aquila) (UTM WGS 84: 33T 364900.4709623), lake bottom between 0.5 and 8 m depth, 1300 m, 19 September 2023, *L. Rosati*, *L. Cancellieri*, *M.M. Azzella* (HLUC); Lago di Scanno, Scanno (L'Aquila) (UTM WGS 84: 33T 405320.4642277), lake bottom between 0.5 and 2 m depth, 922 m, 9 September 2023, leg. *L. Rosati*, *G. Filibeck*, det. *L. Rosati*, *M.M. Azzella* (HLUC). – Species new for the flora of Abruzzo.

This species has been reported only for a few Italian administrative regions, probably due to the difficulties in distinguishing it from *C. vulgaris* L. (Bazzichelli and Abdelahad 2009; Ravera et al. 2019). Nevertheless, genetic analyses performed by Schneider et al. (2016) showed that *C. contraria* belongs to a distinct lineage characterized by having a diplostichous and tylacanthous cortex (but spines varying in length), more related to *C. hispida* group rather than to *C. vulgaris* group. *Chara contraria* is quite common in the reservoir of Campotosto within *Chara globularis* Thuill. and/or *C. vulgaris* vegetation. We occasionally recorded it as the dominant species. On the contrary, in the natural lake of Scanno it is very rare and only associated to the vegetation dominated by *C. vulgaris* (Filibeck et al. 2023).

L. Rosati, M.M. Azella, G. Filibeck

***Chara globularis* Thuill. (Characeae)**

+ **ABR**: Lago di Campotosto, Parco Nazionale del Gran Sasso e Monti della Laga, Campotosto (L'Aquila) (UTM WGS 84: 33T 364900.4709623), lake bottom between 1 and 8 m depth, 1300 m, 19 September 2023, *L. Rosati*, *L. Cancellieri*, *M.M. Azzella* (UTV, HLUC); Lago di Scanno, Scanno (L'Aquila) (UTM WGS 84: 33T 405918.4641894), lake bottom between 3 and 7 m depth, 922 m, 9 September 2023, leg. *L. Rosati*, *G. Filibeck*, det. *L. Rosati*, *M.M. Azzella* (UTV, HLUC); Lago di Barrea, Parco Nazionale d'Abruzzo Lazio e Molise, Barrea (L'Aquila) (UTM WGS 84: 33T 414901.4623485), lake bottom between 0.5 and 5 m depth, 975 m, 20 July 2023, leg. *L. Rosati*, *G. Filibeck*, det. *L. Rosati*, *M.M. Azzella* (UTV, HLUC); Lago della Montagna Spaccata, Alfedena (L'Aquila) (UTM WGS 84: 33T 417315.4619457), lake bottom between 0.5 and 8 m depth, 1060 m, 22 August 2023, leg. *L. Rosati*, *G. Filibeck*, det. *L. Rosati*, *M.M. Azzella* (UTV, HLUC). – Species new for the flora of Abruzzo.

This species has been reported for most Italian administrative regions (Bazzichelli and Abdelahad 2009) and recently also for Liguria (Ravera et al. 2019). It is a species common in Italy and the most frequently reported of the genus after *C. vulgaris* L.

Probably, the lack of records from some regions is mainly due to a scarcity of specific studies. We have frequently observed it as the dominant species of the submerged vegetation in the Campotosto reservoir and in the natural lake of Scanno, mainly at 3–6 m depth. It is less common in the artificial basins of Barrea and Montagna Spaccata (see Filibeck et al. 2023 and Ravera et al. 2023 for ecological and floristic information on the submerged communities in these lakes).

L. Rosati, L. Cancellieri, G. Filibeck

***Chara globularis* Thuill. (Characeae)**

+ **BAS**: Lago Pantano, Pignola (Potenza), lake bottom at 0.7 m depth (UTM WGS 84: 33T 562897.4493268), 764 m, 8 August 2015, leg. *L. Rosati*, *G. Potenza*, det. *L. Rosati* (HLUC). – Species new for the flora of Basilicata.

In the collection site, Characeae are very rare and occur as small patches, interspersed within a *Ceratophyllum demersum* L. dominated vegetation.

L. Rosati, G. Potenza

***Chara gymnophylla* A.Braun (Characeae)**

+ **ABR**: Lago di Campotosto, Parco Nazionale del Gran Sasso e Monti della Laga, Campotosto (L'Aquila) (UTM WGS 84: 33T 365613 4709500), lake bottom between 1 and 6 m depth, 1300 m, 19 September 2023, *L. Rosati*, *L. Cancellieri*, *M.M. Azzella* (HLUC); Lago di Barrea, Parco Nazionale d'Abruzzo Lazio e Molise, Barrea (L'Aquila) (UTM WGS 84: 33T 414867.4623504), lake bottom between 1 and 5 m depth, 975 m, 20 July 2023, leg. *L. Rosati*, *G. Filibeck*, det. *L. Rosati*, *M.M. Azzella* (HLUC). – Species confirmed for the flora of Abruzzo.

Chara gymnophylla is a controversial taxon, considered by some authors only as a variety of *C. vulgaris* L. (Bazzichelli and Abdelahad 2009; Schneider et al. 2016) and by others as a good species (e.g., Caisová and Gąbka 2009; Guiry and Guiry 2024). Probably for this reason, in Italy it has been recorded only for some administrative regions (Bazzichelli and Abdelahad 2009) and was not previously listed for Abruzzo, even if the sample illustrating this taxon in Bazzichelli and Abdelahad (2009) was collected in August 2008 from Lecce nei Marsi (L'Aquila, Abruzzo). Thus, our records are a confirmation for the flora of Abruzzo. *Chara gymnophylla* can be distinguished from *C. vulgaris* s.str. because of its ecorticated branchlets (or with 1–2 corticated basal segments) plus completely ecorticate fertile segments (Bazzichelli and Abdelahad 2009; Caisová and Gąbka 2009).

L. Rosati, M.M. Azzella, L. Cancellieri

***Nitella tenuissima* (Desv.) Kutzing (Characeae)**

+ **TOS**: pond in a coppice along the road SP 441, Chiusdino (Siena) (UTM WGS84: 32T 674115.4779143), 318 m, 27 April 2023, *T. Fiaschi*, *S. Cannucci*, *C. Angiolini* (SIENA). – Species new for the flora of Toscana.

Inside a shallow pond (about 850 m^2), in a *Quercus cerris* L. coppice, not far from the street, we found a consistent fertile population of *N. tenuissima* together with an even larger population of *Chara globularis* Thuill. These are two indicator species of the Habitat Directive "Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp." (code 3140; Biondi et al. 2009). The populations have been found near the pond bank. Indeed, species of small dimensions like *N. tenuissima*, occur in the shallow part of the wetlands, while larger species, such as *C. globularis*, in the deepest parts. In Italy, *Nitella tenuissima* has been recorded in Lombardia, Veneto, Lazio, and Sicilia (Bazzichelli and Abdelahad 2009).

T. Fiaschi, S. Cannucci, C. Angiolini

BRYOPHYTES

Brachythecium albicans (Hedw.) Schimp. (Brachytheciaceae)

+ **BAS**: Piano Iannace (Potenza) (UTM WGS84: 33S 602151.4421774), on open soil at the border of the beech wood, 1705 m, 6 July 2012, leg. *M. Puglisi*, det. *M. Puglisi*, *G. Bacilliere* (CAT). – Species confirmed for the flora of Basilicata.

Brachythecium albicans is a boreo-temperate species, frequently occurring on sandy or gravelly, unshaded and preferably acid soils in open habitats. This species is distinguished by its pale whitish-green or yellow-green, string-like shoots. Despite being quite common in Italy, for some southern regions (Campania, Calabria and Basilicata) there are exclusively old reports based on collections published before 1968 (Aleffi et al. 2020). This record is a confirmation of the species for the flora of Basilicata more than 80 years after the last reports (Zodda 1913; Giacomini 1938).

M. Puglisi, G. Bacilliere, G. Miraglia

Didymodon sinuosus (Mitt.) Delogne (Pottiaceae)

+ **TAA**: Villa Lagarina, Guerrieri-Gonzaga Park (Trento) (UTM WGS84: 32T 657387.5086611), along a 5 m long section of the limestone stone irrigation gully, 195 m, 7 February 2024, *F. Prosser* (ROV 07001); *ibidem* (UTM WGS84: 32T 657262.5086641), 205 m, *F. Prosser* (ROV 07002). – Species new for the flora of Trentino-Alto Adige.

Didymodon sinuosus was found in one of the best-preserved historical parks in Trentino, in two points of the gully that was built together with the garden about two centuries ago (Codroico 2004). This species usually grows on damp, calcareous rocks along watercourses, but also park-like areas (Meier and Roloff 2017). In Villa Lagarina, *D. sinuosus* is accompanied by *Amblystegium serpens* (Hedw.) Schimp., *Brachythecium rutabulum* (Hedw.) Schimp., *Plagiomnium cuspidatum* (Hedw.) T.J.Kop. This species is common in the central-southern part of Italy, while it is quite rare in the northern regions (Aleffi et al. 2020).

F. Prosser

***Fissidens osmundoides* Hedw. (Fissidentaceae)**

+ **TOS**: Chiusdino (Siena) (UTM WGS84: 32T 674113.4779118), in the rocky bed of a stream in a deciduous forest, near a pond, 324 m, 15 October 2023, *T. Fiaschi*, *E. Fanfarillo*, *I. Bonini* (SIENA). – Species confirmed for the flora of Toscana.

Fissidens osmundoides is a circumpolar boreo-arctic montane species, that grows on wet rocks, in meadows, and along streams (Cortini Pedrotti 2001). According to Aleffi et al. (2020), this species occurs in all the administrative regions of northern Italy, in Umbria, Lazio, and Campania; its presence in Toscana was considered doubtful, based on a record published before 1968 (Pellegrini 1942).

T. Fiaschi, E. Fanfarillo, I. Bonini

***Physcomitrium patens* (Hedw.) Mitt. (Funariaceae)**

+ **TOS**: Chiusdino (Siena) (UTM WGS84: 32T 675041.4781574), in the muddy bed of a dried-up pond, 270 m, 15 October 2023, *T. Fiaschi*, *C. Angiolini*, *E. Fanfarillo*, *I. Bonini* (SIENA). – Species new for the flora of Toscana.

Physcomitrium patens is an Eurosiberian Temperate, short-lived pioneer species, that colonizes wet mud and sediment (Blockeel et al. 2014). In Italy, it has a fragmented distribution throughout the country. In the north, it is recorded for Lombardia, Trentino-Alto Adige, Veneto, and historically (before 1968) for Piemonte. Moreover, further south it occurs in Abruzzo, Calabria and Sicilia (Aleffi et al. 2020). In the new locality *Ph. patens* was found with abundant capsules.

T. Fiaschi, I. Bonini, C. Angiolini

***Riccia ciliifera* Link ex Lindenb. (Ricciaceae)**

+ **TOS**: Botanical Garden, Pisa (UTM WGS84: 32T 612513.4841820), on damp clay along the paths that separate the flowerbeds, 4 m, 18 Feb 2022, *M. Tiburtini* (PI061638). – Species confirmed for the flora of Toscana.

Riccia ciliifera is a liverwort species quite common in Italy, that was first recorded for Toscana in 1901 by Attilio Tassi, in the Botanical Garden of Siena (Aleffi et al. 2020). *Riccia ciliifera* can be distinguished from other members of *R.* subg. *Riccia* by wide thallus and violet-purple thalli margins. This species is closely related to *R. gougetiana* Durieu & Mont., from which it differs for the thallus colour and larger lobes, smaller cells of ventral scales, spore ornamentation pattern and size (larger in *R. gougetiana*).

M. Tiburtini, G. Pandeli, G. Brusa

FUNGI

***Biatoropsis hafellneri* Millanes, Diederich, M.Westb. & Wedin (Tremellaceae)**

+ **ITA** (**SAR**): Monte di Seneghe, loc. Cuguzzu, along the forest road to loc. Fontanas (Oristano) (UTM WGS84: 32T 4440628 462640), on thalli of *Usnea cornuta* Körb.,

711 m, 2 July 2023, leg. *P. Giordani*, det. *W. v. Brackel* (GE2868, hb Brackel 8997). – Species new to Italy (Sardegna).

This recently described lichenicolous fungus is confined to the thallus of *Usnea* Dill. ex Adans. species (*U. fragilescens* Hav. ex Lynge agg., especially *Usnea cornuta* Körb.), where it causes the formation of typical pale to medium orange galls, containing 1-septate basidia with laterally elongating cells. This species is known from several countries in Europe and Macaronesia (Millanes et al. 2016; Roux et al. 2020; Diederich et al. 2022). At the site it was found on epiphytic thalli of *U. cornuta* growing on branches and trunks of *Quercus ilex* L. in a dense mature forest. The species is new for the flora of the Mediterranean.

W. v. Brackel, P. Giordani

***Cantharellus pallens* Pilát (Hydnaceae)**

+ **CAL**: Botanical Garden, University of Calabria, Rende (Cosenza) (UTM WGS84: 33S 605968.4357304), on the ground in a hardwood coppice stand (*Quercus pubescens* Willd. as prevailing tree species), 18 October 2023, *N.G. Passalacqua*, *A.B. De Giuseppe*, *G. Sicoli* (CLU F331). – Species new to Calabria.

Sparse groups of gregarious basidiomata referable to the genus *Cantharellus* Adans. ex Fr. were detected on the ground in a coppice stand mainly composed of deciduous oak trees. *Cantharellus pallens* is very similar to the better known *C. cibarius* Fr., which produces smaller but more strongly and uniformly yellow-coloured pilei without pruina on the upper surface (Courtecuisse and Duhem 1995; Knudsen et al. 1997; Matteucci 2013). According to Onofri et al. (2013), this fungus had not been reported from Calabria. In a later report (Caroti et al. 2015), the illustration referred to this species for Calabria seems to fit better with another species, i.e. *Cantharellus alborufescens* (Malençon) Papetti & S. Alberti, so much so that no further occurrence of *C. pallens* was indicated in the more recent check list of the macromycetes of Calabria (Siniscalco et al. 2018a, b).

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

***Coprinellus domesticus* (Bolton) Vilgalys, Hopple & Jacq. Johnson (Psathyrellaceae)**

+ **CAL**: Botanical Garden, University of Calabria, Rende (Cosenza) (UTM WGS84: 33S 605988.4357068), on the ground in the grass, close to the butt of a cut Italian poplar tree (*Populus nigra* L. subsp. *italica* Duroi), 220 m, 20 March 2023, *G. Sicoli*, *A.B. De Giuseppe*, *N.G. Passalacqua* (CLU F332). – Species new to Calabria.

A solitary coprinoid basidiome was observed on the ground among the grass in the proximity of the collar of a cut Italian poplar tree. In Italy, *C. domesticus* has been reported as widespread in many regions, but not in Calabria, so far (Onofri et al. 2013).

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

***Coprinellus silvaticus* (Peck) Gminder (Psathyrellaceae)**

+ **CAL**: Botanical Garden, University of Calabria, Rende (Cosenza) (UTM WGS84: 33S 605841.4357398), on the ground in the litter of a downy oak tree (*Quercus pubescens* Willd.) coppice stand, 210 m, 24 November 2021, *G. Sicoli*, *N.G. Passalacqua*, *A.B. De Giuseppe* (CLU F334). – Species new to Calabria.

A solitary and apparently fragile basidiome, 3 cm high, with a plicate and acutely campanulate pileus was observed on the ground, emerging from the litter close to the base of an old stump of a presumably downy oak tree in a mixed deciduous and broad-leaved tree coppice stand. This fungus has been reported in a few regions between central and northern Italy, but in southern Italy only in Sicilia, so far (Onofri et al. 2013).

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

***Dacrymyces capitatus* Schwein. (Dacrymycetaceae)**

+ **CAL**: Botanical Garden, University of Calabria, Rende (Cosenza) (UTM WGS84: 33S 605841.4357398), on the wood of a dead branch fallen on the ground from a downy oak tree (*Quercus pubescens* Willd.), 200 m, 27 September 2023, *G. Sicoli*, *N.G. Passalacqua*, *A.B. De Giuseppe* (CLU F333). – Species new to Calabria.

A group of gelatinous, pustulate, discoid and shortly stipitate fungal-like structures were observed on the dead wood of a branch laying on the ground at the base of a downy oak tree. They were also orange-coloured and densely appressed, each measuring 1–3 mm in diameter. Under the light microscope these structures revealed to consist of septate but clampless, thick-walled and rough hyphae, some of them apically bifurcate, each branch bearing a cylindrical to allantoid and 3–4-septate hyaline spore measuring 12–15 × 4–6 µm. The above characteristics led to identify this fungus as a basidiomycete belonging to *D. capitatus* (Jülich 1989; Torkelsen 1997), a rarely observed species in Italy, apparently not yet recorded in Calabria (Onofri et al. 2013).

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

***Inosperma quietiodor* (Bon) Matheny & Esteve-Rav. (Inocybaceae)**

+ **LIG**: Santuario Basilica nostra Signora di Montallegro, Rapallo (Genova), on the ground under the crown of holm oak (*Quercus ilex* L.) (UTM WGS84: 32T 520782.4912978), 600 m, 14 October 2020, *F. Boccardo* (GDOR 4978). – Species new to Liguria.

Inosperma quietiodor is an ectomycorrhizal fungus similar to *I. cookei* (Bres.) Matheny & Esteve-Rav., from which it can be mainly distinguished for the different smell. It is similar to that of *Lactarius quietus* (Fr.) Fr. in young specimens of *I. quietiodor*, and honey-like in *I. cookei*. The spore dimensions of the Ligurian collection (9.0–10.5 × 5.0–6.0 µm) fit well with those reported by Kuyper (1986) and Ferrari et al. (2014). This species is widespread in Europe but apparently rare (Kuyper 1986). It has been reported in Italy from Piemonte (Ferrari et al. 2014).

F. Dovana, F. Boccardo, V. Cavallaro

***Nigropuncta rugulosa* D.Hawksw. (Ascomycota)**

+ **LOM**: Southern Rhaetian Alps, Presanella-group, Passo del Tonale, S above the pass towards Passo del Paradiso (Brescia) (UTM WGS84: 32T 621719.5123345), gentle slope exposed to the N, granitic boulder field surrounded by krummholz of *Alnus alnobetula* (Ehrh.) K.Koch, in overhangs of big boulders, on thallus of *Bellemerea cinereorufescens* (Ach.) Clauzade & Cl.Roux, ca. 1950 m, 24 July 2006, *J. Hafellner*, *L. Muggia* (no. 85840 GZU). – Species new to Lombardia.
+ **VDA**: Alpi Pennine, Colle de Gran San Bernardo, just SW below the pass (Aosta) (UTM WGS84: 32T 357153.5081436), outcrops of siliceous rocks in alpine grassland on steep slope exposed to the S, on vertical rock faces, on thallus of *Bellemerea cinereorufescens* (Ach.) Clauzade & Cl.Roux, ca. 2500 m, 1 August 2001, *J. Hafellner*, *P.L. Nimis*, *M. Tretiach*) (no. 87142 GZU). – Species new to Val d'Aosta.
+ **PIE**: Alpi Cozie, mountains W of Pinerolo, northeastern slopes and ridges of the Punta Cialáncia S above the village Perrero (Torino) (UTM WGS84: 32T 351702.4971705), boulders and cliffs of siliceous rocks, on steep rock faces of cliffs exposed to the N, on thallus of *Bellemerea cinereorufescens* (Ach.) Clauzade & Cl.Roux, ca. 2350 m, 26 July 2001, *J. Hafellner* (with *P.L. Nimis* and *M. Tretiach*) (no. 69397 GZU); Alpi Marittime, Rocca dell'Abisso W of Colle di Tenda, E below summit, steep slopes towards uppermost Vallone dell'Abisso (Cuneo) (UTM WGS84: 32T 380673.4888905), cliffs, outcrops and dispersed boulders of gneiss exposed to the E, on steep rock faces, on thallus of *Bellemerea cinereorufescens* (Ach.) Clauzade & Cl.Roux, ca. 2630 m, 22 July 2000, *A. Hafellner*, *J. Hafellner* (with *M. Tretiach*) (no. 87392 GZU). – Species new to Piemonte.

Nigropuncta rugulosa is widely distributed and not rare in the Holarctic. In Italy, this species was so far only recorded by one of the author's early collections from the mountain "Äusserer Nockenkopf" in Trentino-Alto Adige (northwestern Südtirol) (Hawksworth and Poelt 1986; Brackel 2016; Nimis and Martellos 2024).

