An Updated Checklist of The Alien Flora In a Mediterranean Region of Europe: The Case of Calabria (Southern Italy)

Giovanni Spampinato

University of Reggio Calabria Department of Agriculture: Università degli Studi Mediterranea di Reggio Calabria Dipartimento di Agraria

Valentina Lucia Astrid Laface

University of Reggio Calabria Department of Agriculture: Università degli Studi Mediterranea di Reggio Calabria Dipartimento di Agraria

Giandomenico Posillipo

University of Reggio Calabria Department of Agriculture: Università degli Studi Mediterranea di Reggio Calabria Dipartimento di Agraria

Ana Cano Ortiz

University of Jaen: Universidad de Jaen

Ricardo Quinto Canas

University of Algarve: Universidade do Algarve

Carmelo Maria Musarella (✉ carmelo.musarella@unirc.it)

Università degli Studi Mediterranea di Reggio Calabria <https://orcid.org/0000-0002-0120-190X>

Research Article

Keywords: Alien species, biodiversity, exotic plant, floristic data, herbarium specimens, IAS, invasiveness, new floristic records, plant diversity

Posted Date: August 18th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-797854/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

An updated checklist of the Calabrian alien vascular flora is presented. The alien flora of the Calabria region (Southern Italy) representing almost 12% of the regional flora and comprises 381 alien taxa, among which there are 370 angiosperms, 9 gymnosperms and 2 ferns. In relation to the state of spread, 35 invasive alien species (IAS) have been identified (4 of these are included in the list of Union Concern, *sensu* Regulation (EU) no. 1143/2014) which represent 9% of the Calabrian alien flora.

In the last years the alien flora in Calabria has increased: in particular, alien species have increased over a decade from 190 to the current 381 taxa. If on the one hand this is due to new introductions, resulting from the globalization that relentlessly affects the whole planet, on the other hand it is to be linked to awareness of the problem of alien species and the increasing intensity of research in recent decades.

This study would provide a baseline for further advanced studies on the management of invasive species and on the invasion ecology.

Introduction

Biological invasions are one of the greatest threats to biodiversity in the world, second in severity only to the destruction of natural habitats (Lawler et al. 2006; Seebens et al. 2017). Alien species are identified as a significant component of human-caused global environmental change, which also affects the conservation of biodiversity and the function of invaded ecosystems (Weber 2003; Pyšek et al. 2004; Richardson and Pyšek 2006). Aliens can affect the quality of habitats available to other species and consequently the ecosystem services provided (Gutiérrez 2017; Vilà and Hulme 2017; Castro-Diéz et al. 2019). Many studies ascertained and documented that alien species, especially invasive ones, can also cause considerable socio-economic and health damage (Richardson et al. 2000; Bacher et al. 2017).

Alien plants are becoming an important component of the wild flora and are a real challenge for current and future environmental and habitat management (Maes 2013; Gigante et al. 2018).

Alien plants checklists are critical to understanding plant invasions in many places around the world (Celesti-Grapow et al. 2009, 2010, 2016; Galasso et al. 2018a; Lazzaro et al. 2020; Viciani et al. 2020). The datasets on the floristic state, the biological attributes, the geographic distribution on the alien species are a significant tool for defining the models of plant invasions and invasiveness of the species (Pyšek et al. 2002, 2004).

The total number of alien plants in the European flora, estimated at around 6000 taxa, has tripled in the last half-century and is increasing through to 2050 (Lambdon et al. 2008; Pyšek et al. 2017; Seebens et al. 2017, 2021).

Many studies are available for Italy on a national or regional scale (Stinca et al. 2017; Rosati et al. 2020). Galasso et al. (2018a) estimate for the Italian territory 1741 alien species, of which 236 invasive (20 of

these species are included in the list of EU relevance (Implementing Regulation (EU) 2016/1141, of 13 July 2016 and 2019/1262 of 25 July 2019, European Commission 2019). This checklist has been updated by several other works until today (Galasso et al. 2018b, c, 2019a, b, 2020a, b, 2021). Furthermore, Lazzaro et al. (2019) proposed a list of 96 alien species that should be included in the Italian national list according to Regulation (EU) n. 1143/2014.

For Calabria there are various contributions, published mainly thanks to the research of our working group (Musarella et al. 2019, 2020; Spampinato et al. 2019; Musarella 2020; Rosati et al. 2020; Laface et al. 2020), but there was no a comprehensive analysis of the regional alien vascular flora.

The aim of this study is to present an updated checklist of the alien vascular flora of the Calabria Region (Southern Italy), which provides as much information as possible on the distribution and invasive status of the alien and habitat.

Materials And Methods

Data sources and terminology

The dataset for the current checklist originates from preliminary list of Italian alien species based on Celesti-Grapow et al. (2010), Galasso et al. (2018a) and Bartolucci et al. (2018), updated with the above mentioned literature for Italy and Calabria in particular and integrated with additional and updated information, field collections and survey. Collected specimens are preserved at Herbarium of Mediterranean University of Reggio Calabria (REGGIO), acronym according with Thiers (2021). Historical record (species no longer registered for 50 years, probably casual alien that have not settled), and doubtful record (doubtfully occurring in the region, probably reported by mistake or confusion with other species), are listed in the checklist but not included in this study.

Each species record is supplemented with data on taxonomy, life form and growth type, presence status, invasive and residence status, habitats, frequency.

Nomenclature of taxa follows Galasso et al. (2018a) and Bartolucci et al. (2018), while that of families' the APG system (Stevens 2001 onwards).

Data relating to the geographical distribution, origin and introduction pathway come from several online databases on alien species (CABI 2021; EPPO 2021; GBIF 2021; ISSG 2021; Portal to the Flora of Italy 2021; POWO 2021). Taxonomic distributions of alien plants were summarized in families and genera comparing with native species according to Bartolucci et al. (2018, 2021). Introduction pathways were assessed by distinguishing the following categories: ornamental, forest, agricultural and unknown (species without information on the purpose of introduction).

We classified "Invasive status" of alien plant species according to Richardson et al. (2000, 2011) and Pyšek et al. (2004) as "Casual" (alien plants that may reproduce occasionally outside cultivation without

form self-replacing populations, their persistence depends on repeated introductions), “Naturalized” (alien plants that sustain self-replacing populations and reproduce without direct human intervention from seed or vegetative parts capable of independent growth), “Invasive” (a subset of naturalized plants with the potential to spread over a large area in natural or human-made habitats, thanks to high reproductive efficiency and ability to long-distance dispersion from the parent plants), “Regional alien” (taxa native in other parts of the Italy but alien in Calabria). Plant kept only in cultivation are not included in this study.

Taxa without certainty as to whether they are native or alien are considered cryptogenic (Carlton 1996). They are listed in the check-list (Annex 1), but not considered in this study.

Alien taxa were distinguished with respect to the “Residence time”, as archaeophytes (introduced before ca. 1500) or and neophytes (introduced after ca. 1500), following criteria suggested by Richardson et al. (2000) and Pyšek et al. (2004).

The life forms, according to Raunkiaer classification (Raunkiaer 1934), followed Pignatti (2017a, b, 2018; Pignatti et al. 2019).

The following habitat group were distinguished: Artificial surfaces (Constructed, industrial and other artificial habitats, ruderal sites and linear infrastructure), Agricultural areas (Regularly or recently cultivated agricultural, horticultural and domestic habitats), Natural and seminatural habitats. The latter were divided into: grasslands, riparian habitats, shrubs, wetlands (including water bodies), woodlands and coasts. The distribution of the taxa among the different habitats as deduced from literature and from field observations on their frequency of occurrence. When a taxon is present in more than one habitat, the prevailing one is reported.

Study area

Calabria is the southernmost region of the Italian Peninsula (Fig. 1). It has an area of 15080.55 km² with a population of 1,877,728 inhabitants (ISTAT 2021) corresponding to an average density of 126.6 inhabitants/km².

Calabria is a narrow peninsula into the central Mediterranean basin, approximately 250 km long, surrounded on three sides by the sea, with a coastal development of 715 km. The region is crossed from north to south by a series of mountainous reliefs with varying altitudes between 1400 m and 2200 m a.s.l., which together constitute the Calabrian Apennines, a continuation of the southern Apennines.

The territory is mostly hilly (49%), there are few plains (9%) and large areas are mountainous (42%). As regards the use of the soil in Calabria, in accordance with the Land Cover Corine categories (ISPRA 2019) these are the percentages: Artificial surfaces 3.7 %, Agricultural areas 48.6%, Forest and semi natural areas 48.3% (of which 31% Forests), Wetlands 0.003%, Inland Water bodies 0.3 %.

Annual precipitation varies from 600 to 1800 mm, and mean annual temperature from 12 to 19°C. The prevailing bioclimate is the Mediterranean pluviseasonal oceanic type widespread from sea level up to

about 1000–1100 m a.s.l., while at higher altitudes the bioclimate is of the oceanic temperate type (Pesaresi et al. 2017).

The flora of the Calabria Region is estimated at 2768 native taxa (species and subspecies) (Bartolucci et al. 2018, 2021), to which 342 alien taxa must be added (Galasso et al. 2018a; Bartolucci et al. 2018, 2021).