J. Hafellner

***Urocystis eranthidis* (Pass.) Ainsw. & Sampson (Urocystidaceae)**

+ **CAL**: Piano del Ratto, Civita (Cosenza), on petioles of living leaves of *Eranthis hyemalis* (L.) Salisb. (UTM WGS 84: 33S 609636.4414586), 1382 m, 5 May 2023, *D. Puntillo* (CLU F486). – Species new to Calabria.

This species may be confused with a smut fungus recently described on *Eranthis longistipitata* host as *Entyloma eranthidis* T.Denchev, Denchev, Kemler & Begerow, but it shows single spores or arranged in irregular groups while in *U. eranthidis* the spores are in balls with collapsed sterile cells around. *Urocystis eranthidis* has been included in the Berlin Red List as threatened with extinction due to the rarefaction of the host plant (Scholz and Scholz 2005). In Calabria the species is quite rare as it is extremely localized. In Italy is known from Piemonte, Emilia-Romagna, Umbria and Marche (Ciferri 1938).

D. Puntillo, M. Puntillo

***Xanthoriicola physciae* (Kalchbr.) D.Hawksw. (Ascomycota)**

+ **FVG**: Southern Alps, Carnic Alps, W of Ampezzo by the road to Passo del Pura, near Albergo e Ristorante Pura (Udine) (UTM WGS84: 33T 328363.5142458), solitary *Juglans regia* L. in a meadow, on branches in the lower canopy, on apothecia of *Xanthoria parietina* (L.) Th.Fr., 715 m, 17 August 1994, *J. Hafellner* (GZU - JH87839). – Species new to Friuli-Venezia Giulia.
+ **VEN**: southern Alps, Venetian Alps, Nevegal SE of Belluno, slopes exposed to NE, surroundings of the valley station of the chair-lift on Col Faverghera (Belluno) (UTM WGS84: 33T 289558.5107681), mixed coniferous forest, on bark of *Picea abies* (L.) H.Karst., on apothecia of *Xanthoria parietina* (L.) Th.Fr., 1030 m, 31 August 2002, *J. Hafellner* (GZU - JH61057). – Species new to Veneto.
+ **PIE**: Western Alps, Alpi Cozie, at the entrance into the Vallone dell'Arma, just W of the village Fèdio (Cuneo) (UTM WGS84: 32T 362234.4909422), scattered trees in a pasture, on bark of *Populus* spec. (hybrid), on apothecia of *Xanthoria parietina* (L.) Th.Fr., 980 m, 23 July 2000, *J. Hafellner*, *P. L. Nimis*, *M. Tretiach*) (GZU - JH87661). – Species new to Piemonte.

In Italy, most records of this otherwise common species are recent and originate from the central and southern parts of the country (Brackel 2016). In the north of Italy, this species has so far been reported only for Lombardia (Santesson 1994; Brackel 2013). Interestingly, there is no historical record of this conspicuous fungus.

J. Hafellner

LICHENS

***Arthonia phlyctiformis* Nyl. (Arthoniaceae)**

+ **ITA** (**PUG**): Giardini Pubblici G. Garibaldi (formerly Villa della Lupa) di Lecce (Lecce) (UTM WGS84: 34T 260071.4471008), on fallen branches, March 2023, leg. *P. Pinault*, conf. *C. Roux*, *M. Grube* (Herb. Pinault, TSB). – Species new to Italy (Puglia).

This epiphytic species is clearly lichenized with non-Trentepohlioid algae, and is seemingly apparently not rare along the eastern coast of the Iberian Peninsula, especially on acid-barked trees, and is also known from France (Languedoc-Roussillon and Pyrénées-Orientales, see Gerstmans and Ertz 2016).

P. Pinault, P.L. Nimis, J. Nascimbene

***Bellemerea alpina* (Sommerf.) Clauzade & Cl.Roux (Lecideales)**

+ **TOS**: Northern Apennines, surroundings of Abetone, Val di Luce, Alpe Tre Potenze, along lift route Sciovia "La Fariola" (Pistoia) (UTM WGS84: 32T 631036.4886844), on siliceous boulders on slope exposed to the N, c. 1730 m, 27 October 1978, *J. Hafellner* (no. 3859 GZU); *ibidem*, 27 October 1978, *J. Poelt* (GZU). – Species new to Toscana.

This species grows on siliceous boulders including metal-rich rock types, preferably on slightly to medium-inclined rock faces. It shows a bipolar distribution, since it is widely distributed in the Northern Hemisphere and common in the Alps from the treeline ecotone to the alpine belt (Nimis et al. 2018). In Italy, *B. alpina* has so far been reported mostly for the northern regions (Nimis and Martellos 2024). A historical record from Sicilia is regarded as doubtful (Nimis 1993), so that this record is the first outside the Alps in Italy.

J. Hafellner

***Bellemerea cinereorufescens* (Ach.) Clauzade & Cl.Roux (Lecideales)**

+ **VDA**: Alpi Pennine, Colle del Gran San Bernardo, just SW below the pass, (Aosta) (UTM WGS84: 32T 357153.5081436), outcrops of siliceous rocks in alpine grassland on steep slope exposed to the S, on vertical rock faces, c. 2500 m, 1 August 2001, *J. Hafellner*, *P.L. Nimis*, *M. Tretiach*) (no. 87126 GZU). – Species confirmed for Val d'Aosta.
+ **TOS**: Northern Apennines, surroundings of Abetone, Val di Luce, Alpe Tre Potenze, along lift route Sciovia "La Fariola" (Pistoia) (UTM WGS84: 32T 631036.4886844), on siliceous boulders on slope exposed to the N, 1500–1820 m, 27 October 1978, *J. Poelt* (GZU) Label text in German language. – Species new to Toscana.

Bellemerea cinereorufescens shows a bipolar distribution, since it is widely distributed in the Northern Hemisphere and common in the Alps concentrated in the alpine belt (Nimis et al. 2018). This species is recorded for the Alps in Italy (Nimis and Martellos 2024), but many of the records are historical (Nimis 1993) as is the one for Valle d'Aosta (Cengia Sambo 1932). Outside the Alps it has been reported from a few localities in the Emilia-Romagna (Fariselli et al. 2020) but these records need confirmation. Historical records for Sardegna and Sicilia have been regarded as doubtful (Nimis and Martellos 2024). For some further records from localities in northern regions see in the Fungi section under *Nigropuncta rugulosa*.

J. Hafellner

***Circinaria nimisii* Sohrabi, H.Mayrhofer, Obermayer & S.D.Leav. (Megasporaceae)**

+ **ITA** (**ABR**): Gran Sasso Massif, below Corno Piccolo (L'Aquila) (UTM WGS84: 380609.4703809 33T), on vertical faces of calcareous rocks, 2350 m, 9 August 1996, *P.L. Nimis*, *M. Tretiach* (TSB 13559). – Species new to Italy (Abruzzo).

This species was recently described from Mt. Olympus (Greece) as a vagrant lichen in steppe-like vegetation over calcareous substrata. Specimens collected on rock in the Gran Sasso Massif (central Apennines) were provisionally identified by Nimis and Tretiach (1999) as *Aspicilia desertorum* auct. p.p. non (Kremp.) Mereschk. and then assigned to the *Circinaria elmorei*-group by Nimis (2016). However, these specimens correspond perfectly with the description of *C. nimisii* (Sohrabi et al. 2023), with the only difference that the thalli are in this case very easily detachable, but not truly vagrant.

P.L. Nimis, J. Nascimbene

***Lecania cyrtellina* (Nyl.) Sandst. (Ramalinaceae)**

+ **TOS**: Botanical Garden of the University of Pisa (Pisa) (UTM WGS84: 32T 612451.4841719), on the bark of *Jubaea chilensis* (Molina) Baill., 4 m, 3 April 2023, leg. *A. Guttová*, *L. Paoli*, det. *L. Paoli*, *Z. Fačkovcová*, *A. Guttová*, (SAV0017676). – Species new to Toscana.

Lecania cyrtellina is a crustose lichen with sessile lecanorine apothecia (at least when young), often clustered, growing mainly on base-rich barks of deciduous trees. This species is very similar to *L. cyrtella* (Ach.) Th.Fr. from which can be distinguished by smaller apothecia (0.1–0.3 mm vs. 0.2–0.7 mm) and smaller ascospores (mostly 1-septate vs. unicellular) (Nimis and Martellos 2024).

L. Paoli, A. Guttová

***Lecanora horiza* (Ach.) Linds. (Lecanoraceae)**

+ **PIE**: Grugliasco (Torino), garden of the University campus (UTM WGS84: 32T 389099.4991344), on bark of *Acer* sp., 300 m, 10 January 2024, *S. Ongaro*, *D. Isocrono* (ORO292). – Species new to Piemonte.

Lecanora horiza is a mainly Mediterranean member of the *L. subfusca* group, much rarer in the northern than in the Mediterranean parts (Nimis 2024). Lichens of the *L. subfusca* group shows large morphological variability, especially in the size and shape of apothecia (Malíček 2014): epihymenium without crystals, medulla with small irregular crystals not dissolving in K, fine granules soluble in K in the thalline exciple with an adjacent crystal-free zone are the diagnostic features. This species is similar to *L. allophana* (Ach.) Nyl. that differs in having an indistinct cortex and larger ascospores.

D. Isocrono, S. Ongaro

***Lecidella flavosorediata* (Vězda) Hertel & Leuckert (Lecanoraceae)**

+ **EMR**: Between Ponte Scodellino and Case Prasottano, Borgo Val di Taro (Parma), on trunks of *Quercus cerris* L. in a broadleaved woodland (UTM WGS84: 32T 559710.4924880), 499 m, 14 November 2023, leg. *L. Francesconi*, *G. Gheza*, det. *L. Francesconi*, *G. Gheza*, *H. Mayrhofer* (GZU). – Species new to Emilia-Romagna.

Lecidella flavosorediata is an epiphytic species with conspicuous yellowish soredia (Tønsberg 1992), most frequent on deciduous trees and conifers in southern Italy (Ravera et al. 2022). This species is distinguished from other mainly sterile crustose sorediate lichens by its chemistry (arthothelin and granulosin; Tønsberg 1992). It was scatteredly reported from several administrative regions throughout Italy (Nimis and Martellos 2024).

L. Francesconi, G. Gheza, H. Mayrhofer

***Mycobilimbia sphaeroides* (Dicks.) S.Ekman & Printzen (Ramalinaceae)**

+ **CAM**: Parco Nazionale del Cilento, Vallo di Diano e Alburni, loc. Vesalo, Laurino (Salerno) (UTM WGS84 33T 531031.4459202), on trunks of *Alnus cordata* (Loisel.) Duby along the river Calore, 980 m, 5 February 2024, *S. Ravera* (PAL). – Species new to Campania.

Mycobilimbia sphaeroides is a crustose species which grows on sheltered, mature deciduous tree trunks often around their bases, in old woodlands. In the collecting site, this species colonizes large portions of alder bark with fertile thalli of *Lobaria pulmonaria* (L.) Hoffm. and the Lobarion species *Fuscopannaria ignobilis* (Anzi) P.M.Jørg. *Lobarina scrobiculata* (Scop.) Cromb., *Pectenia plumbea* (Lightf.) P.M.Jørg., L.Lindblom, Wedin & S.Ekman, *Ricasolia amplissima* (Scop.) De Not., and *Vahliella saubinetii* (Mont.) P.M.Jørg.

S. Ravera

***Naetrocymbe rhododendri* (Arnold) Hafellner & Türk (Naetrocymbaceae)**

+ **LOM**: trail between Rifugio Albani and Passo dello Scagnello, Colere (Bergamo), on dead stems of dwarf shrubs in a high-altitude open habitat on limestone (UTM WGS84: 32T 581589.5090883), 1980 m, 26 August 2023, *G. Gheza*, *L. Di Nuzzo* (BOLO). – Species new to Lombardia.

Naetrocymbe rhododendri typically occurs on the bark of dwarf shrubs in subalpine and alpine heaths. It was reported scatteredly from the Italian Alps, where it is likely more widespread (Nimis and Martellos 2024). It can be identified by its typical spores, which are club-shaped, bicellular, with one cell larger than the other, often both guttulate.

G. Gheza, C. Pistocchi, L. Di Nuzzo

***Parmelia discordans* Nyl. (Parmeliaceae)**

+ **ITA** (**SAR**): Fonni (Nuoro) (UTM WGS84 32T 524915.4436399), on granite boulders on pastures 5 km SE of village, 1300 m, 1 May 2012, *J. Malíček* (PRA). – Species new to Italy (Sardegna).

Parmelia discordans is a foliose species which grows on siliceous rocks and screes, closely related to *P. omphalodes* (L.) Ach., from which it differs mainly in the content of protocetraric acid. So far, it is known only in Europe (GBIF.org 2024) where it is mainly coastal in Scandinavia, and usually restricted to upland areas in central and southern Europe (Nimis and Martellos 2024).

J. Malíček, S. Ravera

***Peltigera lepidophora* (Vain.) Bitter (Peltigeraceae)**

+ **LIG**: Alpi Liguri, mountain ridge S above the village Monesi, on the ridge W above the Colle del Garezzo (Imperia) (UTM WGS84: 32T 401686 4877849), small outcrops of

calcareous schist in subalpine pasture, in fissures filled with soil, 1850 m, 21 July 2000, *J. Hafellner*, *P. L. Nimis*, *M. Tretiach*) (GZU - JH87261). – Species new to Liguria.

Diagnostic for *P. lepidophora* are the peltate isidia and the slightly tomentose upper surface (Vitikainen 1994). The species is easily overlooked because of its small size or in the dry stage mistaken for juvenile *P. leucophlebia* (Nyl.) Gyeln. This species shows a circumpolar distribution in the Holarctic. It is also reported from the Andes in South America, the Himalayas in Asia, New Zealand and Hawaii (Poelt 1990; Vitikainen 1994). Apart from some other mountains systems, this species is known in Europe throughout the Alps (Nimis et al. 2018). In Italy, this species has been reported from almost all Alpine regions, from the high mountain areas of the Apennines, and from Sicilia (Nimis 1993, 2016; Nimis and Martellos 2024).

J. Hafellner, P. L. Nimis, M. Tretiach

***Porpidia tuberculosa* (Sm.) Hertel & Knoph (Lecideaceae)**

+ **LOM**: Central Alps, Southern Rhaetian Alps, Presanella-group, Passo del Tonale, S above the pass towards Passo del Paradiso, gentle slope exposed to the N (Brescia) (UTM WGS84: 32T 621719.5123345), boulder field surrounded by krummholz, on inclined rock faces of big siliceous boulders, 1950 m, 24 July 2006, leg. *J. Hafellner*, *L. Muggia*, det. *J. Hafellner* (GZU - JH87838). – Species confirmed for Lombardia.
+ **CAL**: Serre di Catanzaro, Monte Corvo (Catanzaro), (UTM WGS84: 33S 620896.4360354), outcrops of siliceous rocks, 1020 m, 14 July 1988, *J. Poelt* (GZU). – Species new to Calabria.
+ **SIC**: Le Madonie, by the road from Piano Battaglia to Petralia Sottana, Bosco Pomieri (Palermo) (UTM WGS84: 33S 417772.4190200), in a small shady ravine, on boulders of siliceous sandstone along the creek, 1300 m, 31 May 1988, *J. Hafellner* (GZU - JH12363); *ibidem*, 31 May 1988, *J. Poelt* (GZU). – Species new to Sicilia.

Porpidia tuberculosa usually grows at sites with high humidity on persistently moist siliceous rocks near the ground. This species is widely distributed in Italy (Nimis and Martellos 2024). However, as it is found mostly as a sterile saxicolous crust, it is often overlooked or ignored. Only a historical record by S. Garovaglio (Nimis 1993) is available for Lombardia. In Sicilia the species has so far been recorded from offshore islands, namely by Jatta (1886, under the name *Lecidea sorediza* Nyl.) from one of the Pelagie Islands and by Klement (1969, under the name *Lecidea sorediza* Nyl.) from the Aeolian Islands. However, these latter records need confirmation (Nimis 1993, 2016).

J. Hafellner

***Scytinium plicatile* (Ach.) Otálora, P.M.Jørg. & Wedin (Collemataceae)**

+ **TOS**: Natural Reserve Monte Penna, Castell'Azzara (Grosseto) (UTM WGS84: 32T 718245.4739165), on partially shaded calcareous outcrops, in a mixed *Acer* sp. pl. forest near the top of Mt. Penna, on overhanging rock, 1045 m, 14 April 2023, leg. *A. Guttová*, *L. Paoli*, det. *A. Guttová* (SAV0017680). – Species confirmed for Toscana.

Scytinium plicatile is a subfoliose to squamulose lichen, with cyanobacterial photobiont and thallus strongly gelatinous when wet, forming irregular (up to 5 cm) rosettes. In the study site, it grows together with other Collemataceae, namely *Enchylium polycarpon* (Hoffm.) Otálora, P.M.Jørg. & Wedin, *Lathagrium cristatum* (L.) Otálora, P.M.Jørg. & Wedin, *S. turgidum* (Ach.) Otálora, P.M.Jørg. & Wedin. The publication of a previous record of *S. plicatile* from Toscana dates back to 1871 (as reported in Nimis 1993).

A. Guttová, L. Paoli

***Usnea cornuta* Körb. (Parmeliaceae)**

+ **SAR**: S'Arcu de Schisorgiu, pass in road Santadi-S. Lucia, com. Assemini (Cagliari), (UTM WGS84: 32S 485570 4317899), on twigs of *Erica arborea* L., in macchia on mountain ridge, 375 m, 16 April 1997, leg. *H. Sipman*, *L. Zedda*, det. *P. Clerk* (B). Monte di Seneghe, loc. Cuguzzu, along the forest road to loc. Fontanas (Oristano) (UTM WGS84: 32T 4440628 462640), on the bark of *Quercus ilex* L., 711 m, 2 July 2023, leg. *P. Giordani*, det. *W. v. Brackel*. conf. *V. Otte* (GE2867). – Species new to Sardegna.

Usnea cornuta is growing on damp sites with frequent fog, mostly in the montane belt. This species is restricted to humid-temperate, oceanic areas (Nimis 2024). The recorded population (GE2867) was found in a mature forest of *Quercus ilex* L., characterised by the presence of numerous species of the *Lobarion* community, such as *Lobaria pulmonaria* (L.) Hoffm., *Ricasolia virens* (With.) H.H. Blom. & Tønsberg and *Sticta limbata* (Sm.) Ach. (Benesperi et al. 2018). The species is included in the Italian red list of epiphytic lichens as "Endangered" (Nascimbene et al. 2013).

P. Giordani, W. v. Brackel, L. Zedda

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RESEARCH ARTICLE

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Notulae to the Italian alien vascular flora: 17

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Abstract

In this contribution, new data concerning the distribution of vascular flora alien to Italy are presented. It includes new records and status changes from casual to naturalized for Italy or for Italian administrative regions for taxa in the genera *Callianthe*, *Chamaecyparis*, *Chamaeiris*, *Cotoneaster*, *Erigeron*, *Freesia*, *Hemerocallis*, *Juglans*, *Kalanchoë*, *Ludwigia*, *Nassella*, *Paulownia*, *Physocarpus*, *Pistia*, *Saccharum*, *Setaria*, and *Vachellia*. Nomenclatural and distribution updates, published elsewhere, and corrections are provided as supplementary material.

Keywords

Alien species, floristic data, Italy, nomenclature

How to contribute

The text for the new records, status changes from casual to naturalized or invasive, 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

Callianthe picta (Gillies ex Hook. & Arn.) Donnell (Malvaceae)

+ (NAT) **ITALIA** (**SAR**): Alghero (Sassari), Santa Maria La Palma, strada SP55bis (WGS84: 40.658894°N, 8.273345°E), vegetazione antropogenica, 28 m, 12 January 2024, *F. Mascia*, *A. Maccioni* (FI, SS). – Naturalized alien species new for the flora of Italy (Sardegna).

This species is native to north-eastern Argentina, southern Brazil, Paraguay and Uruguay (POWO 2024a [onwards]); the plants were identified according to Tang et al. (2007), Donnell et al. (2012), and Takeuchi (2024 [onwards]). A dozen adults and a large number of seedlings were recorded in a roadside ditch.