Statistical analysis

The processed data were subjected to statistical analysis. To prove that the observed values fit the expected frequencies, the variables arranged in the form of contingency tables were standardised and the chi-square test " χ^2 " was carried out. All analyses were performed with Microsoft Excel® spreadsheet software.

Results

Taxonomic diversity

The critical analysis of bibliographic information, herbarium specimens, and observation and field collections carried out in this study, made it possible to update the checklist of the alien vascular flora to Calabria (see Annex 1).

Overall, the alien flora of this region includes 381 taxa (among species, subspecies and hybrids), belonging to 243 genera and 84 families (Table 1). They belong mainly to angiosperms eudicots (67 families, 282 taxa), followed by Monocots (19 families, 88 taxa), gymnosperms (2 families, 9 taxa), ferns and allies (2 families, 2 taxa). Taking into account the regional vascular flora (Bartolucci et al. 2018, 2021) alien taxa represent 12% of the Calabrian flora.

The distribution of alien taxa among the families is strongly unbalanced (Fig. 2). Most taxa are distributed in a few families, the largest of which are Asteraceae (39 taxa), Poaceae (38), Fabaceae (28), Solanaceae (23), while many families contain 1 or 2 taxa (Fig. 2).

The genera with the highest number of alien taxa are *Amaranthus* (9 taxa), *Prunus* (8), *Euphorbia*, *Oxalis* (7), *Vitis*, *Bidens*, *Cyperus*, *Solanum* (5). Most genera include only one species. The richest genera include weed species or species of agronomic interest.

Table 1
Taxonomic diversity of Calabrian flora (° this study, °° Bartolucci et al. 2018, 2021)

Category	N. alien taxa of Calabria°	N. native taxa of Italy°°
Species	381	2786
Genus	243	813
Family	84	149

New Aliens to Calabrian flora

The field research carried out along this study has identified several new alien vascular taxa for the flora of Calabria.

A complete list of these taxa is given in Annex 2 with complete information on collection locations and growth environment. Four taxa are new to the European flora (*Camptosema rubicundum*, *Ipomoea hederacea*, *Kalanchoë laxiflora*, *Musa ×paradisiaca*), 2 to the Italian peninsula (*Pelargonium graveolens*, *Schinus terebinthifolia*) and 14 to the Calabrian flora (*Aeonium arboreum*, *Asparagus asparagoides*, *Aspidistra elatior*, *Bidens sulphurea*, *Catalpa bignonioides*, *Citrus ×aurantium*, *Crassula ovata*, *Cucurbita ficifolia*, *Dimorphotheca ecklonis*, *Graptopetalum paraguayense* subsp. *paraguayense*, *Nicotiana tabacum*, *Phytolacca dioica*, *Portulaca umbraticola*, *Talinum paniculatum*, *Tecomaria capensis*).

Species status

In relation to the invasive status (Fig. 3), the largest group is the "casual" ones with over 58% of the flora (220 taxa), followed by the "naturalized" (126 taxa) 33%. Invasive alien species (IAS) are 35 and represent about 9% of the Calabrian alien vascular flora (4 of these are included in the Union list: *Acacia saligna*, *Cenchrus setaceus*, *Ailanthus altissima*, *Hydrocotyle ranunculoides*, the latter is a "historical report", recently not found for the region).

Regarding the residence status, 75% of the Calabrian alien taxa are neophytes (286), while the 20% are archaeophytes (76) and the 5% are regional alien (19). Comparing "residence status" and "invasive status", neophytes are in proportion better represented among the invasive aliens, where they make up almost all taxa (33 out of 35 taxa).

Life forms

The life forms spectrum (Fig. 4) highlights that Therophytes (30%, 116 taxa) and Phanerophytes (29%, 111 taxa) are dominant life forms among the Calabrian alien flora, followed by Hemicryptophytes (14%, 54 taxa), Geophytes (13%, 50), while other life forms such as Chamaephytes (8%, 29 taxa), Nanophanerophytes (4%, 17 taxa) and Hydrophytes (1%, 4 taxa) are less representative.

The analysis of statistical inference carried out with the chi-square test shows for the group of Phanerophytes/Nanophanerophytes (P/NP) a level of significance lower than 0.05 (**) and therefore on

average significant between the casual and the naturalized/invasive. In the case of Therophytes (T), the significance level is low as it is less than 0.1 (*). For the other life form categories, the differences are not significant (Fig. 5).

Comparison with the life forms spectrum of the native Calabrian flora (Pignatti 1994) shows that while the Therophytes have a similar percentage in native and alien species, the Phanerophytes/Nanophanerophytes have a much higher percentage among the aliens (33.6%) than among the natives (9.6%) (Fig. 6). The higher frequency of Phanerophytes/Nanophanerophytes results from the introduction and widespread use of trees and shrubs for ornamental purposes as *Acer negundo*, *Amorpha fruticosa*, *Austrocylindropuntia subulata*, *Schinus molle*, *Sesbania punicea*, but also forestry as *Acacia saligna*, *Robinia pseudacacia*, *Populus xcanadensis*, *Eucalyptus camaldulensis*, *E. occidentalis* or agricultural crops as *Ricinus communis*, *Vitis rupestris*, *Opuntia ficus-indica*.

The chi-square test confirms that the difference between alien and native Phanerophytes/Nanophanerophytes (P/NP) has a high significance level < 0.001 (***). Regarding the Hemicryptophytes (H), the significance level is low as it is below 0.1 (*). There are no significant differences for the other categories of life forms (Fig. 6).

Habitat

In Calabria, alien taxa grow mostly on artificial surfaces (194 taxa, 51%), especially in urban and suburban territory. Well represented is also the group of taxa growing on agricultural surfaces (20%) such as crops and orchards. As many as 109 taxa (28.6%) occur in natural and semi-natural habitats especially in riparian 7%, wetlands (6%), shrubs (5%) (Fig. 7). This data is quite alarming because shows that about to a third of the alien taxa in Calabria grow in natural environments which are in themselves vulnerable due to the anthropic pressure linked to the urbanization of the coastal strip, which is very accentuated in some places.

Geographical origin

Most of the alien taxa (156) recorded are native from Americas with 41% (95 from South America: 25%; 61 from North America: 16%). The second most important source is Asia, having 20% of alien taxa, while Africa follows with 15%. To a lesser extent, they are from Mediterranean Region (9%), Europe (5%) and Eurasia (4%). Finally, 2% are currently spread over a large distribution area (cosmopolitan), 2% from Australia, and other 2% are of uncertain origin (Fig. 8).

Introduction pathways

Most alien species are introduced intentionally as ornamental plants (55%), others are introduced as economically useful plants for agricultural (20%) or forestry (3%) purposes, or unintentional (22%) often as contaminated of seeds or soils.

Discussion

The alien vascular flora of Calabria accounts 381 taxa for approximately 12% of the regional flora. This is a conspicuous number of taxa when compared with other much larger Mediterranean territories such as Algeria with 211 alien plant taxa (Meddour et al. 2020), Turkey (340 taxa) (Uludağ et al. 2017) or Greece (343) (Arianoutsou 2010a), but in line with the number of alien plant taxa present in other Italian regions (Bartolucci et al. 2021).

The density of alien taxa per surface in Calabria ($\log \text{taxa}/\log \text{area}$) is 0.62, while that of naturalized taxa is 0.53: these data put Calabria among the Mediterranean territories with the highest invasiveness rate.

Compared to the other Italian regions, the number of alien taxa put Calabria among the less populated ones with an agricultural vocation, such as Puglia (361 taxa) and Abruzzo (350), far from the industrialized and densely populated regions of the north of the Italian country, such as Lombardy (776) and Veneto (618) (Galasso et al. 2018a).

The abundance of neotropical thermophilic taxa of South America origin is favoured by the Mediterranean bioclimate that affects a large part of the region, up to about 1000 m altitude.

Over the last decade, the number of alien taxa in Calabria has risen from 190 recorded in 2009 by Celesti-Grapo (2009), to 267 in 2018 (Galasso et al. 2018a), to the current 381 taxa. This is due to new introductions as a result of globalization, which is relentlessly affecting the entire planet, but on the other hand it is linked to the awareness of the problem of alien species and the increasing intensity of research in recent decades.

The highly significant preponderance of Phanerophytes/Nanophanerophytes among the aliens is a common character in the invasive flora of various territory due to predilection of gardeners for ornamental trees (Crawley et al. 1996). The dominance of Phanerophytes/Nanophanerophytes and Therophytes in the alien flora is a common feature with other Mediterranean territories (Arianoutsou et al. 2010b; Podda et al. 2012). These two life forms appear the most suitable to overcome the long dry season typical of the Mediterranean bioclimate. They occupy different niches and base their success in colonizing new territories on different strategies: Phanerophytes cope with water scarcity through their architecture, while Therophytes avoid the dry season (Allen 2001).

Conclusions

This study highlights a progressive and constant increase in alien taxa in the vascular flora of Calabria. The coastal environments are those most threatened by the expansion of alien taxa; road and railway infrastructures are the main ways of spreading alien plants. On the other hand, waterways and disturbed humid environments also contribute to the maintenance and expansion of exotic species. Further investigations are needed to better quantify the damage caused by invasive species to natural ecosystems and habitats.