A. Maccioni, F. Mascia

***Chamaecyparis lawsoniana* (A.Murray) Parl. (Cupressaceae)**

+ (NAT) **ITALIA** (**PIE**): Alto (Cuneo), nei pressi del cimitero (WGS84: 44.107883°N, 8.000641°E), margine di un bosco di latifoglie in prossimità di un impluvio fresco, 631 m, 30 November 2023, *M. Lonati*, *D. Barberis* (FI). – Status change from casual to naturalized alien for the flora of Italy (Piemonte).

This species was first recorded as a casual alien in Piemonte by Galasso et al. (2022). The observed individuals derived from seeds of mature plants used as ornamentals in the nearby cemetery. Presently, they form an uneven-aged woody patch, with many plants, from 5 to 7 m tall, regularly fruiting. Dozens of seedlings grow in the area, potentially leading to a further expansion of the population.

M. Lonati, D. Barberis

***Chamaeiris orientalis* (Mill.) M.B.Crespo (Iridaceae)**

+ (NAT) **SAR**: Stintino (Sassari), Pischina Salidda (WGS84: 40.927490°N, 8.226195°E), area di ristagno temporaneo d'acqua, 1 m, 25 June 2023, *M. Fois*, *A. Cuena-Lombraña* (FI, CAG). – Naturalized alien species new for the flora of Sardegna.

This species has probably been cultivated for its aesthetic value and appears to be able to disperse and reproduce without human intervention. A dense stand with nearly one hundred flowering individuals was found in Stintino, probably established after hydrochorous dispersal. Other smaller stands are scattered in canals and ditches in the countryside around Sassari.

M. Fois, A. Cuena-Lombraña

***Cotoneaster pannosus* Franch. (Rosaceae)**

+ (NAT) **VEN**: Verona (Verona), aree agricole a N dell'Interporto Quadrante Europa (WGS84: 45.428677°N, 10.934232°E), spontanea in filare alberato al limitare di campi agricoli coltivati, 75 m, 20 June 2023, leg. *D. Fontana*, *J. Bettin*, det. *D. Fontana*, *A. Giacò* (FI). – Naturalized alien species new for the flora of Veneto.

The population consists of few individuals scattered in a hedgerow near cropped fields. Since the shrubs show distinct sizes, one can assume that they originated through dispersion from the plants in the hedgerow. As an additional proof of sexual reproduction, at the time of collection most of the plants were flowering and fruiting.

D. Fontana, A. Giacò

***Erigeron karvinskianus* DC. (Asteraceae)**

+ (NAT) **MOL**: Campobasso (Campobasso), Stazione Centrale dei treni (WGS84: 41.5576343°N, 14.6630261°E), muro in cemento del parcheggio della stazione, 685 m, SE, 31 October 2023, leg. *M. Varricchione*, det. *D. Ciaramella* (FI). – Naturalized alien species new for the flora of Molise.

Dozens of individuals of the species grow spontaneously in the gaps between limestone blocks of the SE-facing retaining wall, spanning an area of approximately 500 m^2 along with *Dittrichia viscosa* (L.) Greuter subsp. *viscosa*, *Ficus carica* L., *Parietaria judaica* L., and *Verbena officinalis* L. The potential expansion of this species in other parts of the city should be monitored carefully.

D. Ciaramella, M. Varricchione

***Freesia leichtlinii* Klatt subsp. *alba* (G.L.Mey.) J.C.Manning & Goldblatt (Iridaceae)**

+ (NAT) **ABR**: Chieti (Chieti), cimitero locale (WGS84: 42.352755°N, 14.185811°E), margine di un percorso pedonale regolarmente sfalciato, 262 m, 12 April 2022, *A. Pica*, *J. Lupoletti* (FI). – Status change from casual to naturalized alien for the flora of Abruzzo.

In Abruzzo, this species was first reported as a casual alien by Galasso et al. (2018). Several individuals, currently in expansion, grow as naturalized in the local cemetery covering an area of about 10 m². According to Buldrini et al. (2023), cemeteries often host alien species and could potentially spread from there to the surrounding area.

A. Pica, J. Lupoletti

***Hemerocallis fulva* (L.) L. (Asphodelaceae)**

+ (NAT) **CAM**: Roccamonfina (Caserta), loc. Pepini, strada SP90 (WGS84: 41.300953°N, 14.001941°E), margini stradali nel castagneto, 600 m, 23 June 2020, *A. Croce* (FI, NAP barcode NAP0003033). – Status change from casual to naturalized alien for the flora of Campania.

In Campania, this neophyte was first reported a long time ago (Terracciano 1890) and, since then, it has been observed in several localities (Del Guacchio and La Valva 2017). The species is expanding since several years in Roccamonfina and Sessa Aurunca (Caserta)(WGS84: 41.266033°N, 13.976723°E), about 4 km away from each other.

A. Croce, E. Del Guacchio

***Juglans nigra* L. (Juglandaceae)**

+ (NAT) **SAR**: Domusnovas (Sud Sardegna), Oridda, naturalizzata lungo l'asta fluviale del Rio Oridda (WGS84: 39.406420°N, 8.620684°E), bosco di impluvio, 580 m, 16 August 2023, *G. Bacchetta*, *L. Podda* (FI, CAG). – Naturalized alien species new for the flora of Sardegna.

Several adult individuals at different growth stages, including seedlings, were found in the Oridda valley along the river at an impluvium with high soil moisture, occupying an area of approximately 200 m^2. *Juglans nigra* was found in an area where experiments on the introduction of alien species (Pavari and de Philippis 1941) and, subsequently, reforestation and afforestation activities by the Regional Forest Agency were carried out.

G. Bacchetta, L. Podda

***Kalanchoë* ×*houghtonii* D.B.Ward (Crassulaceae)**

+ (NAT) **MOL**: Termoli (Campobasso), area industriale presso il Fiume Biferno, sull'ex piazzale cementato nel complesso industriale abbandonato (WGS84: 41.957403°N, 15.023689°E), piazzale cementato abbandonato, 5 m, 14 November 2022, leg. *D. Fontana*, *J. Bettin*, det. *D. Fontana*, *J. Franzoni* (FI). – Naturalized alien nothospecies new for the flora of Molise.

The population is particularly abundant in an abandoned industrial area, where it grows in a concrete-covered area.

D. Fontana, J. Franzoni

***Ludwigia hexapetala* (Hook. & Arn.) Zardini, H.Y.Gu & P.H.Raven (Onagraceae)**

+ (NAT) **TOS**: Carrara (Massa-Carrara), fraz. Marina di Carrara, Canale Fossa Maestra (WGS84: 44.045912°N, 10.020584°E), sponda canale, 1 m, 13 September 2023, *L. Pinzani*, *E. Pelella*, *D. Di Lernia*, *F. Mariani*, *S. Ceschin* (FI, URT). – Naturalized alien species new for the flora of Toscana.

Ludwigia hexapetala was found in extensive populations, both in water and along the banks, covering a large stretch of the canal. This invasive alien species of European Union concern, listed in Regulation (EU) 1143/2014, is currently invading many Italian water-bodies, where it negatively affects water quality and impacts native plant communities (Pelella et al. 2023b), becoming a threat to the more vulnerable species (Pelella et al. 2023a).

L. Pinzani, E. Pelella

***Nassella tenuissima* (Trin.) Barkworth (Poaceae)**

+ (NAT) **ITALIA** (**LAZ**): Viterbo (Viterbo), Via A. Cerasa (WGS84: 42.427550°N, 12.095200°E), sidewalk curb joint, 170 m, 2 May 2023, *L. Cancellieri* (FI). – Status change from casual to naturalized alien for the flora of Italy; naturalized alien species new for the flora of Lazio.

Several individuals of multiple generations grow in the trenches of trees lining the street and in the joints of the sidewalk curbs. The plants reproduce autonomously, producing seeds that gradually colonize other, more distant, portions of the pavement.

L. Cancellieri

***Paulownia tomentosa* (Thunb.) Steud. (Paulowniaceae)**

+ (NAT) **CAL**: Molochio (Reggio Calabria), loc. Morgane, Vallone Acquafredda (WGS84: 38.296262°N, 16.025038°E), bosco ripariale a *Salix alba* e *Populus alba*, 358 m, 6 November 2023, leg. *A. Morabito*, det. *A. Morabito*, *C.M. Musarella* (FI). – Naturalized alien species new for the flora of Calabria.

We observed several flowering and fruiting individuals.

A. Morabito, C.M. Musarella

***Physocarpus opulifolius* (L.) Maxim. (Rosaceae)**

+ (NAT) **TAA**: Merano (Bolzano), fraz. Sinigo, Rio Valsura presso la zona industriale e artigianale di Sinigo (WGS84: 46.625929°N, 11.177888°E), vegetazione delle aree ripariali periodicamente sommerse, 278 m, 13 October 2023, leg. *G. Mei*, det. *G. Mei*, *A. Stinca* (FI, *Herb. G. Mei*); Terlano (Bolzano), fraz. Vilpiano, confluenza tra il Rio Vilpiano e il Fiume Adige (WGS84: 46.550767°N, 11.222301°E), vegetazione ripariale periodicamente sommersa e fortemente alterata, 254 m, 25 October 2023, leg. *G. Mei*, det. *G. Mei*, *A. Stinca* (*Herb. G. Mei*). – Naturalized alien species new for the flora of Trentino-Alto Adige.

The presence of a population with about 15 individuals at different stages of development, including a fair number of seedlings, in the periodically submerged areas of the Rio Valsura and some individuals of different ages in other localities downstream (e.g., WGS84: 46.603991°N, 11.184034°E, and 46.617427°N, 11.184161°E), suggests the established presence in Trentino-Alto Adige of *Physocarpus opulifolius*. In this region, this species is capable of propagating autonomously by seeds.

G. Mei, A. Stinca

***Pistia stratiotes* L. (Araceae)**

+ (NAT) **LAZ**: Roma (Roma), Villa Doria Pamphilj, canale tra l'ingresso alla villa in Via della Nocetta 30 ed il Giardino dei Giusti dell'Umanità di Roma (WGS84: 41.881634°N, 12.437535°E), canale, trovati circa 50 individui, sito molto disturbato, 50 m, 7 August 2023, *D. Di Lernia*, *S. Ceschin* (FI). – Status change from casual to naturalized alien for the flora of Lazio.

The invasive alien aquatic species of European Union concern, listed in Regulation (EU) 1143/2014 from August 2, 2024, *Pistia stratiotes*, was recently recorded in Lazio as a casual alien (Roma-Marzio et al. 2023). The finding site is located inside a very disturbed canal running through a public park. In summer, about 20 individuals of the species were found along this canal, whose numbers have more than doubled in a few months to form a rich population accompanied mainly by *Lemna minor* L. and, secondarily, by *Helosciadium nodiflorum* (L.) W.D.J.Koch subsp. *nodiflorum* and *Veronica anagallis-aquatica* L. subsp. *anagallis-aquatica*.

D. Di Lernia, S. Ceschin

***Saccharum biflorum* Forssk. (Poaceae)**

+ (NAT) **SAR**: Villasor (Sud Sardegna), loc. Acquacotta (WGS84: 39.403490°N, 8.848590°E), terreni umidi disturbati, 56 m, 13 January 2009, *F. Mascia* (CAG); Capoterra (Cagliari), loc. Tanca di Nissa (WGS84: 39.168813°N, 9.008524°E), agrumeti abbandonati, 3 m, 8 April 2013, *F. Mascia* (CAG); Elmas (Cagliari), Strada rurale Sa Bruvurera (WGS84: 39.28312°N, 9.02907°E), margini stradali lungo campi abbandonati, 12 m, 26 January 2024, *A. Lallai*, *F. Mascia* (FI, CAG). – Staus change from undefined to naturalized alien for the flora of Sardegna.

According to local people from Assemini (Cagliari), *Saccharum biflorum* was introduced by farmers in the second half of the 1960s, to form hedges protecting crops. In cultivation the species reproduces clonally, but its dispersal on the island can be attributed to its ability to vegetatively and sexually reproduce, as demonstrated in other areas where it occurs as an alien (Bonnett et al. 2014; Guarino et al. 2023). Accordingly, this species is considered naturalized for Sardegna.

A. Lallai, F. Mascia

***Setaria italica* (L.) P.Beauv. subsp. *pycnocoma* (Steud.) de Wet (Poaceae)**

+ (NAT) **TAA**: Avio (Trento), Pieve di Avio (WGS84: 45.732745°N, 10.928641°E), vegetazione prativa della scarpata stradale e dei campi limitrofi, 182 m, 11 August 2023, leg. *G. Mei*, *E. Grande*, det. *G. Mei*, *A. Stinca* (FI). – Status change from casual to naturalized alien for the flora of Trentino-Alto Adige.

Populations of this subspecies are widespread along roadsides, in peri-urban prairies and between rows of vineyards also in other localities (e.g.: Avio [Trento], loc. Ai Prati [WGS84: 45.733901°N, 10.942455°E], 12 August 2023, *G. Mei*, *E. Grande*, *A. Stinca*; Sabbionara [Trento], loc. Sant'Antonio [WGS84: 45.743398°N, 10.949965°E], 12 August 2023, *G. Mei*, *E. Grande*, *A. Stinca*; Ora-Auer [Bolzano], loc. San Floriano [WGS84: 46.395229°N, 11.312820°E], 19 September 2023, *G. Mei*, *E. Grande*, *A. Stinca*). Accordingly, this taxon is considered naturalized in Trentino-Alto Adige.

G. Mei, A. Stinca

***Vachellia farnesiana* (L.) Wight & Arn. (Fabaceae)**

+ (NAT) **ITALIA** (**CAL**): Brancaleone (Reggio Calabria), loc. Brancaleone Superiore (WGS84: 37.971633°N, 16.084061°E), praterie steppiche ad *Ampelodesmos mauritanicus* e *Hyparrhenia hirta*, 161 m, 23 May 2021, *V.L.A. Laface*, *C.M. Musarella* (FI, REGGIO). – Status change from casual to naturalized alien for the flora of Italy (Calabria).

In Calabria, *Vachellia farnesiana* was reported as a casual alien since 2019 (Galasso et al. 2019). It forms dense, impenetrable fertile populations that occupy steppe grasslands with *Ampelodesmos mauritanicus* (Poir.) T.Durand & Schinz and *Hyparrhenia hirta* (L.) Stapf (Habitat 6220* according to Directive 92/43/EEC).

V.L.A. Laface, C.M. Musarella

Nomenclatural and distribution updates from other literature sources

Nomenclatural, status, and distribution updates according to Lucchese (2017), Bonali (2020), Gariboldi (2021), Ciaschetti and Di Cecco (2023), Martini et al. (2023), Iamonico and Nicolella (2024), Iamonico et al. (2024), Klak et al. (2024), Lonati et al. (2024), Musarella et al. (2024), Patti et al. (2024), POWO (2024b [onwards], 2024c

[onwards], 2024d [onwards]), Roma-Marzio et al. (2024), and Ruggero et al. (2024) and corrections according to Galasso et al. (2024), are provided in Suppl. material 1.

G. Galasso, F. Bartolucci

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Supplementary material 1

Supplementary data

Authors: Gabriele Galasso, Fabrizio Bartolucci

Data type: pdf

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

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RESEARCH ARTICLE

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Pleurotus nebrodensis (Basidiomycota), a rare endemic mushroom of Sicily: current and future issues

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Abstract

This paper deals with the basidiomycete *Pleurotus nebrodensis*, one of the rare examples of endemic fungi in Italy and Europe. After clarifying the taxonomy of this taxon, including a comparison with a species from China misidentified as "*Pleurotus nebrodensis*", we describe the characteristics of its natural habitat, and provide a new morphological description and information on its pilot-scale cultivation, current conservation status according to IUCN criteria and conservation strategies. New ITS region sequences were deposited in GenBank. Furthermore, the antibacterial and anti-cancer properties of *P. nebrodensis* are mentioned, making it a potential medicinal mushroom. Finally, a critical analysis, on a phylogenetic basis, of the Italian production of substrates inoculated with "*P. nebrodensis*" strains is also included.

Keywords

Basidiomycete, fungal diversity, medicinal mushroom, mediterranean area

Introduction

The term endemism refers to a species whose occurrence is indigenous and exclusive to limited territories and lacking in the surrounding and distant ones. Endemic species are generally extremely vulnerable to climate change because evolution has led them to

be formed exactly for that site (Veron et al. 2019). The application of the term endemic for fungi is problematic, although some cases have been demonstrated over time. The study of fungal endemism, especially on islands, is often hampered by insufficient data making it difficult to apply the term endemic and evaluate case studies (Stallman et al. 2022). In the State of Biodiversity in Italy, published in 2005 (Blasi et al. 2005), 56 fungal species are reported as possible endemics.

The environmental characteristics of Sicily and its numerous ecosystems allow for high levels of biodiversity to be found on the island in all groups of organisms. Plant species endemic to Sicily amount to about 15% and include taxa with a punctiform distribution (Di Gristina et al. 2022) while only one fungal species, *Pleurotus nebrodensis* (Inzenga) Quél. (Pleurotaceae), is currently reported as endemic (Ferraro et al. 2022).

Along with *Alessioporus ichnusanus* (Alessio, Galli & Littini) Gelardi, Vizzini & Simonini (Angelini et al. 2021) and *Poronia punctata* (L.) Fr. (Ceci et al. 2021), *P. nebrodensis* is one of the few Italian fungal species currently included on the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species and is in the TOP 50 Mediterranean Island Plants (https://top50.iucn-mpsg.org/species/39). This condition makes *in situ* and *ex situ* conservation strategies necessary.

Among the conservation strategies indicated by Courtecuisse (2001), that of natural habitat conservation appears to be the most effective. Based on International Union for Conservation of Nature (IUCN) criteria, the Extent of Occurrence (EOO) of the *P. nebrodensis* population is less than 100 km^2. The population is severely fragmented and there has been a progressive decline in the number of localities, now fewer than ten (Pasta et al. 2017). The number of mature individuals is <150 with alternating pattern in the fruiting years with an average of *ca*. 70 basidiomata/year. This is mainly due to the increasing number of collectors (professional and amateur), motivated by the high commercial price (50–60 euros per kg) and the remarkable organoleptic properties of this mushroom, despite the absence of a real market for the product. Another negative drawback of the increasing human pressure is the harvesting of young basidiomata, which may seriously affect fruiting of this prized species in the near future (Gargano et al. 2011).

Article 5 of the Madonie Park's Regulation on the Collection of Epigean Mushrooms, issued in 2017, the territory within which all the growth localities of the rare endemic mushroom fall, states that the collection of *P. nebrodensis* in zone A, a wild zone under total protection, is prohibited, while in the other zones collection of basidiomata smaller than 3 cm in size is prohibited. *P. nebrodensis* is also protected by the park's regulations as well as by Regional Law No. 3 (February 1, 2006).

Moreover, subpopulations of *P. nebrodensis* fall within Natura 2000 sites, which are all included in the territory of the Madonie Mountains and more specifically in the following localities: ITA020004 "M. San Salvatore, M. Catarineci, Vallone Mandarini, humid environments, "ITA020016 "Monte Quacella, Monte dei Cervi, Pizzo. Carbonara, Monte Ferro, Pizzo Otiero", and ITA020020 "Evergreen oak forests of Geraci Siculo and Castelbuono".

One of the strategies for *ex situ* conservation, particularly for saprotrophic fungi whose mycelium can be easily reproduced in the laboratory, is that of cultivation

outside its habitat. This has considerable relevance in the case of fungal species at risk of extinction or closely confined to threatened habitats. In the Mediterranean region, the cultivation of *Pleurotus* species is diffused and represents *ca*. 10–20% of total mushroom production (Ferraro et al. 2022). The *ex situ* cultivation of *P. nebrodensis* is part of the project "PLEURÒN - Project for the cultivation of *Pleurotus nebrodensis* in a protected environment for food, medicinal and phytogenic purposes", recently approved (2023) by the Sicilian Administrative Region and aimed at cultivating the mushroom on a pilot scale and in a protected environment. The partnership consists of Consortia for Research, Universities and farms located in the Madonie territory. This ambitious project is based on previous positive experiences in growing *Pleurotus* mushrooms in Italy (Varese et al. 2011; Venturella et al. 2016). In particular, *P. nebrodensis* can be grown at different altitudes within semi-shaded tunnels. Moreover, cultivated *P. nebrodensis* basidiomata have the same organoleptic features as the wild basidiomata (Zervakis and Venturella 2002). Thus, *ex situ* cultivation will provide additional income to local farmers, with the possibility of selling the product at lower prices than those of mushrooms collected in the wild. Finally, *ex situ* cultivation would ensure a gradual reduction in pressure from the many seekers of the prized mushroom in nature.