Most of the new entries are represented by plants escaped from gardens, confirming the importance of the cultivation of ornamental plants as a source of introductions.

Future solutions to contain the problem depend not only on the tools made available by the legislator and on the interventions implemented by the administrators of local authorities, but also on the ability of researchers and administrators to find technical solutions and to make citizens aware of the rules and behaviors to be adopted, especially in the nursery field, to contain the spread of alien species (Caddeo et al. 2020).

Declarations

Acknowledgements

The authors are very grateful to Ms. Monika Mojtova for the linguistic revision of the text.

Funding: Not applicable.

Conflicts of interest/Competing interests: The authors declare that they have no conflict of interest.

Availability of data and material: All data generated or analyzed during this study are included in this published article and its supplementary information files.

Code availability: Not applicable.

Authors' contributions (optional: please review the submission guidelines from the journal whether statements are mandatory)

Ethics approval: Not applicable.

Consent to participate: Not applicable.

Consent for publication (include appropriate statements): Not applicable.

References

1. Allen HD (2001) Mediterranean ecogeography. Pearson Education Limited. Edinburgh
2. Arianoutsou M, Bazos I, Delipetrou P, Kokkoris Y (2010a) The alien flora of Greece: taxonomy, life traits and habitat preferences. *Biol Invasions* 12:3525–3549. <https://doi.org/10.1007/s10530-010-9749-0>
3. Arianoutsou M, Delipetrou P, Celesti-Grapo L, Basnou C, Bazos I, Kokkoris Y, Blasi C, Vilà M (2010b) Comparing naturalized alien plants and recipient habitats across an east–west gradient in the Mediterranean Basin. *J Biogeogr* 37:1811–1823

4. Bacher S, Blackburn TM, Essl F, Genovesi P, Heikkilä J (2017) Socio-economic impact classification of alien taxa (SEICAT). *Methods Ecol Evol* 9:159–168. <https://doi.org/10.1111/2041-210x.12844>
5. Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A et al (2018) An updated checklist of the vascular flora native to Italy. *Plant Biosyst* 152:179–303
6. Bartolucci F, Galasso G, Peruzzi L, Conti F (2021) Report 2020 on plant biodiversity in Italy: native and alien vascular flora. *Natural History Sci* 8(1):41–54. <https://doi.org/10.4081/nhs.2021.520>
7. CABI (2021) Retrieved 30 June 2021
8. Caddeo A, Cogoni A, Iriti G, Loi MC, Marignani M et al (2020) Dai balconi ai parchi urbani: buone pratiche per un giardinaggio consapevole. Life ASAP Pubblicazione realizzata nell'ambito dell'azione B4 del progetto LIFE15 GIE/IT/001039 "Alien Species Awareness Program" (ASAP)
9. Carlton JT (1996) Biological invasions and cryptogenic species. *Ecology* 77:1653–1655
10. Castro-Díez P, Vaz AS, Silva JS, Loo M, Alonso A et al (2019) Godoy Global effects of non-native tree species on multiple ecosystem services. *Biol Rev* 94(4):1477–1501. <https://doi.org/10.1111/brv.12511>
11. Celesti-Grapow L, Alessandrini A, Arrigoni PV, Banfi E, Bernardo L et al (2009) The inventory of the non-native flora of Italy. *Plant Biosyst* 143(2):386–430. <https://doi.org/10.1080/11263500902722824>
12. Celesti-Grapow L, Pretto F, Carli E, Blasi C (eds) (2010) Non-native and invasive vascular flora of the regions of Italy. Casa Editrice Università La Sapienza, Roma (in Italian)
13. Celesti-Grapow L, Bassi L, Brundu G, Camarda I, Carli E et al (2016) Plant invasions on small Mediterranean islands: an overview. *Plant Biosyst* 150(5):1119–1133. <https://doi.org/10.1080/11263504.2016.1218974>
14. Crawley MJ, Harvey PH, Purvis A (1996) Comparative Ecology of the Native and Alien Floras of the British Isles. *Philosophical Transactions: Biological Sciences*, 351(1345): 1251–1259. Retrieved August 3, 2021, from <http://www.jstor.org/stable/56200>
15. EPPO (2021) Retrieved 30 June 2021
16. European Commission (2019) Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the Prevention and Management of the Introduction and Spread of Invasive Alien Species. *Off J Eur Union* 2014, 317, 35–55
17. Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E et al (2018a) An updated checklist of the vascular flora alien to Italy. *Plant Biosyst* 152(3):556–592. <https://doi.org/10.1080/11263504.2018.1441197>
18. Galasso G, Domina G, Adorni M, Ardenghi NMG, Bonari G et al (2018b) Notulae to the Italian alien vascular flora: 5. *Ital Bot* 5:45–56. <https://doi.org/10.3897/italianbotanist.5.25910>
19. Galasso G, Domina G, Alessandrini A, Ardenghi NMG, Bacchetta G et al (2018c) Notulae to the Italian alien vascular flora: 6. *Ital Bot* 6:65–90. <https://doi.org/10.3897/italianbotanist.6.30560>