In this survey we report the taxonomy, ecology, distribution, and potential applications of this important Sicilian endemic fungus. In addition, because the binomial "*Pleurotus nebrodensis*" is often misapplied, an attempt is made to help clarify the exact taxonomic placement of the mycelium marketed by a leading company selling mushroom-growing substrates under the name "*Pleurotus nebrodensis*".

Materials and methods

Collection, habitat details and morphological characters

Field research carried out in pastures of the Madonie mountains (N. Sicily, Italy) led to the collection of a white-colored mushroom on dead roots of *Prangos ferulacea* (L.) Lindl., a perennial herbaceous plant distributed in the Mediterranean Basin, the Bulgarian Black Sea coast, and the Caucasus. In accordance with the Prodrome of Vegetation in Italy (Biondi and Blasi 2005), *P. ferulacea* is part of the plant association no. 62.2.1 *Cerastio-Astragalion nebrodensis* Pignatti & Nimis ex Brullo 1984 in which xerophilous and basiphilous communities occurring on dolomitic substrates with more or less pronounced slopes, mainly on consolidated rocks and sometimes on rocky ridges, are present (Fig. 1). This plant association is distributed throughout the Madonie mountains in the supramediterranean thermotype.

Field excursions were carried out in the years 2022 and 2023 during the fruiting period of *P. nebrodensis* extending from late April to early June. The research localities fall in the area of Monte dei Cervi (1794 m), a mountain falling within the territories of Scillato and Polizzi Generosa, 37°52'45"N, 13°58'14"E (DMS), and Vallone Faguare a canyon located at 1,263 m a.s.l., 37°51'42"N, 14°03'54"E (DMS) in the

Figure 1. Pastures of *Prangos ferulacea* on the Madonie mountains of northern Sicily (Photo G. Venturella).

territory of Petralia Sottana (Madonie mountains). Based on the classification of Rivas-Martinez (1995), the bioclimatic characters of the area can be overall referred to the mesomediterranean (average temperature: 13–16 °C) and supramediterranean (average temperature: 8–13 °C) thermotypes, with ombrotype varying between subhumid (average rainfall: 600–1000 mm) and humid (average rainfall: >1000 mm).

Six fresh basidiomata of *P. nebrodensis* were collected and identified according to macroscopic characters (cap, flesh, lamellae, stipe, type of occurrence, color of spore prints, etc.). In addition, microscopic characters (basidiospores, basidia, cheilocystidia, hyphal system, hyphal wall, hyphae, and pellis) were observed at 40X-1000X (AmScope, Irvine, USA). The morphological examination was carried out according to Venturella et al. (2015).

The specimens (Fig. 2A) were dried at 40 °C in a 475 W stainless steel dryer (Mauro Valla, Borgotaro, Italy) and deposited in the Herbarium SAF of the Department of Agricultural, Food and Forest Sciences (SAAF 503) of the University of Palermo. The nomenclature of fungi follows Index Fungorum while the binomial of plants is referred to Euro + Med PlantBase (www.emplantbase.org).

Establishment of pure cultures

A piece of tissue from fresh basidiomata was placed on potato dextrose agar (PDA) in Petri dishes under aseptic conditions under a laminar flow hood. The Petri dishes were sealed with Parafilm and incubated at 25 ± 2 °C. The pure culture is kept in the Mycotheca of the Herbarium SAF (SAF 40) (Fig. 2B).

Figure 2. *Pleurotus nebrodensis* samples **a** Exsiccata of *P. nebrodensis* deposited in the Herbarium SAF of Palermo University **b** Pure culture of *P. nebrodensis* (Photo G. Mirabile).

Extraction of DNA, amplification, ITS sequencing and phylogenetic analysis

Twelve marketed cultivation bags (four strains, indicated as 1, G, 6, and 8, in three replicates), inoculated with *P. nebrodensis* mycelium, provided by Italmiko (Senise, Potenza), were analyzed in order to identify, by a molecular approach, the exact taxonomic identity of basidiomata. DNA was extracted from fresh basidiomata using the Extract-N-Amp™ kit (Sigma-Aldrich, St. Louis, USA) following the manufacturer's instructions. DNA purity and concentration were measured at 260/280 nm and 260/230 nm using the NanoDrop ND-1000 spectrophotometer (Thermo Fisher Scientific, Waltham, USA). The Internal Transcribed Spacer (ITS) region of rDNA was amplified using ITS1F and ITS4 primers by polymerase chain reaction (PCR) in a total reaction volume of 20 µl (4 µl of extracted DNA, 1 µl of each primer at 10 µM ,10 µl of the Extract-N-Amp PCR reaction mix (Sigma-Aldrich, St. Louis, USA), and 4 µl of sterilized distilled water. The amplification was performed in a MultiGene OptiMax thermocycler (Labnet International Inc., Edison, USA) with the following parameters: 3 min of initial denaturation cycle at 94 °C; 35 cycles at 94 °C for 30 s; annealing stage at 55 °C for 30 s; elongation for 45 s at 72 °C and 10 min of final extension at 72 °C. PCR product was separated in 1.5% agarose gel by electrophoresis and detected under UV light. PCR product was purified using Exo I-SAP protocol (Applied Biosystems, Foster City, USA) and sent to BMR Genomics (Padova, Italy) for sequencing. In the sequencing reaction, only primer ITS1F was used. The obtained sequence was manually adjusted and compared with those in GenBank using the BLASTn tool (https://blast.ncbi.nlm.nih.gov).

The new sequences were deposited in GenBank. Sequences with 99–100% of similarity, as well as *P. eryngii* complex representative sequences from a previous ITS-phylogenetic study (Table 1, Zervakis et al. 2014) were obtained from GenBank and aligned with the isolated sequence obtained in this study. Alignments were performed using ClustalW software and manually adjusted, if necessary, using MEGA11. The Neighbour-Joining algorithm was used to generate the phylogenetic tree and the evolutionary distances were calculated based on Maximum Composite Likelihood. Bootstrap percentages were calculated from 1000 re-samplings.

Table 1. Strains of *Pleurotus* used for ITS-phylogenetic analysis. Those obtained in this study are in bold.

Taxon	Host	Geographic origin	Accession number
P. eryngii var. *eryngii*	*Eryngium* sp.	China	HM998840
P. eryngii var. *eryngii*	*Eryngium* sp.	Ukraine	HM998820
P. eryngii var. *eryngii*	*Eryngium* sp.	Italy	KF743828
P. eryngii var. *eryngii*	*Eryngium maritimum*	Greece	HM998811
P. eryngii	Commercial	China	HM998841
P. eryngii	Apiaceae	Iran	HM998833
P. eryngii	**Commercial**	**Italy**	OR681547
P. eryngii var. *elaeoselini*	*Laserpitium latifolium*	Italy	HM998827
P. eryngii var. *elaeoselini*	*Laserpitium siler*	Italy	HM998825
P. eryngii var. *elaeoselini*	*Elaeoselinum asclepium*	Italy	HM998819
P. eryngii var. *elaeoselini*	*Laserpitium latifolium*	Italy	KF743824
P. eryngii var. *ferulae*	*Ferula communis*	France	HM998808
P. eryngii var. *ferulae*	*Ferula communis*	Greece	HM998813
P. eryngii var. *ferulae*	*Ferula communis*	Greece	HM998814
P. eryngii var. *thapsiae*	*Thapsia garganica*	Italy	HM998815
P. eryngii subsp. *tuoliensis*	*Ferula* sp.	Iran	HM998836
P. eryngii subsp. *tuoliensis*	*Ferula sinkiangensis*	China	HM998839
P. eryngii subsp. *tuoliensis*	*Ferula sinkiangensis*	China	HM998842
P. nebrodensis	*Prangos ferulacea*	Greece	KF743821
P. nebrodensis	*Prangos ferulacea*	Italy	HM998818
P. nebrodensis	*Prangos ferulacea*	Greece	KF743820
P. nebrodensis	*Prangos ferulacea*	Greece	HM998826
P. nebrodensis	*Prangos ferulacea*	Italy	HM998816
P. nebrodensis	*Prangos ferulacea*	Italy	HM998832
P. nebrodensis	*Prangos ferulacea*	Italy	KF743830
P. nebrodensis	**Commercial**	**Italy**	OR681545
P. nebrodensis	**Commercial**	**Italy**	OR681546
P. nebrodensis	**Commercial**	**Italy**	OR681548
P. ferulaginis	Apiaceae	Iran	KF743829
P. ferulaginis	*Ferulago campestris*	Italy	KF743833
P. ferulaginis	*Ferulago campestris*	Italy	KF743826
P. ferulaginis	*Ferulago campestris*	Italy	KF743827

Results

Taxonomy

Pleurotus nebrodensis (Inzenga) Quél. was described under the binomial *Agaricus nebrodensis* by Giuseppe Inzenga (Inzenga 1863), one of the most eminent mycologists of the second half of the 19th century. Different binomials have been attributed to *P. nebrodensis* many of them have subsequently fallen into synonymy with *P. nebrodensis*. Saccardo (1915) considered *P. nebrodensis* as a variety of *Pleurotus eryngii* (DC.) Quél. while other authors report the binomials of *Agaricus fossulatus* Cooke (Aitchinson 1888) or *Dendrosarcus fossulatus* (Cooke) Kuntze (1898). The study of herbarium material deposited at the Muséum National d'Histoire Naturelle in Paris (Venturella 2000) revealed that the *exsiccatum* positioned in the center of the herbarium sheet (Fig. 3A) corresponds to *P. nebrodensis* and is

perfectly superimposable on the original drawing of Giuseppe Inzenga (Fig. 3B). The subsequent elucidation by Venturella et al. (2016) confirmed Inzenga's intuition that *P. nebrodensis* is a valid species and that the binomial *A. fossulatus* is to be referred to *P. nebrodensis* subsp. *fossulatus* (Cooke) Zervakis & Venturella, and is a related Asiatic taxon growing on *P. ferulacea.*

Morphological description

The basidiomata of *P. nebrodensis* (Fig. 4) are fleshy with a pileus 3.0–15.0 cm wide, applanate, uplifted, shallowly depressed, convex or conchate, light ivory to cream. The margin of the pileus is plane, incurved, uplifted with a surface entire or eroded, smooth. The cuticle is glossy or translucent, dry, smooth (glabrous) or becoming cracked. The color of the flesh is cream, with consistency hard-tough to turgid, color unchanging when cut, sulphur-yellow when dry, 1–2 mm thick at the margin and 1–4 cm thick at the center. The taste is mildly farinaceous. Lamellae 4–8 mm width, 2.5–7.5 cm length, annexed to decurrent, gill spacing sub-distant to close, moderately broad in thickness, light ivory, margin of gills smooth to eroded, face of gills waxy, lamellulae present, extending one-half to one-third the length of gills. Stipe 1.5–3 cm width, 2.5–4.5 cm length, terete in cross section, slightly tapered to tapered at the base. Consistency fibrous, flesh solid to stuffed. Stipe eccentrically or lateral attached to pileus, inserted in the root residues of *P. ferulacea*, basal tomentum and veil absent. The stipe surface is smooth, light ivory colored. The habit is solitary or connate. Basidiospore print light ivory to cream. Basidiospores 12.5–15.1(–18) × 5.2–6.1 µm, cream, asymmetrical, cylindrical to phaseoliform, smooth, hyaline, guttulate. Basidia 4-spored, with basidioles 40–50 × 10–11.5(–14) µm, sterigmata 3–4.5 µm. Cheilocystidia (leptocystidia) 50–60 × 6.2–7.5(–9) µm, clavate, apex mucronate to capitulate. Hyphal system monomitic. Hyphal wall thin. Hyphae septate with clamp connections. Specialized hyphae absent, no pigmentation. Pellis in two layers, 5–10 µm width.

Figure 3. *Pleurotus nebrodensis* **a** herbarium sheet deposited in PC showing a specimen of Sicilian provenance of *P. nebrodensis* (sub. *Agaricus nebrodensis* Inz.) in the center **b** the original drawing of the medium-sized basidiome of *P. nebrodensis* by Giuseppe Inzenga (1863).

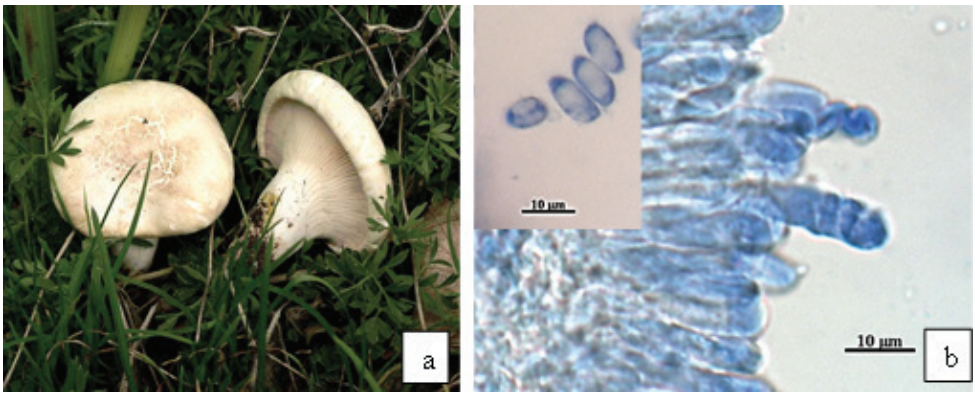

Figure 4. Basidiomata of *Pleurotus nebrodensis* **a** *In situ* (Photo G. Venturella) **b** microscopic features (basidia and spores) (Photo G. Mirabile).

Analysis of mycelium contained in commercial cultivation bags

In a separate publication, the commercial strains on the international market under the name "*Pleurotus nebrodensis*" were verified, and it was shown that the great part of them do not correspond to *P. nebrodensis* but should be referred to another taxon, i.e. *Pleurotus* subsp. *tuoliensis* (C.J. Mou) Zervakis & Venturella (Venturella et al. 2016). Fresh mushrooms morphologically similar to *P. nebrodensis* of uncertain taxonomic identity are still cultivated and marketed in Italy. Based on the certified source material belonging to true *P. nebrodensis*, preserved in the Herbarium SAF of the Department of Agricultural and Forestry Sciences (University of Palermo, Italy) we investigated 12 cultivation bags, labelled by the provider and inoculated with mycelium of "*P. nebrodensis*" and marketed by a leading company located in southern Italy that applied for certification.

Molecular and phylogenetic analysis of the twelve marketed cultivation bags (Fig. 5) showed that the mushrooms grown in bags labeled as 1 and 8 clustered with *P. nebrodensis*. The mushrooms obtained in the bags labeled with the letter "G" falls in the cluster *P. eryngii sensu stricto*, shown in Fig. 6.

Regarding the three replication of cultivation bags labeled as 6, two of them belongs to *P. nebrodensis* cluster (Fig. 6), while one replication, which presented a completely different mycelium morphology, resulted as *Irpex latemarginatus* (Durieu & Mont.) C.C. Chen & Sheng H. Wu, probably a contaminant.

Discussion

Italy, located in the center of the Mediterranean basin, is considered one of 34 global biodiversity hotspots (Mittermeier et al. 2011). Hotspots are key locations for biodiversity conservation because they have a high rate of endemic species. Sicily, due

Figure 5. Bag "G" producing *Pleurotus eryngii* mushrooms (left) and bag n. 1 producing the *P. nebrodensis* (right) (Photos G. Mirabile).

to its insularity and the topography of the land, is home to a rich animal, plant and fungal diversity. *Pleurotus nebrodensis* and its habitat are currently not protected by any international conservation rules. Consequently, there is an urgent need to raise awareness among policy makers and the scientific community to implement appropriate conservation actions and sustainable use towards this important natural resource. The regulation on mushroom picking by the Madonie Park Authority to limit the negative impact on *P. nebrodensis* fructification is often ignored by gatherers given the poor controls. *Ex situ* cultivation will reduce the pressure due to overharvesting in natural habitats and at the same time lower the cost of this prized mushroom, which is currently too high for the pockets of most consumers. Finally, given the environmental and economic value of the *P. nebrodensis* stand, it is desirable to encourage the involvement of citizens and an increase in public awareness for the protection and enhancement of *P. nebrodensis*. Citizen interest in this mushroom can also stimulated by the demonstrated medical application potential of *P. nebrodensis*. Different medicinal properties are attributed to the genus *Pleurotus* (Fr.) P. Kumm (Lesa et al. 2022). In recent years, data have been published on the antibacterial and antitumor properties of other *Pleurotus* species fruiting in the Mediterranean Basin. As regards *P. nebrodensis* from Sicily, it contains biologically active compounds that act in modulating the immune system and inhibiting the growth of cancer cells (Alam et al. 2011). Specifically, the water extract of *P. nebrodensis* is able to suppress proliferation of colon cancer cells without significant effects on proliferation of normal cells. It also has a potential application in contrasting the biofilm mode of growth of human pathogens. Cold water extracts were tested on human colon cancer cells (Fontana et al. 2014) with positive effects on antitumor activity and immunomodulation and increased natural killer cell activity.

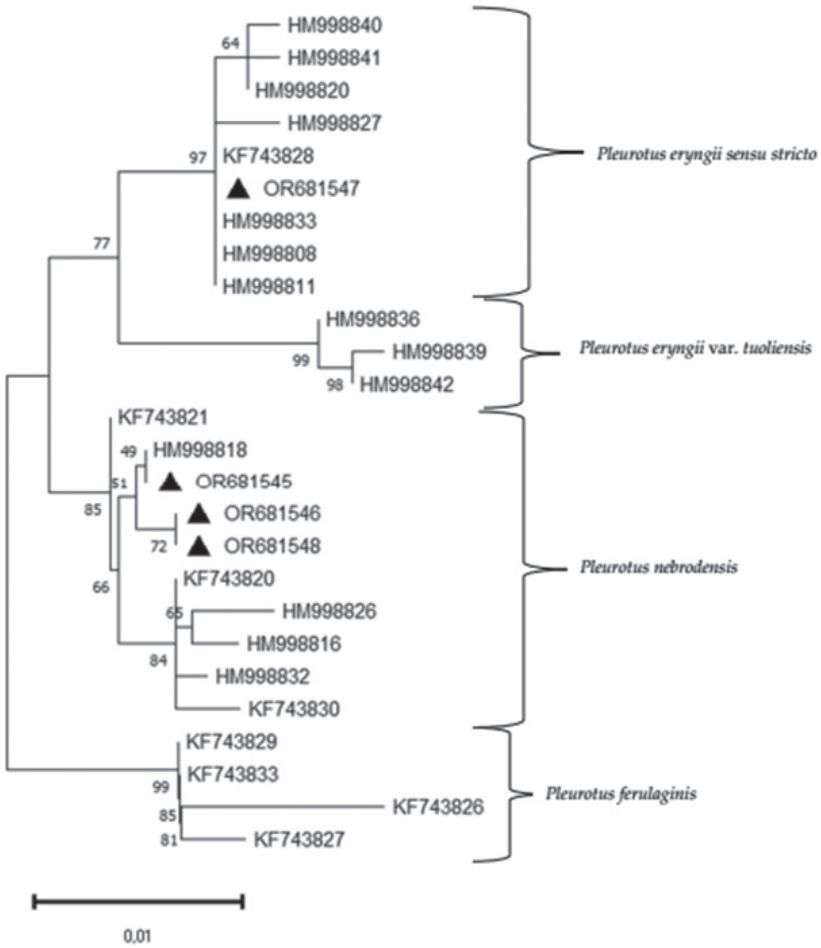

Figure 6. Phylogenetic tree obtained from the analysis of ITS1-5.8S-ITS2 sequences obtained from this study (labelled with black triangle) and additional sequences from NCBI.

The same extracts were also tested *in vivo* against medically relevant bacteria, such as *Pseudomonas aeruginosa*, *Staphylococcus epidermidis*, *S. aureus*, and *Escherichia coli*. These findings open interesting perspectives for the inclusion of *P. nebrodensis* among the most valuable mushroom-based products to be used in integrated medicine.