20. Galasso G, Domina G, Ardenghi NMG, Aristarchi C, Bacchetta G et al (2019a) Notulae to the Italian alien vascular flora: 7. *Ital Bot* 7:157–182. <https://doi.org/10.3897/italianbotanist.7.36386>
21. Galasso G, Domina G, Andreatta S, Angiolini C, Ardenghi NMG et al (2019b) Notulae to the Italian alien vascular flora: 8. *Ital Bot* 8:63–93. <https://doi.org/10.3897/italianbotanist.8.48621>
22. Galasso G, Domina G, Adorni M, Angiolini C, Apruzzese M et al (2020a) Notulae to the Italian alien vascular flora: 9. *Ital Bot* 9:47–70. <https://doi.org/10.3897/italianbotanist.9.53401>
23. Galasso G, Domina G, Azzaro D, Bagella S, Barone G et al (2020b) Notulae to the Italian alien vascular flora: 10. *Ital Bot* 10:57–71. <https://doi.org/10.3897/italianbotanist.10.60736>
24. Galasso G, Domina G, Andreatta S, Argenti E, Bacchetta G et al (2021) Notulae to the Italian alien vascular flora: 11. *Ital Bot* 11:93–119. <https://doi.org/10.3897/italianbotanist.11.68063>
25. GBIF.org (2021) GBIF Home Page. Available from: <https://www.gbif.org> [13 July 2021]
26. Gigante D, Acosta ATR, Agrillo E, Armiraglio S, Assini S et al (2018) Habitat conservation in Italy: the state of the art in the light of the first European red list of terrestrial and freshwater habitats. *Rend Lincei Sci Fis Nat* 29:251–265
27. Gutiérrez JL (2017) Modification of Habitat Quality by Non-native Species. In: Vilà M, Hulme P (eds) *Impact of Biological Invasions on Ecosystem Services*, vol 12. Springer, Cham. https://doi.org/10.1007/978-3-319-45121-3_3 Invading Nature - Springer Series in Invasion Ecology
28. ISPRA (2019) *Annuario dei dati ambientali 2019*. <https://annuario.isprambiente.it/ada/downreport/html/7037#C7037> Retrieved 30 June 2021
29. ISSG (Invasive Species Specialist Group) ISSG 20152021. The Global Invasive Species Database. Version 2015.1. Retrieved 30 June 2021
30. ISTAT (2021) <http://dati.istat.it/Index.aspx?QueryId=18565>. Retrieved January 30 June 2021
31. Karamura DA (1998) Numerical Taxonomic Studies of the East African Highland Bananas (*Musa AAA-East Africa*) in Uganda. The University of Reading
32. Laface VLA, Musarella CM, Cano Ortiz A, Quinto Canas R, Cannavò S, Spampinato G (2020) Three New Alien Taxa for Europe and a Chorological Update on the Alien Vascular Flora of Calabria (Southern Italy). *Plants* 9:1181. <https://doi.org/10.3390/plants9091181>
33. Lambdon PW, Pyšek P, Basnou C, Hejda M, Arianoutsou M et al (2008) Alien flora of Europe: species diversity, temporal trends, geographical patterns and research needs. *Preslia* 80:101–149
34. Lawler JJ, Aukema JE, Grant JB, Halpern BS, Kareiva P et al (2006) Conservation science: A 20-year report card. *Front Ecol Environ* 4(9):473–480
35. Lazzaro L, Bolpagni R, Barni E, Brundu G, Blasi C et al (2019) Towards alien plant prioritization in Italy: methodological issues and first results. *Plant Biosyst* 153(5):740–746. <https://doi.org/10.1080/11263504.2019.1640310>
36. Lazzaro L, Bolpagni R, Buffa G, Gentili R, Lonati M et al (2020) Impact of invasive alien plants on native plant communities and Natura 2000 habitats: State of the art, gap analysis and perspectives in Italy. *J Environ Manage* 274:111140. <https://doi.org/10.1016/j.jenvman.2020.111140>