There is also a need to resolve the confusion that exists in the commercial exploitation of material bearing the name "*Pleurotus nebrodensis*" through accurate taxonomic identification in order to ensure that products on the market are of safe origin and genetic purity. This covers both the production of mushrooms for the food market and the supply of dried powders for the production of mushroom-based products. In the first case, there is a problem that can be traced to a practice long in use by mushroom hunters in the Madonie mountains of mixing basidiomata of *P. nebrodensis* with another morphologically similar white fungus named *P. eryngii* var. *elaeoselini*

Venturella, Zervakis & La Rocca (Fig. 7). However, this taxon is genetically separated from *P. nebrodensis* as it falls into the species complex of *P. eryngii* (Zervakis et al. 2014).

It has been recently demonstrated that the Italian market for mushroom-based products is characterized by products of dubious origin (Risoli et al. 2023). Thus, the future use of dried powders of *P. nebrodensis* in the production of mushroom-based products, one of the main targets of the above-mentioned project recently funded by the Sicilian Administrative Region, cannot disregard a careful review of all the genetic material sold by the companies that produce substrates and mushrooms in order to enable them to supply the market with the real "*P. nebrodensis*". In addition, based on the results that will emerge from the PLEURON project, we suggest not to allow the cultivation of species related to *P. nebrodensis* in the Madonie territory in order to avoid the risk of genetic mixing between congeneric species.

Figure 7. Basidiomata of *Pleurotus eryngii* var. *elaeoselini* are almost impossible to distinguish macroscopically from those of *P. nebrodensis*. (Photo G. Venturella).

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RESEARCH ARTICLE

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Chromosome numbers for the Italian flora: 14

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Abstract

In this contribution, new chromosome data obtained on material collected in Italy are presented. It includes the first counts for four subspecies of the Italian endemic *Centaurea aplolepa* Moretti, i.e. *C. aplolepa* subsp. *aplolepa*, *C. aplolepa* subsp. *bertolonii*, *C. aplolepa* subsp. *levantina*, and *C. aplolepa* subsp. *parvula*. In addition, the first chromosome count for an Italian population of *Silene canescens* (Caryophyllaceae) is provided.

Keywords

Asteraceae, Caryophyllaceae, *Centaurea*, cytotaxonomy, endemism, *Silene*

How to contribute

Texts concerning new chromosome data should be submitted electronically to Antonio Giacò (antonio.giaco@biologia.unipi.it), including indications on voucher specimens and methods used.

Chromosome counts

Centaurea aplolepa Moretti subsp. *aplolepa* (Asteraceae)

Chromosome number. $2n = 18$ (Fig. 1).

Voucher specimen. Italy. Liguria. Capo Noli (Savona), sulle pareti rocciose (WGS84: 44.196751°N, 8.424978°E), 12 July 2023, *A. Giacò, L. Peruzzi* (PI066169).

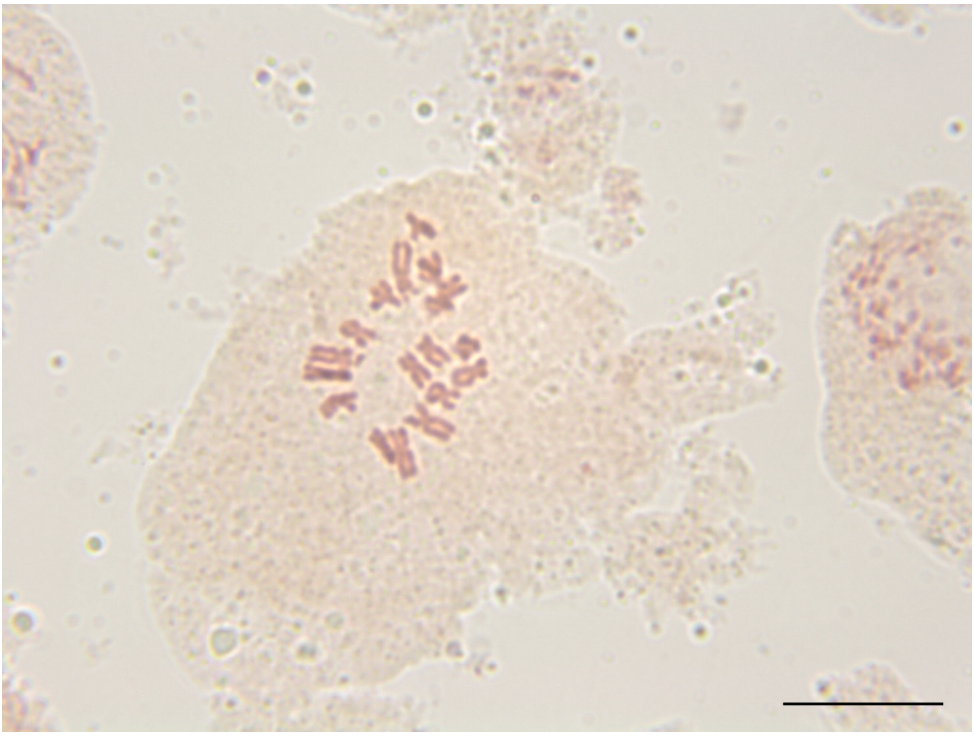

Figure 1. *Centaurea aplolepa* Moretti subsp. *aplolepa* from Capo Noli (Savona), 2*n* = 18. Scale bar: 10 μm.

Method. Squash preparations were made on root tips obtained from germinating seeds. Root tips were pre-treated with 0.4% colchicine for 3 h and then fixed in Carnoy solution for 1 h. After hydrolysis in 1N HCl at 60 °C for 7.5 minutes, the tips were stained with leuco-basic fuchsine.

Observations. *Centaurea aplolepa* is endemic to the Tyrrhenian portion of central-northern Italy and includes ten subspecies (Greuter 2008). The autonymic subspecies is endemic to western Liguria, where it grows on garrigues and cliffs along the coastline (Arrigoni 2003). The chromosome number, obtained from seeds, is reported here for the first time, and is in accordance with chromosome counts previously published for other subspecies of *C. aplolepa* (Viegi et al. 1972; Viegi and Cela Renzoni1976).

A. Giacò, L. Peruzzi

***Centaurea aplolepa* Moretti subsp. *bertolonii* (Arrigoni) Greuter (Asteraceae)**

Chromosome number. 2*n* = 18 (Fig. 2).

Voucher specimen. Italy. Liguria. Italia, Genova, nei pressi di Forte Sperone (WGS84: 44.437325°N, 8.931887°E), 12 July 2023, *A. Giacò, L. Peruzzi* (PI066182).

Method. Squash preparations were made on root tips obtained from germinating seeds. Root tips were pre-treated with 0.4% colchicine for 3 h and then fixed in Carnoy

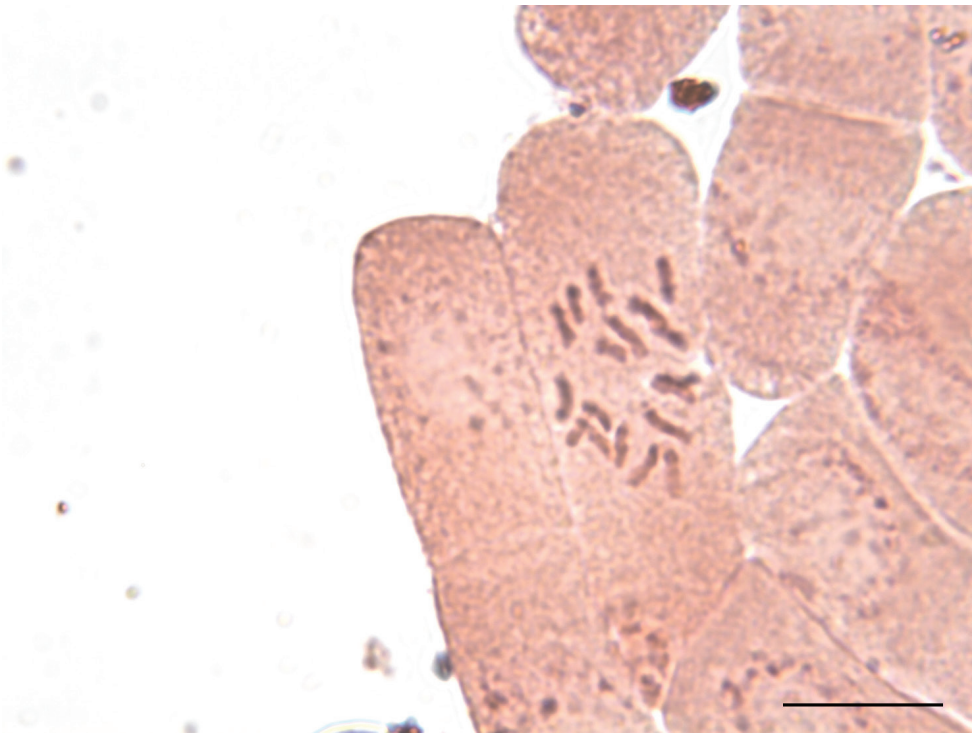

Figure 2. *Centaurea aplolepa* Moretti subsp. *bertolonii* (Arrigoni) Greuter from Genova, 2*n* = 18. Scale bar: 10 μm.

solution for 1 h. After hydrolysis in 1N HCl at 60 °C for 7.5 minutes, the tips were stained with leuco-basic fuchsine.

Observations. *Centaurea aplolepa* subsp. *bertolonii* is endemic to the hills over and west of Genova, showing a distribution range that is approximatively in-between those of *C. aplolepa* subsp. *aplolepa* to the west and *C. aplolepa* subsp. *levantina* and *C. aplolepa* subsp. *lunensis* to the east (Arrigoni 2003). The chromosome number, obtained from seeds, is reported here for the first time.

A. Giacò, M. Pentassuglia, L. Peruzzi

***Centaurea aplolepa* subsp. *levantina* (Arrigoni) Greuter (Asteraceae)**

Chromosome number. 2*n* = 18 (Fig. 3).

Voucher specimen. Italy. Liguria. Sestri Levante (Genova) (WGS84: 44.269873°N, 9.38648°E), piccoli affioramenti rocciosi presso il molo, *A. Giacò, L. Peruzzi* (PI066170).

Method. Squash preparations were made on root tips obtained from germinating seeds. Root tips were pre-treated with 0.4% colchicine for 3 h and then fixed in Carnoy solution for 1 h. After hydrolysis in 1N HCl at 60 °C for 7.5 minutes, the tips were stained with leuco-basic fuchsine.

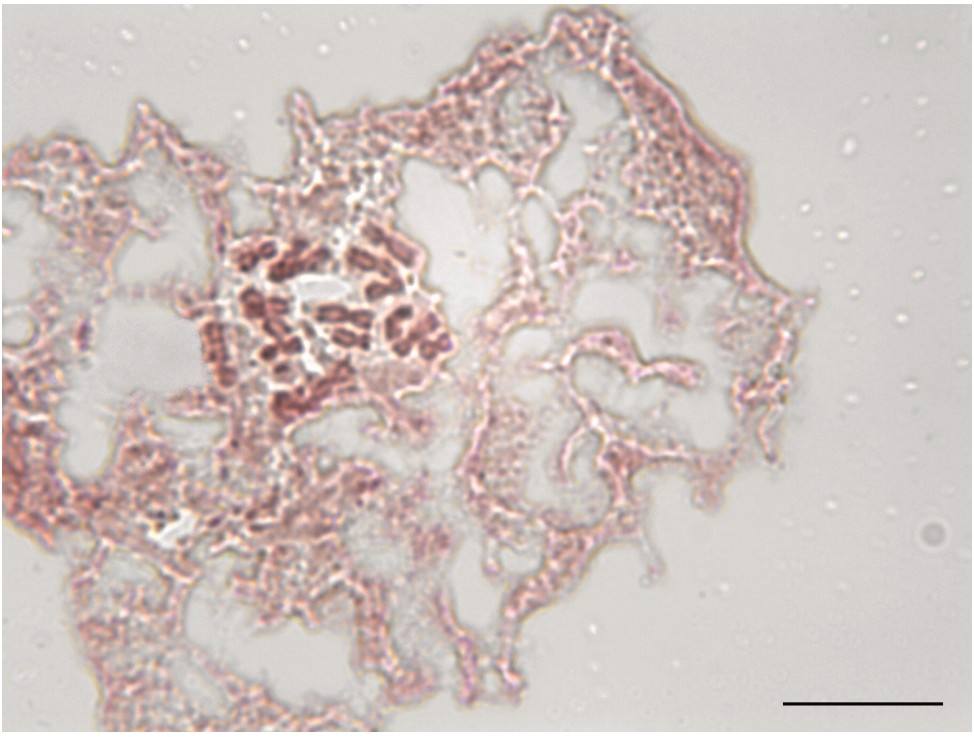

Figure 3. *Centaurea aplolepa* Moretti subsp. *levantina* (Arrigoni) Greuter from Sestri Levante (Genova), $2n = 18$. Scale bar: 10 µm.

Observations. According to Arrigoni (2003), *Centaurea aplolepa* subsp. *levantina* is a coastal ecotype endemic to eastern Liguria. The chromosome number, obtained from seeds, is reported here for the first time.

A. Giacò, M. Pentassuglia, L. Peruzzi

***Centaurea aplolepa* subsp. *parvula* (Ces.) Arcang. (Asteraceae)**

Chromosome number. $2n = 18$ (Fig. 4).

Voucher specimen. Italy. Piemonte. Acqui Terme, su calanchi (WGS84: 44.58492°N, 8.35745°E), 12 August 2023, *A. Mo* (PI066166).

Method. Squash preparations were made on root tips obtained from germinating seeds. Root tips were pre-treated with 0.4% colchicine for 3 h and then fixed in Carnoy solution for 1 h. After hydrolysis in 1N HCl at 60 °C for 7.5 minutes, the tips were stained with leuco-basic fuchsine.

Observations. Albeit *Centaurea aplolepa* subsp. *parvula* was not included by Arrigoni (2003) in his taxonomic revision of the *Centaurea paniculata* L. group, according to Bartolucci et al. (2024), this subspecies is endemic to Liguria and Piemonte. While in Liguria it is only reported for Rossiglione (Genova) (Gola 1912), the only record for Piemonte is represented by the type locality, at Acqui Terme

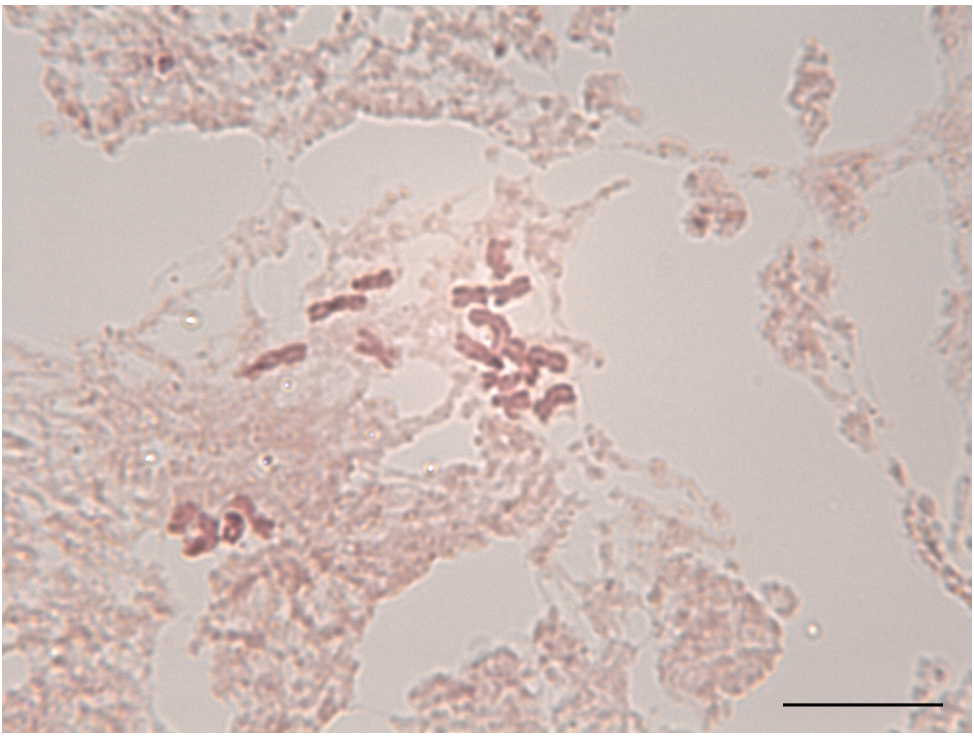

Figure 4. *Centaurea aplolepa* Moretti subsp. *parvula* (Ces.) Arcang. from Acqui Terme (Alessandria), $2n = 18$. Scale bar: 10 µm.

(Alessandria). During a field trip, we found there several populations growing on badlands. The chromosome number, obtained from seeds, is reported here for the first time.

A. Giacò, A. Mo

***Silene canescens* Ten. (Caryophyllaceae)**

Chromosome number. $2n = 24$ (Fig. 5).

Voucher specimen. Italy. Toscana. Marina di Torre del Lago (Viareggio, Lucca), retroduna (WGS84: 43.829054°N, 10.253978°E), 15 Jun 2023, *A. Mo* (seeds collected and deposited at the germplasm bank of the Department of Biology, University of Pisa; a herbarium specimen collected from the same area in 2012 is conserved at PI under the barcode PI063832).

Method. Squash preparations were made on root tips obtained from germinating seeds. Root tips were pre-treated with 0.4% colchicine for 3 h and then fixed in Carnoy solution for 1 h. After hydrolysis in 1 N HCl at 60 °C for 8 minutes, the tips were stained with leuco-basic fuchsine.

Observations. *Silene canescens* Ten. is a psammophyte belonging to a species complex distributed throughout the sandy shores of southern Europe (Chater et al. 1993).

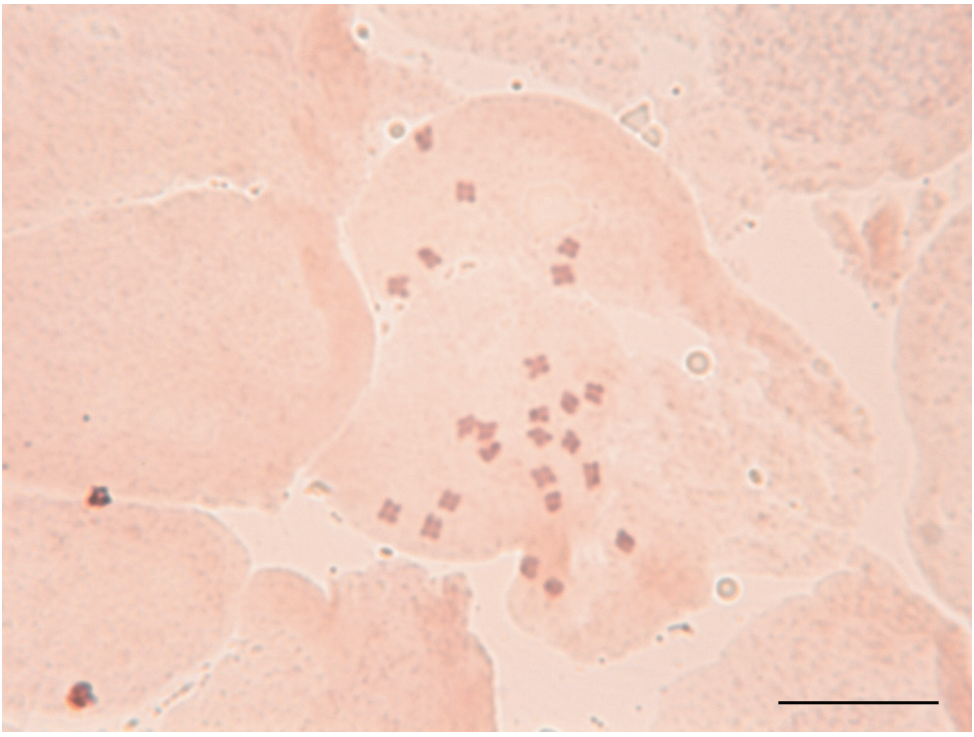

Figure 5. *Silene canescens* Ten. from Torre del Lago (Toscana), 2*n* = 24. Scale bar: 10 μm.

Difficulties to delineate its distribution range are due to the confusion with the closely related *S. colorata* Poir. (Valsecchi 1995). In Italy, *S. canescens* is considered taxonomically doubtful, but it occurs in most of the Thyrrenian and Adriatic coasts (Bartolucci et al. 2024). Here we document the first chromosome count (2*n* = 2*x* = 24) for an Italian population of this species, which is line with previous karyological data (Blackburn and Morton 1957), also concerning the related *S. colorata* (Rice et al. 2015).

J. Franzoni, A. Carta, A. Mo

Acknowledgements

AG is thankful to G. Casazza for having provided precise locations of occurrence of *Centaurea* populations in Liguria.

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RESEARCH ARTICLE

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Vascular flora of the isthmus of Feniglia (southern Tuscany, Italy)

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Abstract

We studied the vascular flora of the isthmus of Feniglia, a Nature Reserve in southern Tuscany stretching between the Italian Peninsula and Mt. Argentario. Since the nineteenth century, the area has undergone significant environmental modifications due to intensive grazing and deforestation. Later, rehabilitation interventions were carried out, including reforestation and planting of dune species, making it an interesting protected area to study for its botanical aspects. Therefore, we aim to compile the floristic inventory of this distinctive Mediterranean area by integrating old and new data. The checklist comprises 502 specific and subspecific taxa of vascular plants. The life-form spectrum shows a predominance of therophytes, followed by hemicryptophytes. The chorological spectrum highlights the dominance of Mediterranean species, followed by Euromediterranean and Eurasian species. The presence of 15 species of regional importance, 3 species of the Italian red list and 3 Italian endemics (*Ornithogalum exscapum* Ten., *Limonium multiforme* Pignatti, *Linaria purpurea* (L.) Mill.) is noteworthy. Despite the environmental changes undergone in this area, our study reports the presence of remarkable species, including rare ones such as *Atriplex littoralis* L., *Ruppia spiralis* L. ex Dumort., and species at their distribution margin in the Italian Peninsula, such as *Staphisagria macrosperma* Spach, *Juncus sorrentinoi* Parl. and *Maresia nana* (DC.) Batt. Additionally the presence of 26 alien species, of which 15 are invasive, 9 naturalized and 2 casual, indicates a relatively low

presence of alien species. Notwithstanding the significant environmental changes that the Feniglia isthmus has experienced in the last century and the high tourist pressure during the summer, the presence of the protected area suggested the effectiveness and benefits of such a form of protection for plant diversity.

Keywords
Coastal biodiversity, conservation, dune, flora, lagoon, Mediterranean, pine forest, protected area

Introduction

Floristic research stands as a baseline for pursuing biodiversity conservation. Acquiring this knowledge demands, however, substantial effort, including field and herbarium surveys, and plant determination endeavours. Unfortunately, these time-demanding tasks are leading to a significant decline, despite their fundamental importance in understanding and conserving our natural heritage (Prather et al. 2004).

Here, we studied the flora of the isthmus of Feniglia, a Nature Reserve in southern Tuscany stretching between the Italian Peninsula and Mt. Argentario. The area encompasses different macrohabitats, including pine forest, dune and lagoon. A well-represented macrohabitat in the study area is the pine forest, a forest type of artificial origin common along the Tuscan coasts. Pine forests line the sandy coastal regions of the Italian peninsula, spanning from the initial backdunes to the innermost settled dune environments. The coastal pine forest vegetation is primarily composed of *Pinus pinea* L. Initially serving as protective barriers shielding farmland from sea spray, these forests historically played a key role in producing pine nuts, timber, and resin. Planted predominantly from the latter half of the 20th century onwards, they were aimed at defending coastlines from water ingress and erosion (Bonari et al. 2017a). Dune systems are among the most threatened coastal ecosystems in Europe (Janssen et al. 2016). These are transitional ecosystems between marine and terrestrial environments, hosting exclusive species and habitats, and with a strong natural dynamics (Costa et al. 1996; Van der Meulen and Udo de Haes 1996; Bertacchi 2017; Gigante et al. 2018). Such dynamism is often negatively affected by urban sprawl, agriculture, reforestation, industry and human recreation activities (Schlacher et al. 2007; Malavasi et al. 2013; Sarmati et al. 2019). These anthropogenic pressures depend heavily on the surrounding landscape. For example, the presence of bathing facilities, cities and industrial and agricultural areas contributes negatively to the degradation of this ecosystem (Garcia-Lozano et al. 2018; Sarmati et al. 2019). The dunes of the Mediterranean region are, however, not always found in man-made settings. They are often surrounded by a more natural landscape such as forests, meadows or wetlands. This latter case, meaning dunes with proximity to wetlands, are somewhat rare. Coastal wetlands encompass river deltas, coastal lakes, marshes, temporary ponds and lagoons. According to Perez-Ruzafa et al. (2011), only 54 main coastal lagoons exist in the Mediterranean Basin. It turns out that coastal dunes are rarely in contact with coastal lagoons. Usually, these lagoons are dominated by shrubs and/or herbs, without forest vegetation or hosting

only sparse trees. One of these particular coastal areas is the isthmus of Feniglia, which is currently a State Nature Reserve. The isthmus of Feniglia hosts noteworthy vegetation types and species. For this reason, it was recognised as a protected biotope (Selvi and Stefanini 2005). Furthermore, it was identified as a distinctive biotope of the Mediterranean Macchia by the Nature Conservation Commission, as designated by the C.N.R. (Selvi and Stefanini 2005).

In the early 1800s, the isthmus of Feniglia was sold by the municipality of Orbetello to private owners who used it to largely exploit it for grazing and logging. This land-use change has led to several major environmental changes that have endangered the lagoon. For this reason, in 1911 a rehabilitation project started, with reforestation and planting of species typical of the Mediterranean coastal areas (Landi et al. 2012). It is likely the oldest ecological rehabilitation operation settled in Europe (Bonari et al. 2021).

The area encompassing the Duna Feniglia State Nature Reserve has been the subject of numerous botanical surveys aimed at assessing the conservation status of the dune ecosystem and devising potential intervention strategies (Bellarosa et al. 1989, 1996; Landi et al. 2012; Bonari et al. 2021). Additionally, studies of a more focused floristic and vegetation nature have been conducted (Gellini and Grossoni 1982; Celletti 1991–1992; Angiolini et al. 2013; Bonari et al. 2017b). A comprehensive analysis of the vascular flora of the isthmus of Feniglia, however, is still lacking. Accordingly, the aims of this work, undertaken more than a century after the ecological rehabilitation of the area, are twofold: firstly, to establish a comprehensive understanding of the vascular flora within the aforementioned Nature Reserve by compiling a dedicated floristic inventory. This is achieved through direct field surveys supplemented by bibliographic resources and herbarium records. Secondly, the study aims to highlight the presence of plant species with significant conservation and phytogeographic value.

Materials and methods

Study area

The study area (42°25.14132'N, 11°24.2731'E) located in southern Tuscany (Grosseto, Italy; Fig. 1) is a dune system that stretches for 6 km in length and 1 km in width, covering an area of approximately 4.92 km^2 and reaching a maximum height of 14 meters above sea level (Angiolini et al. 2013). The Feniglia isthmus connects the Mt. Argentario promontory with the peninsular Tuscany coastline. Together with another sandy strip, it isolates the Orbetello lagoon from the surrounding Mediterranean Sea. The area covers the entire Duna Feniglia State Nature Reserve (EUAP0123) and includes the Special Protection Area (SPA) “Duna di Feniglia” (IT51A0028), a sandy strip that marks the southern end of the Orbetello lagoon. Furthermore, a portion of the Duna Feniglia, facing the lagoon, is part of the “Laguna di Orbetello” (IT51A0026), which is both a SPA and a Special Area of Conservation (SAC). The area also enters within

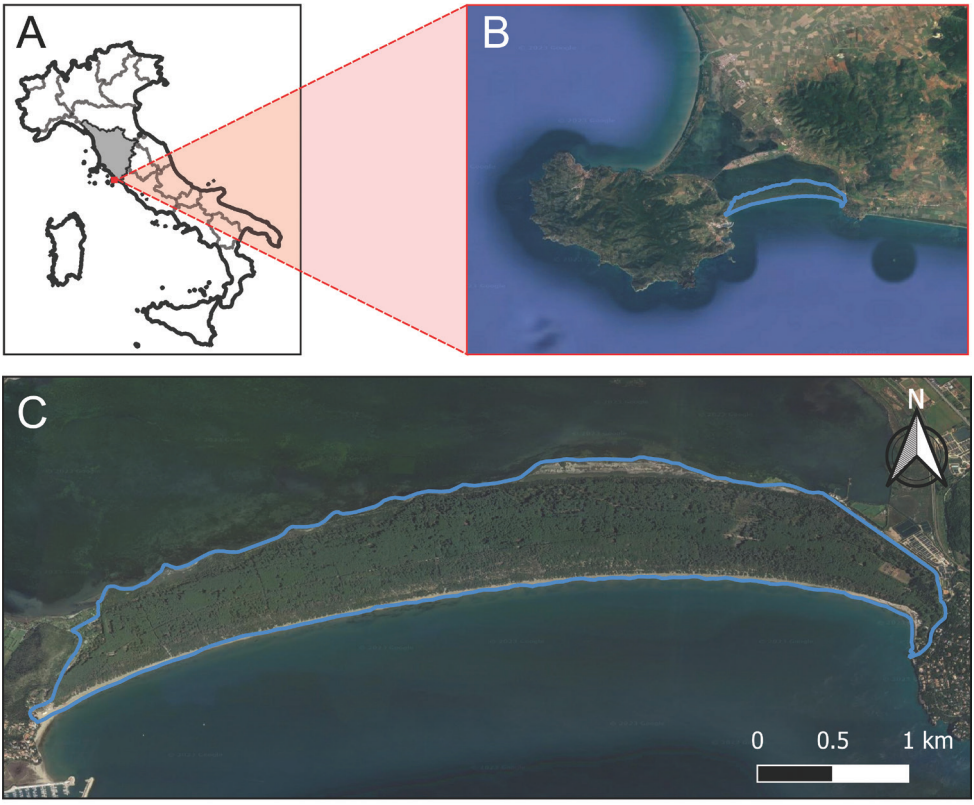

Figure 1. A location of the study area in Italy and Tuscany **B** close up on the study area and surrounding landscape **C** borders of the study area (blue line) Image source: Google Earth 2024.

the geotope of regional importance "Laguna di Orbetello" and borders the "Monte Argentario, Isolotto di Porto Ercole e Argentarola" (SPA and SAC; IT51A0025), while the part facing the sea borders the "Pelagos Sanctuary for the Conservation of Marine Mammals" (EUAP1174) a Specially Protected Area of Mediterranean Importance (SPAMI). Though not adjacent to the study area, there is also a RAMSAR site "Laguna di Orbetello" (AR_GR04), State Nature Reserve "Laguna di Orbetello di Ponente (EUAP0127) and Regional Nature Reserve "Laguna di Orbetello" (EUAP1030). The bioclimate of the study area can be classified as Pluviseasonal oceanic (Mediterranean); the thermotype is Lower mesomediterranean and the ombrotype is Upper dry, while regarding continentality, the climate is Weak Euoceanic (Pesaresi et al. 2014, 2017). The data of a thermopluviometric station located in the municipality of Orbetello (0 m a.s.l.), 2 km apart, reported, in the period 2000–2023, an average temperature of 24.8 °C in the hottest month (August), and 8.9 °C in the coldest month (January)and an average annual rainfall of 551 mm distributed in 55 days, with a peak during the late autumn period and a minimum during the summer (www.sir.toscana.it).

Landscape transformations and history of the isthmus of Feniglia

The isthmus of Feniglia was formed during the late Quaternary period through the accumulation of sandy or sandy-clay sediments eroded from Mt. Argentario (Mancini 1953). These deposits mainly consist of sand rich in carbonates, influenced by strong southwest winds and transported by sea waves (Mancini 1953; Carmignani and Lazzarotto 2004). With the formation of Feniglia, Mt. Argentario, once an island in the Tuscan Archipelago, turned into a promontory. Given the presence of endemic animals and plants, its biogeographical significance is remarkable (Manganelli et al. 2017; Barbato et al. 2018). In the early 1800s, the Orbetello municipality sold the dune to private property that used it for grazing and wood. Deforestation caused sand to fill the Orbetello lagoon, creating shallow marshes and increasing the risk of malaria. This sand influx also harmed fishing, a vital economic activity. To improve water circulation, authorities built canals linking the lagoon to the sea. Reforestation plans in 1900 aimed to control sand movement, delayed until 1910 due to landowners' opposition. Eventually, a law in 1910 designated all of Feniglia as public land (Bellarosa et al. 1996). In 1911, a project was initiated for the consolidation and reforestation, mainly using *Pinus pinaster* Aiton subsp. *pinaster* and *P. pinea* L. as forest species, of the Isthmus of Feniglia to prevent the lagoon from silting up (Fig. 2). The project also included the planting of species typical of Mediterranean dune grassland and shrubland formations along the coast such as *Calamagrostis arenaria* (L.) Roth subsp. *arundinacea* (Husn.) Banfi, Galasso & Bartolucci, *Cakile maritima* Scop. subsp. *maritima*, *Juniperus macrocarpa* Sm., *Euphorbia paralias* L. and *Medicago marina* L. (Landi et al. 2012). The reforestation works were carried out on about 360 hectares until 1925 when the dune became part of the Azienda Forestali Demaniali (Ciabatti et al. 2009). In the same period, an experiment was carried out to introduce non-native species such as *Pinus radiata* D.Don, *Hesperocyparis macrocarpa* (Hartw. ex Gordon) Bartel, *Robinia pseudoacacia* L. and other alien species (Selvi et al. 2006), some of which are still found in the area. In the following decades, the reforested area, namely a pine forest, reached approximately 460 hectares.

Field surveys and data analysis

For the compilation of the floristic inventory of the isthmus of Feniglia, we first retrieve all past botanical research conducted entirely or partly in our study area (Caruel 1860; Sommier 1902), including those done shortly after the start of the reforestation project (Sforzi et al. 1914; Liguori 1928) and those 70–80 years after reforestation (Géhu et al. 1984; Bellarosa et al. 1996; Vagge and Biondi 1999). We also considered data present in theses (Celletti 1991–1992; Sturba 2012–2013; Gizzi 2017–2018) and more recent studies (Landi et al. 2012; Angiolini et al. 2013; Ciccarelli et al. 2015; Bonari et al. 2017b). We complemented our data mining with several floristic surveys in 2023. We excluded from the analyses the species found before the reforestation (Caruel 1860; Levier and Sommier 1891; Sommier 1902; Baroni 1908) and those reported in the

Figure 2. The Feniglia Dune in 1911, before the reforestation work began (**A**) and how it looks at present (**B**). Photo credits: A. Liguori, 1928 (**A**) and G. Bonari, 2017 (**B**).

theses but identified as errors. The species used in reforestation were included in the flora only if they were naturalised, while the others were excluded. These species are listed in the Suppl. material 1.

The collected specimens are kept in the herbarium of Siena (SIENA) and Viterbo (UTV). The codes of the herbaria follow Thiers (2020 onwards).

The species were mainly identified according to Pignatti (1982), Tison and De Foucault (2014) and Pignatti et al. (2017–2019) but additional texts were also used (Castroviejo et al. 1984–2005; Arrigoni 2016–2021). The nomenclature of the taxa follows Bartolucci et al. (2024) and Galasso et al. (2024). Chorotypes were simplified as follows: Alien, Atlantic, Boreal, Endemic, Eurasiatic, Euromediterranean, Mediterranean, Orophilous and Wide distribution. Life forms and chorotypes were attributed according to Pignatti et al. (2017–2019). Ecological indicators (Ellenberg 1974) adapted to the flora of Italy were taken from Pignatti et al. (2005) or their updates, when available (Guarino et al. 2012; Domina et al. 2018). Our ecological indicator values had different scales. Light (L), Temperature (T) and Continentality (C) ranged between 1–12, Soil reaction (R), Moisture (U) and Nitrogen (N) ranged between 1–9, while Salinity (S) ranged between 0–7. Furthermore, to help interpret the ecological preferences of confirmed species, we classified each taxon into one or more of the following preferential macrohabitats: F = forest; D = dune; L = lagoon. When no evident preference was detected for a given species, the category other (O) was applied. This classification was later used in analysis. To verify the conservation status of each taxon, we checked the Tuscan attention list and the Italian Red List of vascular plants (Sposimo and Castelli 2005; Orsenigo et al. 2020). We used the data available on WikiplantbaseToscana (Peruzzi and Bedini 2013 onwards) as a proxy for the regional distribution and rarity of the species. For the national distribution and the status of occurrence (i.e. archaeophyte and neophyte, at both regional and Italian levels), we used the data available on Portal of the Flora of Italy (from 2023 onwards) as a proxy. For the distribution of woody species, we also consulted Roma-Marzio et al. (2016). We also calculated the H/T ratio as a bioclimatic index (Sabato and Valenziano 1975; Cannucci et al. 2019). We conducted the analyses for the whole flora and separated them by macrohabitats.

Finally, we computed the expected number of species based on the extent of the study area using the Species-Area Relationship (SAR) formula proposed by D'Antraccoli et al. (2019) along with the constants provided for Italy by D'Antraccoli et al. (2023). We performed the analysis for the whole flora and separately for native and alien taxa.

The analyses and graphs were done using R Studio v. 4.3.0 (R Core Team 2023).

Results

Floristic inventory

The floristic inventory of the isthmus of Feniglia includes 502 taxa (species and subspecies). These taxa are distributed across 80 families and 279 genera (Fig. 3). The most represented families are Poaceae (72 taxa), Asteraceae (54), Fabaceae (52), Caryophyllaceae (24), Brassicaceae (17), Lamiaceae (15) and Amaranthaceae (15). The genera with more taxa are *Trifolium* (16 taxa), *Euphorbia* (9), *Medicago* (8), *Carex* (7),

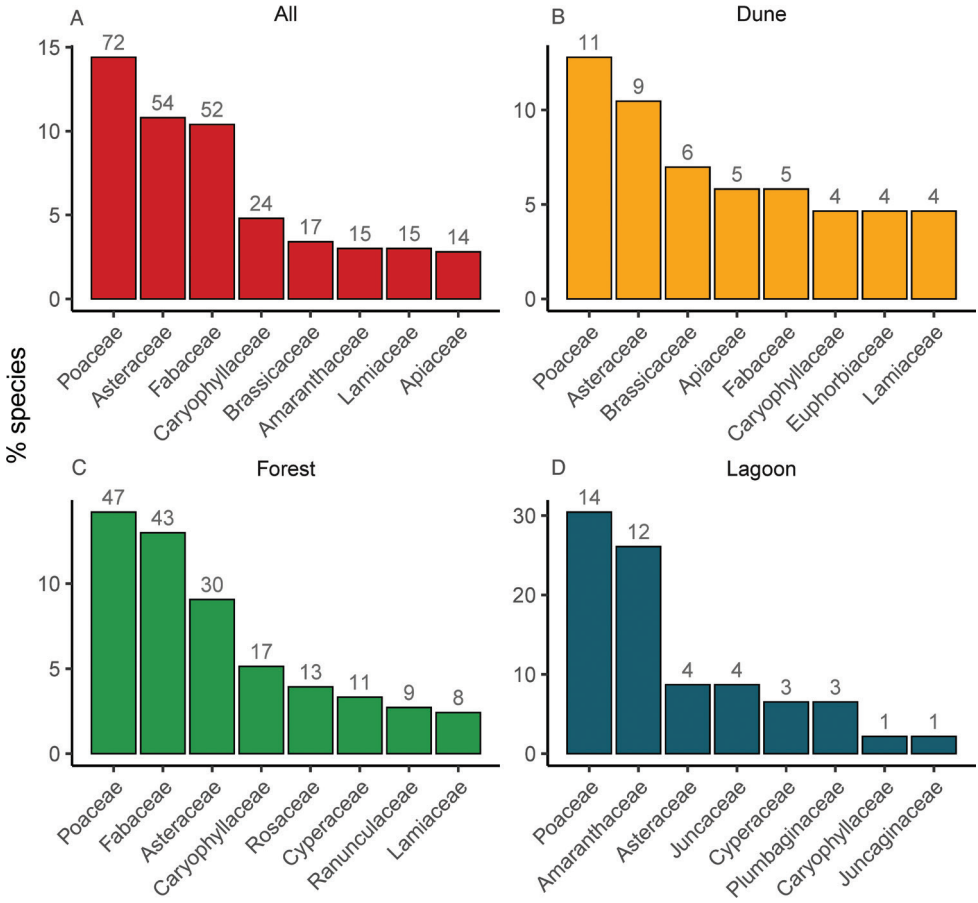

Figure 3. Bar plot of the 8 most represented families (percentages) across the inventoried flora (**A**) and divided as per macrohabitats of dune (**B**), forest (**C**) and lagoon (**D**).