37. Lorenzi H, Souza HM (2008) Plantas ornamentais no Brasil: arbustivas, herbáceas e trepadeiras. 4.ed. – Nova Odessa. Instituto Plantarum, p 1088
38. Maes J (2013) A Model for the Assessment of Habitat Conservation Status in the EU. JRC Scientific and Policy Report. European Commission Joint Research Centre Institute for Environment and Sustainability. Publication Office of the European Commission, Luxembourg
39. Meddour R, Sahar O, Fried G (2020) A preliminary checklist of the alien flora of Algeria (North Africa): taxonomy, traits and invasiveness potential. *Bot Lett* 167(4):453–470. <https://doi.org/10.1080/23818107.2020.1802775>
40. Molina AB, Roa VN (eds) (2000) Advancing banana and plantain R&D in Asia and the Pacific. Proceedings of the 9th INIBAP-ASPNET Regional Advisory Committee meeting held in South China Agricultural University, Guangzhou, China, 2–5 November 1999
41. Musarella CM (2020) *Solanum torvum* Sw. (Solanaceae): a new alien species for Europe. *Genet Resour Crop Evol* 67(2):515–522. <https://doi.org/10.1007/s10722-019-00822-5>
42. Musarella CM, Laface VLA, Morabito A, Cano-Ortiz A, Cannavò S, Spampinato G (2019) Aggiornamenti sulla flora alloctona calabrese: Novità e conferme. *Notiz Soc Bot Ital* 3:39–40
43. Musarella CM, Stinca A, Cano-Ortiz A, Laface VLA, Petrilli R, Esposito A, Spampinato G (2020) New data on the alien vascular flora of Calabria (southern Italy). *Ann Bot* 10:55–66
44. Pesaresi S, Biondi E, Casavecchia S (2017) Bioclimates of Italy. *Journal of Maps* 13(2):955–960. <https://doi.org/10.1080/17445647.2017.1413017>
45. Pignatti S (1994) *Ecologia del paesaggio*. UTET Editore - Torino
46. Pignatti S (2017a) *Flora d'Italia: In 4 Volumi. Volume 1: Flora d'Italia & Flora Digitale*, 2nd ed.; Edagricole-Edizioni Agricole di New Business Media srl: Milano, Italy. ISBN 978-88-506-5242-6
47. Pignatti S (2017b) *Flora d'Italia: In 4 Volumi. Volume 2: Flora d'Italia & Flora Digitale*, 2nd ed.; Edagricole-Edizioni Agricole di New Business Media srl: Milano, Italy. ISBN 978-88-506-5243-3
48. Pignatti S (2018) *Flora d'Italia: In 4 Volumi. Volume 3: Flora d'Italia & Flora Digitale*, 2nd ed.; Edagricole-Edizioni Agricole di New Business Media srl: Milano, Italy. ISBN 978-88-506-5244-0
49. Pignatti S, Guarino R, La Rosa M (2019) *Flora d'Italia: In 4 Volumi Volume 4: Flora d'Italia & Flora Digitale*, 2nd ed.; Edagricole-Edizioni Agricole di New Business Media srl: Milano, Italy. ISBN 978-88-506-5245-7
50. Podda L, Lazzeri V, Mascia F, Mayoral O, Bacchetta G (2012) The checklist of the Sardinian exotic flora: an update. *Not Bot Horti Agrob* 40(2):14–21. <https://doi.org/10.15835/nbha4028225>
51. Portal to the Flora of Italy (2021) Available at <http://dryades.units.it/floritaly>. Retrieved 30 June 2021
52. POWO (2019) *Plants of the World Online*. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet; <http://www.plantsoftheworldonline.org/> Retrieved 30 June 2021
53. Pyšek P, Jarošík V, Kucera T (2002) Patterns of invasion in temperate nature reserves. *Biol Cons* 104:13–24