Juncus (7), *Quercus* (7) and *Vicia* (7). In the dune macrohabitat, the most represented families are Poaceae (11 taxa), Asteraceae (9), Brassicaceae (6), Apiaceae (5) and Fabaceae (5). In the forest macrohabitat, the most represented families are Poaceae (47), Fabaceae (43), Asteraceae (30), Caryophyllaceae (17) and Rosaceae (163). In the lagoon macrohabitat, the most represented families are Poaceae (14), Amaranthaceae (12), Juncaceae (4), Asteraceae (4) Cyperaceae (3) and Plumbaginaceae (3). The species excluded from the floristic list are 46 and are divided into 31 species not recently found, 10 erroneous species reported in theses, and 5 species used in reforestation but not self-maintaining.

As results from the SAR analysis, the observed number of taxa exceeds the expected value of 377 by +33.16%. For native species, we found +27.35% taxa compared to the expected value of 373, while for alien species we found +42.11% taxa compared to the expected value of 19.

Life-form spectrum

The life-form spectrum shows that the most represented species are therophytes (223 taxa), hemicryptophytes (120) and phanerophytes (60; Fig. 4A). The H/T ratio is 0.54. In the dune macrohabitat, the most represented species are therophytes (29), chamaephytes (15) and phanerophytes (15; Fig. 4B). In the forest macrohabitat, the most represented species are therophytes (139), hemicryptophytes (76) and phanerophytes (56; Fig. 4C). In the lagoon macrohabitat, the most represented are therophytes (16), hemicryptophytes and chamaephytes (9; Fig. 4D).

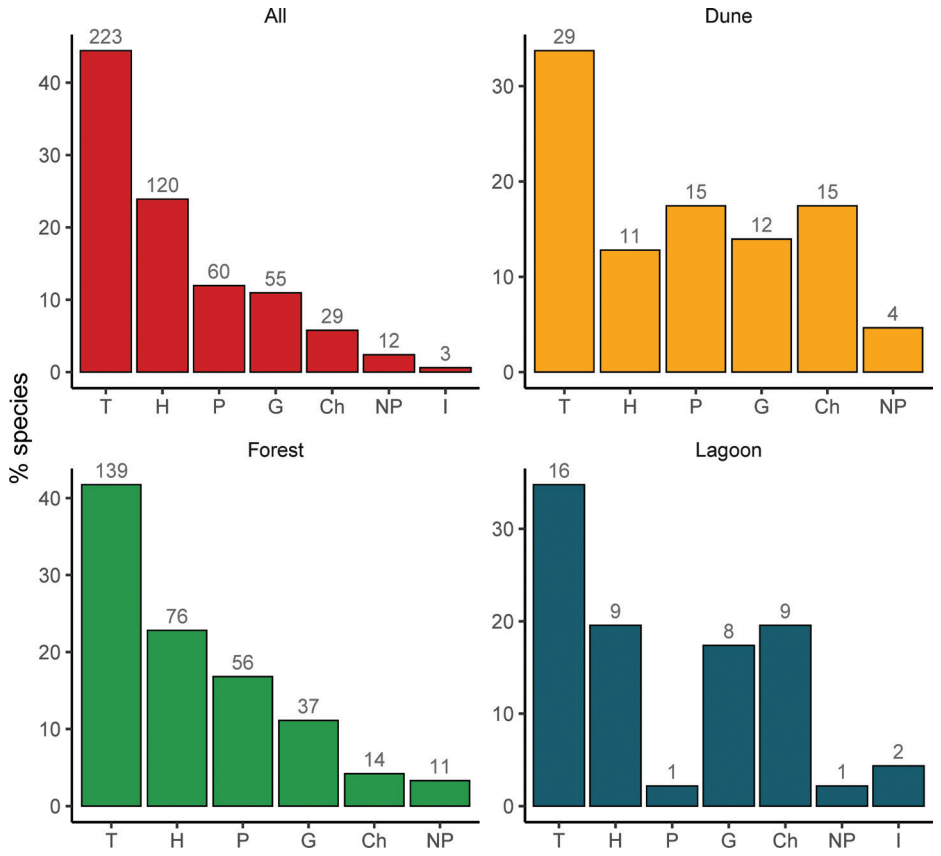

Figure 4. Bar plot graph of the life-form spectrum of the whole flora (**A**) and divided as per macrohabitat of dune (**B**), forest (**C**) and lagoon (**D**). T = Therophytes; H = Hemicryptophytes; P = Phanerophytes; G = Geophytes; Ch = Chamaephytes; NP = Nano-phanerophytes; I = Hydrophytes.

Chorological spectrum

The chorological spectrum shows that the most represented species have Mediterranean (157 taxa), Euromediterranean (115) and Eurasiatic distribution (91; Fig. 5A). In the dune macrohabitat, the most represented species have Mediterranean (43), Euromediter-

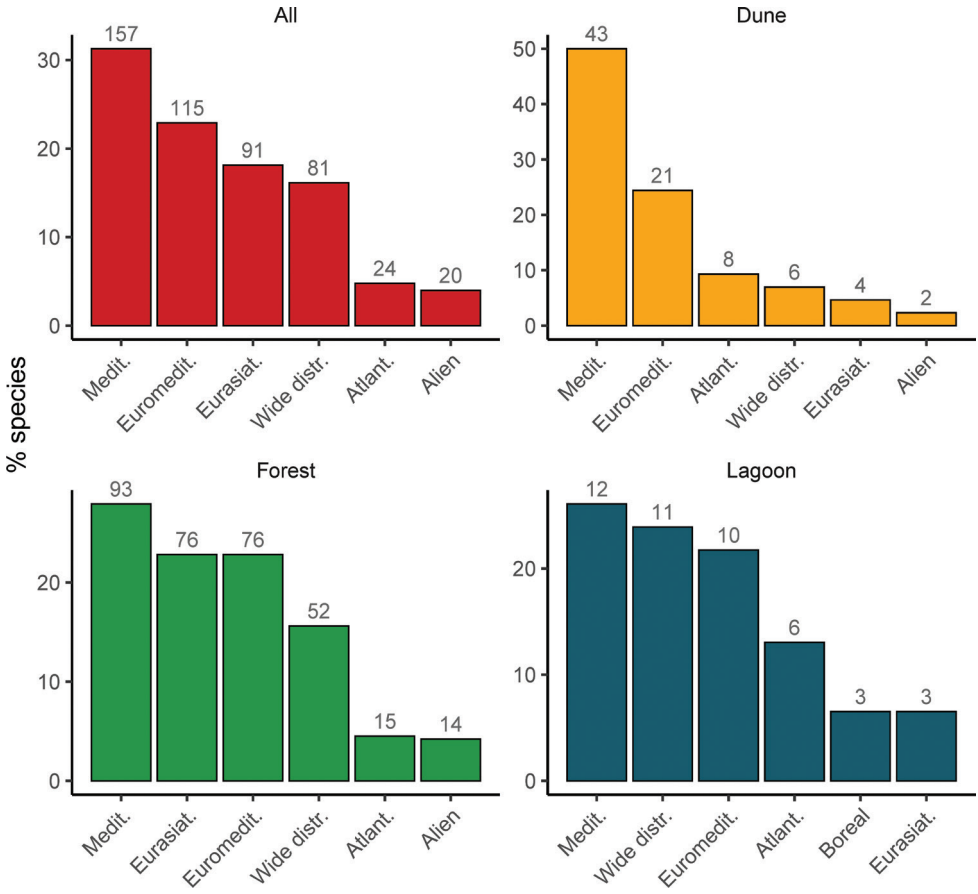

Figure 5. Bar plot graph of the 6 main chorological spectra of the whole flora (**A**) and divided as per macrohabitat of dune (**B**), forest (**C**) and lagoon (**D**). Medit. = Mediterranean; Euromedit = Euromediterranean; Euroasiat = Euroasiatic; Wide distr. = Wide distribution; Atlant. = Atlantic.

ranean (21) and Atlantic distributions (8; Fig. 5B). In the forest macrohabitat, the most represented species have Mediterranean (93), Eurasiatic (76) and Euromediterranean distributions (76; Fig. 5C). In the lagoon macrohabitat, the most represented species have a Mediterranean (12), Wide (11) and Euromediterranean distributions (10; Fig. D).

Ecological indicators

The median Ecological indicators for the whole flora (Fig. 6A) are light (8), temperature (8), soil reaction (6), continentality (5), moisture (3), nitrogen (3) and salinity (0). In the dune macrohabitat (Fig. 6B), heliophilous species are the most represented (11). In the forest macrohabitat (Fig. 6C), heliophilous and light-demanding species (8), while in the lagoon (Fig. 6D) light is the highest indicator value (9.5).

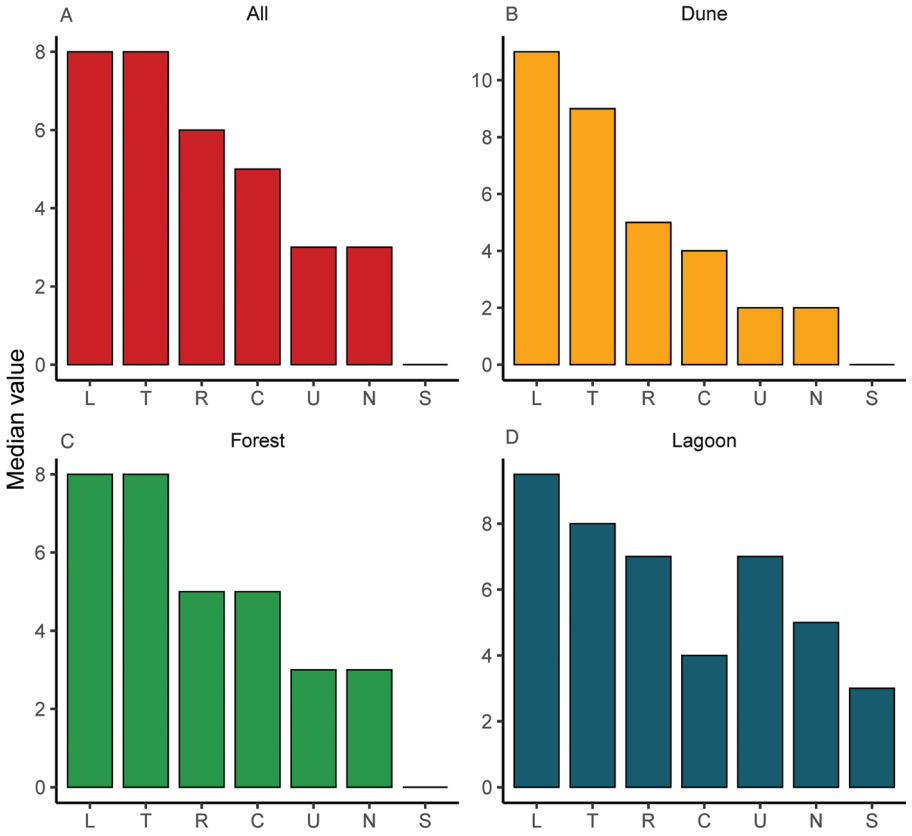

Figure 6. Bar plot graph of the Ecological indicators (median values) for the whole flora (**A**) and divided as per macrohabitat of the dune (**B**), forest (**C**) and lagoon (**D**). L = Light; T = Temperature; R = Soil Reaction; C = Continentality; U = Soil Moisture; N = Soil Nutrients; S = Salinity.

Species of attention lists and alien species

In total, we found 15 species of the Tuscan Attention List and 3 species of the Italian Red List (Table 1).

We found 16 species considered rare in Tuscany such as *Atriplex littoralis* L., *Brachypodium phoenicoides* (L.) Roem. & Schult., *Catapodium hemipoa* (Delile ex Spreng.) M.Laínz, *Clypeola jonthlaspi* L., *Daucus guttatus* Sm., *Euphorbia terracina* L., *Juncus sorrentinoi* Parl., *J. subulatus* Forssk., *Maresia nana* (DC.) Batt., *Nanozostera noltei* (Hornem.) Toml. & Posl., *Plumbago europaea* L., *Puccinellia festuciformis* (Host) Parl. subsp. *lagascana* M.A.Juliá & J.M.Monts., *Rostraria hispida* (Savi) Doğan, *Ruppia spiralis* L. ex Dumort., *Sphenopus divaricatus* (Gouan) Rchb. subsp. *divaricatus*, *Thinopyrum elongatum* (Host) D.R.Dewey., *Vicia segetalis* Thuill. We found 3 species new for the province of Grosseto. They are *Cucurbita maxima* Duchesne subsp. *maxima*, *Dichondra micrantha* Urb. and *Vicia segetalis* Thuill. We found 4 species at the northern distribu-

Table 1. Species included in the Tuscan Attention List (TOS) and Italian Red List (ITA), DD = Data Deficient; NT = Near Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered.

Species	TOS	ITA
Daucus guttatus Sm.	NT	-
Euphorbia barrelieri Savi	-	EN
Isoëtes histrix Bory	VU	-
Juncus sorrentinoi Parl.	CR	DD
Juncus subulatus Forssk.	VU	-
Limonium multiforme Pignatti	NT	-
Marcus-kochia ramosissima (Desf.) Al-Shehbaz	EN	-
Maresia nana (DC.) Batt.	EN	-
Nanozostera noltei (Hornem.) Toml. & Posl.	EN	-
Ruppia spiralis L. ex Dumort.	VU	NT
Salicornia fruticosa (L.) L.	VU	-
Salicornia procumbens Sm.	VU	-
Sphenopus divaricatus (Gouan) Rchb. subsp. *divaricatus*	VU	-
Stachys maritima Gouan	EN	-
Staphisagria macrosperma Spach	VU	-
Suaeda vera J.F.Gmel.	VU	-
Triglochin barrelieri Loisel.	-	EN

tion limit: *Erodium laciniatum* (Cav.) Willd. subsp. *laciniatum*, *Juncus sorrentinoi* Parl., *Maresia nana* (DC.) Batt., *Staphisagria macrosperma* Spach and *Suaeda vera* J.F.Gmel.

We found 26 alien species at Italian level, of which 4 archaeophytes and 22 neophytes. The invasive status of these species in Italy is distributed into three categories: 15 species are invasive, 9 naturalised and 2 casual while we found 27 alien species for Tuscany divided as follows 9 invasive, 10 naturalised and 8 casual (*Ulmus laevis* Pall. is a regional alien species) (Table 2).

Discussion

The floristic inventory of the isthmus of Feniglia reveals the botanical diversity of the area, including rare and protected species, also due to its particular geography and geomorphological features, thus demonstrating relevant ecological and phytogeographical importance.

The proportion of species belonging to the Poaceae, Asteraceae and Fabaceae families is similar to the general pattern of the Italian flora, though the first two families are reversed. Similarly to the flora of the neighbouring Mt. Argentario (Baldini 1995) and Lake Burano (Angiolini et al. 2002), as well as the flora of Tuscan coastal dunes (Ciccarelli et al. 2015), the present study aligns with prior botanical findings. The high number of Poaceae is related to the presence of xerophilous and discontinuous small grasslands. These scattered grasslands can be attributed to a priority habitat according to Habitats Directive 92/43/EEC: Sub-steppe of annual grasses and plants of the Thero-Brachypodietea (Natura 2000 code: 6220; Biondi et al. 2009) that occurs as a mosaic in the pine forest understorey, especially in clearings (Bonari et al. 2018). As

Table 2. Alien species in Tuscany (TOS) and Italy (ITA), divided into Archaeophytes (A) and Neophytes (N), and their associated status (INV = Invasive; CAS = Casual; NAT = Naturalised).

Species	TOS	ITA
Carpobrotus acinaciformis (L.) L.Bolus	N INV	N INV
Citrullus lanatus (Thunb.) Matsum. & Nakai	A CAS	A CAS
Crepis sancta (L.) Bornm. subsp. *nemausensis* (P.Fourn.) Babc.	N INV	N INV
Cucurbita maxima Duchesne subsp. *maxima*	N CAS	N CAS
Cupressus sempervirens L.	A NAT	A NAT
Datura stramonium L.	N NAT	N INV
Dichondra micrantha Urb.	N NAT	N NAT
Erigeron bonariensis L.	N INV	N INV
Erigeron canadensis L.	N INV	N INV
Erigeron sumatrensis Retz.	N INV	N INV
Eucalyptus camaldulensis Dehnh. subsp. *camaldulensis*	N NAT	N INV
Eucalyptus globulus Labill. subsp. *globulus*	N NAT	N NAT
Euphorbia maculata L.	N INV	N INV
Hesperocyparis arizonica (Greene) Bartel	N NAT	N NAT
Hesperocyparis macrocarpa (Hartw. ex Gordon) Bartel	N CAS	N NAT
Malus domestica (Suckow) Borkh.	A CAS	A NAT
Opuntia stricta (Haw.) Haw.	N INV	N INV
Oxalis articulata Savigny	N NAT	N INV
Oxalis dillenii Jacq.	N NAT	N INV
Pinus pinea L.	A NAT	A NAT
Populus ×canadensis Moench	N CAS	N INV
Robinia pseudoacacia L.	N INV	N INV
Syringa vulgaris L.	N CAS	N NAT
Ulmus laevis Pall.	N CAS	-
Veronica peregrina L.	N CAS	N NAT
Xanthium orientale L.	N INV	N INV
Xanthium spinosum L.	N NAT	N INV

far as the other families are concerned, the flora of Feniglia follows the pattern of the Italian flora (Bartolucci et al. 2018; Galasso et al. 2018). Furthermore, it is noteworthy the abundance of Amaranthaceae and Cyperaceae species. The former, including genera associated with coastal salt marshes, make up the late summer-autumn flowering components (Piva and Scortegagna 1993). The latter family includes species linked to wet habitats, such as taxa of the genus *Carex*, as the isthmus encompasses part of the coastal lagoon and hosts freshwater wetlands in mosaic with the pine forest (Angiolini et al. 2013). The high number of species belonging to the genus *Trifolium* is noteworthy. The presence of sandy soils rich in silica and numerous dry grasslands with therophytes could justify the high presence of *Trifolium* sp. pl. (Scoppola at al. 2018). The natural presence of numerous species of the genus *Quercus* in such a limited area is noteworthy and would merit a specific study of these populations. Numerous species also belong to the genera *Euphorbia* and *Medicago*, some specialising in dune and back dune environments. Notably, vascular cryptogams are represented by only two species, *Isoëtes histrix* Bory and *Pteridium aquilinum* (L.) Kuhn subsp. *aquilinum*, playing a

minor role in this coastal area. The limited water availability during the summer season and the absence of rocky substrates appear to be limiting factors influencing the low presence of ferns in this area. Compared to the prediction based on SARs, the results show that the study area exhibits high floristic richness.

Biological spectrum

The life-form spectrum shows a marked dominance of therophytes, represented by species with a short vegetative cycle and adapted to well-drained and nutrient-poor soils. The abundance of therophytes is in line with what has been reported for Mt. Argentario (Baldini 1995) and Lake Burano (Angiolini et al. 2002). Hemicryptophytes can be mostly found in mesophilic herbaceous communities of the understory (*Brachypodium sylvaticum* (Huds.) P.Beauv. subsp. *sylvaticum* and *Oloptum miliaceum* (L.) Röser & H.R.Hamasha) or in thermophilic grasslands (*Anthoxanthum odoratum* L. and *Ranunculus bulbosus* L.). The significant presence of nano-phanerophytes and phanerophytes, the latter being more abundant compared to the nearby Mt. Argentario (Baldini 1995) and Lake Burano (Angiolini et al. 2002), is linked to the presence of dynamic stages of natural dune vegetation, represented by maquis and holm oak formations, which establish themselves within the pine forest, especially where the pine cover thins out (Bonari et al. 2017a). Geophytes prevail in woodland environments (e.g. *Dioscorea communis* (L.) Caddick & Wilkin) and wetlands (e.g. *Isoëtes histrix* Bory) (Lattanzi et al. 2004); they are, however, present in lower percentages compared to the flora of neighbouring areas (Baldini 1998; Angiolini et al. 2002), probably due to the occurrence of ungulates that impact on this habitat by eating plant bulbs (Fattorini and Ferretti 2020). The relatively low presence of chamaephytes confirms the good state of the phanerophytes component in forest communities despite the storm of 2019 causing damages. Hydrophytes are represented by a few species: *Nanozostera noltei* (Hornem.) Toml. & Posl., *Posidonia oceanica* (L.) Delile and *Ruppia spiralis* L. ex Dumort. The limited presence of hydrophytes and helophytes in the flora of the isthmus of Feniglia can be attributed to the ephemeral presence of freshwater bodies. The hydrophytes present grow in saltwater or brackish waters. Even the permanent or semi-permanent ponds that form in the lagoon area are saline or brackish, thus providing unfavourable conditions for freshwater hydrophytes. The H/T ratio reflects a Mediterranean-type bioclimate; this result is similar to values reported for protected areas of the surroundings (Diaccia Botrona: 0.7; Sforzi and Selvi 1999; Lake Burano: 0.67; Angiolini et al. 2002), which indicates a mesomediterranean climate. In these areas, the climate is not typically thermomediterranean, possibly due to the mitigation effect of the brackish environment. Despite this, the H/T ratio of plain areas of the nearby Maremma Regional Park is significantly different (1.04; Arrigoni 2003). This difference is probably partly due to the much larger size of the area that includes environments that are not present in our study area, such as pastures and olive groves.