54. Pyšek P, Richardson DM, Rejmánek M, Webster G, Williamson M et al (2004) Alien plants in checklists and floras: Towards better communication between taxonomists and ecologists. *Taxon* 53(1):131–143. <https://doi.org/10.2307/4135498>
55. Pyšek P, Pergl J, Essl F, Lenzner B, Dawson W et al (2017) Naturalized alien flora of the world: Species diversity, taxonomic and phylogenetic patterns, geographic distribution and global hotspots of plant invasion. *Preslia*, 89(3): 203–274. <https://doi.org/10.23855/preslia.2017.203>
56. Raunkiaer C (1934) The life-forms of plants and statistical plant geography. Clarendon Press, Oxford
57. Richardson DM, Pyšek P (2006) Plant invasions: merging the concepts of species invasiveness and community invasibility. *Prog Phys Geogr* 30:409–431
58. Richardson DM, Pyšek P, Rejmánek M, Barbour MG, Panetta FD et al (2000) Naturalization and invasion of alien plants: Concepts and definitions. *Diversity Distrib* 6:93–107
59. Richardson DM, Pyšek P, Carlton JT (2011) A compendium of essential concepts and terminology in biological invasions. In: Richardson DM (ed) *Fifty Years of Invasion Ecology: The Legacy of Charles Elton*. Blackwell Publishing, Oxford, pp 409–420
60. Rosati L, Fascetti S, Romano VA, Potenza G, Lapenna MR et al (2020) New Chorological Data for the Italian Vascular Flora. *Diversity* 12:22. <https://doi.org/10.3390/d12010022>
61. Seebens H, Blackburn TM, Dyer EE, Genovesi P, Hulme PE et al (2017) *Nat Commun* 8:14435. <https://doi.org/10.1038/ncomms14435>
62. Seebens H, Bacher S, Blackburn T, Capinha C, Dawson W et al (2021) Projecting the continental accumulation of alien species through to 2050. *Glob Chang Biol* 27:970–982
63. Sell P, Murrell G (2009) *Flora of Great Britain and Ireland 3: Mimosaceae – Lentibulariaceae*, vol III. Cambridge University Press, pp 342–348
64. Spampinato G, Cannavò S, Cano-Ortiz A, Caruso G, Laface VLA et al (2019) Invasività di *Cenchrus setaceus* (Forssk.) Morrone in Italia. *Notiz Soc Bot Ital* 3:1–10
65. Stevens PF (2001) onwards) Angiosperm Phylogeny website. Version 14, July 2017. <http://www.mobot.org/MOBOT/research/APweb/>
66. Stinca A, Chianese G, D’Auria G, Del Guacchio E, Fascetti S et al (2017) New alien vascular species for the flora of southern Italy. *Webbia* 72(2):295–301. <https://doi.org/10.1080/00837792.2017.1349236>
67. Thiers B (2021) Index Herbariorum: A Global Directory of Public Herbaria and Associated Sta. New York Botanical Garden’s Virtual Herbarium. 2019. Available online: <http://sweetgum.nybg.org/science/ih/> (accessed on 30 June 2021)
68. Uludağ A, Aksoy N, Yazlık A, Arslan ZF, Yazmış E et al (2017) Alien flora of Turkey: checklist, taxonomic composition and ecological attributes. *NeoBiota* 35:61–85. <https://doi.org/10.3897/neobiota.35.12460>
69. Weber E (2003) *Invasive plant species of the world: a reference guide to environmental weeds*. CAB Int Publ, Wallingford

70. Viciani D, Vidali M, Gigante D, Bolpagni R, Villani M et al (2020) A first checklist of the alien-dominated vegetation in Italy. *Plant Sociol* 57:29–54
71. Vilà M, Hulme PE (2017) *Impact of biological invasions on ecosystem services*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-45121-3>
72. Wood JRI, Williams BRM, Mitchell TC, Carine MA, Harris DJ et al (2015) A foundation monograph of *Convolvulus* L. (Convolvulaceae). *PhytoKeys* 51:1–278. <https://doi.org/10.3897/phytokeys.51.7104>

Figures

Figure 1

Geographical position of Calabria region in the Mediterranean basin.

Figure 2

The most represented families of the Calabria alien flora (>4 taxa). Residence status is distinct.

Figure 3

Number of taxa per invasive status (casual, invasive and naturalized) among residence status (neophytes, archaeophytes and regional alien).

Figure 4

Distribution of life forms in casual, naturalized and invasive taxa in the Calabrian alien vascular flora.

Figure 5

Alien taxa recorded for the Calabria region classified according to Raunkiaer life forms classification subdivided into casual taxa (white bars) and invasive/naturalized taxa (black bars). The bars indicate the number of taxa of each life form to the total number of incidences within casual and invasive/naturalized. Significant differences are indicated above the bars (* < 0.05 , ** < 0.01 , *** < 0.001).

Figure 6

Comparison of alien and native taxa in the Calabria region, subdivided according to Raunkiaer life forms. Regarding the "Alien" taxa (white bars) and "Native" taxa (black bars), the bars indicate the percentage contribution of each life form to the total number of incidences within alien and native. Significant differences are indicated above the bars (* < 0.05, ** < 0.01, *** < 0.001).

Figure 7

Number and percentage of alien plant taxa according to habitats types in Calabria.

Figure 8

Geographical origin of the alien vascular flora of Calabria. The number of taxa and the residence status are given.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Annex1.docx](#)
- [Annex2.docx](#)