In all macrohabitats, therophytes are the most common biological form. This is in agreement with the Mediterranean climate and indicates that there is no life form

more suitable for thriving in this environment. The forest macrohabitat reflects the biological form distribution of the overall flora, except for the absence of hydrophytes. This is due to its large area and because it is the most heterogeneous environment, being transitional between dune and lagoon macrohabitats. In the dune macrohabitat, life forms are equally represented, except for nano-phanerophytes. These latter species are the least represented. In the lagoon environment, the limited presence of phanerophytes and nano-phanerophytes is due to various physico-chemical factors, including salinity, anaerobic and muddy substrate, along with fluctuations of water levels, which reduce their occurrence.

Chorological spectrum

The chorological analysis of the whole flora highlights the abundance of Mediterranean and Euromediterranean species. This confirms the picture outlined by the biological spectrum and agrees with the climate of the study area, in turn, consistent with the findings in other coastal areas of Tuscany such as Mt. Argentario (Baldini 1995), Diaccia Botrona (Sforzi and Selvi 1999) and Lake Burano (Angiolini et al. 2002). Eurasian species are well represented. Those with widespread distribution are scarce and primarily identified by cosmopolitan species associated with the Atlantic distribution. Similar values to the European ones are observed, with a less significant boreal component. While being an area with various environments, the flora of Mt. Argentario also has a significant component of Atlantic and Western European species (Baldini 1995). There are a few endemic species, such as *Linaria purpurea* (L.) Mill., widespread in central and southern Italy, excluding Sardinia; *Ornithogalum exscapum* Ten., found in the pine forest, that is endemic to central and southern Italy, excluding Sardinia and Marche regions, and *Limonium multiforme* Pignatti, an endemic species of the Tuscan coast, distributed along the entire rocky coastline from Livorno to the Ansedonia Promontory (Rizzotto 1999).

In all macrohabitats, Mediterranean species are dominant, in accordance with the overall flora. In the dune macrohabitat, they constitute half of the total flora. Many of them are species that have specialised to live in this environment and are often exclusive. The forest macrohabitat more faithfully reflects the composition of the total flora because it is the most widespread and heterogeneous environment that is in contact with both the dune and lagoon macrohabitats. In the lagoon macrohabitat, there are specialised species with a wide distribution chorotype, including many species from the northwest, such as Boreal and Atlantic species. In the lagoon, no alien species occur because they are often ruderal or escaped from gardens. The harsh ecological conditions of the lagoon environment are not favourable.

Ecological indicators

The Ecological indicators of the flora are in line with the values of the Italian flora, except for the values of Temperature, which are slightly higher, and the values of Soil

Moisture, which are significantly lower. These discrepancies stem from the geographical and ecological conditions of the isthmus of Feniglia. The forest macrohabitat is the most similar to the whole flora. This is because a large portion of species is found in this habitat and because it is the most extensive. The dune macrohabitat shows a higher value of light. This is due to the ecological conditions of the dune, where the flora is specialised to cope with high solar radiation. Specific chemical and physical conditions characterise the lagoon macrohabitat, and consequently, its flora profoundly differs. Soil moisture, soil nutrients and salinity values are higher compared to the values of the total flora due to the specialisation of the species present.

Species of attention lists and alien species

We list here the most interesting species in the study area.

Atriplex littoralis L. is an annual species that thrives in arid environments often characterised by marked salinity, alkalinity, and high nitrate content (Pignatti et al. 2017–2019). This species has been found in the lagoon area of Feniglia, within communities predominantly dominated by *Salicornia* spp. In Italy, the species is only present in Friuli Venezia Giulia, Veneto, Emilia-Romagna, Liguria and Tuscany regions; Feniglia, therefore, represents the southern distribution limit for the Italian populations. There are doubtful reports for other Italian regions and historical reports for Apulia (Portal of the Flora of Italy 2023). In Tuscany, only historical or undated records exist, thus making populations of Feniglia the only recent and certain ones.

Daucus guttatus Sm. is a rare annual species of the family Apiaceae reported in 1991 for the dune area of Lake Burano (Angiolini et al. 2002; Selvi 2010). It prefers uncultivated and abandoned clearings but is easily found in coastal environments with sandy soils (back dunes). Its distribution concerns central-southern Italy; it is reported for all the peninsular regions except for the Marche region (Portal of the Flora of Italy 2023). In the Tuscan Attention List, it is reported as 'Near Threatened' (NT) because, despite the strong alteration of its living environments, the population was known in a protected area. It is the overall fifth report of the species in Tuscany, but only the second recent one.

Juncus sorrentinoi Parl. is a species with a western Mediterranean distribution, of considerable conservation interest due to its rarity at the national level and ecological specialisation. In Italy, it is only present in Sardinia and Tuscany and historical reports for Sicily (Portal of the Flora of Italy 2023). It is a silicicolous species, living in ephemeral humid environments with a sandy-mineral substrate, such as small pools, drip sites and streams. This report represents the second record for Tuscany. The only previously known population was for Mt. Leoni (Selvi 1998), consisting of a few individuals in clearings of sparsely vegetated acidophilus shrubland at serious risk of fire and forest evolution (Selvi 2010). Listed in Annex A of Regional Law 56/2000, it is categorised as "Vulnerable" (VU) in Re.Na.To (Sposimo and Castelli 2005). The threats are represented by the evolution of evergreen shrub vegetation.

Maresia nana (DC.) Batt. is a psammophilous species that inhabits sandy coastal environments. In Italy, it has been reported in Lazio, Molise, Apulia, Abruzzo, Ba-

silicata, and Sicily, historical reports for Emilia-Romagna (Portal of the Flora of Italy 2023). Regarding Tuscany, past authors confirmed the presence of *M. nana* along the beaches of Follonica and Mt. Argentario (Fiori 1929). Only recently its presence has been confirmed on the beaches of the isthmus of Feniglia, which currently seems to be the only site where the species is known in Tuscany (Selvi and Stefanini 2005; Selvi 2007). In Re.Na.To. (Sposimo and Castelli 2005), it is reported as "Endangered" because dune habitats are threatened by human expansion.

Plumbago europaea L. is a Mediterranean chamaephyte that grows in uncultivated areas, roadside verges and walls (Pignatti et al. 2017–2019). In the isthmus of Feniglia, it is present in the lagoon, in communities dominated by *Salicornia* spp., in meadows, and the pine forest. In Italy, it is found in all the peninsular and insular regions, in Liguria, in Veneto, and in Emilia-Romagna. *P. europea* is considered alien in Emilia-Romagna, Veneto and Tuscany regions (Portal of the Flora of Italy 2023). In accordance with Arrigoni (2003) and Selvi (2010), who found *P. europea* in other areas of the Grosseto province, we consider the populations present in Feniglia to be native and therefore deem the alien status for the Tuscany region as incorrect.

Staphisagria macrosperma Spach is an annual helio-xerophilous species of considerable size, with a narrow Mediterranean distribution, typically found in arid fallow lands, olive groves and old ruins. In Italy, it is found in Marche, Lazio, Abruzzo, Apulia, Basilicata, Calabria, Sardinia and Sicily and historical reports for Campania (Portal of the Flora of Italy 2023). In Tuscany, it was collected over a century ago in three locations: on the hill of Ansedonia (Grosseto), near Suvereto (Livorno) and on the island of Elba near Porto Azzurro (Caruel 1860; Baroni 1897). In the early 2000s, it was rediscovered on the hill of Ansedonia within the excavation area of the Roman city of Cosa (Selvi 2002); in Re.Na.To. (Sposimo and Castelli 2005), it is reported as "Vulnerable". The population of the Feniglia is locally abundant near to the entrance to the reserve on the Ansedonia side (Peruzzi et al. 2015).

Suaeda vera J.F.Gmel. is a succulent, cosmopolitan species that prefers sunny coastal environments typically characterised by high salinity levels. The distribution in the Mediterranean basin has become, however, increasingly fragmented and reduced due to the alteration of coastal habitats. In Italy, it is found in Tuscany, Emilia-Romagna, Lazio, Veneto, Friuli Venezia Giulia, Abruzzo, Apulia, Basilicata, Calabria, Sardinia and Sicily and historical reports for Campania and Liguria (Portal of the Flora of Italy 2023). The designation of "Vulnerable" status in Re.Na.To. (Sposimo and Castelli 2005) to some extent reflects this issue and the limited extent of the area occupied.

Among the species reported in the past but not recently found, there are some included in the Italian Red List as Least Concern, *Allium chamaemoly* L. subsp. *chamaemoly*, *Ophrys tenthredinifera* Willd. (under the name *O. tenthredinifera* subsp. *neglecta* (Parl.) E.G.Camus) (Orsenigo et al. 2020). The reporting of a specimen from 1856 of *Polygala flavescens* DC. subsp. *maremmana* (Fiori) Arrigoni found in the Feniglia isthmus is particularly interesting (Arrigoni 2014). This species is endemic to Mt. Argentario (Arrigoni 2014; Peruzzi et al. 2019). It was likely present before reforestation efforts; however, it has not been rediscovered in the study area and has thus been excluded from the current floristic list.

Despite the SARs results, alien species presence is limited. Alien species present are generally rare, except for *Erigeron* spp., which often colonise the small patchy grasslands in the pine forest. Although *Pinus pinea* L., which is considered by some authors an alien species, along with *P. pinaster* Aiton. and *P. halepensis* Mill., it forms the priority habitat of Directive 2270*.

Despite that, previous studies have shown its relatively limited effect in shaping floristic composition in coastal areas. Dune species can, to some extent, still occur in the understory of this forest type according to a gradient of salinity (Bonari et al. 2017a). Furthermore, being a Mediterranean species, it can be considered alien only to a certain extent. Accordingly, not all authors agree in considering this species as alien in Italy (Calvia et al. 2022).

The ecological and geomorphological conditions have undoubtedly aided in the isolation of Feniglia, limiting the arrival of alien species, as evidenced by the low number of alien species present in the dune. Of the numerous alien species used in reforestation, very few have naturalised, and the majority are no longer present (Bonari et al. 2021). Among alien species, *Hesperocyparis macrocarpa* (Hartw. ex Gordon) Bartel is reported as new to Tuscany, while *Ulmus laevis* Pall. is reported as new to the Province of Grosseto. The discovery of this new phanerophyte is relevant in the context of the woody flora of Tuscany (Roma-Marzio et al. 2016). The lagoon environment, with its unique physicochemical characteristics and the absence of alien species, can be defined as a barrier that protects Feniglia.

Conclusions

The importance of floristic studies serves as a benchmark for future research, not only in botany but also in related fields. In this context, this work contributes to the knowledge of the vascular flora of the isthmus of Feniglia, an area that has witnessed significant changes in management and protection over the centuries. Feniglia has undergone important vegetation changes, transitioning from the dominance of shrublands to pastures, then dunes, and later forests. Reforestation was the most recent significant human intervention, after which no other significant interventions were carried out on the structure of the vegetation. There are species of particular conservation interest, many of them rare or found in Feniglia isthmus their geographical distribution limit. The low presence of alien species is an excellent indicator of naturalness, especially considering that the few alien species occur with very limited populations. From the biogeographical point of view, it is also important to highlight the role the area plays as an ecological corridor, connecting the Italian Peninsula to the former island of Argentario, while from a conservation perspective, the recognition of the isthmus of Feniglia as a protected area under different designation types (i.e. Nature Reserve, Special Protection Area and Special Area of Conservation), favoured its preservation.

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Supplementary material 1

Floristic list of the isthmus of Feniglia

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Data type: docx

Explanation note: Floristic inventory of vascular flora of the isthmus of Feniglia (southern Tuscany, Italy)

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SHORT COMMUNICATION

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Typification of the name *Sempervivum dolomiticum* Facchini (Crassulaceae)

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Abstract

The designation of type material is a crucial step in taxonomy. It enables the establishment of a strong morphological reference for plant species description and identification. In the current work, we investigated the MUSE-preserved collections to trace back the original study material employed by Francesco Facchini to describe *Sempervivum dolomiticum* Facchini. This chasmophyte is an Italian endemic occurring in the eastern Dolomites. A lectotype and an isotype have been designated.

Keywords

Alpine flora, chasmophytes, Dolomites, herbaria

Introduction

Sempervivum dolomiticum Facchini (Facchini 1855) is an alpine chasmophytic species endemic to Italy. Its distribution is limited to the administrative regions of Veneto and Trentino-Alto Adige/Süd Tirol (Bartolucci et al. 2018; Argenti et al. 2019; Pignatti et al. 2019). A nomenclatural study of *S. dolomiticum* (Crassulaceae) revealed that this name has not yet been typified (Peruzzi et al. 2015). Our contribution has the

aim to identify the type material of *S. dolomiticum* and is part of ongoing research on the names of vascular plants described for the Italian Alps (e.g. Orsenigo and Galasso 2019; Orsenigo et al. 2019).

Materials and methods

This study is based on the examination of relevant literature and on a survey of the original material in the herbarium of the Italian botanist Francesco Facchini (1788–1852). The *exsiccata* are currently stored at the MUSE herbarium (TR, MUSE – Museo delle Scienze, Thiers B. 2018 onwards) in the "Ambrosi-Facchini" and "Gelmi" collections (Pedrotti and Tisi 1993; Festi and Prosser 2008). The protologue of *S. dolomiticum* (Facchini, 1855) has been meticulously scrutinized and compared with Facchini's collected material. The designation of type material has been done according to McNeill (2014) and Turland et al. (2018). Moreover, current presence of the species in its *locus classicus* was confirmed through a field survey conducted in the summer of 2019.

Typification of the name

***Sempervivum dolomiticum* Facchini, Z. Ferdinandeums Tirol 5(3): 56(–57). 1855.**

Type. Italy. "*Sempervivum* (1843/9/23) Sas della Porta. In tre pendici fino alla sommità, meno 5–10 passi. In alto, come gli altri semprevivi fra l'erba per difesa." "NB. Petala lata [?] 5'" longa, 1 1/3 lata reperta, medio striosatura fiore purpurea. Corolla *S. arachnoidei* major, sed quidem forma etiam germina. Squamae ut *S. funkii*, montani, etc..", 23 September 1843, *F. Facchini* (**lectotype designated here:** TR-BOT 002203, image available at https://www.muse.it/home/ricerca-e-collezioni/le-collezioni-scientifiche/catalogo-online-collezioni-muse/#/dettaglio/d01a09a4-d253-4b2d-ba6a-58e5c706c24a).

Ind. Loc. "Sas della Porta. In tre pendici fino alla sommità, meno 5–10 passi". Reg. Trentino–Alto Adige, Prov. Trento. TAA.

Isotype. Italy. "*Sempervivum* (1843/9/23) Alpe del Sas della Porta (Sec. = Kolf.) cum fol. Caulinis superioribus" 23 September 1843, *F. Facchini* TR-BOT 002204, image available at https://www.muse.it/home/ricerca-e-collezioni/le-collezioni-scientifiche/catalogo-online-collezioni-muse/#/dettaglio/db45fec9-a402-4ed5-a5b5-22e839671107).

Note. Code TR-BOT 002203 and TR-BOT 002204 refer to the herbarium vouchers selected as lectotype and isotype. However, the TR herbarium provides a code for each handwritten original note attached to the voucher. In particular, the Gelmi and Ambrosi-Facchini collections are study herbaria, and often the notes have been added on multiple occasions. As a consequence, a single voucher may be registered with more than one code. This is the case of isotype TR-BOT 002204, which has an additional note (marked TR-BOT 002205, visible at the provided link).

Nomenclatural notes. In the original description of *S. dolomiticum*, Facchini noted that this species co-occurs with *Sempervivum arachnoideum* L. (1753: 465) ("*[…] germina angustiora S. aracnoidei*"), specifically noting the absence of apical trichomes in the rosette. Additionally, among the diagnostic characteristics, Facchini identified: leaves with marginal hairs, purple petals, linear-lanceolate leaves, and lanceolate petals (see Fig. 1). We could trace seven specimens of *S. dolomiticum* in the TR collections. Amongst these, five were collected by Facchini himself while two were collected by Enrico Gelmi (Table 1). The sampling locations of two specimens collected by Facchini (TR-BOT002203 and TR-BOT002204) match with the protologue: "*[…] in Alpe Seekofl*", corresponding to the locality Croda del Becco, a mountainous part of the complex of Croda Rossa, bordering Veneto and Trentino Alto Adige. Between the two sheets, the lectotype has been chosen based on the conservation status of the sample and the quality of the notes: voucher TR-BOT002203 was chosen as lectotype and voucher TR-BOT002204 as isotype. Notes on these vouchers report the same date and location and the plant material is probably part of a single gathering. The quality of the

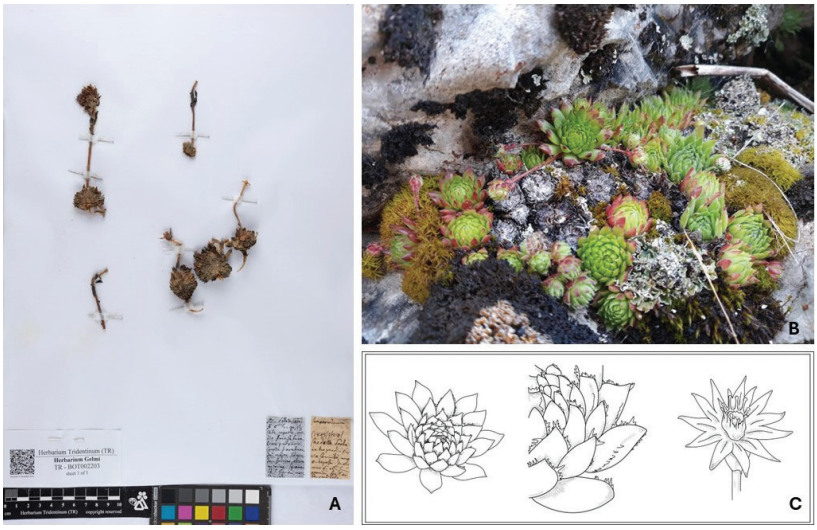

Figure 1. Photograph of the lectotype of the name *Sempervivum dolomiticum* Facchini, TR-BOT002203 (**A**); photograph of the plant in its natural habitat at the type locality Croda del Becco (*locus classicus*) (**B**), drawing based on living topotypical material, summarizing the main diagnostic characters: rosette with no apical hairs, linear-lanceolate leaves with marginal hairs, lanceolate petals (**C**).

Table 1. List of *exsiccata* belonging to "Ambrosi-Facchini" and "Gelmi" collections considered in this study.

Specimen code	Collection name	Sampling locality	Sampling date	Collector
TR-BOT002200	Gelmi	Fiemme, San Pellegrino, Trentino	31 July 1892	Enrico Gelmi
TR-BOT002201	Gelmi	Cirelle, Trento	10 October 1846	Enrico Gelmi
TR-BOT002203	Gelmi	Sas della Porta, Bolzano	23 September1843	Francesco Facchini
TR-BOT002204	Gelmi	Alpe del Sas della Porta, Bolzano	23 September 1843	Francesco Facchini
TR-BOT002206	Gelmi	Not specified	Not specified	Francesco Facchini
TR-BOT002208	Gelmi	Trento	29 June 1848	Francesco Facchini
TR-BOT050525	Ambrosi-Facchini	Soraga, Soraga di Fassa, Trentino	23, 24 July 1850	Francesco Facchini

specimens is low in all the herbarium vouchers considered in this study, probably due to difficulties in desiccating and preserving succulent plant tissues. Nevertheless, we can evaluate the selected types as fully compliant with the species description.

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